LLGL

0.02 Beta

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Chapter 1

LLGL 0.02 Beta Documentation

LLGL (Low Level Graphics Library)

Overview

- **Version**: 0.02 Beta
- **License**: 3-Clause BSD License

Progress

- **OpenGL Renderer**: ∼90% done
- **Direct3D 11 Renderer**: ∼90% done
- **Direct3D 12 Renderer**: ∼15% done
- **Vulkan Renderer**: ∼30% done
- **Metal enderer**: ∼5% done

Getting Started

```
#include <LLGL/LLGL.h>

int main()
{
    // Create a window to render into
    LLGL::WindowDescriptor windowDesc;

    windowDesc.title    = L"LLGL Example";
    windowDesc.visible  = true;
    windowDesc.centered = true;
    windowDesc.width    = 640;
    windowDesc.height   = 480;

    auto window = LLGL::Window::Create(windowDesc);

    // Add keyboard/mouse event listener
    auto input = std::make_shared<LLGL::Input>();
    window->AddEventListener(input);

    //TO BE CONTINUED ...

    // Main loop
    while (window->ProcessEvents() && !input->KeyPressed(LLGL::Key::Escape))
    {

        // Draw with OpenGL, or Direct3D, or Vulkan, or whatever ...

    }

    return 0;
}
```

Thin Abstraction Layer

```
// Unified Interface:
CommandBuffer::DrawIndexed(std::uint32_t numIndices, std::uint32_t firstIndex);

// OpenGL Implementation:
void GLCommandBuffer::DrawIndexed(std::uint32_t numIndices, std::uint32_t firstIndex) {
    const GLsizeiptr indices = firstIndex * renderState_.indexBufferStride;
    glDrawElements(
        renderState_.drawMode,
        static_cast<GLsizei>(numIndices),
        renderState_.indexBufferDataType,
        reinterpret_cast<const GLvoid*>(indices)
    );
}

// Direct3D 11 Implementation
void D3D11CommandBuffer::DrawIndexed(std::uint32_t numIndices, std::uint32_t firstIndex) {
    context_->DrawIndexed(numIndices, firstIndex, 0);
}

// Direct3D 12 Implementation
void D3D12CommandBuffer::DrawIndexed(std::uint32_t numIndices, std::uint32_t firstIndex) {
    commandList_->DrawIndexedInstanced(numIndices, 1, firstIndex, 0, 0);
}

// Vulkan Implementation
void VKCommandBuffer::DrawIndexed(std::uint32_t numIndices, std::uint32_t firstIndex) {
    vkCmdDrawIndexed(commandBuffer_, numIndices, 1, firstIndex, 0, 0);
}

// Metal implementation
void MTCommandBuffer::DrawIndexed(std::uint32_t numIndices, std::uint32_t firstIndex) {
    if (numPatchControlPoints_ > 0) {
        [renderEncoder_
            drawIndexedPatches:             numPatchControlPoints_
            patchStart:                     static_cast<NSUInteger>(firstIndex) / numPatchControlPoints_
            patchCount:                     static_cast<NSUInteger>(numIndices) / numPatchControlPoints_
            patchIndexBuffer:               nil
            patchIndexBufferOffset:         0
            controlPointIndexBuffer:        indexBuffer_
            controlPointIndexBufferOffset:  indexTypeSize_ * (static_cast<NSUInteger>(firstIndex))
            instanceCount:                  1
            baseInstance:                   0
        ];
    } else {
        [renderEncoder_
            drawIndexedPrimitives:  primitiveType_
            indexCount:             static_cast<NSUInteger>(numIndices)
            indexType:              indexType_
            indexBuffer:            indexBuffer_
            indexBufferOffset:      indexTypeSize_ * static_cast<NSUInteger>(firstIndex)
        ];
    }
}
```

Chapter 2

Todo List

Member LLGL::BlendDescriptor::blendFactor

Move this into a dynamic function "CommandBuffer::SetBlendFactor".

Member LLGL::BufferType

Maybe replace this enum by "ResourceType".

Member LLGL::ESProfile

This is incomplete, do not use!

Member LLGL::FrameProfile::bufferReads

Not available yet.

Member LLGL::FrameProfile::textureCopies

Not available yet.

Member LLGL::FrameProfile::textureMappings

Not available yet.

Member LLGL::Image::Fill (Offset3D offset, Extent3D extent, const ColorRGBAd &fillColor)

Not implemented yet.

Member LLGL::Image::MirrorXYPlane ()

Not implemented yet

Member LLGL::Image::MirrorXZPlane ()

Not implemented yet

Member LLGL::Image::MirrorYZPlane ()

Not implemented yet

Member LLGL::Image::Resize (const Extent3D &extent, const SamplerFilter filter)

Not implemented yet.

Member LLGL::ImageInitialization::clearValue

Currently only supports initialization of color and depth. Default initialization of stencil values is not supported yet.

Class LLGL::RenderingProfiler

Refactor this for the new ResourceHeap and RenderPass interfaces.

Class LLGL::ResourceHeap

Maybe rename to "ResourceViewHeap" again?

Class LLGL::ShaderUniform

Complete documentation.

Class LLGL::VideoAdapterDescriptor

Currently unused in the interface.

Class LLGL::VideoOutputDescriptor

Currently unused in the interface.

Class LLGL::VsyncDescriptor

Maybe remove this entire structure and only use a "vsyncInterval" parameter.

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File Index

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Chapter 8

Module Documentation

8.1 Global functions for Strict-Weak-Order (SWO) comparisons.

Functions

- LLGL_EXPORT bool LLGL::CompareSWO (const DisplayModeDescriptor &lhs, const DisplayMode↩ Descriptor &rhs)

  Compares the two display modes in a strict-weak-order (SWO) fashion.

8.1.1 Detailed Description

8.1.2 Function Documentation

8.1.2.1 LLGL_EXPORT bool LLGL::CompareSWO (const DisplayModeDescriptor & *lhs*, const DisplayModeDescriptor & *rhs*)

Compares the two display modes in a strict-weak-order (SWO) fashion.

8.2 Global operators for basic data structures.

Functions

- LLGL_EXPORT Extent2D LLGL::operator+ (const Extent2D &lhs, const Extent2D &rhs)

  Returns the sum of left hand side extent 'lhs' and the right hand side extent 'rhs'.
- LLGL_EXPORT Extent2D LLGL::operator- (const Extent2D &lhs, const Extent2D &rhs)

  Returns the subtractionn of left hand side extent 'lhs' and the right hand side extent 'rhs'.
- LLGL_EXPORT Extent3D LLGL::operator+ (const Extent3D &lhs, const Extent3D &rhs)

  Returns the sum of left hand side extent 'lhs' and the right hand side extent 'rhs'.
- LLGL_EXPORT Extent3D LLGL::operator- (const Extent3D &lhs, const Extent3D &rhs)

  Returns the subtractionn of left hand side extent 'lhs' and the right hand side extent 'rhs'.
- LLGL_EXPORT Offset2D LLGL::operator+ (const Offset2D &lhs, const Offset2D &rhs)

  Returns the sum of left hand side offset 'lhs' and the right hand side offset 'rhs'.
- LLGL_EXPORT Offset2D LLGL::operator- (const Offset2D &lhs, const Offset2D &rhs)

  Returns the subtractionn of left hand side offset 'lhs' and the right hand side offset 'rhs'.
- LLGL_EXPORT Offset3D LLGL::operator+ (const Offset3D &lhs, const Offset3D &rhs)

  Returns the sum of left hand side offset 'lhs' and the right hand side offset 'rhs'.
- LLGL_EXPORT Offset3D LLGL::operator- (const Offset3D &lhs, const Offset3D &rhs)

  Returns the subtractionn of left hand side offset 'lhs' and the right hand side offset 'rhs'.
- bool LLGL::operator== (const Offset2D &lhs, const Offset2D &rhs)

  Returns true if the left hand side offset 'lhs' is equal to the right hand side offset 'rhs'.
- bool LLGL::operator!= (const Offset2D &lhs, const Offset2D &rhs)

  Returns true if the left hand side offset 'lhs' is unequal to the right hand side offset 'rhs'.
- bool LLGL::operator== (const Offset3D &lhs, const Offset3D &rhs)

  Returns true if the left hand side offset 'lhs' is equal to the right hand side offset 'rhs'.
- bool LLGL::operator!= (const Offset3D &lhs, const Offset3D &rhs)

  Returns true if the left hand side offset 'lhs' is unequal to the right hand side offset 'rhs'.
- bool LLGL::operator== (const Extent2D &lhs, const Extent2D &rhs)

  Returns true if the left hand side extent 'lhs' is equal to the right hand side extent 'rhs'.
- bool LLGL::operator!= (const Extent2D &lhs, const Extent2D &rhs)

  Returns true if the left hand side extent 'lhs' is unequal to the right hand side extent 'rhs'.
- bool LLGL::operator== (const Extent3D &lhs, const Extent3D &rhs)

  Returns true if the left hand side extent 'lhs' is equal to the right hand side extent 'rhs'.
- bool LLGL::operator!= (const Extent3D &lhs, const Extent3D &rhs)

  Returns true if the left hand side extent 'lhs' is unequal to the right hand side extent 'rhs'.

8.2.1 Detailed Description

8.2.2 Function Documentation

8.2.2.1 bool LLGL::operator!= (const **Offset2D** & *lhs*, const **Offset2D** & *rhs*) `[inline]`

Returns true if the left hand side offset 'lhs' is unequal to the right hand side offset 'rhs'.

8.2.2.2 bool LLGL::operator!= (const **Offset3D** & *lhs*, const **Offset3D** & *rhs*) `[inline]`

Returns true if the left hand side offset 'lhs' is unequal to the right hand side offset 'rhs'.

8.2.2.3 bool LLGL::operator!= (const Extent2D & *lhs,* const Extent2D & *rhs*) [inline]

Returns true if the left hand side extent 'lhs' is unequal to the right hand side extent 'rhs'.

8.2.2.4 bool LLGL::operator!= (const Extent3D & *lhs,* const Extent3D & *rhs*) [inline]

Returns true if the left hand side extent 'lhs' is unequal to the right hand side extent 'rhs'.

8.2.2.5 LLGL_EXPORT Extent2D LLGL::operator+ (const Extent2D & *lhs,* const Extent2D & *rhs*)

Returns the sum of left hand side extent 'lhs' and the right hand side extent 'rhs'.

Remarks

If the operation results in a numerical overflow, the respective components will be clamped to its maximum, i.e. `std::numeric_limits<std::uint32_t>::max()`.

8.2.2.6 LLGL_EXPORT Extent3D LLGL::operator+ (const Extent3D & *lhs,* const Extent3D & *rhs*)

Returns the sum of left hand side extent 'lhs' and the right hand side extent 'rhs'.

Remarks

If the operation results in a numerical overflow, the respective components will be clamped to its maximum, i.e. `std::numeric_limits<std::uint32_t>::max()`.

8.2.2.7 LLGL_EXPORT Offset2D LLGL::operator+ (const Offset2D & *lhs,* const Offset2D & *rhs*)

Returns the sum of left hand side offset 'lhs' and the right hand side offset 'rhs'.

Remarks

If the operation results in a numerical overflow or underflow, the respective components will be clamped into the range `[std::numeric_limits<std::int32_t>::min(), std::numeric_↩ limits<std::int32_t>::max()]`.

8.2.2.8 LLGL_EXPORT Offset3D LLGL::operator+ (const Offset3D & *lhs,* const Offset3D & *rhs*)

Returns the sum of left hand side offset 'lhs' and the right hand side offset 'rhs'.

Remarks

If the operation results in a numerical overflow or underflow, the respective components will be clamped into the range `[std::numeric_limits<std::int32_t>::min(), std::numeric_↩ limits<std::int32_t>::max()]`.

8.2.2.9 LLGL_EXPORT Extent2D LLGL::operator- (const Extent2D & *lhs*, const Extent2D & *rhs*)

Returns the subtractionn of left hand side extent 'lhs' and the right hand side extent 'rhs'.

Remarks

If the operation results in a numerical underflow, the respective components will be clamped to its minimum, i.e. 0.

8.2.2.10 LLGL_EXPORT Extent3D LLGL::operator- (const Extent3D & *lhs*, const Extent3D & *rhs*)

Returns the subtractionn of left hand side extent 'lhs' and the right hand side extent 'rhs'.

Remarks

If the operation results in a numerical underflow, the respective components will be clamped to its minimum, i.e. 0.

8.2.2.11 LLGL_EXPORT Offset2D LLGL::operator- (const Offset2D & *lhs*, const Offset2D & *rhs*)

Returns the subtractionn of left hand side offset 'lhs' and the right hand side offset 'rhs'.

Remarks

If the operation results in a numerical overflow or underflow, the respective components will be clamped into the range `[std::numeric_limits<std::int32_t>::min(), std::numeric_↩ limits<std::int32_t>::max()]`.

8.2.2.12 LLGL_EXPORT Offset3D LLGL::operator- (const Offset3D & *lhs*, const Offset3D & *rhs*)

Returns the subtractionn of left hand side offset 'lhs' and the right hand side offset 'rhs'.

Remarks

If the operation results in a numerical overflow or underflow, the respective components will be clamped into the range `[std::numeric_limits<std::int32_t>::min(), std::numeric_↩ limits<std::int32_t>::max()]`.

8.2.2.13 bool LLGL::operator== (const Offset2D & *lhs*, const Offset2D & *rhs*) `[inline]`

Returns true if the left hand side offset 'lhs' is equal to the right hand side offset 'rhs'.

8.2.2.14 bool LLGL::operator== (const Offset3D & *lhs*, const Offset3D & *rhs*) `[inline]`

Returns true if the left hand side offset 'lhs' is equal to the right hand side offset 'rhs'.

8.2.2.15 bool LLGL::operator== (const Extent2D & *lhs*, const Extent2D & *rhs*) `[inline]`

Returns true if the left hand side extent 'lhs' is equal to the right hand side extent 'rhs'.

8.2.2.16 bool LLGL::operator== (const Extent3D & *lhs*, const Extent3D & *rhs*) `[inline]`

Returns true if the left hand side extent 'lhs' is equal to the right hand side extent 'rhs'.

8.3 Global type aliases to callback interfaces.

Typedefs

- using LLGL::DebugCallback = std::function< void(const std::string &type, const std::string &message)>

  Debug callback function interface.
- using LLGL::ValidateRenderingCapsFunc = std::function< bool(const std::string &info, const std::string &attrib)>

  Callback interface for the ValidateRenderingCaps function.

8.3.1 Detailed Description

8.3.2 Typedef Documentation

8.3.2.1 using **LLGL::DebugCallback** = typedef std::function<void(const std::string& type, const std::string& message)>

Debug callback function interface.

Parameters

`in`	*type*	Descriptive type of the message.
`in`	*message*	Specifies the debug output message.

Remarks

This output is renderer dependent.

8.3.2.2 using **LLGL::ValidateRenderingCapsFunc** = typedef std::function<bool(const std::string& info, const std::string& attrib)>

Callback interface for the ValidateRenderingCaps function.

Parameters

`in`	*info*	Specifies a description why an attribute did not fulfill the requirement.
`in`	*attrib*	Name of the attribute which did not fulfill the requirement.

Returns

True to continue the validation process, or false to break the validation process.

See also

ValidateRenderingCaps

8.4 Buffer utility functions to determine buffer types.

Functions

- LLGL_EXPORT bool LLGL::IsRWBuffer (const StorageBufferType type)

  Returns true if the storage buffer type denotes a read/write (RW) buffer.
- LLGL_EXPORT bool LLGL::IsTypedBuffer (const StorageBufferType type)

  Returns true if the storage buffer type denotes a simply typed buffer.
- LLGL_EXPORT bool LLGL::IsStructuredBuffer (const StorageBufferType type)

  Returns true if the storage buffer type denotes a structured buffer.
- LLGL_EXPORT bool LLGL::IsByteAddressBuffer (const StorageBufferType type)

  Returns true if the storage buffer type denotes a byte addresse buffer.

8.4.1 Detailed Description

8.4.2 Function Documentation

8.4.2.1 LLGL_EXPORT bool LLGL::IsByteAddressBuffer (const StorageBufferType *type*)

Returns true if the storage buffer type denotes a byte addresse buffer.

Returns

True if `type` either StorageBufferType::ByteAddressBuffer or StorageBufferType::RWByteAddressBuffer.

8.4.2.2 LLGL_EXPORT bool LLGL::IsRWBuffer (const StorageBufferType *type*)

Returns true if the storage buffer type denotes a read/write (RW) buffer.

Returns

True if `type` either StorageBufferType::RWBuffer, StorageBufferType::RWStructuredBuffer, Storage↩ BufferType::RWByteAddressBuffer, StorageBufferType::AppendStructuredBuffer, or StorageBufferType::↩ ConsumeStructuredBuffer.

8.4.2.3 LLGL_EXPORT bool LLGL::IsStructuredBuffer (const StorageBufferType *type*)

Returns true if the storage buffer type denotes a structured buffer.

Returns

True if `type` either StorageBufferType::StructuredBuffer, StorageBufferType::RWStructuredBuffer, Storage↩ BufferType::AppendStructuredBuffer, or StorageBufferType::ConsumeStructuredBuffer.

8.4.2.4 LLGL_EXPORT bool LLGL::IsTypedBuffer (const StorageBufferType *type*)

Returns true if the storage buffer type denotes a simply typed buffer.

Returns

True if `type` either StorageBufferType::Buffer or StorageBufferType::RWBuffer.

8.5 Hardware format utility functions.

Functions

- LLGL_EXPORT std::uint32_t LLGL::FormatBitSize (const Format format)

  Returns the bit size of the specified hardware format.
- LLGL_EXPORT bool LLGL::SplitFormat (const Format format, DataType &dataType, std::uint32_t &components)

  Splits the specified hardware format into a data type and the number of components.
- LLGL_EXPORT bool LLGL::IsCompressedFormat (const Format format)

  Returns true if the specified hardware format is a compressed format, i.e. either Format::BC1RGB, Format::BC1R↩ GBA, Format::BC2RGBA, or Format::BC3RGBA.
- LLGL_EXPORT bool LLGL::IsDepthStencilFormat (const Format format)

  Returns true if the specified hardware format is a depth or depth-stencil format, i.e. Format::D16UNorm, Format::↩ D24UNormS8UInt, Format::D32Float, or Format::D32FloatS8X24UInt.
- LLGL_EXPORT bool LLGL::IsDepthFormat (const Format format)

  Returns true if the specified hardware format is a depth format, i.e. Format::D16UNorm, Format::D24UNormS8UInt, Format::D32Float, or Format::D32FloatS8X24UInt.
- LLGL_EXPORT bool LLGL::IsStencilFormat (const Format format)

  Returns true if the specified hardware format is a stencil format, i.e. Format::D24UNormS8UInt or Format::D32↩ FloatS8X24UInt.
- LLGL_EXPORT bool LLGL::IsNormalizedFormat (const Format format)

  Returns true if the specified hardware format is a normalized format (like Format::RGBA8UNorm, Format::R8SNorm etc.).
- LLGL_EXPORT bool LLGL::IsIntegralFormat (const Format format)

  Returns true if the specified hardware format is an integral format (like Format::RGBA8UInt, Format::R8SInt etc.).
- LLGL_EXPORT bool LLGL::IsFloatFormat (const Format format)

  Returns true if the specified hardware format is a floating-point format (like Format::RGBA32Float, Format::R32Float etc.).

8.5.1 Detailed Description

8.5.2 Function Documentation

8.5.2.1 LLGL_EXPORT std::uint32_t LLGL::FormatBitSize (const Format *format*)

Returns the bit size of the specified hardware format.

Returns

Number of bits for one vector of the specified hardware format.

Remarks

This function does not return the size in bytes because some compressed block formats require less than one byte for a single color vector.

See also

Format

8.5.2.2 LLGL_EXPORT bool LLGL::IsCompressedFormat (const Format *format*)

Returns true if the specified hardware format is a compressed format, i.e. either Format::BC1RGB, Format::BC1↩RGBA, Format::BC2RGBA, or Format::BC3RGBA.

See also

Format

8.5.2.3 LLGL_EXPORT bool LLGL::IsDepthFormat (const Format *format*)

Returns true if the specified hardware format is a depth format, i.e. Format::D16UNorm, Format::D24UNormS8UInt, Format::D32Float, or Format::D32FloatS8X24UInt.

See also

Format

8.5.2.4 LLGL_EXPORT bool LLGL::IsDepthStencilFormat (const Format *format*)

Returns true if the specified hardware format is a depth or depth-stencil format, i.e. Format::D16UNorm, Format↩::D24UNormS8UInt, Format::D32Float, or Format::D32FloatS8X24UInt.

See also

Format

8.5.2.5 LLGL_EXPORT bool LLGL::IsFloatFormat (const Format *format*)

Returns true if the specified hardware format is a floating-point format (like Format::RGBA32Float, Format::R32Float etc.).

Remarks

This does not include depth-stencil formats or compressed formats.

See also

IsDepthStencilFormat
IsCompressedFormat
Format

8.5.2.6 LLGL_EXPORT bool LLGL::IsIntegralFormat (const Format *format*)

Returns true if the specified hardware format is an integral format (like Format::RGBA8UInt, Format::R8SInt etc.).

Remarks

This also includes all normalized formats.

See also

IsNormalizedFormat
Format

8.5.2.7 LLGL_EXPORT bool LLGL::IsNormalizedFormat (const Format *format*)

Returns true if the specified hardware format is a normalized format (like Format::RGBA8UNorm, Format::R8SNorm etc.).

Remarks

This does not include depth-stencil formats or compressed formats.

See also

IsDepthStencilFormat
IsCompressedFormat
Format

8.5.2.8 LLGL_EXPORT bool LLGL::IsStencilFormat (const Format *format*)

Returns true if the specified hardware format is a stencil format, i.e. Format::D24UNormS8UInt or Format::D32↩
FloatS8X24UInt.

See also

Format

8.5.2.9 LLGL_EXPORT bool LLGL::SplitFormat (const Format *format,* DataType & *dataType,* std::uint32_t & *components*)

Splits the specified hardware format into a data type and the number of components.

See also

DataType
Format

8.6 Data type utility functions.

Functions

- LLGL_EXPORT std::uint32_t LLGL::DataTypeSize (const DataType dataType)

  Returns the size (in bytes) of the specified data type.
- LLGL_EXPORT bool LLGL::IsIntDataType (const DataType dataType)

  Determines if the argument refers to a signed integer data type.
- LLGL_EXPORT bool LLGL::IsUIntDataType (const DataType dataType)

  Determines if the argument refers to an unsigned integer data type.
- LLGL_EXPORT bool LLGL::IsFloatDataType (const DataType dataType)

  Determines if the argument refers to a floating-pointer data type.

8.6.1 Detailed Description

8.6.2 Function Documentation

8.6.2.1 LLGL_EXPORT std::uint32_t LLGL::DataTypeSize (const DataType *dataType*)

Returns the size (in bytes) of the specified data type.

8.6.2.2 LLGL_EXPORT bool LLGL::IsFloatDataType (const DataType *dataType*)

Determines if the argument refers to a floating-pointer data type.

Returns

True if the specified data type equals one of the following enumeration entries: DataType::Float16, Data↩Type::Float32, DataType::Float64.

8.6.2.3 LLGL_EXPORT bool LLGL::IsIntDataType (const DataType *dataType*)

Determines if the argument refers to a signed integer data type.

Returns

True if the specified data type equals one of the following enumeration entries: DataType::Int8, DataType::↩Int16, DataType::Int32.

8.6.2.4 LLGL_EXPORT bool LLGL::IsUIntDataType (const DataType *dataType*)

Determines if the argument refers to an unsigned integer data type.

Returns

True if the specified data type equals one of the following enumeration entries: DataType::UInt8, DataType↩::UInt16, DataType::UInt32.

8.7 Image utility functions to classify and convert image data.

Functions

- LLGL_EXPORT std::uint32_t LLGL::ImageFormatSize (const ImageFormat imageFormat)

  Returns the size (in number of components) of the specified image format.
- LLGL_EXPORT std::uint32_t LLGL::ImageDataSize (const ImageFormat imageFormat, const DataType dataType, std::uint32_t numPixels)

  Returns the required data size (in bytes) of an image with the specified format, data type, and number of pixels.
- LLGL_EXPORT bool LLGL::IsCompressedFormat (const ImageFormat imageFormat)

  Returns true if the specified color format is a compressed format, i.e. either ImageFormat::CompressedRGB, or ImageFormat::CompressedRGBA.
- LLGL_EXPORT bool LLGL::IsDepthStencilFormat (const ImageFormat imageFormat)

  Returns true if the specified color format is a depth-stencil format, i.e. either ImageFormat::Depth or ImageFormat↩ ::DepthStencil.
- LLGL_EXPORT bool LLGL::FindSuitableImageFormat (const Format format, ImageFormat &imageFormat, DataType &dataType)

  Finds a suitable image format for the specified texture hardware format.
- LLGL_EXPORT bool LLGL::ConvertImageBuffer (const SrcImageDescriptor &srcImageDesc, const Dst↩ ImageDescriptor &dstImageDesc, std::size_t threadCount=0)

  Converts the image format and data type of the source image (only uncompressed color formats).
- LLGL_EXPORT ByteBuffer LLGL::ConvertImageBuffer (const SrcImageDescriptor &srcImageDesc, Image↩ Format dstFormat, DataType dstDataType, std::size_t threadCount=0)

  Converst the image format and data type of the source image (only uncompressed color formats) and returns the new generated image buffer.
- LLGL_EXPORT ByteBuffer LLGL::GenerateImageBuffer (ImageFormat format, DataType dataType, std↩ ::size_t imageSize, const ColorRGBAd &fillColor)

  Generates an image buffer with the specified fill data for each pixel.
- LLGL_EXPORT ByteBuffer LLGL::GenerateEmptyByteBuffer (std::size_t bufferSize, bool initialize=true)

  Generates a new byte buffer with zeros in each byte.

8.7.1 Detailed Description

8.7.2 Function Documentation

8.7.2.1 LLGL_EXPORT bool LLGL::ConvertImageBuffer (const SrcImageDescriptor & *srcImageDesc*, const DstImageDescriptor & *dstImageDesc*, std::size_t *threadCount* = 0)

Converts the image format and data type of the source image (only uncompressed color formats).

Parameters

in	*srcImageDesc*	Specifies the source image descriptor.
out	*dstImageDesc*	Specifies the destination image descriptor.
in	*threadCount*	Specifies the number of threads to use for conversion. If this is less than 2, no multi-threading is used. If this is 'Constants::maxThreadCount', the maximal count of threads the system supports will be used (e.g. 4 on a quad-core processor). By default 0.

Returns

True if any conversion was necessary. Otherwise, no conversion was necessary and the destination buffer is not modified!

Note

Compressed images and depth-stencil images cannot be converted.

Exceptions

std::invalid_argument	If a compressed image format is specified either as source or destination.
std::invalid_argument	If a depth-stencil format is specified either as source or destination.
std::invalid_argument	If the source buffer size is not a multiple of the source data type size times the image format size.
std::invalid_argument	If the source buffer is a null pointer.
std::invalid_argument	If the destination buffer size does not match the required output buffer size.
std::invalid_argument	If the destination buffer is a null pointer.

See also

Constants::maxThreadCount
DataTypeSize
ImageFormatSize

8.7.2.2 LLGL_EXPORT ByteBuffer LLGL::ConvertImageBuffer (const SrcImageDescriptor & *srcImageDesc*, ImageFormat *dstFormat*, DataType *dstDataType*, std::size_t *threadCount* = `0`)

Converst the image format and data type of the source image (only uncompressed color formats) and returns the new generated image buffer.

Parameters

`in`	*srcImageDesc*	Specifies the source image descriptor.
`in`	*dstFormat*	Specifies the destination image format.
`in`	*dstDataType*	Specifies the destination image data type.
`in`	*threadCount*	Specifies the number of threads to use for conversion. If this is less than 2, no multi-threading is used. If this is 'Constants::maxThreadCount', the maximal count of threads the system supports will be used (e.g. 4 on a quad-core processor). By default 0.

Returns

Byte buffer with the converted image data or null if no conversion is necessary. This can be casted to the respective target data type (e.g. `unsigned char`, `int`, `float` etc.).

Note

Compressed images and depth-stencil images cannot be converted.

Exceptions

std::invalid_argument	If a compressed image format is specified either as source or destination.
std::invalid_argument	If a depth-stencil format is specified either as source or destination.
std::invalid_argument	If the source buffer size is not a multiple of the source data type size times the image format size.
std::invalid_argument	If the source buffer is a null pointer.

See also

Constants::maxThreadCount
ByteBuffer
DataTypeSize
ImageFormatSize

8.7.2.3 LLGL_EXPORT bool LLGL::FindSuitableImageFormat (const Format *format*, ImageFormat & *imageFormat*, DataType & *dataType*)

Finds a suitable image format for the specified texture hardware format.

Parameters

`in`	*textureFormat*	Specifies the input texture format.
`out`	*imageFormat*	Specifies the output image format.
`out`	*dataType*	Specifies the output image data type.

Returns

True if a suitable image format has been found. Otherwise, the output parameter 'imageFormat' and 'dataType' have not been modified.

Remarks

Texture formats that cannot be converted to an image format are all 16-bit floating-point types, and Format↩ ::Undefined.

8.7.2.4 LLGL_EXPORT ByteBuffer LLGL::GenerateEmptyByteBuffer (std::size_t *bufferSize*, bool *initialize* = `true`)

Generates a new byte buffer with zeros in each byte.

Parameters

`in`	*bufferSize*	Specifies the size (in bytes) of the buffer.
`in`	*initialize*	Specifies whether to initialize the byte buffer with zeros. By default true.

Returns

The new allocated and initialized byte buffer.

Remarks

Use GenerateImageBuffer to generate an image buffer with a fill color.

See also

GenerateImageBuffer

8.7.2.5 LLGL_EXPORT ByteBuffer LLGL::GenerateImageBuffer (ImageFormat *format*, DataType *dataType*, std::size_t *imageSize*, const ColorRGBAd & *fillColor*)

Generates an image buffer with the specified fill data for each pixel.

Parameters

in	*format*	Specifies the image format of each pixel in the output image.
in	*dataType*	Specifies the data type of each component of each pixel in the output image.
in	*imageSize*	Specifies the 1-Dimensional size (in pixels) of the output image. For a 2D image, this can be width times height for instance.
in	*fillColor*	Specifies the color to fill the image for each pixel.

Returns

The new allocated and initialized byte buffer.

Remarks

This can be used to generate a single-colored n-Dimensional image. Usage example for a 2D image:

```
// Generate 2D image of size 512 x 512 with a half-transparent yellow color
auto imageBuffer = LLGL::GenerateImageBuffer(
    LLGL::ImageFormat::RGBA,
    LLGL::DataType::UInt8,
    512 * 512,
    LLGL::ColorRGBAd { 1.0, 1.0, 0.0, 0.5 }
);
```

8.7.2.6 LLGL_EXPORT std::uint32_t LLGL::ImageDataSize (const ImageFormat *imageFormat*, const DataType *dataType*, std::uint32_t *numPixels*)

Returns the required data size (in bytes) of an image with the specified format, data type, and number of pixels.

Parameters

in	*imageFormat*	Specifies the image format.
in	*dataType*	Specifies the data type of each pixel component.
in	*numPixels*	Specifies the number of picture elements (pixels).

Remarks

The counterpart for texture buffers is the function TextureBufferSize.

See also

TextureBufferSize

8.7.2.7 LLGL_EXPORT std::uint32_t LLGL::ImageFormatSize (const ImageFormat *imageFormat*)

Returns the size (in number of components) of the specified image format.

Parameters

in	*imageFormat*	Specifies the image format.

Returns

Number of components of the specified image format, or 0 if 'imageFormat' specifies a compressed color format.

Note

Compressed formats are not supported.

See also

IsCompressedFormat(const ImageFormat)
ImageFormat

8.7.2.8 LLGL_EXPORT bool LLGL::IsCompressedFormat (const ImageFormat *imageFormat*)

Returns true if the specified color format is a compressed format, i.e. either ImageFormat::CompressedRGB, or ImageFormat::CompressedRGBA.

See also

ImageFormat

8.7.2.9 LLGL_EXPORT bool LLGL::IsDepthStencilFormat (const ImageFormat *imageFormat*)

Returns true if the specified color format is a depth-stencil format, i.e. either ImageFormat::Depth or ImageFormat↩
::DepthStencil.

See also

ImageFormat

8.8 Global type-to-string conversion functions.

Functions

- LLGL_EXPORT const char ∗ LLGL::ToString (const ShaderType t)

  Returns a string representation for the spcified ShaderType value, or null if the input type is invalid.
- LLGL_EXPORT const char ∗ LLGL::ToString (const ErrorType t)

  Returns a string representation for the specified ErrorType value, or null if the input type is invalid.
- LLGL_EXPORT const char ∗ LLGL::ToString (const WarningType t)

  Returns a string representation for the specified WarningType value, or null if the input type is invalid.
- LLGL_EXPORT const char ∗ LLGL::ToString (const ShadingLanguage t)

  Returns a string representation for the specified ShadingLanguage value, or null if the input type is invalid.
- LLGL_EXPORT const char ∗ LLGL::ToString (const Format t)

  Returns a string representation for the specified Format value, or null if the input type is invalid.

8.8.1 Detailed Description

8.8.2 Function Documentation

8.8.2.1 LLGL_EXPORT const char∗ LLGL::ToString (const ShaderType *t*)

Returns a string representation for the spcified ShaderType value, or null if the input type is invalid.

Remarks

Return value examples are "vertex", "tessellation control".

8.8.2.2 LLGL_EXPORT const char∗ LLGL::ToString (const ErrorType *t*)

Returns a string representation for the specified ErrorType value, or null if the input type is invalid.

Remarks

Return value examples are "invalid argument", "unsupported feature".

8.8.2.3 LLGL_EXPORT const char∗ LLGL::ToString (const WarningType *t*)

Returns a string representation for the specified WarningType value, or null if the input type is invalid.

Remarks

Return value examples are "improper argument", "pointless operation".

8.8.2.4 LLGL_EXPORT const char* LLGL::ToString (const ShadingLanguage *t*)

Returns a string representation for the specified ShadingLanguage value, or null if the input type is invalid.

Remarks

Return value examples are "GLSL 450", "HLSL 2.0c".

8.8.2.5 LLGL_EXPORT const char* LLGL::ToString (const Format *t*)

Returns a string representation for the specified Format value, or null if the input type is invalid.

Remarks

Return value examples are "R8UNorm", "RGBA16Float", "D24UNormS8UInt", "RGB DXT1".

8.9 Texture utility functions to determine texture dimension and buffer sizes.

Functions

- LLGL_EXPORT std::uint32_t LLGL::NumMipLevels (std::uint32_t width, std::uint32_t height=1, std::uint32_t depth=1)

  Returns the number of MIP-map levels for a texture with the specified size.
- LLGL_EXPORT std::uint32_t LLGL::NumMipLevels (const TextureDescriptor &textureDesc)

  Returns the number of MIP-map levels for the specified texture descriptor.
- LLGL_EXPORT std::uint32_t LLGL::TextureBufferSize (const Format format, std::uint32_t numTexels)

  Returns the required buffer size (in bytes) of a texture with the specified hardware format and number of texels.
- LLGL_EXPORT std::uint32_t LLGL::TextureSize (const TextureDescriptor &textureDesc)

  Returns the texture size (in texels) of the specified texture descriptor, or zero if the texture type is invalid.
- LLGL_EXPORT bool LLGL::IsMipMappedTexture (const TextureDescriptor &textureDesc)

  Returns true if the specified texture descriptor describes a texture with MIP-mapping enabled.
- LLGL_EXPORT bool LLGL::IsArrayTexture (const TextureType type)

  Returns true if the specified texture type is an array texture.
- LLGL_EXPORT bool LLGL::IsMultiSampleTexture (const TextureType type)

  Returns true if the specified texture type is a multi-sample texture.
- LLGL_EXPORT bool LLGL::IsCubeTexture (const TextureType type)

  Returns true if the specified texture type is a cube texture.

8.9.1 Detailed Description

8.9.2 Function Documentation

8.9.2.1 LLGL_EXPORT bool LLGL::IsArrayTexture (const TextureType *type*)

Returns true if the specified texture type is an array texture.

Returns

True if `type` is either TextureType::Texture1DArray, TextureType::Texture2DArray, TextureType::Texture↩ CubeArray, or TextureType::Texture2DMSArray.

8.9.2.2 LLGL_EXPORT bool LLGL::IsCubeTexture (const TextureType *type*)

Returns true if the specified texture type is a cube texture.

Returns

True if `type` is either TextureType::TextureCube or TextureType::TextureCubeArray.

8.9.2.3 LLGL_EXPORT bool LLGL::IsMipMappedTexture (const TextureDescriptor & *textureDesc*)

Returns true if the specified texture descriptor describes a texture with MIP-mapping enabled.

Returns

True if the texture type is not a multi-sampled texture and the number of MIP-map levels in the descriptor is either zero or greater than one.

See also

TextureDescriptor::mipLevels

8.9.2.4 LLGL_EXPORT bool LLGL::IsMultiSampleTexture (const TextureType *type*)

Returns true if the specified texture type is a multi-sample texture.

Returns

True if `type` is either TextureType::Texture2DMS, or TextureType::Texture2DMSArray.

8.9.2.5 LLGL_EXPORT std::uint32_t LLGL::NumMipLevels (std::uint32_t *width*, std::uint32_t *height* = `1`, std::uint32_t *depth* = `1`)

Returns the number of MIP-map levels for a texture with the specified size.

Parameters

`in`	*width*	Specifies the texture width.
`in`	*height*	Specifies the texture height or number of layers for 1D array textures. By default 1 (if 1D textures are used).
`in`	*depth*	Specifies the texture depth or number of layers for 2D array textures. By default 1 (if 1D or 2D textures are used).

Remarks

The height and depth are optional parameters, so this function can be easily used for 1D, 2D, and 3D textures.

Returns

1 + floor(log2(max{ width, height, depth })).

8.9.2.6 LLGL_EXPORT std::uint32_t LLGL::NumMipLevels (const TextureDescriptor & *textureDesc*)

Returns the number of MIP-map levels for the specified texture descriptor.

Parameters

in	*textureDesc*	Specifies the descriptor whose parameters are used to determine the number of MIP-map levels.

Remarks

This function will deduce the number MIP-map levels automatically only if the member "mipLevels" is zero. Otherwise, the value of this member is returned.

See also

NumMipLevels(std::uint32_t, std::uint32_t, std::uint32_t)

8.9.2.7 LLGL_EXPORT std::uint32_t LLGL::TextureBufferSize (const Format *format,* std::uint32_t *numTexels*)

Returns the required buffer size (in bytes) of a texture with the specified hardware format and number of texels.

Parameters

in	*format*	Specifies the texture format.
in	*numTexels*	Specifies the number of texture elements (texels). For the DXT compressed texture formats, this must be a multiple of 16, since these formats compress the image in 4x4 texel blocks.

Returns

The required buffer size (in bytes), or zero if the input is invalid.

Remarks

The counterpart for image data is the function ImageDataSize.

See also

ImageDataSize

8.9.2.8 LLGL_EXPORT std::uint32_t LLGL::TextureSize (const TextureDescriptor & *textureDesc*)

Returns the texture size (in texels) of the specified texture descriptor, or zero if the texture type is invalid.

See also

TextureDescriptor::type

8.10 Global utility functions, especially to fill descriptor structures.

Functions

- LLGL_EXPORT TextureDescriptor LLGL::Texture1DDesc (Format format, std::uint32_t width, long flags=TextureFlags::Default)

  Returns a TextureDescriptor structure with the TextureType::Texture1D type.
- LLGL_EXPORT TextureDescriptor LLGL::Texture2DDesc (Format format, std::uint32_t width, std::uint32_t height, long flags=TextureFlags::Default)

  Returns a TextureDescriptor structure with the TextureType::Texture2D type.
- LLGL_EXPORT TextureDescriptor LLGL::Texture3DDesc (Format format, std::uint32_t width, std::uint32_t height, std::uint32_t depth, long flags=TextureFlags::Default)

  Returns a TextureDescriptor structure with the TextureType::Texture3D type.
- LLGL_EXPORT TextureDescriptor LLGL::TextureCubeDesc (Format format, std::uint32_t width, std::uint32↩_t height, long flags=TextureFlags::Default)

  Returns a TextureDescriptor structure with the TextureType::TextureCube type.
- LLGL_EXPORT TextureDescriptor LLGL::Texture1DArrayDesc (Format format, std::uint32_t width, std↩::uint32_t arrayLayers, long flags=TextureFlags::Default)

  Returns a TextureDescriptor structure with the TextureType::Texture1DArray type.
- LLGL_EXPORT TextureDescriptor LLGL::Texture2DArrayDesc (Format format, std::uint32_t width, std↩::uint32_t height, std::uint32_t arrayLayers, long flags=TextureFlags::Default)

  Returns a TextureDescriptor structure with the TextureType::Texture2DArray type.
- LLGL_EXPORT TextureDescriptor LLGL::TextureCubeArrayDesc (Format format, std::uint32_t width, std↩::uint32_t height, std::uint32_t arrayLayers, long flags=TextureFlags::Default)

  Returns a TextureDescriptor structure with the TextureType::TextureCubeArray type.
- LLGL_EXPORT TextureDescriptor LLGL::Texture2DMSDesc (Format format, std::uint32_t width, std↩::uint32_t height, std::uint32_t samples, long flags=TextureFlags::Default)

  Returns a TextureDescriptor structure with the TextureType::Texture2DMS type.
- LLGL_EXPORT TextureDescriptor LLGL::Texture2DMSArrayDesc (Format format, std::uint32_t width, std↩::uint32_t height, std::uint32_t arrayLayers, std::uint32_t samples, long flags=TextureFlags::Default)

  Returns a TextureDescriptor structure with the TextureType::Texture2DMSArray type.
- LLGL_EXPORT BufferDescriptor LLGL::VertexBufferDesc (uint64_t size, const VertexFormat &vertexFormat, long flags=0)

  Returns a BufferDescriptor structure for a vertex buffer.
- LLGL_EXPORT BufferDescriptor LLGL::IndexBufferDesc (uint64_t size, const IndexFormat &indexFormat, long flags=0)

  Returns a BufferDescriptor structure for an index buffer.
- LLGL_EXPORT BufferDescriptor LLGL::ConstantBufferDesc (uint64_t size, long flags=BufferFlags::↩DynamicUsage)

  Returns a BufferDescriptor structure for a constant buffer.
- LLGL_EXPORT BufferDescriptor LLGL::StorageBufferDesc (uint64_t size, const StorageBufferType storageType, std::uint32_t stride, long flags=BufferFlags::MapReadAccess|BufferFlags::MapWriteAccess)

  Returns a BufferDescriptor structure for a storage buffer.
- LLGL_EXPORT ShaderDescriptor LLGL::ShaderDescFromFile (const ShaderType type, const char ∗filename, const char ∗entryPoint=nullptr, const char ∗profile=nullptr, long flags=0)

  Returns a ShaderDescriptor structure.
- LLGL_EXPORT ShaderProgramDescriptor LLGL::ShaderProgramDesc (const std::initializer_list< Shader ∗ > &shaders, const std::initializer_list< VertexFormat > &vertexFormats={})

  Returns a ShaderProgramDescriptor structure and assigns the input shaders into the respective structure members.
- LLGL_EXPORT ShaderProgramDescriptor LLGL::ShaderProgramDesc (const std::vector< Shader ∗ > &shaders, const std::vector< VertexFormat > &vertexFormats={})

  Returns a ShaderProgramDescriptor structure and assigns the input shaders into the respective structure members.

- LLGL_EXPORT PipelineLayoutDescriptor LLGL::PipelineLayoutDesc (const ShaderReflectionDescriptor &reflectionDesc)

  Converts the specified shader reflection descriptor into a pipeline layout descriptor.
- LLGL_EXPORT PipelineLayoutDescriptor LLGL::PipelineLayoutDesc (const char ∗layoutSignature)

  Generates a pipeline layout descriptor by parsing the specified string.
- LLGL_EXPORT RenderPassDescriptor LLGL::RenderPassDesc (const RenderTargetDescriptor &render←TargetDesc)

  Converts the specified render target descriptor into a render pass descriptor with default settings.

8.10.1 Detailed Description

8.10.2 Function Documentation

8.10.2.1 LLGL_EXPORT BufferDescriptor LLGL::ConstantBufferDesc (uint64_t *size,* long *flags =* BufferFlags::DynamicUsage)

Returns a BufferDescriptor structure for a constant buffer.

See also

RenderSystem::CreateBuffer

8.10.2.2 LLGL_EXPORT BufferDescriptor LLGL::IndexBufferDesc (uint64_t *size,* const IndexFormat & *indexFormat,* long *flags =* 0)

Returns a BufferDescriptor structure for an index buffer.

See also

RenderSystem::CreateBuffer

8.10.2.3 LLGL_EXPORT PipelineLayoutDescriptor LLGL::PipelineLayoutDesc (const ShaderReflectionDescriptor & *reflectionDesc*)

Converts the specified shader reflection descriptor into a pipeline layout descriptor.

Remarks

This can be used to specifiy a pipeline layout that fits the shader layout declaration. Some rendering APIs, such as OpenGL 2.0, do not provide sufficient functionality for shader reflection. Hence, this utility function cannot be used in conjunction with all renderer versions.

8.10.2.4 LLGL_EXPORT PipelineLayoutDescriptor LLGL::PipelineLayoutDesc (const char ∗ *layoutSignature*)

Generates a pipeline layout descriptor by parsing the specified string.

Parameters

in	*layoutSignature*	Specifies the string for the layout signature. This string must not be null. The syntax for this string is as follows: • Each type of each binding point (i.e. BindingDescriptor::type) is specified by one of the following identifiers: – `cbuffer` for constant buffers (i.e. ResourceType::ConstantBuffer). – `sbuffer` for storage buffers (i.e. ResourceType::StorageBuffer). – `texture` for textures (i.e. ResourceType::Texture). – `sampler` for sampler states (i.e. ResourceType::Sampler). • The slot of each binding point (i.e. BindingDescriptor::slot) is specified as an integral number within brackets (e.g. `"texture(1)"`). • The array size of each binding point (i.e. BindingDescriptor::arraySize) can be optionally specified right after the slot within squared brackets (e.g. `"texture(1[2])"`). • Optionally, multiple slots can be specified within the brackets if separated by commas (e.g. `"texture(1[2],3)"`). • Each binding point is separated by a comma, the last comma begin optional (e.g. `"texture(1),sampler(2),"` or `"texture(1),sampler(2)"`). • The stage flags (i.e. BindingDescriptor::stageFlags) can be specified after the each binding point with a preceding colon using the following identifiers: – `vert` for the vertex shader stage (i.e. StageFlags::VertexStage). – `tesc` for the tessellation-control shader stage (i.e. StageFlags::TessControlStage). – `tese` for the tessellation-evaluation shader stage (i.e. StageFlags::TessEvaluationStage). – `geom` for the geometry shader stage (i.e. StageFlags::GeometryStage). – `frag` for the fragment shader stage (i.e. StageFlags::FragmentStage). – `comp` for the compute shader stage (i.e. StageFlags::ComputeStage). • If no stage flag is specified, all shader stages will be used. • Whitespaces are ignored (e.g. blanks `' '`, tabulators `'\t'`, new-line characters `'\n'` and `'\r'` etc.), see C++ STL function `std::isspace`.

Remarks

Here is a usage example:

```
// Standard way of declaring a pipeline layout:
LLGL::PipelineLayoutDescriptor myLayoutDescStd;
{
    myLayoutDescStd.bindings =
    {
        LLGL::BindingDescriptor {
      LLGL::ResourceType::ConstantBuffer,
      LLGL::StageFlags::FragmentStage |
      LLGL::StageFlags::VertexStage, 0 },
        LLGL::BindingDescriptor {
      LLGL::ResourceType::Texture,
      LLGL::StageFlags::FragmentStage,                              1 },
        LLGL::BindingDescriptor {
      LLGL::ResourceType::Texture,
      LLGL::StageFlags::FragmentStage,                                 2 },
        LLGL::BindingDescriptor {
      LLGL::ResourceType::Sampler,
      LLGL::StageFlags::FragmentStage,                                 3 },
    };
}
auto myLayout = myRenderer->CreatePipelineLayout(myLayoutDescStd);

// Abbreviated way of declaring a pipeline layout using the utility function:
auto myLayoutDescUtil = LLGL::PipelineLayoutDesc(
    "cbuffer(0):frag:vert,"
    "texture(1,2):frag,"
    "sampler(3):frag,"
);
auto myLayout = myRenderer->CreatePipelineLayout(myLayoutDescUtil);
```

Exceptions

std::invalid_argument	If the input parameter is null of parsing the layout signature failed.

8.10.2.5 LLGL_EXPORT RenderPassDescriptor LLGL::RenderPassDesc (const RenderTargetDescriptor & *renderTargetDesc*)

Converts the specified render target descriptor into a render pass descriptor with default settings.

Remarks

This can be used to specify a render pass that is compatible with a render target.

8.10.2.6 LLGL_EXPORT ShaderDescriptor LLGL::ShaderDescFromFile (const ShaderType *type*, const char ∗ *filename*, const char ∗ *entryPoint* = `nullptr`, const char ∗ *profile* = `nullptr`, long *flags* = 0)

Returns a ShaderDescriptor structure.

Remarks

The source type is determined by the filename extension using the following rules:

- `.hlsl`, `.fx`, `.glsl`, `.vert`, `.tesc`, `.tese`, `.geom`, `.frag`, `.comp`, and `.metal` result into a code file (i.e. ShaderSourceType::CodeFile)
- All other file extensions result into a binary file (i.e. ShaderSourceType::BinaryFile).

See also

RenderSystem::CreateShader

8.10.2.7 LLGL_EXPORT ShaderProgramDescriptor LLGL::ShaderProgramDesc (const std::initializer_list< Shader ∗ > & *shaders*, const std::initializer_list< VertexFormat > & *vertexFormats* = { })

Returns a ShaderProgramDescriptor structure and assigns the input shaders into the respective structure members.

Parameters

in	*shaders*	Specifies the list of shaders to attach to the shader program. Null pointers in the list are ignored.
in	*vertexFormats*	Specifies the list of vertex formats. By default empty.

See also

RenderSystem::CreateShaderProgram

8.10.2.8 LLGL_EXPORT ShaderProgramDescriptor LLGL::ShaderProgramDesc (const std::vector< Shader * > & *shaders*, const std::vector< VertexFormat > & *vertexFormats* = { })

Returns a ShaderProgramDescriptor structure and assigns the input shaders into the respective structure members.

Parameters

in	*shaders*	Specifies the list of shaders to attach to the shader program. Null pointers in the list are ignored.
in	*vertexFormats*	Specifies the list of vertex formats. By default empty.

See also

RenderSystem::CreateShaderProgram

8.10.2.9 LLGL_EXPORT BufferDescriptor LLGL::StorageBufferDesc (uint64_t *size*, const StorageBufferType *storage↩ Type*, std::uint32_t *stride*, long *flags* = BufferFlags::MapReadAccess|BufferFlags::MapWriteAccess)

Returns a BufferDescriptor structure for a storage buffer.

See also

RenderSystem::CreateBuffer

8.10.2.10 LLGL_EXPORT TextureDescriptor LLGL::Texture1DArrayDesc (Format *format*, std::uint32_t *width*, std::uint32_t *arrayLayers*, long *flags* = TextureFlags::Default)

Returns a TextureDescriptor structure with the TextureType::Texture1DArray type.

See also

RenderSystem::CreateTexture

8.10.2.11 LLGL_EXPORT TextureDescriptor LLGL::Texture1DDesc (Format *format*, std::uint32_t *width*, long *flags* = TextureFlags::Default)

Returns a TextureDescriptor structure with the TextureType::Texture1D type.

See also

RenderSystem::CreateTexture

8.10.2.12 LLGL_EXPORT TextureDescriptor LLGL::Texture2DArrayDesc (Format *format*, std::uint32_t *width*, std::uint32_t *height*, std::uint32_t *arrayLayers*, long *flags* = TextureFlags::Default)

Returns a TextureDescriptor structure with the TextureType::Texture2DArray type.

See also

RenderSystem::CreateTexture

8.10.2.13 LLGL_EXPORT TextureDescriptor LLGL::Texture2DDesc (Format *format*, std::uint32_t *width*, std::uint32_t *height*, long *flags* = TextureFlags::Default)

Returns a TextureDescriptor structure with the TextureType::Texture2D type.

See also

RenderSystem::CreateTexture

8.10.2.14 LLGL_EXPORT TextureDescriptor LLGL::Texture2DMSArrayDesc (Format *format*, std::uint32_t *width*, std::uint32_t *height*, std::uint32_t *arrayLayers*, std::uint32_t *samples*, long *flags* = TextureFlags::Default)

Returns a TextureDescriptor structure with the TextureType::Texture2DMSArray type.

See also

RenderSystem::CreateTexture

8.10.2.15 LLGL_EXPORT TextureDescriptor LLGL::Texture2DMSDesc (Format *format*, std::uint32_t *width*, std::uint32_t *height*, std::uint32_t *samples*, long *flags* = TextureFlags::Default)

Returns a TextureDescriptor structure with the TextureType::Texture2DMS type.

See also

RenderSystem::CreateTexture

8.10.2.16 LLGL_EXPORT TextureDescriptor LLGL::Texture3DDesc (Format *format*, std::uint32_t *width*, std::uint32_t *height*, std::uint32_t *depth*, long *flags* = TextureFlags::Default)

Returns a TextureDescriptor structure with the TextureType::Texture3D type.

See also

RenderSystem::CreateTexture

8.10.2.17 LLGL_EXPORT TextureDescriptor LLGL::TextureCubeArrayDesc (Format *format*, std::uint32_t *width*, std::uint32_t *height*, std::uint32_t *arrayLayers*, long *flags* = TextureFlags::Default)

Returns a TextureDescriptor structure with the TextureType::TextureCubeArray type.

See also

RenderSystem::CreateTexture

8.10.2.18 LLGL_EXPORT TextureDescriptor LLGL::TextureCubeDesc (Format *format*, std::uint32_t *width*, std::uint32_t *height*, long *flags* = TextureFlags::Default)

Returns a TextureDescriptor structure with the TextureType::TextureCube type.

See also

RenderSystem::CreateTexture

8.10.2.19 LLGL_EXPORT BufferDescriptor LLGL::VertexBufferDesc (uint64_t *size*, const VertexFormat & *vertexFormat*, long *flags* = 0)

Returns a BufferDescriptor structure for a vertex buffer.

See also

RenderSystem::CreateBuffer

Chapter 9

Namespace Documentation

9.1 LLGL Namespace Reference

Namespaces

- Constants

  Namespace with all constants used as default arguments.
- Log
- Version

  Namespace with functions to determine LLGL version.

Classes

- struct ApplicationDescriptor

  Application descriptor structure.
- struct AttachmentClear

  Attachment clear command structure.
- struct AttachmentDescriptor

  Render target attachment descriptor structure.
- struct AttachmentFormatDescriptor

  Render target attachment descriptor structure.
- struct BindingDescriptor

  Layout structure for a single binding point of the pipeline layout descriptor.
- struct BlendDescriptor

  Blending state descriptor structure.
- struct BlendTargetDescriptor

  Blend target state descriptor structure.
- class Buffer

  Hardware buffer interface.
- class BufferArray

  Hardware buffer container interface.
- struct BufferDescriptor

  Hardware buffer descriptor structure.
- struct BufferFlags

  Buffer creation flags enumeration.

- class Canvas

    Canvas interface for mobile platforms.
- struct CanvasDescriptor

    Canvas descriptor structure.
- struct ClearFlags

    Command buffer clear flags.
- struct ClearValue

    Clear value structure for color, depth, and stencil clear operations.
- class Color

    Base color class with N components.
- class Color< T, 3u >

    RGB color class with components: r, g, and b.
- class Color< T, 4u >

    RGBA color class with components: r, g, b, and a.
- class CommandBuffer

    Command buffer interface.
- struct CommandBufferDescriptor

    Command buffer descriptor structure.
- class CommandBufferExt

    Extended command buffer interface with dynamic state access for shader resources (i.e. Constant Buffers, Storage Buffers, Textures, and Samplers).
- struct CommandBufferFlags

    Command buffer creation flags.
- class CommandQueue

    Command queue interface.
- class ComputePipeline

    Compute pipeline interface.
- struct ComputePipelineDescriptor

    Compute pipeline descriptor structure.
- struct DepthBiasDescriptor

    Depth bias descriptor structure to control fragment depth values.
- struct DepthDescriptor

    Depth state descriptor structure.
- class Display

    Display interface to query the attributes of all connected displays/monitors.
- struct DisplayModeDescriptor

    Display mode descriptor structure.
- struct DstImageDescriptor

    Descriptor structure for an image that is used as destination for writing the image data.
- struct Extent2D

    2-Dimensional extent structure.
- struct Extent3D

    3-Dimensional extent structure.
- class Fence

    Fence interface for CPU/GPU synchronization.
- struct FrameProfile

    Profile of a rendered frame.
- class GraphicsPipeline

    Graphics pipeline interface.
- struct GraphicsPipelineDescriptor

    Graphics pipeline descriptor structure.

- class Image

  Utility class to manage the storage and attributes of an image.
- struct ImageInitialization

  Structure of image initialization for textures without initial image data.
- class IndexFormat

  Index buffer format class.
- class Input

  Default window event listener to receive user input.
- struct MultiSamplingDescriptor

  Multi-sampling descriptor structure.
- struct NativeContextHandle

  iOS native context handle structure.
- struct NativeHandle

  iOS native handle structure.
- class NonCopyable

  Base class for all interfaces in LLGL.
- struct Offset2D

  2-Dimensional offset structure.
- struct Offset3D

  3-Dimensional offset structure.
- struct OpenGLDependentStateDescriptor

  Graphics API dependent state descriptor for the OpenGL renderer.
- class PipelineLayout

  Pipeline layout interface.
- struct PipelineLayoutDescriptor

  Pipeline layout descritpor structure.
- struct ProfileOpenGLDescriptor

  OpenGL profile descriptor structure.
- class QueryHeap

  Query heap interface that holds a certain number of queries that are all of the same type.
- struct QueryHeapDescriptor

  Query heap descriptor structure.
- struct QueryPipelineStatistics

  Query data structure for pipeline statistics.
- struct RasterizerDescriptor

  Rasterizer state descriptor structure.
- class RenderContext

  Render context interface.
- struct RenderContextDescriptor

  Render context descriptor structure.
- struct RendererID

  Renderer identification number enumeration.
- struct RendererInfo

  Renderer basic information structure.
- struct RenderingCapabilities

  Structure with all attributes describing the rendering capabilities of the render system.
- class RenderingDebugger

  Rendering debugger interface.
- struct RenderingFeatures

  Contains the attributes for all supported rendering features.
- struct RenderingLimits

Contains all rendering limitations such as maximum buffer size, maximum texture resolution etc.

- class RenderingProfiler

  Rendering profiler model class.
- class RenderPass

  Render pass interface.
- struct RenderPassDescriptor

  Render pass descriptor structure.
- class RenderSystem

  Render system interface.
- class RenderSystemChild

  Base class for all interfaces whoes instances are owned by the RenderSystem.
- struct RenderSystemConfiguration

  Render system configuration structure.
- struct RenderSystemDescriptor

  Render system descriptor structure.
- class RenderTarget

  Render target interface.
- struct RenderTargetDescriptor

  Render target descriptor structure.
- class Resource

  Base class for all hardware resource interfaces.
- class ResourceHeap

  Resource heap interface.
- struct ResourceHeapDescriptor

  Resource heap descriptor structure.
- struct ResourceViewDescriptor

  Resource view descriptor structure.
- class Sampler

  Sampler interface.
- struct SamplerDescriptor

  Texture sampler descriptor structure.
- struct Scissor

  Scissor dimensions.
- class Shader

  Shader interface.
- struct ShaderCompileFlags

  Shader compilation flags enumeration.
- struct ShaderDescriptor

  Shader source and binary code descriptor structure.
- struct ShaderDisassembleFlags

  Shader disassemble flags enumeration.
- class ShaderProgram

  Shader program interface.
- struct ShaderProgramDescriptor

  Descriptor structure for shader programs.
- struct ShaderReflectionDescriptor

  Shader reflection descriptor structure.
- class ShaderUniform

  Shader uniform setter interface.
- struct SrcImageDescriptor

  Descriptor structure for an image that is used as source for reading the image data.

- struct StageFlags

  Shader stage flags enumeration.
- struct StencilDescriptor

  Stencil state descriptor structure.
- struct StencilFaceDescriptor

  Stencil face descriptor structure.
- struct StreamOutputAttribute

  Stream-output attribute structure.
- struct StreamOutputFormat

  Stream-output format descriptor structure.
- class Surface

  The Surface interface is the base interface for Window (on Desktop platforms) and Canvas (on movile platforms).
- class Texture

  Texture interface.
- struct TextureDescriptor

  Texture descriptor structure.
- struct TextureFlags

  Texture creation flags enumeration.
- struct TextureRegion

  Texture region structure.
- class Timer

  Interface for a Timer class.
- struct UniformDescriptor

  Shader uniform descriptor structure.
- struct UninitializeTag

  Common uninitialize tag.
- struct VertexAttribute

  Vertex attribute structure.
- struct VertexFormat

  Vertex format structure.
- struct VideoAdapterDescriptor

  Video adapter descriptor structure.
- struct VideoModeDescriptor

  Video mode descriptor structure.
- struct VideoOutputDescriptor

  Video output structure.
- struct Viewport

  Viewport dimensions.
- struct VsyncDescriptor

  Vertical-synchronization (Vsync) descriptor structure.
- struct VulkanRendererConfiguration

  Structure for a Vulkan renderer specific configuration.
- class Window

  Window interface for desktop platforms.
- struct WindowBehavior

  Window behavior structure.
- struct WindowDescriptor

  Window descriptor structure.

Typedefs

- template<typename T >
  using ColorRGBT = Color< T, 3 >
- using ColorRGBb = ColorRGBT< bool >
- using ColorRGBf = ColorRGBT< float >
- using ColorRGBd = ColorRGBT< double >
- using ColorRGBub = ColorRGBT< std::uint8_t >
- template<typename T >
  using ColorRGBAT = Color< T, 4 >
- using ColorRGBAb = ColorRGBAT< bool >
- using ColorRGBAf = ColorRGBAT< float >
- using ColorRGBAd = ColorRGBAT< double >
- using ColorRGBAub = ColorRGBAT< std::uint8_t >
- using ByteBuffer = std::unique_ptr< char[ ]>

  Common byte buffer type.
- using DebugCallback = std::function< void(const std::string &type, const std::string &message)>

  Debug callback function interface.
- using ValidateRenderingCapsFunc = std::function< bool(const std::string &info, const std::string &attrib)>

  Callback interface for the ValidateRenderingCaps function.
- using UniformLocation = std::int32_t

  Shader uniform location type, as zero-based index in 32-bit signed integer format.

Enumerations

- enum BufferType {
  BufferType::Vertex, BufferType::Index, BufferType::Constant, BufferType::Storage,
  BufferType::StreamOutput }

  Hardware buffer type enumeration.
- enum StorageBufferType {
  StorageBufferType::Undefined, StorageBufferType::Buffer, StorageBufferType::StructuredBuffer, Storage↩
  BufferType::ByteAddressBuffer,
  StorageBufferType::RWBuffer, StorageBufferType::RWStructuredBuffer, StorageBufferType::RWByte↩
  AddressBuffer, StorageBufferType::AppendStructuredBuffer,
  StorageBufferType::ConsumeStructuredBuffer }

  Storage buffer type enumeration.
- enum RenderConditionMode {
  RenderConditionMode::Wait, RenderConditionMode::NoWait, RenderConditionMode::ByRegionWait,
  RenderConditionMode::ByRegionNoWait,
  RenderConditionMode::WaitInverted, RenderConditionMode::NoWaitInverted, RenderConditionMode::By↩
  RegionWaitInverted, RenderConditionMode::ByRegionNoWaitInverted }

  Render condition mode enumeration.
- enum Format {

Format::Undefined, Format::R8UNorm, Format::R8SNorm, Format::R8UInt, Format::R8SInt, Format::R16UNorm, Format::R16SNorm, Format::R16UInt, Format::R16SInt, Format::R16Float, Format::R32UInt, Format::R32SInt, Format::R32Float, Format::RG8UNorm, Format::RG8SNorm, Format::RG8UInt, Format::RG8SInt, Format::RG16UNorm, Format::RG16SNorm, Format::RG16UInt, Format::RG16SInt, Format::RG16Float, Format::RG32UInt, Format::RG32SInt, Format::RG32Float, Format::RGB8UNorm, Format::RGB8SNorm, Format::RGB8UInt, Format::RGB8SInt, Format::RGB16UNorm, Format::RGB16SNorm, Format::RGB16UInt, Format::RGB16SInt, Format::RGB16Float, Format::RGB32UInt, Format::RGB32SInt, Format::RGB32Float, Format::RGBA8UNorm, Format::RGBA8SNorm, Format::RGBA8UInt, Format::RGBA8SInt, Format::RGBA16UNorm, Format::RGBA16SNorm, Format::RGBA16UInt, Format::RGBA16SInt, Format::RGBA16Float, Format::RGBA32UInt, Format::RGBA32SInt, Format::RGBA32Float, Format::R64Float, Format::RG64Float, Format::RGB64Float, Format::RGBA64Float, Format::BGRA8UNorm, Format::BGRA8SNorm, Format::BGRA8UInt, Format::BGRA8SInt, Format::BGRA8sRGB, Format::D16UNorm, Format::D24UNormS8UInt, Format::D32Float, Format::D32FloatS8X24UInt, Format::BC1RGB, Format::BC1RGBA, Format::BC2RGBA, Format::BC3RGBA }

Hardware vector and pixel format enumeration.

- enum DataType {
DataType::Int8, DataType::UInt8, DataType::Int16, DataType::UInt16, DataType::Int32, DataType::UInt32, DataType::Float16, DataType::Float32, DataType::Float64 }

  Renderer data types enumeration.

- enum PrimitiveType { PrimitiveType::Points, PrimitiveType::Lines, PrimitiveType::Triangles }

  Primitive type enumeration.

- enum PrimitiveTopology {
PrimitiveTopology::PointList, PrimitiveTopology::LineList, PrimitiveTopology::LineStrip, PrimitiveTopology::↩ LineLoop,
PrimitiveTopology::LineListAdjacency, PrimitiveTopology::LineStripAdjacency, PrimitiveTopology::Triangle↩ List, PrimitiveTopology::TriangleStrip,
PrimitiveTopology::TriangleFan, PrimitiveTopology::TriangleListAdjacency, PrimitiveTopology::TriangleStrip↩ Adjacency, PrimitiveTopology::Patches1,
PrimitiveTopology::Patches2, PrimitiveTopology::Patches3, PrimitiveTopology::Patches4, Primitive↩ Topology::Patches5,
PrimitiveTopology::Patches6, PrimitiveTopology::Patches7, PrimitiveTopology::Patches8, Primitive↩ Topology::Patches9,
PrimitiveTopology::Patches10, PrimitiveTopology::Patches11, PrimitiveTopology::Patches12, Primitive↩ Topology::Patches13,
PrimitiveTopology::Patches14, PrimitiveTopology::Patches15, PrimitiveTopology::Patches16, Primitive↩ Topology::Patches17,
PrimitiveTopology::Patches18, PrimitiveTopology::Patches19, PrimitiveTopology::Patches20, Primitive↩ Topology::Patches21,
PrimitiveTopology::Patches22, PrimitiveTopology::Patches23, PrimitiveTopology::Patches24, Primitive↩ Topology::Patches25,
PrimitiveTopology::Patches26, PrimitiveTopology::Patches27, PrimitiveTopology::Patches28, Primitive↩ Topology::Patches29,
PrimitiveTopology::Patches30, PrimitiveTopology::Patches31, PrimitiveTopology::Patches32 }

  Primitive topology enumeration.

- enum CompareOp {
CompareOp::NeverPass, CompareOp::Less, CompareOp::Equal, CompareOp::LessEqual, CompareOp::Greater, CompareOp::NotEqual, CompareOp::GreaterEqual, CompareOp::AlwaysPass }

  Compare operations enumeration.

- enum StencilOp {
StencilOp::Keep, StencilOp::Zero, StencilOp::Replace, StencilOp::IncClamp, StencilOp::DecClamp, StencilOp::Invert, StencilOp::IncWrap, StencilOp::DecWrap }

  Stencil operations enumeration.

- enum BlendOp {
  BlendOp::Zero, BlendOp::One, BlendOp::SrcColor, BlendOp::InvSrcColor,
  BlendOp::SrcAlpha, BlendOp::InvSrcAlpha, BlendOp::DstColor, BlendOp::InvDstColor,
  BlendOp::DstAlpha, BlendOp::InvDstAlpha, BlendOp::SrcAlphaSaturate, BlendOp::BlendFactor,
  BlendOp::InvBlendFactor, BlendOp::Src1Color, BlendOp::InvSrc1Color, BlendOp::Src1Alpha,
  BlendOp::InvSrc1Alpha }

  Blending operations enumeration.

- enum BlendArithmetic {
  BlendArithmetic::Add, BlendArithmetic::Subtract, BlendArithmetic::RevSubtract, BlendArithmetic::Min,
  BlendArithmetic::Max }

  Blending arithmetic operations enumeration.

- enum PolygonMode { PolygonMode::Fill, PolygonMode::Wireframe, PolygonMode::Points }

  Polygon filling modes enumeration.

- enum CullMode { CullMode::Disabled, CullMode::Front, CullMode::Back }

  Polygon culling modes enumeration.

- enum LogicOp {
  LogicOp::Disabled, LogicOp::Clear, LogicOp::Set, LogicOp::Copy,
  LogicOp::CopyInverted, LogicOp::NoOp, LogicOp::Invert, LogicOp::AND,
  LogicOp::ANDReverse, LogicOp::ANDInverted, LogicOp::NAND, LogicOp::OR,
  LogicOp::ORReverse, LogicOp::ORInverted, LogicOp::NOR, LogicOp::XOR,
  LogicOp::Equiv }

  Logical pixel operation enumeration.

- enum ImageFormat {
  ImageFormat::R, ImageFormat::RG, ImageFormat::RGB, ImageFormat::BGR,
  ImageFormat::RGBA, ImageFormat::BGRA, ImageFormat::ARGB, ImageFormat::ABGR,
  ImageFormat::Depth, ImageFormat::DepthStencil, ImageFormat::CompressedRGB, ImageFormat::↩
  CompressedRGBA }

  Image format enumeration that applies to each pixel of an image.

- enum Key {

Key::LButton, Key::RButton, Key::Cancel, Key::MButton,
Key::XButton1, Key::XButton2, Key::Back, Key::Tab,
Key::Clear, Key::Return, Key::Shift, Key::Control,
Key::Menu, Key::Pause, Key::Capital, Key::Escape,
Key::Space, Key::PageUp, Key::PageDown, Key::End,
Key::Home, Key::Left, Key::Up, Key::Right,
Key::Down, Key::Select, Key::Print, Key::Exe,
Key::Snapshot, Key::Insert, Key::Delete, Key::Help,
Key::D0, Key::D1, Key::D2, Key::D3,
Key::D4, Key::D5, Key::D6, Key::D7,
Key::D8, Key::D9, Key::A, Key::B,
Key::C, Key::D, Key::E, Key::F,
Key::G, Key::H, Key::I, Key::J,
Key::K, Key::L, Key::M, Key::N,
Key::O, Key::P, Key::Q, Key::R,
Key::S, Key::T, Key::U, Key::V,
Key::W, Key::X, Key::Y, Key::Z,
Key::LWin, Key::RWin, Key::Apps, Key::Sleep,
Key::Keypad0, Key::Keypad1, Key::Keypad2, Key::Keypad3,
Key::Keypad4, Key::Keypad5, Key::Keypad6, Key::Keypad7,
Key::Keypad8, Key::Keypad9, Key::KeypadMultiply, Key::KeypadPlus,
Key::KeypadSeparator, Key::KeypadMinus, Key::KeypadDecimal, Key::KeypadDivide,
Key::F1, Key::F2, Key::F3, Key::F4,
Key::F5, Key::F6, Key::F7, Key::F8,
Key::F9, Key::F10, Key::F11, Key::F12,
Key::F13, Key::F14, Key::F15, Key::F16,
Key::F17, Key::F18, Key::F19, Key::F20,
Key::F21, Key::F22, Key::F23, Key::F24,
Key::NumLock, Key::ScrollLock, Key::LShift, Key::RShift,
Key::LControl, Key::RControl, Key::LMenu, Key::RMenu,
Key::BrowserBack, Key::BrowserForward, Key::BrowserRefresh, Key::BrowserStop,
Key::BrowserSearch, Key::BrowserFavorits, Key::BrowserHome, Key::VolumeMute,
Key::VolumeDown, Key::VolumeUp, Key::MediaNextTrack, Key::MediaPrevTrack,
Key::MediaStop, Key::MediaPlayPause, Key::LaunchMail, Key::LaunchMediaSelect,
Key::LaunchApp1, Key::LaunchApp2, Key::Plus, Key::Comma,
Key::Minus, Key::Period, Key::Exponent, Key::Attn,
Key::CrSel, Key::ExSel, Key::ErEOF, Key::Play,
Key::Zoom, Key::NoName, Key::PA1, Key::OEMClear,
Key::Any }

Input key codes.

- enum QueryType {
  QueryType::SamplesPassed, QueryType::AnySamplesPassed, QueryType::AnySamplesPassedConservative,
  QueryType::TimeElapsed,
  QueryType::StreamOutPrimitivesWritten, QueryType::StreamOutOverflow, QueryType::PipelineStatistics }

  Query type enumeration.
- enum OpenGLContextProfile { OpenGLContextProfile::CompatibilityProfile, OpenGLContextProfile::Core↩
  Profile, OpenGLContextProfile::ESProfile }

  OpenGL context profile enumeration.
- enum ErrorType { ErrorType::InvalidArgument, ErrorType::InvalidState, ErrorType::UnsupportedFeature,
  ErrorType::UndefinedBehavior }

  Rendering debugger error types enumeration.
- enum WarningType { WarningType::ImproperArgument, WarningType::ImproperState, WarningType::↩
  PointlessOperation }

  Rendering debugger warning types enumeration.
- enum AttachmentLoadOp { AttachmentLoadOp::Undefined, AttachmentLoadOp::Load, AttachmentLoad↩
  Op::Clear }

  Enumeration for render pass attachment load operations.

- enum AttachmentStoreOp { AttachmentStoreOp::Undefined, AttachmentStoreOp::Store }

  Enumeration for render pass attachment store operations.

- enum ShadingLanguage {
  ShadingLanguage::GLSL = (0x10000), ShadingLanguage::GLSL_110 = (0x10000 | 110), Shading↩Language::GLSL_120 = (0x10000 | 120), ShadingLanguage::GLSL_130 = (0x10000 | 130),
  ShadingLanguage::GLSL_140 = (0x10000 | 140), ShadingLanguage::GLSL_150 = (0x10000 | 150),
  ShadingLanguage::GLSL_330 = (0x10000 | 330), ShadingLanguage::GLSL_400 = (0x10000 | 400),
  ShadingLanguage::GLSL_410 = (0x10000 | 410), ShadingLanguage::GLSL_420 = (0x10000 | 420),
  ShadingLanguage::GLSL_430 = (0x10000 | 430), ShadingLanguage::GLSL_440 = (0x10000 | 440),
  ShadingLanguage::GLSL_450 = (0x10000 | 450), ShadingLanguage::GLSL_460 = (0x10000 | 460),
  ShadingLanguage::ESSL = (0x20000), ShadingLanguage::ESSL_100 = (0x20000 | 100),
  ShadingLanguage::ESSL_300 = (0x20000 | 300), ShadingLanguage::ESSL_310 = (0x20000 | 310),
  ShadingLanguage::ESSL_320 = (0x20000 | 320), ShadingLanguage::HLSL = (0x30000),
  ShadingLanguage::HLSL_2_0 = (0x30000 | 200), ShadingLanguage::HLSL_2_0a = (0x30000 | 201),
  ShadingLanguage::HLSL_2_0b = (0x30000 | 202), ShadingLanguage::HLSL_3_0 = (0x30000 | 300),
  ShadingLanguage::HLSL_4_0 = (0x30000 | 400), ShadingLanguage::HLSL_4_1 = (0x30000 | 410),
  ShadingLanguage::HLSL_5_0 = (0x30000 | 500), ShadingLanguage::HLSL_5_1 = (0x30000 | 510),
  ShadingLanguage::Metal = (0x40000), ShadingLanguage::Metal_1_0 = (0x40000 | 100), Shading↩Language::Metal_1_1 = (0x40000 | 110), ShadingLanguage::Metal_1_2 = (0x40000 | 120),
  ShadingLanguage::SPIRV = (0x50000), ShadingLanguage::SPIRV_100 = (0x50000 | 100), Shading↩Language::VersionBitmask = 0x0000ffff }

  Shading language version enumation.

- enum ScreenOrigin { ScreenOrigin::LowerLeft, ScreenOrigin::UpperLeft }

  Screen coordinate system origin enumeration.

- enum ClippingRange { ClippingRange::MinusOneToOne, ClippingRange::ZeroToOne }

  Clipping depth range enumeration.

- enum CPUAccess { CPUAccess::ReadOnly, CPUAccess::WriteOnly, CPUAccess::WriteDiscard, CPU↩Access::ReadWrite }

  Classifications of CPU access to mapped resources.

- enum AttachmentType { AttachmentType::Color, AttachmentType::Depth, AttachmentType::DepthStencil, AttachmentType::Stencil }

  Render target attachment type enumeration.

- enum ResourceType {
  ResourceType::Undefined, ResourceType::VertexBuffer, ResourceType::IndexBuffer, ResourceType::↩ConstantBuffer,
  ResourceType::StorageBuffer, ResourceType::StreamOutputBuffer, ResourceType::Texture, Resource↩Type::Sampler }

  Hardware resource type enumeration.

- enum SamplerAddressMode {
  SamplerAddressMode::Repeat, SamplerAddressMode::Mirror, SamplerAddressMode::Clamp, Sampler↩AddressMode::Border,
  SamplerAddressMode::MirrorOnce }

  Technique for resolving texture coordinates that are outside of the range [0, 1].

- enum SamplerFilter { SamplerFilter::Nearest, SamplerFilter::Linear }

  Sampling filter enumeration.

- enum ShaderType {
  ShaderType::Undefined, ShaderType::Vertex, ShaderType::TessControl, ShaderType::TessEvaluation,
  ShaderType::Geometry, ShaderType::Fragment, ShaderType::Compute }

  Shader type enumeration.

- enum ShaderSourceType { ShaderSourceType::CodeString, ShaderSourceType::CodeFile, ShaderSource↩Type::BinaryBuffer, ShaderSourceType::BinaryFile }

  Shader source type enumeration.

- enum UniformType {
  UniformType::Undefined, UniformType::Float1, UniformType::Float2, UniformType::Float3,
  UniformType::Float4, UniformType::Double1, UniformType::Double2, UniformType::Double3,
  UniformType::Double4, UniformType::Int1, UniformType::Int2, UniformType::Int3,
  UniformType::Int4, UniformType::UInt1, UniformType::UInt2, UniformType::UInt3,
  UniformType::UInt4, UniformType::Bool1, UniformType::Bool2, UniformType::Bool3,
  UniformType::Bool4, UniformType::Float2x2, UniformType::Float3x3, UniformType::Float4x4,
  UniformType::Float2x3, UniformType::Float2x4, UniformType::Float3x2, UniformType::Float3x4,
  UniformType::Float4x2, UniformType::Float4x3, UniformType::Double2x2, UniformType::Double3x3,
  UniformType::Double4x4, UniformType::Double2x3, UniformType::Double2x4, UniformType::Double3x2,
  UniformType::Double3x4, UniformType::Double4x2, UniformType::Double4x3, UniformType::Sampler,
  UniformType::Image, UniformType::AtomicCounter }

  Shader uniform type enumeration.
- enum TextureType {
  TextureType::Texture1D, TextureType::Texture2D, TextureType::Texture3D, TextureType::TextureCube,
  TextureType::Texture1DArray, TextureType::Texture2DArray, TextureType::TextureCubeArray, TextureType↩
  ::Texture2DMS,
  TextureType::Texture2DMSArray }

  Texture type enumeration.

Functions

- LLGL_EXPORT bool IsRWBuffer (const StorageBufferType type)

  Returns true if the storage buffer type denotes a read/write (RW) buffer.
- LLGL_EXPORT bool IsTypedBuffer (const StorageBufferType type)

  Returns true if the storage buffer type denotes a simply typed buffer.
- LLGL_EXPORT bool IsStructuredBuffer (const StorageBufferType type)

  Returns true if the storage buffer type denotes a structured buffer.
- LLGL_EXPORT bool IsByteAddressBuffer (const StorageBufferType type)

  Returns true if the storage buffer type denotes a byte addresse buffer.
- template<typename T >
  T MaxColorValue ()

  Returns the maximal color value for the data type T. By default 1.
- template<>
  std::uint8_t MaxColorValue< std::uint8_t > ()

  Specialized version. For unsigned 8-bit integers, the return value is 255.
- template<>
  bool MaxColorValue< bool > ()

  Specialized version. For booleans, the return value is true.
- template<typename Dst , typename Src >
  Dst CastColorValue (const Src &value)

  Casts the specified color value and transforms it from the source data type range to the destination data type range.
- template<>
  bool CastColorValue< bool, bool > (const bool &value)

  Specialized template which merely passes the input value as output.
- template<>
  float CastColorValue< float, float > (const float &value)

  Specialized template which merely passes the input value as output.
- template<>
  double CastColorValue< double, double > (const double &value)

  Specialized template which merely passes the input value as output.
- template<>
  std::uint8_t CastColorValue< std::uint8_t, std::uint8_t > (const std::uint8_t &value)

Specialized template which merely passes the input value as output.

- template<typename T , std::size_t N>
  Color< T, N > operator+ (const Color< T, N > &lhs, const Color< T, N > &rhs)
- template<typename T , std::size_t N>
  Color< T, N > operator- (const Color< T, N > &lhs, const Color< T, N > &rhs)
- template<typename T , std::size_t N>
  Color< T, N > operator∗ (const Color< T, N > &lhs, const Color< T, N > &rhs)
- template<typename T , std::size_t N>
  Color< T, N > operator/ (const Color< T, N > &lhs, const Color< T, N > &rhs)
- template<typename T , std::size_t N>
  Color< T, N > operator∗ (const Color< T, N > &lhs, const T &rhs)
- template<typename T , std::size_t N>
  Color< T, N > operator∗ (const T &lhs, const Color< T, N > &rhs)
- template<typename T , std::size_t N>
  Color< T, N > operator/ (const Color< T, N > &lhs, const T &rhs)
- template<typename T , std::size_t N>
  Color< T, N > operator/ (const T &lhs, const Color< T, N > &rhs)
- template<typename T , std::size_t N>
  bool operator== (const Color< T, N > &lhs, const Color< T, N > &rhs)

  Returns true if all components of both colors 'lhs' and 'rhs' are equal.
- template<typename T , std::size_t N>
  bool operator!= (const Color< T, N > &lhs, const Color< T, N > &rhs)

  Returns true if any component of both colors 'lhs' and 'rhs' are unequal.
- LLGL_EXPORT bool operator== (const DisplayModeDescriptor &lhs, const DisplayModeDescriptor &rhs)

  Compares the two specified display mode descriptors on equality.
- LLGL_EXPORT bool operator!= (const DisplayModeDescriptor &lhs, const DisplayModeDescriptor &rhs)

  Compares the two specified display mode descriptors on inequality.
- LLGL_EXPORT bool CompareSWO (const DisplayModeDescriptor &lhs, const DisplayModeDescriptor &rhs)

  Compares the two display modes in a strict-weak-order (SWO) fashion.
- LLGL_EXPORT Extent2D GetExtentRatio (const Extent2D &extent)

  Returns the ratio of the specified extent as another extent, i.e. all attributes are divided by their greatest common divisor.
- LLGL_EXPORT std::uint32_t FormatBitSize (const Format format)

  Returns the bit size of the specified hardware format.
- LLGL_EXPORT bool SplitFormat (const Format format, DataType &dataType, std::uint32_t &components)

  Splits the specified hardware format into a data type and the number of components.
- LLGL_EXPORT bool IsCompressedFormat (const Format format)

  Returns true if the specified hardware format is a compressed format, i.e. either Format::BC1RGB, Format::BC1R↩ GBA, Format::BC2RGBA, or Format::BC3RGBA.
- LLGL_EXPORT bool IsDepthStencilFormat (const Format format)

  Returns true if the specified hardware format is a depth or depth-stencil format, i.e. Format::D16UNorm, Format::↩ D24UNormS8UInt, Format::D32Float, or Format::D32FloatS8X24UInt.
- LLGL_EXPORT bool IsDepthFormat (const Format format)

  Returns true if the specified hardware format is a depth format, i.e. Format::D16UNorm, Format::D24UNormS8UInt, Format::D32Float, or Format::D32FloatS8X24UInt.
- LLGL_EXPORT bool IsStencilFormat (const Format format)

  Returns true if the specified hardware format is a stencil format, i.e. Format::D24UNormS8UInt or Format::D32↩ FloatS8X24UInt.
- LLGL_EXPORT bool IsNormalizedFormat (const Format format)

  Returns true if the specified hardware format is a normalized format (like Format::RGBA8UNorm, Format::R8SNorm etc.).
- LLGL_EXPORT bool IsIntegralFormat (const Format format)

  Returns true if the specified hardware format is an integral format (like Format::RGBA8UInt, Format::R8SInt etc.).
- LLGL_EXPORT bool IsFloatFormat (const Format format)

Returns true if the specified hardware format is a floating-point format (like Format::RGBA32Float, Format::R32Float etc.).

- LLGL_EXPORT std::uint32_t DataTypeSize (const DataType dataType)

  Returns the size (in bytes) of the specified data type.
- LLGL_EXPORT bool IsIntDataType (const DataType dataType)

  Determines if the argument refers to a signed integer data type.
- LLGL_EXPORT bool IsUIntDataType (const DataType dataType)

  Determines if the argument refers to an unsigned integer data type.
- LLGL_EXPORT bool IsFloatDataType (const DataType dataType)

  Determines if the argument refers to a floating-pointer data type.
- LLGL_EXPORT bool IsPrimitiveTopologyPatches (const PrimitiveTopology primitiveTopology)

  Returns true if the specified primitive topology is a patch list.
- LLGL_EXPORT std::uint32_t GetPrimitiveTopologyPatchSize (const PrimitiveTopology primitiveTopology)

  Returns the number of patch control points of the specified primitive topology (in range [1, 32]), or 0 if the topology is not a patch list.
- LLGL_EXPORT std::uint32_t ImageFormatSize (const ImageFormat imageFormat)

  Returns the size (in number of components) of the specified image format.
- LLGL_EXPORT std::uint32_t ImageDataSize (const ImageFormat imageFormat, const DataType dataType, std::uint32_t numPixels)

  Returns the required data size (in bytes) of an image with the specified format, data type, and number of pixels.
- LLGL_EXPORT bool IsCompressedFormat (const ImageFormat imageFormat)

  Returns true if the specified color format is a compressed format, i.e. either ImageFormat::CompressedRGB, or ImageFormat::CompressedRGBA.
- LLGL_EXPORT bool IsDepthStencilFormat (const ImageFormat imageFormat)

  Returns true if the specified color format is a depth-stencil format, i.e. either ImageFormat::Depth or ImageFormat↩ ::DepthStencil.
- LLGL_EXPORT bool FindSuitableImageFormat (const Format format, ImageFormat &imageFormat, Data↩ Type &dataType)

  Finds a suitable image format for the specified texture hardware format.
- LLGL_EXPORT bool ConvertImageBuffer (const SrcImageDescriptor &srcImageDesc, const DstImage↩ Descriptor &dstImageDesc, std::size_t threadCount=0)

  Converts the image format and data type of the source image (only uncompressed color formats).
- LLGL_EXPORT ByteBuffer ConvertImageBuffer (const SrcImageDescriptor &srcImageDesc, ImageFormat dstFormat, DataType dstDataType, std::size_t threadCount=0)

  Converst the image format and data type of the source image (only uncompressed color formats) and returns the new generated image buffer.
- LLGL_EXPORT ByteBuffer GenerateImageBuffer (ImageFormat format, DataType dataType, std::size_↩ t imageSize, const ColorRGBAd &fillColor)

  Generates an image buffer with the specified fill data for each pixel.
- LLGL_EXPORT ByteBuffer GenerateEmptyByteBuffer (std::size_t bufferSize, bool initialize=true)

  Generates a new byte buffer with zeros in each byte.
- LLGL_EXPORT bool operator== (const VsyncDescriptor &lhs, const VsyncDescriptor &rhs)

  Compares the two specified V-sync descriptors on equality.
- LLGL_EXPORT bool operator!= (const VsyncDescriptor &lhs, const VsyncDescriptor &rhs)

  Compares the two specified V-sync descriptors on inequality.
- LLGL_EXPORT bool operator== (const VideoModeDescriptor &lhs, const VideoModeDescriptor &rhs)

  Compares the two specified video mode descriptors on equality.
- LLGL_EXPORT bool operator!= (const VideoModeDescriptor &lhs, const VideoModeDescriptor &rhs)

  Compares the two specified video mode descriptors on inequality.
- LLGL_EXPORT bool ValidateRenderingCaps (const RenderingCapabilities &presentCaps, const RenderingCapabilities &requiredCaps, const ValidateRenderingCapsFunc &callback={})

  Validates the presence of the specified required rendering capabilities.

- LLGL_EXPORT bool IsShaderSourceCode (const ShaderSourceType type)

  Returns true if the specified shader source type is either ShaderSourceType::CodeString or ShaderSourceType::↩ CodeFile.
- LLGL_EXPORT bool IsShaderSourceBinary (const ShaderSourceType type)

  Returns true if the specified shader source type is either ShaderSourceType::BinaryBuffer or ShaderSourceType::↩ BinaryFile.
- LLGL_EXPORT bool operator== (const StreamOutputAttribute &lhs, const StreamOutputAttribute &rhs)
- LLGL_EXPORT bool operator!= (const StreamOutputAttribute &lhs, const StreamOutputAttribute &rhs)
- LLGL_EXPORT const char ∗ ToString (const ShaderType t)

  Returns a string representation for the spcified ShaderType value, or null if the input type is invalid.
- LLGL_EXPORT const char ∗ ToString (const ErrorType t)

  Returns a string representation for the specified ErrorType value, or null if the input type is invalid.
- LLGL_EXPORT const char ∗ ToString (const WarningType t)

  Returns a string representation for the specified WarningType value, or null if the input type is invalid.
- LLGL_EXPORT const char ∗ ToString (const ShadingLanguage t)

  Returns a string representation for the specified ShadingLanguage value, or null if the input type is invalid.
- LLGL_EXPORT const char ∗ ToString (const Format t)

  Returns a string representation for the specified Format value, or null if the input type is invalid.
- LLGL_EXPORT std::uint32_t NumMipLevels (std::uint32_t width, std::uint32_t height=1, std::uint32_↩ t depth=1)

  Returns the number of MIP-map levels for a texture with the specified size.
- LLGL_EXPORT std::uint32_t NumMipLevels (const TextureDescriptor &textureDesc)

  Returns the number of MIP-map levels for the specified texture descriptor.
- LLGL_EXPORT std::uint32_t TextureBufferSize (const Format format, std::uint32_t numTexels)

  Returns the required buffer size (in bytes) of a texture with the specified hardware format and number of texels.
- LLGL_EXPORT std::uint32_t TextureSize (const TextureDescriptor &textureDesc)

  Returns the texture size (in texels) of the specified texture descriptor, or zero if the texture type is invalid.
- LLGL_EXPORT bool IsMipMappedTexture (const TextureDescriptor &textureDesc)

  Returns true if the specified texture descriptor describes a texture with MIP-mapping enabled.
- LLGL_EXPORT bool IsArrayTexture (const TextureType type)

  Returns true if the specified texture type is an array texture.
- LLGL_EXPORT bool IsMultiSampleTexture (const TextureType type)

  Returns true if the specified texture type is a multi-sample texture.
- LLGL_EXPORT bool IsCubeTexture (const TextureType type)

  Returns true if the specified texture type is a cube texture.
- LLGL_EXPORT Extent2D operator+ (const Extent2D &lhs, const Extent2D &rhs)

  Returns the sum of left hand side extent 'lhs' and the right hand side extent 'rhs'.
- LLGL_EXPORT Extent2D operator- (const Extent2D &lhs, const Extent2D &rhs)

  Returns the subtractionn of left hand side extent 'lhs' and the right hand side extent 'rhs'.
- LLGL_EXPORT Extent3D operator+ (const Extent3D &lhs, const Extent3D &rhs)

  Returns the sum of left hand side extent 'lhs' and the right hand side extent 'rhs'.
- LLGL_EXPORT Extent3D operator- (const Extent3D &lhs, const Extent3D &rhs)

  Returns the subtractionn of left hand side extent 'lhs' and the right hand side extent 'rhs'.
- LLGL_EXPORT Offset2D operator+ (const Offset2D &lhs, const Offset2D &rhs)

  Returns the sum of left hand side offset 'lhs' and the right hand side offset 'rhs'.
- LLGL_EXPORT Offset2D operator- (const Offset2D &lhs, const Offset2D &rhs)

  Returns the subtractionn of left hand side offset 'lhs' and the right hand side offset 'rhs'.
- LLGL_EXPORT Offset3D operator+ (const Offset3D &lhs, const Offset3D &rhs)

  Returns the sum of left hand side offset 'lhs' and the right hand side offset 'rhs'.
- LLGL_EXPORT Offset3D operator- (const Offset3D &lhs, const Offset3D &rhs)

  Returns the subtractionn of left hand side offset 'lhs' and the right hand side offset 'rhs'.

- bool operator== (const Offset2D &lhs, const Offset2D &rhs)

  Returns true if the left hand side offset 'lhs' is equal to the right hand side offset 'rhs'.
- bool operator!= (const Offset2D &lhs, const Offset2D &rhs)

  Returns true if the left hand side offset 'lhs' is unequal to the right hand side offset 'rhs'.
- bool operator== (const Offset3D &lhs, const Offset3D &rhs)

  Returns true if the left hand side offset 'lhs' is equal to the right hand side offset 'rhs'.
- bool operator!= (const Offset3D &lhs, const Offset3D &rhs)

  Returns true if the left hand side offset 'lhs' is unequal to the right hand side offset 'rhs'.
- bool operator== (const Extent2D &lhs, const Extent2D &rhs)

  Returns true if the left hand side extent 'lhs' is equal to the right hand side extent 'rhs'.
- bool operator!= (const Extent2D &lhs, const Extent2D &rhs)

  Returns true if the left hand side extent 'lhs' is unequal to the right hand side extent 'rhs'.
- bool operator== (const Extent3D &lhs, const Extent3D &rhs)

  Returns true if the left hand side extent 'lhs' is equal to the right hand side extent 'rhs'.
- bool operator!= (const Extent3D &lhs, const Extent3D &rhs)

  Returns true if the left hand side extent 'lhs' is unequal to the right hand side extent 'rhs'.
- LLGL_EXPORT TextureDescriptor Texture1DDesc (Format format, std::uint32_t width, long flags=Texture↩ Flags::Default)

  Returns a TextureDescriptor structure with the TextureType::Texture1D type.
- LLGL_EXPORT TextureDescriptor Texture2DDesc (Format format, std::uint32_t width, std::uint32_t height, long flags=TextureFlags::Default)

  Returns a TextureDescriptor structure with the TextureType::Texture2D type.
- LLGL_EXPORT TextureDescriptor Texture3DDesc (Format format, std::uint32_t width, std::uint32_t height, std::uint32_t depth, long flags=TextureFlags::Default)

  Returns a TextureDescriptor structure with the TextureType::Texture3D type.
- LLGL_EXPORT TextureDescriptor TextureCubeDesc (Format format, std::uint32_t width, std::uint32_t height, long flags=TextureFlags::Default)

  Returns a TextureDescriptor structure with the TextureType::TextureCube type.
- LLGL_EXPORT TextureDescriptor Texture1DArrayDesc (Format format, std::uint32_t width, std::uint32_↩ t arrayLayers, long flags=TextureFlags::Default)

  Returns a TextureDescriptor structure with the TextureType::Texture1DArray type.
- LLGL_EXPORT TextureDescriptor Texture2DArrayDesc (Format format, std::uint32_t width, std::uint32_↩ t height, std::uint32_t arrayLayers, long flags=TextureFlags::Default)

  Returns a TextureDescriptor structure with the TextureType::Texture2DArray type.
- LLGL_EXPORT TextureDescriptor TextureCubeArrayDesc (Format format, std::uint32_t width, std::uint32_t height, std::uint32_t arrayLayers, long flags=TextureFlags::Default)

  Returns a TextureDescriptor structure with the TextureType::TextureCubeArray type.
- LLGL_EXPORT TextureDescriptor Texture2DMSDesc (Format format, std::uint32_t width, std::uint32_↩ t height, std::uint32_t samples, long flags=TextureFlags::Default)

  Returns a TextureDescriptor structure with the TextureType::Texture2DMS type.
- LLGL_EXPORT TextureDescriptor Texture2DMSArrayDesc (Format format, std::uint32_t width, std::uint32↩ _t height, std::uint32_t arrayLayers, std::uint32_t samples, long flags=TextureFlags::Default)

  Returns a TextureDescriptor structure with the TextureType::Texture2DMSArray type.
- LLGL_EXPORT BufferDescriptor VertexBufferDesc (uint64_t size, const VertexFormat &vertexFormat, long flags=0)

  Returns a BufferDescriptor structure for a vertex buffer.
- LLGL_EXPORT BufferDescriptor IndexBufferDesc (uint64_t size, const IndexFormat &indexFormat, long flags=0)

  Returns a BufferDescriptor structure for an index buffer.
- LLGL_EXPORT BufferDescriptor ConstantBufferDesc (uint64_t size, long flags=BufferFlags::DynamicUsage)

  Returns a BufferDescriptor structure for a constant buffer.

- LLGL_EXPORT BufferDescriptor StorageBufferDesc (uint64_t size, const StorageBufferType storageType, std::uint32_t stride, long flags=BufferFlags::MapReadAccess|BufferFlags::MapWriteAccess)

  Returns a BufferDescriptor structure for a storage buffer.
- LLGL_EXPORT ShaderDescriptor ShaderDescFromFile (const ShaderType type, const char ∗filename, const char ∗entryPoint=nullptr, const char ∗profile=nullptr, long flags=0)

  Returns a ShaderDescriptor structure.
- LLGL_EXPORT ShaderProgramDescriptor ShaderProgramDesc (const std::initializer_list< Shader ∗ > &shaders, const std::initializer_list< VertexFormat > &vertexFormats={})

  Returns a ShaderProgramDescriptor structure and assigns the input shaders into the respective structure members.
- LLGL_EXPORT ShaderProgramDescriptor ShaderProgramDesc (const std::vector< Shader ∗ > &shaders, const std::vector< VertexFormat > &vertexFormats={})

  Returns a ShaderProgramDescriptor structure and assigns the input shaders into the respective structure members.
- LLGL_EXPORT PipelineLayoutDescriptor PipelineLayoutDesc (const ShaderReflectionDescriptor &reflection↩ Desc)

  Converts the specified shader reflection descriptor into a pipeline layout descriptor.
- LLGL_EXPORT PipelineLayoutDescriptor PipelineLayoutDesc (const char ∗layoutSignature)

  Generates a pipeline layout descriptor by parsing the specified string.
- LLGL_EXPORT RenderPassDescriptor RenderPassDesc (const RenderTargetDescriptor &renderTarget↩ Desc)

  Converts the specified render target descriptor into a render pass descriptor with default settings.
- LLGL_EXPORT bool operator== (const VertexAttribute &lhs, const VertexAttribute &rhs)

  Compares the two VertexAttribute types for equality (including their names and all other members).
- LLGL_EXPORT bool operator!= (const VertexAttribute &lhs, const VertexAttribute &rhs)

  Compares the two VertexAttribute types for inequality (including their names and all other members).

9.1.1 Typedef Documentation

9.1.1.1 using **LLGL::ByteBuffer** = typedef std::unique_ptr<char[ ]>

Common byte buffer type.

Remarks

Commonly this would be an std::vector<char>, but the buffer conversion is an optimized process, where the default initialization of an std::vector is undesired. Therefore, the byte buffer type is an std::unique_↩ ptr<char[ ]>.

See also

ConvertImageBuffer

9.1.1.2 using **LLGL::ColorRGBAb** = typedef **ColorRGBAT**<bool>

9.1.1.3 using **LLGL::ColorRGBAd** = typedef **ColorRGBAT**<double>

9.1.1.4 using **LLGL::ColorRGBAf** = typedef **ColorRGBAT**<float>

9.1.1.5 template<typename T > using **LLGL::ColorRGBAT** = typedef **Color**<T, 4>

9.1.1.6 using **LLGL::ColorRGBAub** = typedef **ColorRGBAT**<std::uint8_t>

9.1.1.7 using **LLGL::ColorRGBb** = typedef **ColorRGBT**<bool>

9.1.1.8 using **LLGL::ColorRGBd** = typedef **ColorRGBT**<double>

9.1.1.9 using **LLGL::ColorRGBf** = typedef **ColorRGBT**<float>

9.1.1.10 template<typename T > using **LLGL::ColorRGBT** = typedef **Color**<T, 3>

9.1.1.11 using **LLGL::ColorRGBub** = typedef **ColorRGBT**<std::uint8_t>

9.1.1.12 using **LLGL::UniformLocation** = typedef std::int32_t

Shader uniform location type, as zero-based index in 32-bit signed integer format.

9.1.2 Enumeration Type Documentation

9.1.2.1 enum **LLGL::AttachmentLoadOp** `[strong]`

Enumeration for render pass attachment load operations.

See also

AttachmentFormatDescriptor

Enumerator

Undefined We don't care about the previous content of the respective render target attachment.

Load Loads the previous content of the respective render target attachment.

Clear Clear the previous content of the respective render target attachment.

Remarks

The clear value used for this load operation is specified at the CommandBuffer::BeginRenderPass function.

See also

CommandBuffer::BeginRenderPass

9.1.2.2 enum LLGL::AttachmentStoreOp [strong]

Enumeration for render pass attachment store operations.

See also

AttachmentFormatDescriptor

Enumerator

Undefined We don't care about the outcome of the respective render target attachment.

Remarks

Can be used, for example, if we only need the depth buffer for the depth test, but nothing is written to it.

Store Stores the outcome in the respective render target attachment.

9.1.2.3 enum LLGL::AttachmentType [strong]

Render target attachment type enumeration.

See also

AttachmentDescriptor

Enumerator

Color Attachment is used for color output.

Remarks

A texture attached to a render target with this attachment type must have been created with the TextureFlags::ColorAttachmentUsage flag.

Depth Attachment is used for depth component output.

Remarks

A texture attached to a render target with this attachment type must have been created with the TextureFlags::DepthStencilAttachmentUsage flag.

DepthStencil Attachment is used for depth component and stencil index output.

Remarks

A texture attached to a render target with this attachment type must have been created with the TextureFlags::DepthStencilAttachmentUsage flag.

Stencil Attachment is used for stencil index output.

Remarks

A texture attached to a render target with this attachment type must have been created with the TextureFlags::DepthStencilAttachmentUsage flag.

9.1.2.4 enum LLGL::BlendArithmetic `[strong]`

Blending arithmetic operations enumeration.

See also

BlendTargetDescriptor::colorArithmetic
BlendTargetDescriptor::alphaArithmetic

Enumerator

Add Add source 1 and source 2. This is the default for all renderers.

Subtract Subtract source 1 from source 2.

RevSubtract Subtract source 2 from source 1.

Min Find the minimum of source 1 and source 2.

Max Find the maximum of source 1 and source 2.

9.1.2.5 enum LLGL::BlendOp `[strong]`

Blending operations enumeration.

See also

BlendTargetDescriptor

Enumerator

Zero Data source is the color black (0, 0, 0, 0).

One Data source is the color white (1, 1, 1, 1).

SrcColor Data source is color data (RGB) from a fragment shader.

InvSrcColor Data source is inverted color data (1 - RGB) from a fragment shader.

SrcAlpha Data source is alpha data (A) from a fragment shader.

InvSrcAlpha Data source is inverted alpha data (1 - A) from a fragment shader.

DstColor Data source is color data (RGB) from a framebuffer.

InvDstColor Data source is inverted color data (1 - RGB) from a framebuffer.

DstAlpha Data source is alpha data (A) from a framebuffer.

InvDstAlpha Data source is inverted alpha data (1 - A) from a framebuffer.

SrcAlphaSaturate Data source is alpha data (A) from a fragment shader which is clamped to 1 or less.

BlendFactor Data source is the blend factor (RGBA) from the blend state.

See also

CommandBuffer::SetBlendFactor

InvBlendFactor Data source is the inverted blend factor (1 - RGBA) from the blend state.

See also

CommandBuffer::SetBlendFactor

Src1Color Data sources are both color data (RGB) from a fragment shader with dual-source color blending.

InvSrc1Color Data sources are both inverted color data (1 - RGB) from a fragment shader with dual-source color blending.

Src1Alpha Data sources are both alpha data (A) from a fragment shader with dual-source color blending.

InvSrc1Alpha Data sources are both inverted alpha data (1 - A) from a fragment shader with dual-source color blending.

9.1.2.6 enum LLGL::BufferType [strong]

Hardware buffer type enumeration.

See also

ResourceType

Todo Maybe replace this enum by "ResourceType".

Enumerator

Vertex Vertex buffer type.

Index Index buffer type.

Constant Constant buffer type (also called "Uniform Buffer Object").

Storage Storage buffer type (also called "Shader Storage Buffer Object" or "Read/Write Buffer").

StreamOutput Stream output buffer type (also called "Transform Feedback Buffer").

Note

Only supported with: OpenGL, Direct3D 11, Direct3D 12.

9.1.2.7 enum LLGL::ClippingRange [strong]

Clipping depth range enumeration.

Enumerator

MinusOneToOne Specifies the clipping depth range [-1, 1].

Note

Native clipping depth range in: OpenGL.

ZeroToOne Specifies the clipping depth range [0, 1].

Note

Native clipping depth range in: Direct3D 11, Direct3D 12, Vulkan.

9.1.2.8 enum LLGL::CompareOp [strong]

Compare operations enumeration.

Remarks

This operation is used for depth tests, stencil tests, and texture sample comparisons.

See also

DepthDescriptor::compareOp
StencilFaceDescriptor::compareOp
SamplerDescriptor::compareOp

Enumerator

NeverPass Comparison never passes.

Less Comparison passes if the source data is less than the destination data.

Equal Comparison passes if the source data is euqal to the right-hand-side.

LessEqual Comparison passes if the source data is less than or equal to the right-hand-side.

Greater Comparison passes if the source data is greater than the right-hand-side.

NotEqual Comparison passes if the source data is not equal to the right-hand-side.

GreaterEqual Comparison passes if the source data is greater than or equal to the right-hand-side.

AlwaysPass Comparison always passes.

9.1.2.9 enum LLGL::CPUAccess [strong]

Classifications of CPU access to mapped resources.

See also

RenderSystem::MapBuffer

Enumerator

ReadOnly CPU read access to a mapped resource.

Remarks

If this is used for RenderSystem::MapBuffer, the respective buffer must have been created with the BufferFlags::MapReadAccess flag.

WriteOnly CPU write access to a mapped resource.

Remarks

If this is used for RenderSystem::MapBuffer, the respective buffer must have been created with the BufferFlags::MapWriteAccess flag.

WriteDiscard CPU write access to a mapped resource, where the previous content *can* be discarded.

Remarks

If this is used for RenderSystem::MapBuffer, the respective buffer must have been created with the BufferFlags::MapWriteAccess flag.

Note

Whether the previous content is discarded depends on the rendering API.

ReadWrite CPU read and write access to a mapped resource.

Remarks

If this is used for RenderSystem::MapBuffer, the respective buffer must have been created with both the BufferFlags::MapReadAccess and the BufferFlags::MapWriteAccess flag.

9.1.2.10 enum LLGL::CullMode [strong]

Polygon culling modes enumeration.

See also

RasterizerDescriptor::cullMode

Enumerator

Disabled No culling.

Front Front face culling.

Back Back face culling.

9.1.2.11 enum **LLGL::DataType** `[strong]`

Renderer data types enumeration.

See also

SrcImageDescriptor::dataType

Enumerator

Int8 8-bit signed integer (char).

UInt8 8-bit unsigned integer (unsigned char).

Int16 16-bit signed integer (short).

UInt16 16-bit unsigned integer (unsigned short).

Int32 32-bit signed integer (int).

UInt32 32-bit unsigned integer (unsiged int).

Float16 16-bit floating-point (half).

Float32 32-bit floating-point (float).

Float64 64-bit real type (double).

9.1.2.12 enum **LLGL::ErrorType** `[strong]`

Rendering debugger error types enumeration.

Enumerator

InvalidArgument Error due to invalid argument (e.g. creating a graphics pipeline without a valid shader program being specified).

InvalidState Error due to invalid render state (e.g. rendering without a valid graphics pipeline).

UnsupportedFeature Error due to use of unsupported feature (e.g. drawing with hardware instancing when the renderer hardware does not support it).

UndefinedBehavior Error due to arguments that cause undefined behavior.

9.1.2.13 enum **LLGL::Format** `[strong]`

Hardware vector and pixel format enumeration.

Remarks

This enumeration is used for hardware texture formats and vertex attribute formats.

See also

TextureDescriptor::format
VertexAttribute::format
RenderingCapabilities::textureFormats
OpenGL counterpart: `https://www.khronos.org/registry/OpenGL-Refpages/gl4/html/gl←TexImage1D.xhtml#id-1.6.14.1`
Vulkan counterpart `VkFormat`: `https://www.khronos.org/registry/vulkan/specs/1.←1-extensions/man/html/VkFormat.html`
Direct3D counterpart `DXGI_FORMAT`: `https://msdn.microsoft.com/en-us/library/windows/desktop/b`
`85).aspx`
Metal counterpart `MTLPixelFormat`: `https://developer.apple.com/documentation/metal/mtlpixelf`

Enumerator

Undefined Undefined format.

R8UNorm Color format: red 8-bit normalized unsigned integer component.

R8SNorm Color format: red 8-bit normalized signed integer component.

R8UInt Color format: red 8-bit unsigned integer component.

R8SInt Color format: red 8-bit signed integer component.

R16UNorm Color format: red 16-bit normalized unsigned interger component.

R16SNorm Color format: red 16-bit normalized signed interger component.

R16UInt Color format: red 16-bit unsigned interger component.

R16SInt Color format: red 16-bit signed interger component.

R16Float Color format: red 16-bit floating point component.

R32UInt Color format: red 32-bit unsigned interger component.

R32SInt Color format: red 32-bit signed interger component.

R32Float Color format: red 32-bit floating point component.

RG8UNorm Color format: red, green 8-bit normalized unsigned integer components.

RG8SNorm Color format: red, green 8-bit normalized signed integer components.

RG8UInt Color format: red, green 8-bit unsigned integer components.

RG8SInt Color format: red, green 8-bit signed integer components.

RG16UNorm Color format: red, green 16-bit normalized unsigned interger components.

RG16SNorm Color format: red, green 16-bit normalized signed interger components.

RG16UInt Color format: red, green 16-bit unsigned interger components.

RG16SInt Color format: red, green 16-bit signed interger components.

RG16Float Color format: red, green 16-bit floating point components.

RG32UInt Color format: red, green 32-bit unsigned interger components.

RG32SInt Color format: red, green 32-bit signed interger components.

RG32Float Color format: red, green 32-bit floating point components.

RGB8UNorm Color format: red, green, blue 8-bit normalized unsigned integer components.

Note

Only supported with: OpenGL, Vulkan.

RGB8SNorm Color format: red, green, blue 8-bit normalized signed integer components.

Note

Only supported with: OpenGL, Vulkan.

RGB8UInt Color format: red, green, blue 8-bit unsigned integer components.

Note

Only supported with: OpenGL, Vulkan.

RGB8SInt Color format: red, green, blue 8-bit signed integer components.

Note

Only supported with: OpenGL, Vulkan.

RGB16UNorm Color format: red, green, blue 16-bit normalized unsigned interger components.

Note

Only supported with: OpenGL, Vulkan.

RGB16SNorm Color format: red, green, blue 16-bit normalized signed interger components.

Note

Only supported with: OpenGL, Vulkan.

RGB16UInt Color format: red, green, blue 16-bit unsigned interger components.

Note

Only supported with: OpenGL, Vulkan.

RGB16SInt Color format: red, green, blue 16-bit signed interger components.

Note

Only supported with: OpenGL, Vulkan.

RGB16Float Color format: red, green, blue 16-bit floating point components.

Note

Only supported with: OpenGL, Vulkan.

RGB32UInt Color format: red, green, blue 32-bit unsigned interger components.

RGB32SInt Color format: red, green, blue 32-bit signed interger components.

RGB32Float Color format: red, green, blue 32-bit floating point components.

RGBA8UNorm Color format: red, green, blue, alpha 8-bit normalized unsigned integer components.

RGBA8SNorm Color format: red, green, blue, alpha 8-bit normalized signed integer components.

RGBA8UInt Color format: red, green, blue, alpha 8-bit unsigned integer components.

RGBA8SInt Color format: red, green, blue, alpha 8-bit signed integer components.

RGBA16UNorm Color format: red, green, blue, alpha 16-bit normalized unsigned interger components.

RGBA16SNorm Color format: red, green, blue, alpha 16-bit normalized signed interger components.

RGBA16UInt Color format: red, green, blue, alpha 16-bit unsigned interger components.

RGBA16SInt Color format: red, green, blue, alpha 16-bit signed interger components.

RGBA16Float Color format: red, green, blue, alpha 16-bit floating point components.

RGBA32UInt Color format: red, green, blue, alpha 32-bit unsigned interger components.

RGBA32SInt Color format: red, green, blue, alpha 32-bit signed interger components.

RGBA32Float Color format: red, green, blue, alpha 32-bit floating point components.

R64Float Color format: red 64-bit floating point component.

Note

Only supported with: OpenGL, Vulkan.

RG64Float Color format: red, green 64-bit floating point components.

Note

Only supported with: OpenGL, Vulkan.

RGB64Float Color format: red, green, blue 64-bit floating point components.

Note

Only supported with: OpenGL, Vulkan.

RGBA64Float Color format: red, green, blue, alpha 64-bit floating point components.

Note

Only supported with: OpenGL, Vulkan.

BGRA8UNorm Color format: blue, green, red, alpha 8-bit normalized unsigned integer components.

Note

Only supported with: Vulkan, Direct3D 11, Direct3D 12, Metal.

BGRA8SNorm Color format: blue, green, red, alpha 8-bit normalized signed integer components.

Note

Only supported with: Vulkan.

BGRA8UInt Color format: blue, green, red, alpha 8-bit unsigned integer components.

Note

Only supported with: Vulkan.

BGRA8SInt Color format: blue, green, red, alpha 8-bit signed integer components.

Note

Only supported with: Vulkan.

BGRA8sRGB Color format: blue, green, red, alpha 8-bit normalized unsigned integer components in sRGB non-linear color space.

Note

Only supported with: Vulkan, Direct3D 11, Direct3D 12, Metal.

D16UNorm Depth-stencil format: depth 16-bit normalized unsigned integer component.

D24UNormS8UInt Depth-stencil format: depth 24-bit normalized unsigned integer component, and 8-bit unsigned integer stencil component.

D32Float Depth-stencil format: depth 32-bit floating point component.

D32FloatS8X24UInt Depth-stencil format: depth 32-bit floating point component, and 8-bit unsigned integer stencil components (where the remaining 24 bits are unused).

BC1RGB Compressed color format: RGB S3TC DXT1 with 8 bytes per 4x4 block.

Note

Only supported with: OpenGL, Vulkan.

BC1RGBA Compressed color format: RGBA S3TC DXT1 with 8 bytes per 4x4 block.

BC2RGBA Compressed color format: RGBA S3TC DXT3 with 16 bytes per 4x4 block.

BC3RGBA Compressed color format: RGBA S3TC DXT5 with 16 bytes per 4x4 block.

9.1.2.14 enum LLGL::ImageFormat `[strong]`

Image format enumeration that applies to each pixel of an image.

See also

SrcImageDescriptor::format
ImageFormatSize

Enumerator

R	Single color component: Red.
RG	Two color components: Red, Green.
RGB	Three color components: Red, Green, Blue.
BGR	Three color components: Blue, Green, Red.
RGBA	Four color components: Red, Green, Blue, Alpha.
BGRA	Four color components: Blue, Green, Red, Alpha.
ARGB	Four color components: Alpha, Red, Green, Blue. Old format, mainly used in Direct3D 9.
ABGR	Four color components: Alpha, Blue, Green, Red. Old format, mainly used in Direct3D 9.
Depth	Depth component.
DepthStencil	Depth component and stencil index.
CompressedRGB	Generic compressed format with three color components: Red, Green, Blue.
CompressedRGBA	Generic compressed format with four color components: Red, Green, Blue, Alpha.

9.1.2.15 enum LLGL::Key `[strong]`

Input key codes.

See also

Window::EventListener

Enumerator

LButton	Left mouse button.
RButton	Right mouse button.
Cancel	Control-break processing.
MButton	Middle mouse button (three-button mouse).
XButton1	Windows 2000/XP: X1 mouse button.
XButton2	Windows 2000/XP: X2 mouse button.
Back	BACKSPACE key.
Tab	TAB key.
Clear	CLEAR key.
Return	RETURN (or ENTER) key.
Shift	SHIFT key.
Control	CTRL key.
Menu	ALT key.
Pause	PAUSE key.
Capital	CAPS LOCK key.
Escape	Escape (ESC) key.
Space	Space key.
PageUp	Page up key.

PageDown	Page down key.
End	END key.
Home	HOME (or POS1) key.
Left	Left arrow key.
Up	Up arrow key.
Right	Right arrow key.
Down	Down arrow key.
Select	Select key.
Print	Print key.
Exe	Execute key.
Snapshot	Snapshot key.
Insert	Insert key.
Delete	Delete key.
Help	Help key.
D0	Digit 0.
D1	Digit 1.
D2	Digit 2.
D3	Digit 3.
D4	Digit 4.
D5	Digit 5.
D6	Digit 6.
D7	Digit 7.
D8	Digit 8.
D9	Digit 9.
A	Letter A.
B	Letter B.
C	Letter C.
D	Letter D.
E	Letter E.
F	Letter F.
G	Letter G.
H	Letter H.
I	Letter I.
J	Letter J.
K	Letter K.
L	Letter L.
M	Letter M.
N	Letter N.
O	Letter O.
P	Letter P.
Q	Letter Q.
R	Letter R.
S	Letter S.
T	Letter T.
U	Letter U.

V Letter V.

W Letter W.

X Letter X.

Y Letter Y.

Z Letter Z.

LWin Left Windows key.

RWin Rigth Windows key.

Apps Application key.

Sleep Sleep key.

Keypad0 Keypad 0 key.

Keypad1 Keypad 1 key.

Keypad2 Keypad 2 key.

Keypad3 Keypad 3 key.

Keypad4 Keypad 4 key.

Keypad5 Keypad 5 key.

Keypad6 Keypad 6 key.

Keypad7 Keypad 7 key.

Keypad8 Keypad 8 key.

Keypad9 Keypad 9 key.

KeypadMultiply Keypad multiply '∗'.

KeypadPlus Keypad plus '+'.

KeypadSeparator Keypad separator.

KeypadMinus Keypad minus '-'.

KeypadDecimal Keypad decimal ',' or '.' (depends on language).

KeypadDivide Keypad divide '/'.

F1 F1 function key.

F2 F2 function key.

F3 F3 function key.

F4 F4 function key.

F5 F5 function key.

F6 F6 function key.

F7 F7 function key.

F8 F8 function key.

F9 F9 function key.

F10 F10 function key.

F11 F11 function key.

F12 F12 function key.

F13 F13 function key.

F14 F14 function key.

F15 F15 function key.

F16 F16 function key.

F17 F17 function key.

F18 F18 function key.

F19 F19 function key.

F20 F20 function key.

F21 F21 function key.

F22 F22 function key.

F23 F23 function key.

F24 F24 function key.

NumLock Num lock key.

ScrollLock Scroll lock key.

LShift Left shift key.

RShift Right shift key.

LControl Left control (CTRL) key.

RControl Right control (CTRL) key.

LMenu Left menu key.

RMenu Right menu key.

BrowserBack

BrowserForward

BrowserRefresh

BrowserStop

BrowserSearch

BrowserFavorits

BrowserHome

VolumeMute

VolumeDown

VolumeUp

MediaNextTrack

MediaPrevTrack

MediaStop

MediaPlayPause

LaunchMail

LaunchMediaSelect

LaunchApp1

LaunchApp2

Plus '+'

Comma ','

Minus '-'

Period '.'

Exponent '^'

Attn

CrSel

ExSel

ErEOF

Play

Zoom

NoName

PA1

OEMClear

Any Refers to any key.

9.1.2.16 enum **LLGL::LogicOp** [strong]

Logical pixel operation enumeration.

Remarks

These logical pixel operations are bitwise operations. In the following documentation, 'src' denotes the source color and 'dst' denotes the destination color.

Note

Only supported with: OpenGL, Vulkan, Direct3D 11.1+, Direct3D 12.0.

See also

BlendDescriptor::logicOp

Enumerator

Disabled No logical pixel operation.

Clear Resulting operation: 0.

Set Resulting operation: 1.

Copy Resulting operation: src.

CopyInverted Resulting operation: ∼src.

NoOp Resulting operation: dst.

Invert Resulting operation: ∼dst.

AND Resulting operation: src & dst.

ANDReverse Resulting operation: src & ∼dst.

ANDInverted Resulting operation: ∼src & dst.

NAND Resulting operation: ∼(src & dst).

OR Resulting operation: src | dst.

ORReverse Resulting operation: src | ∼dst.

ORInverted Resulting operation: ∼src | dst.

NOR Resulting operation: ∼(src | dst).

XOR Resulting operation: src ^ dst.

Equiv Resulting operation: ∼(src ^ dst).

9.1.2.17 enum **LLGL::OpenGLContextProfile** [strong]

OpenGL context profile enumeration.

Remarks

Can be used to specify a specific OpenGL profile other than the default (i.e. compatibility profile).

Enumerator

CompatibilityProfile OpenGL compatibility profile. This is the default.

CoreProfile OpenGL core profile.

ESProfile OpenGL ES profile.

Todo This is incomplete, do not use!

9.1.2.18 enum LLGL::PolygonMode `[strong]`

Polygon filling modes enumeration.

See also

RasterizerDescriptor::polygonMode

Enumerator

Fill Draw filled polygon.

Wireframe Draw triangle edges only.

Points Draw vertex points only.

Note

Only supported with: OpenGL, Vulkan.

9.1.2.19 enum LLGL::PrimitiveTopology `[strong]`

Primitive topology enumeration.

See also

GraphicsPipelineDescriptor::primitiveTopology

Enumerator

PointList Point list, where each vertex represents a single point primitive.

LineList Line list, where each pair of two vertices represetns a single line primitive.

LineStrip Line strip, where each vertex generates a new line primitive while the previous vertex is used as line start.

LineLoop Line loop, which is similar to LineStrip but the first and last vertices generate yet another line primitive.

Note

Only supported with: OpenGL.

LineListAdjacency Adjacency line list, which is similar to LineList but each end point has a corresponding adjacent vertex that is accessible in a geometry shader.

Note

Only supported with: OpenGL, Vulkan, Direct3D 11, Direct3D 12.

LineStripAdjacency Adjacency line strip, which is similar to LineStrip but each end point has a corresponding adjacent vertex that is accessible in a geometry shader.

Note

Only supported with: OpenGL, Vulkan, Direct3D 11, Direct3D 12.

TriangleList Triangle list, where each set of three vertices represent a single triangle primitive.

TriangleStrip Triangle strip, where each vertex generates a new triangle primitive with an alternative triangle winding.

TriangleFan Triangle fan, where each vertex generates a new triangle primitive while all share the same first vertex.

Note

Only supported with: OpenGL, Vulkan.

TriangleListAdjacency Adjacency triangle list, which is similar to TriangleList but each triangle edge has a corresponding adjacent vertex that is accessible in a geometry shader.

Note

Only supported with: OpenGL, Vulkan, Direct3D 11, Direct3D 12.

TriangleStripAdjacency Adjacency triangle strips which is similar to TriangleStrip but each triangle edge has a corresponding adjacent vertex that is accessible in a geometry shader.

Note

Only supported with: OpenGL, Vulkan, Direct3D 11, Direct3D 12.

Patches1 Patches with 1 control point that is accessible in a tessellation shader.

Patches2 Patches with 2 control points that are accessible in a tessellation shader.

Patches3 Patches with 3 control points that are accessible in a tessellation shader.

Patches4 Patches with 4 control points that are accessible in a tessellation shader.

Patches5 Patches with 5 control points that are accessible in a tessellation shader.

Patches6 Patches with 6 control points that are accessible in a tessellation shader.

Patches7 Patches with 7 control points that are accessible in a tessellation shader.

Patches8 Patches with 8 control points that are accessible in a tessellation shader.

Patches9 Patches with 9 control points that are accessible in a tessellation shader.

Patches10 Patches with 10 control points that are accessible in a tessellation shader.

Patches11 Patches with 11 control points that are accessible in a tessellation shader.

Patches12 Patches with 12 control points that are accessible in a tessellation shader.

Patches13 Patches with 13 control points that are accessible in a tessellation shader.

Patches14 Patches with 14 control points that are accessible in a tessellation shader.

Patches15 Patches with 15 control points that are accessible in a tessellation shader.

Patches16 Patches with 16 control points that are accessible in a tessellation shader.

Patches17 Patches with 17 control points that are accessible in a tessellation shader.

Patches18 Patches with 18 control points that are accessible in a tessellation shader.

Patches19 Patches with 19 control points that are accessible in a tessellation shader.

Patches20 Patches with 20 control points that are accessible in a tessellation shader.

Patches21 Patches with 21 control points that are accessible in a tessellation shader.

Patches22 Patches with 22 control points that are accessible in a tessellation shader.

Patches23 Patches with 23 control points that are accessible in a tessellation shader.

Patches24 Patches with 24 control points that are accessible in a tessellation shader.

Patches25 Patches with 25 control points that are accessible in a tessellation shader.

Patches26 Patches with 26 control points that are accessible in a tessellation shader.

Patches27 Patches with 27 control points that are accessible in a tessellation shader.

Patches28 Patches with 28 control points that are accessible in a tessellation shader.

Patches29 Patches with 29 control points that are accessible in a tessellation shader.

Patches30 Patches with 30 control points that are accessible in a tessellation shader.

Patches31 Patches with 31 control points that are accessible in a tessellation shader.

Patches32 Patches with 32 control points that are accessible in a tessellation shader.

9.1.2.20 enum LLGL::PrimitiveType [strong]

Primitive type enumeration.

Remarks

These entries are generic terms of a primitive topology.

See also

CommandBuffer::BeginStreamOutput

Enumerator

Points Generic term for all point primitives.

Remarks

This term refers to the following primitive topologies: PrimitiveTopology::PointList.

Lines Generic term for all line primitives.

Remarks

This term refers to the following primitive topologies: PrimitiveTopology::LineList, PrimitiveTopology::LineStrip, PrimitiveTopology::LineLoop, PrimitiveTopology::LineListAdjacency, and PrimitiveTopology::LineStripAdjacency.

Triangles Generic term for all triangle primitives.

Remarks

This term refers to the following primitive topologies: PrimitiveTopology::TriangleList, PrimitiveTopology::TriangleStrip, PrimitiveTopology::TriangleFan, PrimitiveTopology::TriangleListAdjacency, and PrimitiveTopology::TriangleStripAdjacency.

9.1.2.21 enum LLGL::QueryType [strong]

Query type enumeration.

See also

QueryHeapDescriptor::type

Enumerator

SamplesPassed Number of samples that passed the depth test. This can be used as render condition.

AnySamplesPassed Non-zero if any samples passed the depth test. This can be used as render condition.

AnySamplesPassedConservative Non-zero if any samples passed the depth test within a conservative rasterization. This can be used as render condition.

TimeElapsed Elapsed time (in nanoseconds) between the begin- and end query command.

StreamOutPrimitivesWritten Number of vertices that have been written into a stream output (also called "Transform Feedback").

StreamOutOverflow Non-zero if any of the streaming output buffers (also called "Transform Feedback Buffers") has an overflow.

PipelineStatistics Pipeline statistics such as number of shader invocations, generated primitives, etc.

See also

QueryPipelineStatistics
RenderingFeatures::hasPipelineStatistics

9.1.2.22 enum LLGL::RenderConditionMode `[strong]`

Render condition mode enumeration.

Remarks

The condition is determined by the type of the QueryHeap object.

See also

RenderContext::BeginRenderCondition

Enumerator

Wait Wait until the occlusion query result is available, before conditional rendering begins.

NoWait Do not wait until the occlusion query result is available, before conditional rendering begins.

ByRegionWait Similar to Wait, but the renderer may discard the results of commands for any framebuffer region that did not contribute to the occlusion query.

ByRegionNoWait Similar to NoWait, but the renderer may discard the results of commands for any framebuffer region that did not contribute to the occlusion query.

WaitInverted Same as Wait, but the condition is inverted.

NoWaitInverted Same as NoWait, but the condition is inverted.

ByRegionWaitInverted Same as ByRegionWait, but the condition is inverted.

ByRegionNoWaitInverted Same as ByRegionNoWait, but the condition is inverted.

9.1.2.23 enum LLGL::ResourceType `[strong]`

Hardware resource type enumeration.

Remarks

This is primarily used to describe the source type for a layout binding (see BindingDescriptor), which is why all buffer types are enumerated but not the texture types.

See also

BindingDescriptor::type
BufferType

Enumerator

Undefined Undefined resource type.

VertexBuffer Vertex buffer resource.

See also

Buffer
BufferType::Vertex

IndexBuffer Index buffer resource.

See also

Buffer
BufferType::Index

ConstantBuffer Constant buffer (or uniform buffer) resource.

See also

Buffer
BufferType::Constant

StorageBuffer Storage buffer resource.

See also

Buffer
BufferType::Storage

StreamOutputBuffer Stream-output buffer resource.

See also

Buffer
BufferType::StreamOutput

Texture Texture resource.

See also

Texture
TextureType

Sampler Sampler state resource.

See also

Sampler

9.1.2.24 enum **LLGL::SamplerAddressMode** `[strong]`

Technique for resolving texture coordinates that are outside of the range [0, 1].

See also

SamplerDescriptor::addressModeU
SamplerDescriptor::addressModeV
SamplerDescriptor::addressModeW

Enumerator

Repeat Repeat texture coordinates within the interval [0, 1).

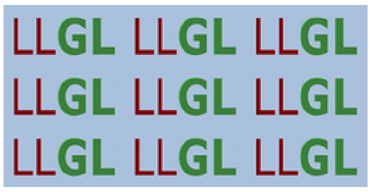


Figure 9.1 SamplerAddressMode::Repeat example

Mirror Flip texture coordinates at each integer junction.

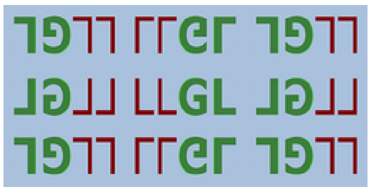


Figure 9.2 SamplerAddressMode::Mirror example

Clamp Clamp texture coordinates to the interval [0, 1].

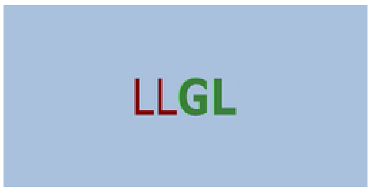


Figure 9.3 SamplerAddressMode::Clamp example

Border Sample border color for texture coordinates that are outside the interval [0, 1].

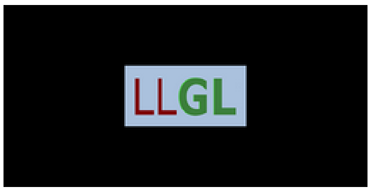


Figure 9.4 SamplerAddressMode::Border example

MirrorOnce Takes the absolute value of the texture coordinates and then clamps it to the interval [0, 1], i.e. mirror around 0.

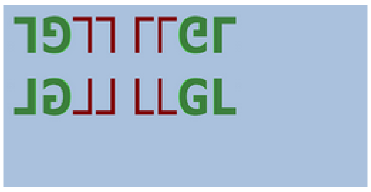


Figure 9.5 SamplerAddressMode::MirrorOnce example

9.1.2.25 enum **LLGL::SamplerFilter** `[strong]`

Sampling filter enumeration.

See also

SamplerDescriptor::minFilter
SamplerDescriptor::magFilter
SamplerDescriptor::mipMapFilter
Image::Resize(const Extent3D&, const SamplerFilter)

Enumerator

Nearest Take the nearest texture sample.

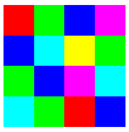


Figure 9.6 SamplerFilter::Nearest example

Linear Interpolate between multiple texture samples.

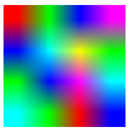


Figure 9.7 SamplerFilter::Linear example

9.1.2.26 enum LLGL::ScreenOrigin `[strong]`

Screen coordinate system origin enumeration.

Enumerator

LowerLeft Specifies a screen origin in the lower-left.

Note

Native screen origin in: OpenGL.

UpperLeft Specifies a screen origin in the upper-left.

Note

Native screen origin in: Direct3D 11, Direct3D 12, Vulkan.

9.1.2.27 enum LLGL::ShaderSourceType `[strong]`

Shader source type enumeration.

See also

ShaderDescriptor::sourceType
ShaderDescriptor::sourceSize

Enumerator

CodeString Refers to `sourceSize+1` bytes, describing shader high-level code (including null terminator).

CodeFile Refers to `sourceSize+1` bytes, describing the filename of the shader high-level code (including null terminator).

BinaryBuffer Refers to `sourceSize` bytes, describing shader binary code.

BinaryFile Refers to `sourceSize+1` bytes, describing the filename of the shader binary code (including null terminator).

9.1.2.28 enum LLGL::ShaderType [strong]

Shader type enumeration.

See also

ShaderDescriptor::type

Enumerator

Undefined Undefined shader type.

Vertex Vertex shader type.

TessControl Tessellation control shader type (also "Hull Shader").

TessEvaluation Tessellation evaluation shader type (also "Domain Shader").

Geometry Geometry shader type.

Fragment Fragment shader type (also "Pixel Shader").

Compute Compute shader type.

9.1.2.29 enum LLGL::ShadingLanguage [strong]

Shading language version enumation.

Remarks

These enumeration entries can be casted to an integer using the bitmask ShadingLanguage::VersionBitmask to get the respective version number:

```
// 'versionNo' will have the value 330
static const auto versionGLSL330 = static_cast<std::uint32_t>(
        LLGL::ShadingLanguage::GLSL_330);
static const auto versionBitmask = static_cast<std::uint32_t>(
        LLGL::ShadingLanguage::VersionBitmask);
static const auto versionNo      = versionGLSL330 & versionBitmask;
```

Enumerator

GLSL GLSL (OpenGL Shading Language).

GLSL_110 GLSL 1.10 (since OpenGL 2.0).

GLSL_120 GLSL 1.20 (since OpenGL 2.1).

GLSL_130 GLSL 1.30 (since OpenGL 3.0).

GLSL_140 GLSL 1.40 (since OpenGL 3.1).

GLSL_150 GLSL 1.50 (since OpenGL 3.2).

GLSL_330 GLSL 3.30 (since OpenGL 3.3).

GLSL_400 GLSL 4.00 (since OpenGL 4.0).

GLSL_410 GLSL 4.10 (since OpenGL 4.1).

GLSL_420 GLSL 4.20 (since OpenGL 4.2).

GLSL_430 GLSL 4.30 (since OpenGL 4.3).

GLSL_440 GLSL 4.40 (since OpenGL 4.4).

GLSL_450 GLSL 4.50 (since OpenGL 4.5).

GLSL_460 GLSL 4.60 (since OpenGL 4.6).

ESSL ESSL (OpenGL ES Shading Language).

ESSL_100 ESSL 1.00 (since OpenGL ES 2.0).

ESSL_300 ESSL 3.00 (since OpenGL ES 3.0).

ESSL_310 ESSL 3.10 (since OpenGL ES 3.1).

ESSL_320 ESSL 3.20 (since OpenGL ES 3.2).

HLSL HLSL (High Level Shading Language).

HLSL_2_0 HLSL 2.0 (since Direct3D 9).

HLSL_2_0a HLSL 2.0a (since Direct3D 9a).

HLSL_2_0b HLSL 2.0b (since Direct3D 9b).

HLSL_3_0 HLSL 3.0 (since Direct3D 9c).

HLSL_4_0 HLSL 4.0 (since Direct3D 10).

HLSL_4_1 HLSL 4.1 (since Direct3D 10.1).

HLSL_5_0 HLSL 5.0 (since Direct3D 11).

HLSL_5_1 HLSL 5.1 (since Direct3D 12 and Direct3D 11.3).

Metal Metal Shading Language.

Note

Not supported yet

Metal_1_0 Metal 1.0 (since iOS 8.0).

Note

Not supported yet

Metal_1_1 Metal 1.1 (since iOS 9.0 and OS X 10.11).

Note

Not supported yet

Metal_1_2 Metal 1.2 (since iOS 10.0 and macOS 10.12).

Note

Not supported yet

SPIRV SPIR-V Shading Language.

SPIRV_100 SPIR-V 1.0.

VersionBitmask Bitmask for the version number of each shading language enumeration entry.

9.1.2.30 enum LLGL::StencilOp `[strong]`

Stencil operations enumeration.

See also

StencilFaceDescriptor

Enumerator

Keep Keep the existing stencil data.

Zero Set stencil data to 0.

Replace Set the stencil data to the reference value.

See also

StencilFaceDescriptor::reference

IncClamp Increment the stencil value by 1, and clamp the result.

DecClamp Decrement the stencil value by 1, and clamp the result.

Invert Invert the stencil data.

IncWrap Increment the stencil value by 1, and wrap the result if necessary.

DecWrap Decrement the stencil value by 1, and wrap the result if necessary.

9.1.2.31 enum LLGL::StorageBufferType [strong]

Storage buffer type enumeration.

Note

Only supported with: Direct3D 11, Direct3D 12.

Enumerator

Undefined	Undefined storage buffer type.
Buffer	Typed buffer.
StructuredBuffer	Structured buffer.
ByteAddressBuffer	Byte-address buffer.
RWBuffer	Typed read/write buffer.
RWStructuredBuffer	Structured read/write buffer.
RWByteAddressBuffer	Byte-address read/write buffer.
AppendStructuredBuffer	Append structured buffer.
ConsumeStructuredBuffer	Consume structured buffer.

9.1.2.32 enum LLGL::TextureType [strong]

Texture type enumeration.

Enumerator

Texture1D	1-Dimensional texture.
Texture2D	2-Dimensional texture.
Texture3D	3-Dimensional texture.
TextureCube	Cube texture.
Texture1DArray	1-Dimensional array texture.
Texture2DArray	2-Dimensional array texture.
TextureCubeArray	Cube array texture.
Texture2DMS	2-Dimensional multi-sample texture.
Texture2DMSArray	2-Dimensional multi-sample array texture.

9.1.2.33 enum LLGL::UniformType [strong]

Shader uniform type enumeration.

Remarks

Because "Bool" is a reserved identifier for an Xlib macro on GNU/Linux, all scalar types also have a component index (e.g. "Bool1" instead of "Bool").

Enumerator

Undefined	Undefined uniform type.
Float1	float uniform.
Float2	float2/ vec2 uniform.
Float3	float3/ vec3 uniform.
Float4	float4/ vec4 uniform.
Double1	double uniform.
Double2	double2/ dvec2 uniform.
Double3	double3/ dvec3 uniform.
Double4	double4/ dvec4 uniform.
Int1	int uniform.
Int2	int2/ ivec2 uniform.
Int3	int3/ ivec3 uniform.
Int4	int4/ ivec4 uniform.
UInt1	uint uniform.
UInt2	uint2/ uvec2 uniform.
UInt3	uint3/ uvec3 uniform.
UInt4	uint4/ uvec4 uniform.
Bool1	bool uniform.
Bool2	bool2/ bvec2 uniform.
Bool3	bool3/ bvec3 uniform.
Bool4	bool4/ bvec4 uniform.
Float2x2	float2x2/ mat2 uniform.
Float3x3	float3x3/ mat3 uniform.
Float4x4	float4x4/ mat4 uniform.
Float2x3	float2x3/ mat2x3 uniform.
Float2x4	float2x4/ mat2x4 uniform.
Float3x2	float3x2/ mat3x2 uniform.
Float3x4	float3x4/ mat3x4 uniform.
Float4x2	float4x2/ mat4x2 uniform.
Float4x3	float4x3/ mat4x3 uniform.
Double2x2	double2x2/ dmat2 uniform.
Double3x3	double3x3/ dmat3 uniform.
Double4x4	double4x4/ dmat4 uniform.
Double2x3	double2x3/ dmat2x3 uniform.
Double2x4	double2x4/ dmat2x4 uniform.
Double3x2	double3x2/ dmat3x2 uniform.
Double3x4	double3x4/ dmat3x4 uniform.
Double4x2	double4x2/ dmat4x2 uniform.
Double4x3	double4x3/ dmat4x3 uniform.
Sampler	Sampler uniform (e.g. "sampler2D").
Image	Image uniform (e.g. "image2D").
AtomicCounter	Atomic counter uniform (e.g. "atomic_uint").

9.1.2.34 enum **LLGL::WarningType** [strong]

Rendering debugger warning types enumeration.

Enumerator

ImproperArgument Warning due to improper argument (e.g. generating 4 vertices while having triangle list as primitive topology).

ImproperState Warning due to improper state (e.g. rendering while viewport is not visible).

PointlessOperation Warning due to a operation without any effect (e.g. drawing with 0 vertices).

9.1.3 Function Documentation

9.1.3.1 template<typename Dst , typename Src > Dst LLGL::CastColorValue (const Src & *value*) [inline]

Casts the specified color value and transforms it from the source data type range to the destination data type range.

See also

MaxColorValue

9.1.3.2 template<> bool **LLGL::CastColorValue**< bool, bool > (const bool & *value*) [inline]

Specialized template which merely passes the input value as output.

9.1.3.3 template<> double **LLGL::CastColorValue**< double, double > (const double & *value*) [inline]

Specialized template which merely passes the input value as output.

9.1.3.4 template<> float **LLGL::CastColorValue**< float, float > (const float & *value*) [inline]

Specialized template which merely passes the input value as output.

9.1.3.5 template<> std::uint8_t **LLGL::CastColorValue**< std::uint8_t, std::uint8_t > (const std::uint8_t & *value*) [inline]

Specialized template which merely passes the input value as output.

9.1.3.6 **LLGL_EXPORT Extent2D** LLGL::GetExtentRatio (const **Extent2D** & *extent*)

Returns the ratio of the specified extent as another extent, i.e. all attributes are divided by their greatest common divisor.

Remarks

This can be used to print out a display mode resolution in a better format (e.g. "16:9" rather than "1920:1080").

See also

DisplayModeDescriptor::resolution

9.1.3.7 LLGL_EXPORT std::uint32_t LLGL::GetPrimitiveTopologyPatchSize (const PrimitiveTopology *primitiveTopology*)

Returns the number of patch control points of the specified primitive topology (in range [1, 32]), or 0 if the topology is not a patch list.

9.1.3.8 LLGL_EXPORT bool LLGL::IsPrimitiveTopologyPatches (const PrimitiveTopology *primitiveTopology*)

Returns true if the specified primitive topology is a patch list.

9.1.3.9 LLGL_EXPORT bool LLGL::IsShaderSourceBinary (const ShaderSourceType *type*)

Returns true if the specified shader source type is either ShaderSourceType::BinaryBuffer or ShaderSourceType↩ ::BinaryFile.

See also

ShaderSourceType

9.1.3.10 LLGL_EXPORT bool LLGL::IsShaderSourceCode (const ShaderSourceType *type*)

Returns true if the specified shader source type is either ShaderSourceType::CodeString or ShaderSourceType::↩ CodeFile.

See also

ShaderSourceType

9.1.3.11 template<typename T > T LLGL::MaxColorValue ( ) [inline]

Returns the maximal color value for the data type T. By default 1.

9.1.3.12 template<> bool LLGL::MaxColorValue< bool > ( ) [inline]

Specialized version. For booleans, the return value is true.

9.1.3.13 template<> std::uint8_t LLGL::MaxColorValue< std::uint8_t > ( ) [inline]

Specialized version. For unsigned 8-bit integers, the return value is 255.

9.1.3.14 LLGL_EXPORT bool LLGL::operator!= (const DisplayModeDescriptor & *lhs*, const DisplayModeDescriptor & *rhs*)

Compares the two specified display mode descriptors on inequality.

9.1.3.15 LLGL_EXPORT bool LLGL::operator!= (const StreamOutputAttribute & *lhs*, const StreamOutputAttribute & *rhs*)

9.1.3.16 LLGL_EXPORT bool LLGL::operator!= (const VertexAttribute & *lhs*, const VertexAttribute & *rhs*)

Compares the two VertexAttribute types for inequality (including their names and all other members).

9.1.3.17 LLGL_EXPORT bool LLGL::operator!= (const VsyncDescriptor & *lhs*, const VsyncDescriptor & *rhs*)

Compares the two specified V-sync descriptors on inequality.

9.1.3.18 LLGL_EXPORT bool LLGL::operator!= (const VideoModeDescriptor & *lhs*, const VideoModeDescriptor & *rhs*)

Compares the two specified video mode descriptors on inequality.

9.1.3.19 template<typename T , std::size_t N> bool LLGL::operator!= (const Color< T, N > & *lhs*, const Color< T, N > & *rhs*)

Returns true if any component of both colors 'lhs' and 'rhs' are unequal.

Remarks

The comparison uses the 'operator ==' of the underlying component type. Note that this comparison is quite limited for floating-point types, due to precision issues.

9.1.3.20 template<typename T , std::size_t N> Color<T, N> LLGL::operator* (const Color< T, N > & *lhs*, const Color< T, N > & *rhs*)

9.1.3.21 template<typename T , std::size_t N> Color<T, N> LLGL::operator* (const Color< T, N > & *lhs*, const T & *rhs*)

9.1.3.22 template<typename T , std::size_t N> Color<T, N> LLGL::operator* (const T & *lhs*, const Color< T, N > & *rhs*)

9.1.3.23 template<typename T , std::size_t N> Color<T, N> LLGL::operator+ (const Color< T, N > & *lhs*, const Color< T, N > & *rhs*)

9.1.3.24 template<typename T , std::size_t N> Color<T, N> LLGL::operator- (const Color< T, N > & *lhs*, const Color< T, N > & *rhs*)

9.1.3.25 template<typename T , std::size_t N> Color<T, N> LLGL::operator/ (const Color< T, N > & *lhs*, const Color< T, N > & *rhs*)

9.1.3.26 template<typename T , std::size_t N> Color<T, N> LLGL::operator/ (const Color< T, N > & *lhs*, const T & *rhs*)

9.1.3.27 template<typename T , std::size_t N> Color<T, N> LLGL::operator/ (const T & *lhs*, const Color< T, N > & *rhs*)

9.1.3.28 LLGL_EXPORT bool LLGL::operator== (const DisplayModeDescriptor & *lhs*, const DisplayModeDescriptor & *rhs*)

Compares the two specified display mode descriptors on equality.

9.1.3.29 LLGL_EXPORT bool LLGL::operator== (const StreamOutputAttribute & *lhs*, const StreamOutputAttribute & *rhs*)

9.1.3.30 LLGL_EXPORT bool LLGL::operator== (const VertexAttribute & *lhs*, const VertexAttribute & *rhs*)

Compares the two VertexAttribute types for equality (including their names and all other members).

9.1.3.31 LLGL_EXPORT bool LLGL::operator== (const VsyncDescriptor & *lhs*, const VsyncDescriptor & *rhs*)

Compares the two specified V-sync descriptors on equality.

9.1.3.32 LLGL_EXPORT bool LLGL::operator== (const VideoModeDescriptor & *lhs*, const VideoModeDescriptor & *rhs*)

Compares the two specified video mode descriptors on equality.

9.1.3.33 template<typename T , std::size_t N> bool LLGL::operator== (const Color< T, N > & *lhs*, const Color< T, N > & *rhs*)

Returns true if all components of both colors 'lhs' and 'rhs' are equal.

Remarks

The comparison uses the 'operator ==' of the underlying component type. Note that this comparison is quite limited for floating-point types, due to precision issues.

9.1.3.34 LLGL_EXPORT bool LLGL::ValidateRenderingCaps (const RenderingCapabilities & *presentCaps*, const RenderingCapabilities & *requiredCaps*, const ValidateRenderingCapsFunc & *callback* = {})

Validates the presence of the specified required rendering capabilities.

Parameters

in	*presentCaps*	Specifies the rendering capabilities that are present for a certain renderer.
in	*requiredCaps*	Specifies the rendering capabilities that are required for the host application to work properly.
in	*callback*	Optional callback to retrieve information about the attributes that did not fulfill the requirement. If this is null the validation process breaks with the first attribute that did not fulfill the requirement. By default null.

Returns

True on success, otherwise at least one attribute did not fulfill the requirement.

Remarks

Here is an example usage to print out all attributes that did not fulfill the requirement:

```
// Initialize the requirements
LLGL::RenderingCapabilities myRequirements;
myRequirements.features.hasStorageBuffers = true;
myRequirements.features.hasComputeShaders = true;
myRequirements.limits.maxComputeShaderWorkGroups[0] = 1024;
myRequirements.limits.maxComputeShaderWorkGroups[1] = 1024;
myRequirements.limits.maxComputeShaderWorkGroups[2] = 1;
myRequirements.limits.maxComputeShaderWorkGroupSize[0] = 8;
myRequirements.limits.maxComputeShaderWorkGroupSize[1] = 8;
myRequirements.limits.maxComputeShaderWorkGroupSize[2] = 8;

// Validate rendering capabilities supported by the render system
LLGL::ValidateRenderingCaps(
    myRenderer->GetRenderingCaps(),
    myRequirements,
    [](const std::string& info, const std::string& attrib) {
        std::cerr << info << ": " << attrib << std::endl;
        return true;
    }
);
```

Note

The following attributes of the RenderingCapabilities structure are ignored: 'screenOrigin' and 'clippingRange'.

See also

RenderingCapabilities
ValidateRenderingCapsFunc

9.2 LLGL::Constants Namespace Reference

Namespace with all constants used as default arguments.

9.2.1 Detailed Description

Namespace with all constants used as default arguments.

9.3 LLGL::Log Namespace Reference

Typedefs

- using ReportCallback = std::function< void(ReportType type, const std::string &message, const std::string &contextInfo, void ∗userData)>

  Report callback function signature.

Enumerations

- enum ReportType { ReportType::Error, ReportType::Warning, ReportType::Information, ReportType::↩ Performance }

  Report type enumeration.

Functions

- LLGL_EXPORT void PostReport (ReportType type, const std::string &message, const std::string &context↩ Info="")
- LLGL_EXPORT void SetReportCallback (const ReportCallback &callback, void ∗userData=nullptr)

  Sets the new report callback. No report callback is specified by default, in which case the reports are ignored.
- LLGL_EXPORT void SetReportCallbackStd (std::ostream &stream=std::cerr)

  Sets the new report callback to the standard output streams.

9.3.1 Typedef Documentation

9.3.1.1 using **LLGL::Log::ReportCallback** = typedef std::function<void(**ReportType** type, const std::string& message, const std::string& contextInfo, void∗ userData)>

Report callback function signature.

Parameters

`in`	*type*	Specifies the type of the report message.
`in`	*message*	Specifies the report message.
`in`	*contextInfo*	Specifies a descriptive string about the context of the report (e.g. `"in 'LLGL::RenderSystem::CreateShader'"`). This may also be empty.
`in`	*userData*	Specifies the user data that was set in the previous call to SetReportCallback.

See also

ReportType
SetReportCallback

9.3.2 Enumeration Type Documentation

9.3.2.1 enum **LLGL::Log::ReportType** `[strong]`

Report type enumeration.

See also

ReportCallback

Enumerator

Error Error message type.

Remarks

For example, when a feature is used that is not supported.

Warning Warning message type.

Remarks

For example, when an operation has no effect like submitting a draw command with zero vertices.

Information Information message type.

Remarks

For example, when a multi-sampling format is not supported so it's set to a lower quality than it was specified.

Performance Performance penelty message type.

Remarks

For example, when unnecessary clear commands are submitted.

9.3.3 Function Documentation

9.3.3.1 LLGL_EXPORT void LLGL::Log::PostReport (ReportType *type,* const std::string & *message,* const std::string & *contextInfo* = "")

Posts a report to the currently set report callback.

See also

ReportCallback

9.3.3.2 LLGL_EXPORT void LLGL::Log::SetReportCallback (const ReportCallback & *callback,* void ∗ *userData* = `nullptr`)

Sets the new report callback. No report callback is specified by default, in which case the reports are ignored.

Parameters

`in`	*callback*	Specifies the new report callback. This can also be null.
`in`	*userData*	Optional raw pointer to some user data that will be passed to the callback each time a report is generated.

Remarks

The reports can be generated in a multi-threaded environment. Even this function can be called on multiple threads. The functionality of the entire Log namespace is synchronized by LLGL. Use SetReportCallbackStd to forward the reports to the standard C++ I/O streams.

See also

PostReport
SetReportCallbackStd

9.3.3.3 LLGL_EXPORT void LLGL::Log::SetReportCallbackStd (std::ostream & *stream* = `std::cerr`)

Sets the new report callback to the standard output streams.

Parameters

in	*stream*	Specifies the output stream. By default `std::cerr`.

See also

SetReportCallback

9.4 LLGL::Version Namespace Reference

Namespace with functions to determine LLGL version.

Functions

- LLGL_EXPORT std::uint32_t GetMajor ()

  Returns the major LLGL version (e.g. 1 stands for "1.00").
- LLGL_EXPORT std::uint32_t GetMinor ()

  Returns the minor LLGL version (e.g. 1 stands for "0.01"). Must be less than 100.
- LLGL_EXPORT std::uint32_t GetRevision ()

  Returns the revision version number. Must be less than 100.
- LLGL_EXPORT std::string GetStatus ()

  Returns the LLGL version status (either "Alpha", "Beta", or empty).
- LLGL_EXPORT std::uint32_t GetID ()

  Returns the full LLGL version as an ID number (e.g. 200317 stands for "2.03 (Rev. 17)").
- LLGL_EXPORT std::string GetString ()

  Returns the full LLGL version as a string (e.g. "0.01 Beta (Rev. 1)").

9.4.1 Detailed Description

Namespace with functions to determine LLGL version.

9.4.2 Function Documentation

9.4.2.1 LLGL_EXPORT std::uint32_t LLGL::Version::GetID ( )

Returns the full LLGL version as an ID number (e.g. 200317 stands for "2.03 (Rev. 17)").

9.4.2.2 LLGL_EXPORT std::uint32_t LLGL::Version::GetMajor ( )

Returns the major LLGL version (e.g. 1 stands for "1.00").

9.4.2.3 LLGL_EXPORT std::uint32_t LLGL::Version::GetMinor ( )

Returns the minor LLGL version (e.g. 1 stands for "0.01"). Must be less than 100.

9.4.2.4 LLGL_EXPORT std::uint32_t LLGL::Version::GetRevision ( )

Returns the revision version number. Must be less than 100.

9.4.2.5 LLGL_EXPORT std::string LLGL::Version::GetStatus ( )

Returns the LLGL version status (either "Alpha", "Beta", or empty).

9.4.2.6 LLGL_EXPORT std::string LLGL::Version::GetString ( )

Returns the full LLGL version as a string (e.g. "0.01 Beta (Rev. 1)").

Chapter 10

Class Documentation

10.1 LLGL::ApplicationDescriptor Struct Reference

Application descriptor structure.

```
#include <RenderSystemFlags.h>
```

Public Attributes

- std::string applicationName

  Descriptive string of the application.
- std::uint32_t applicationVersion

  Version number of the application.
- std::string engineName

  Descriptive string of the engine or middleware.
- std::uint32_t engineVersion

  Version number of the engine or middleware.

10.1.1 Detailed Description

Application descriptor structure.

Note

Only supported with: Vulkan.

See also

VulkanRendererConfiguration::application

10.1.2 Member Data Documentation

10.1.2.1 std::string LLGL::ApplicationDescriptor::applicationName

Descriptive string of the application.

10.1.2.2 std::uint32_t LLGL::ApplicationDescriptor::applicationVersion

Version number of the application.

10.1.2.3 std::string LLGL::ApplicationDescriptor::engineName

Descriptive string of the engine or middleware.

10.1.2.4 std::uint32_t LLGL::ApplicationDescriptor::engineVersion

Version number of the engine or middleware.

The documentation for this struct was generated from the following file:

- RenderSystemFlags.h

10.2 LLGL::AttachmentClear Struct Reference

Attachment clear command structure.

```
#include <CommandBufferFlags.h>
```

Public Member Functions

- AttachmentClear ()=default
- AttachmentClear (const AttachmentClear &)=default
- AttachmentClear & operator= (const AttachmentClear &)=default
- AttachmentClear (const ColorRGBAf &color, std::uint32_t colorAttachment)

  Constructor for a color attachment clear command.
- AttachmentClear (float depth)

  Constructor for a depth attachment clear command.
- AttachmentClear (std::uint32_t stencil)

  Constructor for a stencil attachment clear command.
- AttachmentClear (float depth, std::uint32_t stencil)

  Constructor for a depth-stencil attachment clear command.

Public Attributes

- long flags = 0

  Specifies the clear buffer flags.
- std::uint32_t colorAttachment = 0

  Specifies the index of the color attachment within the active render target. By default 0.
- ClearValue clearValue

  Clear value for color, depth, and stencil buffers.

10.2.1 Detailed Description

Attachment clear command structure.

See also

CommandBuffer::ClearAttachments

10.2.2 Constructor & Destructor Documentation

10.2.2.1 LLGL::AttachmentClear::AttachmentClear ( ) `[default]`

10.2.2.2 LLGL::AttachmentClear::AttachmentClear (const AttachmentClear &) `[default]`

10.2.2.3 LLGL::AttachmentClear::AttachmentClear (const ColorRGBAf & *color*, std::uint32_t *colorAttachment*) `[inline]`

Constructor for a color attachment clear command.

10.2.2.4 LLGL::AttachmentClear::AttachmentClear (float *depth*) `[inline]`

Constructor for a depth attachment clear command.

10.2.2.5 LLGL::AttachmentClear::AttachmentClear (std::uint32_t *stencil*) `[inline]`

Constructor for a stencil attachment clear command.

10.2.2.6 LLGL::AttachmentClear::AttachmentClear (float *depth*, std::uint32_t *stencil*) `[inline]`

Constructor for a depth-stencil attachment clear command.

10.2.3 Member Function Documentation

10.2.3.1 AttachmentClear& LLGL::AttachmentClear::operator= (const AttachmentClear &) `[default]`

10.2.4 Member Data Documentation

10.2.4.1 ClearValue LLGL::AttachmentClear::clearValue

Clear value for color, depth, and stencil buffers.

10.2.4.2 std::uint32_t LLGL::AttachmentClear::colorAttachment = 0

Specifies the index of the color attachment within the active render target. By default 0.

Remarks

This is ignored if the ClearFlags::Color bit is not set in the 'flags' member.

See also

flags

10.2.4.3 long LLGL::AttachmentClear::flags = 0

Specifies the clear buffer flags.

Remarks

This can be a bitwise OR combination of the "ClearFlags" enumeration entries. However, if the ClearFlags↩ ::Color bit is set, all other bits are ignored. It is recommended to clear depth- and stencil buffers always simultaneously if both are meant to be cleared (i.e. use ClearFlags::DepthStencil in this case).

See also

ClearFlags

The documentation for this struct was generated from the following file:

- CommandBufferFlags.h

10.3 LLGL::AttachmentDescriptor Struct Reference

Render target attachment descriptor structure.

```
#include <RenderTargetFlags.h>
```

Public Member Functions

- AttachmentDescriptor ()=default
- AttachmentDescriptor (const AttachmentDescriptor &)=default
- AttachmentDescriptor (AttachmentType type)

  Constructor for the specified depth-, or stencil attachment.
- AttachmentDescriptor (AttachmentType type, Texture ∗texture, std::uint32_t mipLevel=0, std::uint32_t array↩ Layer=0)

  Constructor for the specified depth-, stencil-, or color attachment.

Public Attributes

- AttachmentType type = AttachmentType::Color

  Specifies for which output information the texture attachment is to be used, e.g. for color or depth information. By default AttachmentType::Color.
- Texture ∗ texture = nullptr

  Pointer to the texture which is to be used as target output. By default null.
- std::uint32_t mipLevel = 0

  Specifies the MIP-map level which is to be attached to a render target.
- std::uint32_t arrayLayer = 0

  Specifies the array texture layer which is to be used as render target attachment.

10.3.1 Detailed Description

Render target attachment descriptor structure.

See also

RenderTargetDescriptor

10.3.2 Constructor & Destructor Documentation

10.3.2.1 LLGL::AttachmentDescriptor::AttachmentDescriptor ( ) [default]

10.3.2.2 LLGL::AttachmentDescriptor::AttachmentDescriptor (const AttachmentDescriptor &) [default]

10.3.2.3 LLGL::AttachmentDescriptor::AttachmentDescriptor (AttachmentType *type*) [inline]

Constructor for the specified depth-, or stencil attachment.

10.3.2.4 LLGL::AttachmentDescriptor::AttachmentDescriptor (AttachmentType *type,* Texture ∗ *texture,* std::uint32_t *mipLevel* = 0, std::uint32_t *arrayLayer* = 0) [inline]

Constructor for the specified depth-, stencil-, or color attachment.

10.3.3 Member Data Documentation

10.3.3.1 std::uint32_t LLGL::AttachmentDescriptor::arrayLayer = 0

Specifies the array texture layer which is to be used as render target attachment.

Remarks

This is only used for array textures and cube textures (i.e. TextureType::Texture1DArray, TextureType::↩
Texture2DArray, TextureType::TextureCube, TextureType::TextureCubeArray, and TextureType::Texture2DM↩
SArray). For cube textures (i.e. TextureType::TextureCube and TextureType::TextureCubeArray), each cube has its own 6 array layers. The layer index for the respective cube faces is described at the TextureDescriptor↩
::arrayLayer member.

See also

TextureDescriptor::arrayLayer

10.3.3.2 std::uint32_t LLGL::AttachmentDescriptor::mipLevel = 0

Specifies the MIP-map level which is to be attached to a render target.

Remarks

This is only used for non-multi-sample textures. All multi-sample textures will always use the first MIP-map level (i.e. TextureType::Texture2DMS and TextureType::Texture2DMSArray).

10.3.3.3 Texture∗ LLGL::AttachmentDescriptor::texture = nullptr

Pointer to the texture which is to be used as target output. By default null.

Remarks

If this is null, the attribute 'type' must not be AttachmentType::Color. The texture must also have been created with the flag 'TextureFlags::BindRenderTarget'.

See also

AttachmentDescriptor::type
TextureFlags::BindRenderTarget

10.3.3.4 AttachmentType LLGL::AttachmentDescriptor::type = AttachmentType::Color

Specifies for which output information the texture attachment is to be used, e.g. for color or depth information. By default AttachmentType::Color.

The documentation for this struct was generated from the following file:

- RenderTargetFlags.h

10.4 LLGL::AttachmentFormatDescriptor Struct Reference

Render target attachment descriptor structure.

```
#include <RenderPassFlags.h>
```

Public Member Functions

- AttachmentFormatDescriptor ()=default
- AttachmentFormatDescriptor (const AttachmentFormatDescriptor &)=default
- AttachmentFormatDescriptor (const Format format, const AttachmentLoadOp loadOp=AttachmentLoadOp↩ ::Load, const AttachmentStoreOp storeOp=AttachmentStoreOp::Store)

  Constructor to initialize the format and optionally the load and store operations.

Public Attributes

- Format format = Format::Undefined

  Specifies the render target attachment format. By default Format::Undefined.
- AttachmentLoadOp loadOp = AttachmentLoadOp::Undefined

  Specifies the load operation of the previous attachment content. By default AttachmentLoadOp::Undefined.
- AttachmentStoreOp storeOp = AttachmentStoreOp::Undefined

  Specifies the store operation of the outcome for the respective attachment content. By default AttachmentStoreOp↩ ::Undefined.

10.4.1 Detailed Description

Render target attachment descriptor structure.

Remarks

Two attachment format descriptors are considered compatible when their formats are matching.

See also

RenderPassDescriptor

10.4.2 Constructor & Destructor Documentation

10.4.2.1 LLGL::AttachmentFormatDescriptor::AttachmentFormatDescriptor ( ) [default]

10.4.2.2 LLGL::AttachmentFormatDescriptor::AttachmentFormatDescriptor (const **AttachmentFormatDescriptor** &) [default]

10.4.2.3 LLGL::AttachmentFormatDescriptor::AttachmentFormatDescriptor (const **Format** *format*, const **AttachmentLoadOp** *loadOp* = **AttachmentLoadOp::Load**, const **AttachmentStoreOp** *storeOp* = **AttachmentStoreOp::Store**) [inline]

Constructor to initialize the format and optionally the load and store operations.

10.4.3 Member Data Documentation

10.4.3.1 **Format** LLGL::AttachmentFormatDescriptor::format = **Format::Undefined**

Specifies the render target attachment format. By default Format::Undefined.

Remarks

If the render pass is used for a render context, the appropriate color format can be determined by the Render↩ Context::QueryColorFormat function, and the appropriate depth-stencil format can be determined by the RenderContext::QueryDepthStencilFormat function. If the render pass is used for render targets, the format depends on the render target attachments. If this is undefined, the corresponding attachment is not used.

See also

RenderContext::QueryColorFormat
RenderContext::QueryDepthStencilFormat

10.4.3.2 AttachmentLoadOp LLGL::AttachmentFormatDescriptor::loadOp = AttachmentLoadOp::Undefined

Specifies the load operation of the previous attachment content. By default AttachmentLoadOp::Undefined.

Remarks

If the attachment is meant to be cleared when a render pass begins, set this to AttachmentLoadOp::Clear.

See also

AttachmentLoadOp

10.4.3.3 AttachmentStoreOp LLGL::AttachmentFormatDescriptor::storeOp = AttachmentStoreOp::Undefined

Specifies the store operation of the outcome for the respective attachment content. By default AttachmentStore←
Op::Undefined.

See also

AttachmentStoreOp

The documentation for this struct was generated from the following file:

- RenderPassFlags.h

10.5 LLGL::BindingDescriptor Struct Reference

Layout structure for a single binding point of the pipeline layout descriptor.

```
#include <PipelineLayoutFlags.h>
```

Public Member Functions

- BindingDescriptor ()=default
- BindingDescriptor (const BindingDescriptor &)=default
- BindingDescriptor (ResourceType type, long stageFlags, std::uint32_t slot, std::uint32_t arraySize=1)

  Constructors with all attributes and a default value for a uniform array.

Public Attributes

- ResourceType type = ResourceType::Undefined

  Resource view type for this layout binding. By default ResourceType::Undefined.
- long stageFlags = 0

  Specifies which shader stages are affected by this layout binding. By default 0.
- std::uint32_t slot = 0

  Specifies the zero-based binding slot. By default 0.
- std::uint32_t arraySize = 1

  Specifies the number of binding slots for an array resource. By default 1.

10.5.1 Detailed Description

Layout structure for a single binding point of the pipeline layout descriptor.

See also

PipelineLayoutDescriptor::bindings

10.5.2 Constructor & Destructor Documentation

10.5.2.1 LLGL::BindingDescriptor::BindingDescriptor ( ) `[default]`

10.5.2.2 LLGL::BindingDescriptor::BindingDescriptor (const **BindingDescriptor** &) `[default]`

10.5.2.3 LLGL::BindingDescriptor::BindingDescriptor (**ResourceType** *type*, long *stageFlags*, std::uint32_t *slot*, std::uint32_t *arraySize* = `1`) `[inline]`

Constructors with all attributes and a default value for a uniform array.

10.5.3 Member Data Documentation

10.5.3.1 std::uint32_t LLGL::BindingDescriptor::arraySize = 1

Specifies the number of binding slots for an array resource. By default 1.

Note

For Vulkan, this number specifies the size of an array of resources (e.g. an array of uniform buffers).

10.5.3.2 std::uint32_t LLGL::BindingDescriptor::slot = 0

Specifies the zero-based binding slot. By default 0.

Note

For Vulkan, each binding slot of all layout bindings must have a different value within a pipeline layout.

10.5.3.3 long LLGL::BindingDescriptor::stageFlags = 0

Specifies which shader stages are affected by this layout binding. By default 0.

Remarks

This can be a bitwise OR combination of the StageFlags bitmasks.

See also

StageFlags

10.5.3.4 ResourceType LLGL::BindingDescriptor::type = ResourceType::Undefined

Resource view type for this layout binding. By default ResourceType::Undefined.

The documentation for this struct was generated from the following file:

- PipelineLayoutFlags.h

10.6 LLGL::BlendDescriptor Struct Reference

Blending state descriptor structure.

```
#include <GraphicsPipelineFlags.h>
```

Public Attributes

- bool alphaToCoverageEnabled = false

  Specifies whether to use alpha-to-coverage as a multi-sampling technique when setting a pixel to a render target. By default disabled.
- bool independentBlendEnabled = false

  Specifies whether to enable independent blending in simultaneous color attachments. By default false.
- LogicOp logicOp = LogicOp::Disabled

  Specifies the logic fragment operation. By default LogicOp::Disabled.
- ColorRGBAf blendFactor = { 0.0f, 0.0f, 0.0f, 0.0f }

  Specifies the blending color factor. By default (0, 0, 0, 0).
- BlendTargetDescriptor targets [8]

  Render-target blend states for the respective color attachments. A maximum of 8 targets is supported.

10.6.1 Detailed Description

Blending state descriptor structure.

See also

GraphicsPipelineDescriptor::blend

10.6.2 Member Data Documentation

10.6.2.1 bool LLGL::BlendDescriptor::alphaToCoverageEnabled = false

Specifies whether to use alpha-to-coverage as a multi-sampling technique when setting a pixel to a render target. By default disabled.

Remarks

This is useful when multi-sampling is enabled and alpha tests are implemented in a fragment shader (e.g. to render fences, plants, or other transparent geometries).

10.6.2.2 ColorRGBAf LLGL::BlendDescriptor::blendFactor = { 0.0f, 0.0f, 0.0f, 0.0f }

Specifies the blending color factor. By default (0, 0, 0, 0).

Remarks

This is only used if any blending operations of any blending target is either BlendOp::BlendFactor or Blend↩ Op::InvBlendFactor.

See also

BlendOp::BlendFactor
BlendOp::InvBlendFactor

Todo Move this into a dynamic function "CommandBuffer::SetBlendFactor".

10.6.2.3 bool LLGL::BlendDescriptor::independentBlendEnabled = false

Specifies whether to enable independent blending in simultaneous color attachments. By default false.

Remarks

If this is true, each color attachment has its own blending configuration described in the `targets` array. Otherwise, each color attachment uses the blending configuration described only by the first entry of the `targets` array, i.e. `targets[0]` and all remaining entries `targets[1..7]` are ignored.

See also

targets

10.6.2.4 LogicOp LLGL::BlendDescriptor::logicOp = LogicOp::Disabled

Specifies the logic fragment operation. By default LogicOp::Disabled.

Remarks

Logic pixel operations can not be used in combination with color and alpha blending. Therefore, if this is not LogicOp::Disabled, `independentBlendEnabled` must be false and `blendEnabled` of the first target must be false as well. If logic fragment operations are not supported by the renderer, this must be LogicOp::Disabled.

Note

For Direct3D 11, feature level 11.1 is required.

See also

blendEnabled
RenderingFeatures::hasLogicOp

10.6.2.5 BlendTargetDescriptor LLGL::BlendDescriptor::targets[8]

Render-target blend states for the respective color attachments. A maximum of 8 targets is supported.

Remarks

If `independentBlendEnabled` is set to false, only the first entry is used, i.e. `targets[0]` and all remaining entries `targets[1..7]` are ignored.

See also

independentBlendEnabled

The documentation for this struct was generated from the following file:

- GraphicsPipelineFlags.h

10.7 LLGL::BlendTargetDescriptor Struct Reference

Blend target state descriptor structure.

`#include <GraphicsPipelineFlags.h>`

Public Attributes

- bool blendEnabled = false

  Specifies whether blending is enabled or disabled for the respective color attachment.
- BlendOp srcColor = BlendOp::SrcAlpha

  Source color blending operation. By default BlendOp::SrcAlpha.
- BlendOp dstColor = BlendOp::InvSrcAlpha

  Destination color blending operation. By default BlendOp::InvSrcAlpha.
- BlendArithmetic colorArithmetic = BlendArithmetic::Add

  Color blending arithmetic. By default BlendArithmetic::Add.
- BlendOp srcAlpha = BlendOp::SrcAlpha

  Source alpha blending operation. By default BlendOp::SrcAlpha.
- BlendOp dstAlpha = BlendOp::InvSrcAlpha

  Destination alpha blending operation. By default BlendOp::InvSrcAlpha.
- BlendArithmetic alphaArithmetic = BlendArithmetic::Add

  Alpha blending arithmetic. By default BlendArithmetic::Add.
- ColorRGBAb colorMask = { true, true, true, true }

  Specifies which color components are enabled for writing. By default (true, true, true, true).

10.7.1 Detailed Description

Blend target state descriptor structure.

See also

BlendDescriptor::targets

10.7.2 Member Data Documentation

10.7.2.1 BlendArithmetic LLGL::BlendTargetDescriptor::alphaArithmetic = BlendArithmetic::Add

Alpha blending arithmetic. By default BlendArithmetic::Add.

10.7.2.2 bool LLGL::BlendTargetDescriptor::blendEnabled = false

Specifies whether blending is enabled or disabled for the respective color attachment.

10.7.2.3 BlendArithmetic LLGL::BlendTargetDescriptor::colorArithmetic = BlendArithmetic::Add

Color blending arithmetic. By default BlendArithmetic::Add.

10.7.2.4 ColorRGBAb LLGL::BlendTargetDescriptor::colorMask = { true, true, true, true }

Specifies which color components are enabled for writing. By default (true, true, true, true).

10.7.2.5 BlendOp LLGL::BlendTargetDescriptor::dstAlpha = BlendOp::InvSrcAlpha

Destination alpha blending operation. By default BlendOp::InvSrcAlpha.

10.7.2.6 BlendOp LLGL::BlendTargetDescriptor::dstColor = BlendOp::InvSrcAlpha

Destination color blending operation. By default BlendOp::InvSrcAlpha.

10.7.2.7 BlendOp LLGL::BlendTargetDescriptor::srcAlpha = BlendOp::SrcAlpha

Source alpha blending operation. By default BlendOp::SrcAlpha.

10.7.2.8 BlendOp LLGL::BlendTargetDescriptor::srcColor = BlendOp::SrcAlpha

Source color blending operation. By default BlendOp::SrcAlpha.

The documentation for this struct was generated from the following file:

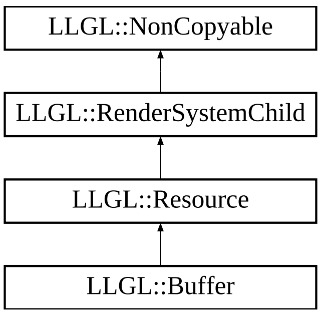
- GraphicsPipelineFlags.h

10.8 LLGL::Buffer Class Reference

Hardware buffer interface.

```
#include <Buffer.h>
```

Inheritance diagram for LLGL::Buffer:



Public Member Functions

- ResourceType QueryResourceType () const override

  Returns the ResourceType for the respective BufferType.
- BufferType GetType () const

  Returns the type of this buffer.

Protected Member Functions

- Buffer (const BufferType type)

10.8.1 Detailed Description

Hardware buffer interface.

See also

RenderSystem::CreateBuffer

10.8.2 Constructor & Destructor Documentation

10.8.2.1 LLGL::Buffer::Buffer (const BufferType *type*) `[protected]`

10.8.3 Member Function Documentation

10.8.3.1 BufferType LLGL::Buffer::GetType ( ) const `[inline]`

Returns the type of this buffer.

10.8.3.2 ResourceType LLGL::Buffer::QueryResourceType ( ) const `[override], [virtual]`

Returns the ResourceType for the respective BufferType.

Implements LLGL::Resource.

The documentation for this class was generated from the following file:

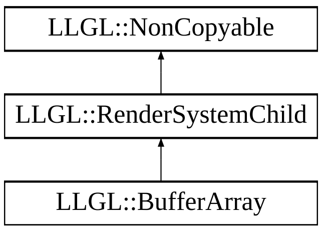
- Buffer.h

10.9 LLGL::BufferArray Class Reference

Hardware buffer container interface.

`#include <BufferArray.h>`

Inheritance diagram for LLGL::BufferArray:



Public Member Functions

- BufferType GetType () const

  Returns the type of buffers this array contains.

Protected Member Functions

- BufferArray (const BufferType type)

10.9.1 Detailed Description

Hardware buffer container interface.

Remarks

This array can only contain buffers which are all from the same type, like an array of vertex buffers for instance.

See also

RenderSystem::CreateBufferArray

10.9.2 Constructor & Destructor Documentation

10.9.2.1 LLGL::BufferArray::BufferArray (const **BufferType** *type*) `[protected]`

10.9.3 Member Function Documentation

10.9.3.1 **BufferType** LLGL::BufferArray::GetType ( ) const `[inline]`

Returns the type of buffers this array contains.

The documentation for this class was generated from the following file:

- BufferArray.h

10.10 LLGL::BufferDescriptor Struct Reference

Hardware buffer descriptor structure.

```
#include <BufferFlags.h>
```

Classes

- struct IndexBuffer

  Index buffer specific descriptor structure.
- struct StorageBuffer

  Storage buffer specific descriptor structure.
- struct VertexBuffer

  Vertex buffer specific descriptor structure.

Public Attributes

- BufferType type = BufferType::Vertex

  Hardware buffer type. By default BufferType::Vertex.
- long flags = 0

  Specifies the buffer creation flags. By default 0.
- std::uint64_t size = 0

  Buffer size (in bytes). This must not be larger than 'RenderingLimits::maxBufferSize'. By default 0.
- VertexBuffer vertexBuffer

  Vertex buffer type descriptor appendix.
- IndexBuffer indexBuffer

  Index buffer type descriptor appendix.
- StorageBuffer storageBuffer

  Storage buffer type descriptor appendix.

10.10.1 Detailed Description

Hardware buffer descriptor structure.

10.10.2 Member Data Documentation

10.10.2.1 long LLGL::BufferDescriptor::flags = 0

Specifies the buffer creation flags. By default 0.

Remarks

This can be bitwise OR combination of the entries of the BufferFlags enumeration.

See also

BufferFlags

10.10.2.2 IndexBuffer LLGL::BufferDescriptor::indexBuffer

Index buffer type descriptor appendix.

10.10.2.3 std::uint64_t LLGL::BufferDescriptor::size = 0

Buffer size (in bytes). This must not be larger than 'RenderingLimits::maxBufferSize'. By default 0.

Remarks

If the buffer type is a storage buffer (i.e. from the type BufferType::Storage), 'size' must be a multiple of 'storageBuffer.stride'.

See also

RenderingLimits::maxBufferSize

10.10.2.4 StorageBuffer LLGL::BufferDescriptor::storageBuffer

Storage buffer type descriptor appendix.

10.10.2.5 BufferType LLGL::BufferDescriptor::type = BufferType::Vertex

Hardware buffer type. By default BufferType::Vertex.

10.10.2.6 VertexBuffer LLGL::BufferDescriptor::vertexBuffer

Vertex buffer type descriptor appendix.

The documentation for this struct was generated from the following file:

- BufferFlags.h

10.11 LLGL::BufferFlags Struct Reference

Buffer creation flags enumeration.

```
#include <BufferFlags.h>
```

Public Types

- enum { MapReadAccess = (1 << 0), MapWriteAccess = (1 << 1), MapReadWriteAccess = (MapRead↩
  Access | MapWriteAccess), DynamicUsage = (1 << 2) }

10.11.1 Detailed Description

Buffer creation flags enumeration.

See also

BufferDescriptor::flags

10.11.2 Member Enumeration Documentation

10.11.2.1 anonymous enum

Enumerator

MapReadAccess Buffer mapping with CPU read access is required.

See also

RenderSystem::MapBuffer

MapWriteAccess Buffer mapping with CPU write access is required.

See also

RenderSystem::MapBuffer

MapReadWriteAccess

DynamicUsage Hint to the renderer that the buffer will be frequently updated from the CPU.

Remarks

This is useful for a constant buffer for instance, that is updated by the host program every frame.

See also

RenderSystem::WriteBuffer

The documentation for this struct was generated from the following file:

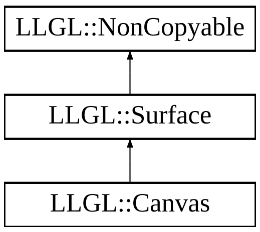
- BufferFlags.h

10.12 LLGL::Canvas Class Reference

Canvas interface for mobile platforms.

```
#include <Canvas.h>
```

Inheritance diagram for LLGL::Canvas:



Classes

- class EventListener

  Interface for all canvas event listeners.

Public Member Functions

- virtual void SetTitle (const std::wstring &title)=0

  Sets the canvas title as UTF16 string. If the OS does not support UTF16 window title, it will be converted to UTF8.
- virtual std::wstring GetTitle () const =0

  Returns the canvas title as UTF16 string.
- bool AdaptForVideoMode (VideoModeDescriptor &videoModeDesc) override

  This default implementation ignores the video mode descriptor completely and always return false.
- void ProcessEvents ()

  Processes the events for this canvas (i.e. touch input, key presses etc.).
- void AddEventListener (const std::shared_ptr< EventListener > &eventListener)

  Adds a new event listener to this canvas.
- void RemoveEventListener (const EventListener ∗eventListener)

  Removes the specified event listener from this canvas.

Static Public Member Functions

- static std::unique_ptr< Canvas > Create (const CanvasDescriptor &desc)

  Creates a platform specific instance of the Canvas interface.

Protected Member Functions

- virtual void OnProcessEvents ()=0

10.12.1 Detailed Description

Canvas interface for mobile platforms.

Remarks

This is the main interface for the windowing system in LLGL on mobile platforms. The couterpart is the Window interface for desktop platforms.

See also

Window

10.12.2 Member Function Documentation

10.12.2.1 bool LLGL::Canvas::AdaptForVideoMode (VideoModeDescriptor & *videoModeDesc*) [override], [virtual]

This default implementation ignores the video mode descriptor completely and always return false.

Implements LLGL::Surface.

10.12.2.2 void LLGL::Canvas::AddEventListener (const std::shared_ptr< EventListener > & *eventListener*)

Adds a new event listener to this canvas.

10.12.2.3 static std::unique_ptr<Canvas> LLGL::Canvas::Create (const CanvasDescriptor & *desc*) [static]

Creates a platform specific instance of the Canvas interface.

Returns

Unique pointer to a new instance of the platform specific Canvas interface or null if the platform does not support canvas (such as Windows, Linux, and macOS).

Remarks

For desktop platforms the interface Window can be used.

See also

Window

10.12.2.4 virtual std::wstring LLGL::Canvas::GetTitle ( ) const [pure virtual]

Returns the canvas title as UTF16 string.

10.12.2.5 virtual void LLGL::Canvas::OnProcessEvents ( ) [protected], [pure virtual]

Called inside the "ProcessEvents" function after all event listeners received the same event.

See also

ProcessEvents
EventListener::OnProcessEvents

10.12.2.6 void LLGL::Canvas::ProcessEvents ( )

Processes the events for this canvas (i.e. touch input, key presses etc.).

10.12.2.7 void LLGL::Canvas::RemoveEventListener (const EventListener * *eventListener*)

Removes the specified event listener from this canvas.

10.12.2.8 virtual void LLGL::Canvas::SetTitle (const std::wstring & *title*) [pure virtual]

Sets the canvas title as UTF16 string. If the OS does not support UTF16 window title, it will be converted to UTF8.

The documentation for this class was generated from the following file:

- Canvas.h

10.13 LLGL::CanvasDescriptor Struct Reference

Canvas descriptor structure.

`#include <CanvasFlags.h>`

Public Attributes

- std::wstring title

  Canvas title as UTF16 string.
- bool borderless = false

  Specifies whether the canvas is borderless. This is required for a fullscreen render context.

10.13.1 Detailed Description

Canvas descriptor structure.

10.13.2 Member Data Documentation

10.13.2.1 bool LLGL::CanvasDescriptor::borderless = false

Specifies whether the canvas is borderless. This is required for a fullscreen render context.

10.13.2.2 std::wstring LLGL::CanvasDescriptor::title

Canvas title as UTF16 string.

The documentation for this struct was generated from the following file:

- CanvasFlags.h

10.14 LLGL::ClearFlags Struct Reference

Command buffer clear flags.

```
#include <CommandBufferFlags.h>
```

Public Types

- enum {
  Color = (1 << 0), Depth = (1 << 1), Stencil = (1 << 2), ColorDepth = (Color | Depth),
  DepthStencil = (Depth | Stencil), All = (Color | Depth | Stencil) }

10.14.1 Detailed Description

Command buffer clear flags.

See also

CommandBuffer::Clear

10.14.2 Member Enumeration Documentation

10.14.2.1 anonymous enum

Enumerator

Color Clears the color attachment.

Depth Clears the depth attachment.

Stencil Clears the stencil attachment.

ColorDepth Clears the color and depth attachments.

DepthStencil Clears the depth and stencil attachments.

All Clears the color, depth and stencil attachments.

The documentation for this struct was generated from the following file:

- CommandBufferFlags.h

10.15 LLGL::ClearValue Struct Reference

Clear value structure for color, depth, and stencil clear operations.

```
#include <CommandBufferFlags.h>
```

Public Attributes

- ColorRGBAf color = { 0.0f, 0.0f, 0.0f, 0.0f }

    Specifies the clear value to clear a color attachment. By default (0.0, 0.0, 0.0, 0.0).
- float depth = 1.0f

    Specifies the clear value to clear a depth attachment. By default 1.0.
- std::uint32_t stencil = 0

    Specifies the clear value to clear a stencil attachment. By default 0.

10.15.1 Detailed Description

Clear value structure for color, depth, and stencil clear operations.

See also

AttachmentClear::clearValue
ImageInitialization::clearValue

10.15.2 Member Data Documentation

10.15.2.1 ColorRGBAf LLGL::ClearValue::color = { 0.0f, 0.0f, 0.0f, 0.0f }

Specifies the clear value to clear a color attachment. By default (0.0, 0.0, 0.0, 0.0).

10.15.2.2 float LLGL::ClearValue::depth = 1.0f

Specifies the clear value to clear a depth attachment. By default 1.0.

10.15.2.3 std::uint32_t LLGL::ClearValue::stencil = 0

Specifies the clear value to clear a stencil attachment. By default 0.

The documentation for this struct was generated from the following file:

- CommandBufferFlags.h

10.16 LLGL::Color< T, N > Class Template Reference

Base color class with N components.

`#include <Color.h>`

Public Member Functions

- Color ()

    Constructors all attributes with the default color value.
- Color (const Color< T, N > &rhs)

    Copy constructor.
- Color (const T &scalar)

    Constructs all attributes with the specified scalar value.
- Color (UninitializeTag)

    Explicitly uninitialized constructor. All attributes are uninitialized!
- Color< T, N > & operator+= (const Color< T, N > &rhs)

    Adds the specified color (component wise) to this color.
- Color< T, N > & operator-= (const Color< T, N > &rhs)

    Substracts the specified color (component wise) from this color.
- Color< T, N > & operator*= (const Color< T, N > &rhs)

    Multiplies the specified color (component wise) with this color.
- Color< T, N > & operator/= (const Color< T, N > &rhs)

    Divides the specified color (component wise) with this color.
- Color< T, N > & operator*= (const T rhs)

    Multiplies the specified scalar value (component wise) with this color.
- Color< T, N > & operator/= (const T rhs)

    Divides the specified scalar value (component wise) with this color.
- T & operator[ ] (std::size_t component)

    Returns the specified vector component.
- const T & operator[ ] (std::size_t component) const

    Returns the specified vector component.
- Color< T, N > operator- () const

    Returns the negation of this color.
- template<typename Dst >
  Color< Dst, N > Cast () const

    Returns a type casted instance of this color.
- T * Ptr ()

    Returns a pointer to the first element of this vector.
- const T * Ptr () const

    Returns a constant pointer to the first element of this vector.

Static Public Attributes

- static const std::size_t components = N

    Specifies the number of vector components.

10.16.1 Detailed Description

template<typename T, std::size_t N>
class LLGL::Color< T, N >

Base color class with N components.

Template Parameters

T	Specifies the data type of the vector components. This should be a primitive data type such as float, double, int etc.
N	Specifies the number of components. There are specialized templates for N = 3, and 4.

10.16.2 Constructor & Destructor Documentation

10.16.2.1 template<typename T, std::size_t N> **LLGL::Color< T, N >::Color ( )** `[inline]`

Constructors all attributes with the default color value.

Remarks

For default color values the 'MaxColorValue' template is used.

See also

MaxColorValue

10.16.2.2 template<typename T, std::size_t N> **LLGL::Color< T, N >::Color (const Color< T, N > & *rhs*)** `[inline]`

Copy constructor.

10.16.2.3 template<typename T, std::size_t N> **LLGL::Color< T, N >::Color (const T & *scalar*)** `[inline]`, `[explicit]`

Constructs all attributes with the specified scalar value.

10.16.2.4 template<typename T, std::size_t N> **LLGL::Color< T, N >::Color (UninitializeTag)** `[inline]`

Explicitly uninitialized constructor. All attributes are uninitialized!

Remarks

Only use this constructor when you want to allocate a large amount of color elements that are being initialized later.

10.16.3 Member Function Documentation

10.16.3.1 template<typename T, std::size_t N> template<typename Dst > **Color<Dst, N> LLGL::Color< T, N >::Cast ( ) const** `[inline]`

Returns a type casted instance of this color.

Remarks

All color components will be scaled to the range of the new color type.

Template Parameters

Dst	Specifies the destination type.

10.16.3.2 template<typename T, std::size_t N> Color<T, N>& LLGL::Color< T, N >::operator*= (const Color< T, N > & *rhs*) `[inline]`

Multiplies the specified color (component wise) with this color.

10.16.3.3 template<typename T, std::size_t N> Color<T, N>& LLGL::Color< T, N >::operator*= (const T *rhs*) `[inline]`

Multiplies the specified scalar value (component wise) with this color.

10.16.3.4 template<typename T, std::size_t N> Color<T, N>& LLGL::Color< T, N >::operator+= (const Color< T, N > & *rhs*) `[inline]`

Adds the specified color (component wise) to this color.

10.16.3.5 template<typename T, std::size_t N> Color<T, N> LLGL::Color< T, N >::operator- ( ) const `[inline]`

Returns the negation of this color.

10.16.3.6 template<typename T, std::size_t N> Color<T, N>& LLGL::Color< T, N >::operator-= (const Color< T, N > & *rhs*) `[inline]`

Substracts the specified color (component wise) from this color.

10.16.3.7 template<typename T, std::size_t N> Color<T, N>& LLGL::Color< T, N >::operator/= (const Color< T, N > & *rhs*) `[inline]`

Divides the specified color (component wise) with this color.

10.16.3.8 template<typename T, std::size_t N> Color<T, N>& LLGL::Color< T, N >::operator/= (const T *rhs*) `[inline]`

Divides the specified scalar value (component wise) with this color.

10.16.3.9 template<typename T, std::size_t N> T& LLGL::Color< T, N >::operator[ ] (std::size_t *component*) `[inline]`

Returns the specified vector component.

Parameters

`in`	*component*	Specifies the vector component index. This must be in the range [0, N).

Exceptions

std::out_of_range	If the specified component index is out of range (Only if the macro 'LLGL_DEBUG' is defined).

10.16.3.10 template<typename T, std::size_t N> const T& LLGL::Color< T, N >::operator[] (std::size_t *component*) const `[inline]`

Returns the specified vector component.

Parameters

`in`	*component*	Specifies the vector component index. This must be in the range [0, N).

Exceptions

std::out_of_range	If the specified component index is out of range (Only if the macro 'LLGL_DEBUG' is defined).

10.16.3.11 template<typename T, std::size_t N> T∗ LLGL::Color< T, N >::Ptr ( ) `[inline]`

Returns a pointer to the first element of this vector.

10.16.3.12 template<typename T, std::size_t N> const T∗ LLGL::Color< T, N >::Ptr ( ) const `[inline]`

Returns a constant pointer to the first element of this vector.

10.16.4 Member Data Documentation

10.16.4.1 template<typename T, std::size_t N> const std::size_t LLGL::Color< T, N >::components = N `[static]`

Specifies the number of vector components.

The documentation for this class was generated from the following file:

- Color.h

10.17 LLGL::Color< T, 3u > Class Template Reference

RGB color class with components: r, g, and b.

`#include <ColorRGB.h>`

Public Member Functions

- Color ()

  Constructors all attributes with the default color value.
- Color (const Color< T, 3 > &rhs)

  Copy constructor.
- Color (const T &scalar)

  Constructs all attributes with the specified scalar value.
- Color (const T &r, const T &g, const T &b)

  Constructs all attributes with the specified color values r (red), g (green), b (blue).
- Color (UninitializeTag)

  Explicitly uninitialized constructor. All attributes are uninitialized!
- Color< T, 3 > & operator+= (const Color< T, 3 > &rhs)

  Adds the specified color (component wise) to this color.
- Color< T, 3 > & operator-= (const Color< T, 3 > &rhs)

  Substracts the specified color (component wise) from this color.
- Color< T, 3 > & operator∗= (const Color< T, 3 > &rhs)

  Multiplies the specified color (component wise) with this color.
- Color< T, 3 > & operator/= (const Color< T, 3 > &rhs)

  Divides the specified color (component wise) with this color.
- Color< T, 3 > & operator∗= (const T rhs)

  Multiplies the specified scalar value (component wise) with this color.
- Color< T, 3 > & operator/= (const T rhs)

  Divides the specified scalar value (component wise) with this color.
- Color< T, 3 > operator- () const

  Returns the negation of this color.
- T & operator[ ] (std::size_t component)

  Returns the specified color component.
- const T & operator[ ] (std::size_t component) const

  Returns the specified color component.
- Color< T, 4 > ToRGBA () const

  Returns this RGB color as RGBA color.
- template<typename Dst >
  Color< Dst, 3 > Cast () const

  Returns a type casted instance of this color.
- T ∗ Ptr ()

  Returns a pointer to the first element of this color.
- const T ∗ Ptr () const

  Returns a constant pointer to the first element of this color.

Public Attributes

- T r
- T g
- T b

Static Public Attributes

- static const std::size_t components = 3

  Specifies the number of color components.

10.17.1 Detailed Description

template<typename T>
class LLGL::Color< T, 3u >

RGB color class with components: r, g, and b.

Remarks

Color components are default initialized with their maximal value, i.e. for floating-points, the initial value is 1.0, because this its maximal color value, but for unsigned-bytes, the initial value is 255.

10.17.2 Constructor & Destructor Documentation

10.17.2.1 template<typename T > LLGL::Color< T, 3u >::Color ( ) `[inline]`

Constructors all attributes with the default color value.

Remarks

For default color values the 'MaxColorValue' template is used.

See also

MaxColorValue

10.17.2.2 template<typename T > LLGL::Color< T, 3u >::Color (const Color< T, 3 > & *rhs*) `[inline]`

Copy constructor.

10.17.2.3 template<typename T > LLGL::Color< T, 3u >::Color (const T & *scalar*) `[inline]`, `[explicit]`

Constructs all attributes with the specified scalar value.

10.17.2.4 template<typename T > LLGL::Color< T, 3u >::Color (const T & *r*, const T & *g*, const T & *b*) `[inline]`

Constructs all attributes with the specified color values r (red), g (green), b (blue).

10.17.2.5 template<typename T > LLGL::Color< T, 3u >::Color (UninitializeTag) `[inline]`, `[explicit]`

Explicitly uninitialized constructor. All attributes are uninitialized!

Remarks

Only use this constructor when you want to allocate a large amount of color elements that are being initialized later.

10.17.3 Member Function Documentation

10.17.3.1 template<typename T > template<typename Dst > Color<Dst, 3> LLGL::Color< T, 3u >::Cast ( ) const `[inline]`

Returns a type casted instance of this color.

Remarks

All color components will be scaled to the range of the new color type.

Template Parameters

Dst	Specifies the destination type.

10.17.3.2 template<typename T > Color<T, 3>& LLGL::Color< T, 3u >::operator*= (const Color< T, 3 > & *rhs*) [inline]

Multiplies the specified color (component wise) with this color.

10.17.3.3 template<typename T > Color<T, 3>& LLGL::Color< T, 3u >::operator*= (const T *rhs*) [inline]

Multiplies the specified scalar value (component wise) with this color.

10.17.3.4 template<typename T > Color<T, 3>& LLGL::Color< T, 3u >::operator+= (const Color< T, 3 > & *rhs*) [inline]

Adds the specified color (component wise) to this color.

10.17.3.5 template<typename T > Color<T, 3> LLGL::Color< T, 3u >::operator- ( ) const [inline]

Returns the negation of this color.

10.17.3.6 template<typename T > Color<T, 3>& LLGL::Color< T, 3u >::operator-= (const Color< T, 3 > & *rhs*) [inline]

Substracts the specified color (component wise) from this color.

10.17.3.7 template<typename T > Color<T, 3>& LLGL::Color< T, 3u >::operator/= (const Color< T, 3 > & *rhs*) [inline]

Divides the specified color (component wise) with this color.

10.17.3.8 template<typename T > Color<T, 3>& LLGL::Color< T, 3u >::operator/= (const T *rhs*) [inline]

Divides the specified scalar value (component wise) with this color.

10.17.3.9 template<typename T > T& LLGL::Color< T, 3u >::operator[ ] (std::size_t *component*) [inline]

Returns the specified color component.

Parameters

in	*component*	Specifies the color component index. This must be 0, 1, or 2.

Exceptions

std::out_of_range	If the specified component index is out of range (Only if the macro 'LLGL_DEBUG' is defined).

10.17.3.10 template<typename T > const T& LLGL::Color< T, 3u >::operator[ ] (std::size_t *component*) const `[inline]`

Returns the specified color component.

Parameters

in	*component*	Specifies the color component index. This must be 0, 1, or 2.

Exceptions

std::out_of_range	If the specified component index is out of range (Only if the macro 'LLGL_DEBUG' is defined).

10.17.3.11 template<typename T > T∗ LLGL::Color< T, 3u >::Ptr ( ) `[inline]`

Returns a pointer to the first element of this color.

10.17.3.12 template<typename T > const T∗ LLGL::Color< T, 3u >::Ptr ( ) const `[inline]`

Returns a constant pointer to the first element of this color.

10.17.3.13 template<typename T > Color<T, 4> LLGL::Color< T, 3u >::ToRGBA ( ) const `[inline]`

Returns this RGB color as RGBA color.

10.17.4 Member Data Documentation

10.17.4.1 template<typename T > T LLGL::Color< T, 3u >::b

10.17.4.2 template<typename T > const std::size_t LLGL::Color< T, 3u >::components = 3 `[static]`

Specifies the number of color components.

10.17.4.3 template< typename T > T LLGL::Color< T, 3u >::g

10.17.4.4 template< typename T > T LLGL::Color< T, 3u >::r

The documentation for this class was generated from the following file:

- ColorRGB.h

10.18 LLGL::Color< T, 4u > Class Template Reference

RGBA color class with components: r, g, b, and a.

```
#include <ColorRGBA.h>
```

Public Member Functions

- Color ()

  Constructors all attributes with the default color value.
- Color (const Color< T, 4 > &rhs)

  Copy constructor.
- Color (const T &scalar)

  Constructs all attributes with the specified scalar value.
- Color (const Color< T, 3u > &rhs)

  Constructs the RGB attributes with the specified RGB color, and the default value for alpha.
- Color (const T &r, const T &g, const T &b)

  Constructs the RGB attributes with the specified color values r (red), g (green), b (blue), and the default value for alpha.
- Color (const T &r, const T &g, const T &b, const T &a)

  Constructs all attributes with the specified color values r (red), g (green), b (blue), a (alpha).
- Color (UninitializeTag)

  Explicitly uninitialized constructor. All attributes are uninitialized!
- Color< T, 4 > & operator+= (const Color< T, 4 > &rhs)

  Adds the specified color (component wise) to this color.
- Color< T, 4 > & operator-= (const Color< T, 4 > &rhs)

  Substracts the specified color (component wise) from this color.
- Color< T, 4 > & operator∗= (const Color< T, 4 > &rhs)

  Multiplies the specified color (component wise) with this color.
- Color< T, 4 > & operator/= (const Color< T, 4 > &rhs)

  Divides the specified color (component wise) with this color.
- Color< T, 4 > & operator∗= (const T rhs)

  Multiplies the specified scalar value (component wise) with this color.
- Color< T, 4 > & operator/= (const T rhs)

  Divides the specified scalar value (component wise) with this color.
- Color< T, 4 > operator- () const

  Returns the negation of this color.
- T & operator[ ] (std::size_t component)

  Returns the specified color component.
- const T & operator[ ] (std::size_t component) const

Returns the specified color component.
- Color< T, 3 > ToRGB () const

  Returns this RGBA color as RGB color.
- template<typename Dst >
  Color< Dst, 4 > Cast () const

  Returns a type casted instance of this color.
- T ∗ Ptr ()

  Returns a pointer to the first element of this color.
- const T ∗ Ptr () const

  Returns a constant pointer to the first element of this color.

Public Attributes

- T r
- T g
- T b
- T a

Static Public Attributes

- static const std::size_t components = 4

  Specifies the number of color components.

10.18.1 Detailed Description

template<typename T>
class LLGL::Color< T, 4u >

RGBA color class with components: r, g, b, and a.

Remarks

Color components are default initialized with their maximal value, i.e. for floating-points, the initial value is 1.0, because this its maximal color value, but for unsigned-bytes, the initial value is 255.

10.18.2 Constructor & Destructor Documentation

10.18.2.1 template<typename T > LLGL::Color< T, 4u >::Color ( ) [inline]

Constructors all attributes with the default color value.

Remarks

For default color values the 'MaxColorValue' template is used.

See also

MaxColorValue

10.18.2.2 template< typename T > LLGL::Color< T, 4u >::Color (const Color< T, 4 > & *rhs*) [inline]

Copy constructor.

10.18.2.3 template< typename T > LLGL::Color< T, 4u >::Color (const T & *scalar*) [inline], [explicit]

Constructs all attributes with the specified scalar value.

10.18.2.4 template< typename T > LLGL::Color< T, 4u >::Color (const Color< T, 3u > & *rhs*) [inline], [explicit]

Constructs the RGB attributes with the specified RGB color, and the default value for alpha.

Remarks

For default color values the 'MaxColorValue' template is used.

See also

MaxColorValue

10.18.2.5 template< typename T > LLGL::Color< T, 4u >::Color (const T & *r,* const T & *g,* const T & *b*) [inline]

Constructs the RGB attributes with the specified color values r (red), g (green), b (blue), and the default value for alpha.

Remarks

For default color values the 'MaxColorValue' template is used.

See also

MaxColorValue

10.18.2.6 template< typename T > LLGL::Color< T, 4u >::Color (const T & *r,* const T & *g,* const T & *b,* const T & *a*) [inline]

Constructs all attributes with the specified color values r (red), g (green), b (blue), a (alpha).

10.18.2.7 template< typename T > LLGL::Color< T, 4u >::Color (UninitializeTag) [inline], [explicit]

Explicitly uninitialized constructor. All attributes are uninitialized!

Remarks

Only use this constructor when you want to allocate a large amount of color elements that are being initialized later.

10.18.3 Member Function Documentation

10.18.3.1 template< typename T > template< typename Dst > Color<Dst, 4> LLGL::Color< T, 4u >::Cast ( ) const [inline]

Returns a type casted instance of this color.

Remarks

All color components will be scaled to the range of the new color type.

Template Parameters

Dst	Specifies the destination type.

10.18.3.2 template<typename T > Color<T, 4>& LLGL::Color< T, 4u >::operator*= (const Color< T, 4 > & *rhs*) `[inline]`

Multiplies the specified color (component wise) with this color.

10.18.3.3 template<typename T > Color<T, 4>& LLGL::Color< T, 4u >::operator*= (const T *rhs*) `[inline]`

Multiplies the specified scalar value (component wise) with this color.

10.18.3.4 template<typename T > Color<T, 4>& LLGL::Color< T, 4u >::operator+= (const Color< T, 4 > & *rhs*) `[inline]`

Adds the specified color (component wise) to this color.

10.18.3.5 template<typename T > Color<T, 4> LLGL::Color< T, 4u >::operator- ( ) const `[inline]`

Returns the negation of this color.

10.18.3.6 template<typename T > Color<T, 4>& LLGL::Color< T, 4u >::operator-= (const Color< T, 4 > & *rhs*) `[inline]`

Substracts the specified color (component wise) from this color.

10.18.3.7 template<typename T > Color<T, 4>& LLGL::Color< T, 4u >::operator/= (const Color< T, 4 > & *rhs*) `[inline]`

Divides the specified color (component wise) with this color.

10.18.3.8 template<typename T > Color<T, 4>& LLGL::Color< T, 4u >::operator/= (const T *rhs*) `[inline]`

Divides the specified scalar value (component wise) with this color.

10.18.3.9 template<typename T > T& LLGL::Color< T, 4u >::operator[ ] (std::size_t *component*) `[inline]`

Returns the specified color component.

Parameters

in	*component*	Specifies the color component index. This must be 0, 1, 2, or 3.

Exceptions

std::out_of_range	If the specified component index is out of range (Only if the macro 'LLGL_DEBUG' is defined).

10.18.3.10 template< typename T > const T& LLGL::Color< T, 4u >::operator[ ] (std::size_t *component*) const [inline]

Returns the specified color component.

Parameters

in	*component*	Specifies the color component index. This must be 0, 1, 2, or 3.

Exceptions

std::out_of_range	If the specified component index is out of range (Only if the macro 'LLGL_DEBUG' is defined).

10.18.3.11 template< typename T > T∗ LLGL::Color< T, 4u >::Ptr ( ) [inline]

Returns a pointer to the first element of this color.

10.18.3.12 template< typename T > const T∗ LLGL::Color< T, 4u >::Ptr ( ) const [inline]

Returns a constant pointer to the first element of this color.

10.18.3.13 template< typename T > Color<T, 3> LLGL::Color< T, 4u >::ToRGB ( ) const [inline]

Returns this RGBA color as RGB color.

10.18.4 Member Data Documentation

10.18.4.1 template< typename T > T LLGL::Color< T, 4u >::a

10.18.4.2 template< typename T > T LLGL::Color< T, 4u >::b

10.18.4.3 template< typename T > const std::size_t LLGL::Color< T, 4u >::components = 4 [static]

Specifies the number of color components.

10.18.4.4 template<typename T > T LLGL::Color< T, 4u >::g

10.18.4.5 template<typename T > T LLGL::Color< T, 4u >::r

The documentation for this class was generated from the following file:

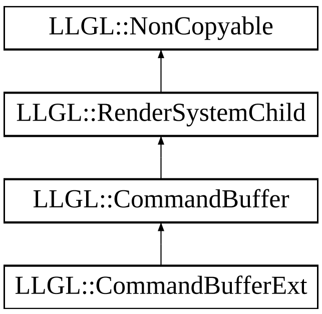
- ColorRGBA.h

10.19 LLGL::CommandBuffer Class Reference

Command buffer interface.

```
#include <CommandBuffer.h>
```

Inheritance diagram for LLGL::CommandBuffer:



Public Member Functions

- virtual void Begin ()=0

  Begins with the encoding (also referred to as "recording") of this command buffer.
- virtual void End ()=0

  Ends the encoding (also referred to as "recording") of this command buffer.
- virtual void UpdateBuffer (Buffer &dstBuffer, std::uint64_t dstOffset, const void ∗data, std::uint16_t data←Size)=0

  Updates the data of the specified buffer during encoding the command buffer.
- virtual void CopyBuffer (Buffer &dstBuffer, std::uint64_t dstOffset, Buffer &srcBuffer, std::uint64_t srcOffset, std::uint64_t size)=0

  Encodes a buffer copy command for the specified buffer region.
- virtual void SetGraphicsAPIDependentState (const void ∗stateDesc, std::size_t stateDescSize)=0

  Sets a few low-level graphics API dependent states.
- virtual void SetViewport (const Viewport &viewport)=0

  Sets a single viewport.
- virtual void SetViewports (std::uint32_t numViewports, const Viewport ∗viewports)=0

  Sets an array of viewports.
- virtual void SetScissor (const Scissor &scissor)=0

  Sets a single scissor rectangle.
- virtual void SetScissors (std::uint32_t numScissors, const Scissor ∗scissors)=0

  Sets an array of scissor rectangles, but only if the scissor test was enabled in the previously set graphics pipeline (otherwise, this function has no effect).

- virtual void SetClearColor (const ColorRGBAf &color)=0

  Sets the new value to clear the color buffer. By default black (0, 0, 0, 0).
- virtual void SetClearDepth (float depth)=0

  Sets the new value to clear the depth buffer with. By default 1.0.
- virtual void SetClearStencil (std::uint32_t stencil)=0

  Sets the new value to clear the stencil buffer. By default 0.
- virtual void Clear (long flags)=0

  Clears the specified group of attachments of the active render target.
- virtual void ClearAttachments (std::uint32_t numAttachments, const AttachmentClear ∗attachments)=0

  Clears the specified attachments of the active render target.
- virtual void SetVertexBuffer (Buffer &buffer)=0

  Sets the specified vertex buffer for subsequent drawing operations.
- virtual void SetVertexBufferArray (BufferArray &bufferArray)=0

  Sets the specified array of vertex buffers for subsequent drawing operations.
- virtual void SetIndexBuffer (Buffer &buffer)=0

  Sets the active index buffer for subsequent drawing operations.
- virtual void SetStreamOutputBuffer (Buffer &buffer)=0

  Sets the active stream-output buffer to the stream-output stage.
- virtual void SetStreamOutputBufferArray (BufferArray &bufferArray)=0

  Sets the active array of stream-output buffers.
- virtual void BeginStreamOutput (const PrimitiveType primitiveType)=0

  Begins with stream-output for subsequent draw calls.
- virtual void EndStreamOutput ()=0

  Ends the current stream-output.
- virtual void SetGraphicsResourceHeap (ResourceHeap &resourceHeap, std::uint32_t firstSet=0)=0

  Binds the specified resource heap to the graphics pipeline.
- virtual void SetComputeResourceHeap (ResourceHeap &resourceHeap, std::uint32_t firstSet=0)=0

  Binds the specified resource heap to the compute pipeline.
- virtual void BeginRenderPass (RenderTarget &renderTarget, const RenderPass ∗renderPass=nullptr, std↩ ::uint32_t numClearValues=0, const ClearValue ∗clearValues=nullptr)=0

  Begins with a new render pass.
- virtual void EndRenderPass ()=0

  Ends the current render pass.
- virtual void SetGraphicsPipeline (GraphicsPipeline &graphicsPipeline)=0

  Sets the active graphics pipeline state.
- virtual void SetComputePipeline (ComputePipeline &computePipeline)=0

  Sets the active compute pipeline state.
- virtual void BeginQuery (QueryHeap &queryHeap, std::uint32_t query=0)=0

  Begins a query of the specified query heap.
- virtual void EndQuery (QueryHeap &queryHeap, std::uint32_t query=0)=0

  Ends the specified query.
- virtual void BeginRenderCondition (QueryHeap &queryHeap, std::uint32_t query=0, const Render↩ ConditionMode mode=RenderConditionMode::Wait)=0

  Begins conditional rendering with the specified query object.
- virtual void EndRenderCondition ()=0

  Ends the current render condition.
- virtual void Draw (std::uint32_t numVertices, std::uint32_t firstVertex)=0

  Draws the specified amount of primitives from the currently set vertex buffer.
- virtual void DrawIndexed (std::uint32_t numIndices, std::uint32_t firstIndex)=0
- virtual void DrawIndexed (std::uint32_t numIndices, std::uint32_t firstIndex, std::int32_t vertexOffset)=0

  Draws the specified amount of primitives from the currently set vertex- and index buffers.

- virtual void DrawInstanced (std::uint32_t numVertices, std::uint32_t firstVertex, std::uint32_t numInstances)=0
- virtual void DrawInstanced (std::uint32_t numVertices, std::uint32_t firstVertex, std::uint32_t numInstances, std::uint32_t firstInstance)=0

  Draws the specified amount of instances of primitives from the currently set vertex buffer.
- virtual void DrawIndexedInstanced (std::uint32_t numIndices, std::uint32_t numInstances, std::uint32_t first↩ Index)=0
- virtual void DrawIndexedInstanced (std::uint32_t numIndices, std::uint32_t numInstances, std::uint32_t first↩ Index, std::int32_t vertexOffset)=0
- virtual void DrawIndexedInstanced (std::uint32_t numIndices, std::uint32_t numInstances, std::uint32_t first↩ Index, std::int32_t vertexOffset, std::uint32_t firstInstance)=0

  Draws the specified amount of instances of primitives from the currently set vertex- and index buffers.
- virtual void Dispatch (std::uint32_t groupSizeX, std::uint32_t groupSizeY, std::uint32_t groupSizeZ)=0

  Dispachtes a compute command.

Protected Member Functions

- CommandBuffer ()=default

10.19.1 Detailed Description

Command buffer interface.

Remarks

This is the main interface to encode graphics and compute commands to be submitted to the GPU. You can assume that all states that can be changed with a setter function are not persistent across several encoding sections, unless the opposite is mentioned. Before any command can be encoded, the command buffer must be set into encode mode, which is done by the CommandBuffer::Begin function. There are only a few exceptions of functions that can be used outside of encoding, which are CommandBuffer::SetClearColor, CommandBuffer::SetClearDepth, and CommandBuffer::SetClearStencil.

10.19.2 Constructor & Destructor Documentation

10.19.2.1 LLGL::CommandBuffer::CommandBuffer ( ) `[protected]`, `[default]`

10.19.3 Member Function Documentation

10.19.3.1 virtual void LLGL::CommandBuffer::Begin ( ) `[pure virtual]`

Begins with the encoding (also referred to as "recording") of this command buffer.

Remarks

All functions of the CommandBuffer interface must be used between a call to `Begin` and `End`, except for the following:

- CommandBuffer::SetClearColor
- CommandBuffer::SetClearDepth
- CommandBuffer::SetClearStencil

See also

End
RecordingFlags

10.19.3.2 virtual void LLGL::CommandBuffer::BeginQuery (QueryHeap & *queryHeap*, std::uint32_t *query* = 0) [pure virtual]

Begins a query of the specified query heap.

Parameters

in	*queryHeap*	Specifies the query heap.
in	*query*	Specifies the zero-based index of the query within the heap to begin with. By default 0. This must be in the half-open range [0, QueryHeapDescriptor::numQueries).

Remarks

The `BeginQuery` and `EndQuery` functions can be wrapped around any drawing and/or compute operation. This can be an occlusion query for instance, which determines how many fragments have passed the depth test. The result of a query can be retrieved by the command queue after this command buffer has been submitted.

See also

EndQuery
RenderSystem::CreateQueryHeap
CommandQueue::QueryResult

10.19.3.3 virtual void LLGL::CommandBuffer::BeginRenderCondition (QueryHeap & *queryHeap*, std::uint32_t *query* = 0, const RenderConditionMode *mode* = RenderConditionMode::Wait) [pure virtual]

Begins conditional rendering with the specified query object.

Parameters

in	*queryHeap*	Specifies the query heap. This query heap must have been created with the `renderCondition` member set to `true`.
in	*query*	Specifies the zero-based index of the query within the heap which is to be used as render condition. By default 0. This must be in the half-open range `[0, QueryHeapDescriptor::numQueries)`.
in	*mode*	Specifies the mode of the render condition.

Remarks

Here is a usage example:

```
myCmdBuffer->BeginQuery(*myOcclusionQuery);
// draw bounding box ...
myCmdBuffer->EndQuery(*myOcclusionQuery);
myCmdBuffer->BeginRenderCondition(*myOcclusionQuery,
      LLGL::RenderConditionMode::Wait);
// draw actual object ...
myCmdBuffer->EndRenderCondition();
```

See also

RenderSystem::CreateQueryHeap
QueryHeapDescriptor::renderCondition

10.19.3.4 virtual void LLGL::CommandBuffer::BeginRenderPass (RenderTarget & *renderTarget*, const RenderPass ∗ *renderPass* = `nullptr`, std::uint32_t *numClearValues* = `0`, const ClearValue ∗ *clearValues* = `nullptr`) `[pure virtual]`

Begins with a new render pass.

Parameters

in	*renderTarget*	Specifies the render target in which the subsequent draw operations will be stored.
in	*renderPass*	Specifies an optional render pass object. If this is null, the default render pass for the specified render target will be used. This render pass object must be compatible with the render pass object the specified render target was created with.
in	*numClearValues*	Specifies the number of clear values that are specified in the `clearValues` parameter. This should be greater than or equal to the number of render pass attachments whose load operation (i.e. AttachmentFormatDescriptor::loadOp) is set to AttachmentLoadOp::Clear. Otherwise, the default values from `SetClearColor`, `SetClearDepth`, and `SetClearStencil` are used.
in	*clearValues*	Optional pointer to the array of clear values. If `numClearValues` is not zero, this must be a valid pointer to an array of at least `numClearValues` entries. Each entry in the array is used to clear the attachment whose load operation is set to AttachmentLoadOp::Clear, where the depth attachment (i.e. RenderPassDescriptor::depthAttachment) and the stencil attachment (i.e. RenderPassDescriptor::stencilAttachment) are combined and appear as the last entry.

Remarks

This function starts a new render pass section and must be ended with the EndRenderPass function. A simple frame setup could look like this:

```
myCmdQueue->Begin(*myCmdBuffer);
{
    myCmdBuffer->BeginRenderPass(*myRenderTarget);
    {
        myCmdBuffer->SetGraphicsPipeline(*myGfxPipeline);
        myCmdBuffer->SetGraphicsResourceHeap(*myResourceHeap);
        myCmdBuffer->Draw(...);
    }
    myCmdBuffer->EndRenderPass();
}
myCmdQueue->End(*myCmdBuffer);
myRenderContext->Present();
```

The following commands can only appear inside a render pass section:

- Drawing commands (i.e. `Draw`, `DrawInstanced`, `DrawIndexed`, and `DrawIndexed↩ Instanced`).
- Clear attachment commands (i.e. `Clear`, and `ClearAttachments`).

The following commands can only appear outside a render pass section:

- Dispatch compute commands (i.e. `Dispatch`).
- Resource read/write from the RenderSystem (i.e. `WriteBuffer`, `MapBuffer` etc.).

See also

RenderSystem::CreateRenderPass
RenderSystem::CreateRenderTarget
RenderTargetDescriptor::renderPass
AttachmentFormatDescriptor::loadOp
EndRenderPass

10.19.3.5 virtual void LLGL::CommandBuffer::BeginStreamOutput (const PrimitiveType *primitiveType*) [pure virtual]

Begins with stream-output for subsequent draw calls.

Parameters

in	*primitiveType*	Specifies the primitive output type of the last vertex processing shader stage (e.g. vertex- or geometry shader).

See also

EndStreamOutput

10.19.3.6 virtual void LLGL::CommandBuffer::Clear (long *flags*) [pure virtual]

Clears the specified group of attachments of the active render target.

Parameters

in	*flags*	Specifies the clear buffer flags. This can be a bitwise OR combination of the ClearFlags enumeration entries. If this contains the ClearFlags::Color bit, all color attachments of the active render target are cleared with the color previously set by `SetClearColor`.

Remarks

To specify the clear values for each buffer type, use the respective `SetClear...` function. To clear only a specific render-target color buffer, use the `ClearAttachments` function. Clearing a depth-stencil attachment while the active render target has no depth-stencil buffer is allowed but has no effect. For efficiency reasons, it is recommended to clear the render target attachments when a new render pass begins, i.e. the clear values of the `BeginRenderPass` function should be prefered over this function. For some render systems (e.g. Metal) this function forces the current render pass to stop and start again in order to clear the attachments.

See also

ClearFlags
SetClearColor
SetClearDepth
SetClearStencil
ClearAttachments
BeginRenderPass

10.19.3.7 virtual void LLGL::CommandBuffer::ClearAttachments (std::uint32_t *numAttachments*, const AttachmentClear ∗ *attachments*) [pure virtual]

Clears the specified attachments of the active render target.

Parameters

in	*numAttachments*	Specifies the number of attachments to clear.
in	*attachments*	Pointer to the array of attachment clear commands. This must not be null!

Remarks

To clear all color buffers with the same value, use the `Clear` function. Clearing a depth-stencil attachment while the active render target has no depth-stencil buffer is allowed but has no effect. For efficiency reasons, it is recommended to clear the render target attachments when a new render pass begins, i.e. the clear values of the `BeginRenderPass` function should be prefered over this function. For some render systems (e.g. Metal) this function forces the current render pass to stop and start again in order to clear the attachments.

See also

Clear
BeginRenderPass

10.19.3.8 virtual void LLGL::CommandBuffer::CopyBuffer (**Buffer** & *dstBuffer,* std::uint64_t *dstOffset,* **Buffer** & *srcBuffer,* std::uint64_t *srcOffset,* std::uint64_t *size*) `[pure virtual]`

Encodes a buffer copy command for the specified buffer region.

Parameters

in	*dstBuffer*	Specifies the destination buffer whose data is to be updated.
in	*dstOffset*	Specifies the destination offset (in bytes) at which the destination buffer is to be updated. This offset plus the size (i.e. `dstOffset + size`) must be less than or equal to the size of the destination buffer.
in	*srcBuffer*	Specifies the source buffer whose data is to be read from.
in	*srcOffset*	Specifies teh source offset (in bytes) at which the source buffer is to be read from. This offset plus the size (i.e. `srcOffset + size`) must be less than or equal to the size of the source buffer.
in	*size*	Specifies the size of the buffer region to copy.

Remarks

It is recommended to call this outside of a render pass. Otherwise, LLGL needs to pause and resume the render pass for the Vulkan backend via a secondary render pass object.

10.19.3.9 virtual void LLGL::CommandBuffer::Dispatch (std::uint32_t *groupSizeX,* std::uint32_t *groupSizeY,* std::uint32_t *groupSizeZ*) `[pure virtual]`

Dispachtes a compute command.

Parameters

in	*groupSizeX*	Specifies the number of thread groups in the X-dimension.
in	*groupSizeY*	Specifies the number of thread groups in the Y-dimension.
in	*groupSizeZ*	Specifies the number of thread groups in the Z-dimension.

See also

SetComputePipeline
RenderingLimits::maxComputeShaderWorkGroups

10.19.3.10 virtual void LLGL::CommandBuffer::Draw (std::uint32_t *numVertices*, std::uint32_t *firstVertex*) [pure virtual]

Draws the specified amount of primitives from the currently set vertex buffer.

Parameters

in	*numVertices*	Specifies the number of vertices to generate.
in	*firstVertex*	Specifies the zero-based offset of the first vertex from the vertex buffer.

Note

The parameter `firstVertex` modifies the vertex ID within the shader pipeline differently for `SV_Vertex↩ ID` in HLSL and `gl_VertexID` in GLSL (or `gl_VertexIndex` for Vulkan), due to rendering API differences. The system value `SV_VertexID` in HLSL will always start with zero, but the system value `gl_↩ VertexID` in GLSL (or `gl_VertexIndex` for Vulkan) will start with the value of `firstVertex`.

10.19.3.11 virtual void LLGL::CommandBuffer::DrawIndexed (std::uint32_t *numIndices*, std::uint32_t *firstIndex*) [pure virtual]

See also

DrawIndexed(std::uint32_t, std::uint32_t, std::int32_t)

10.19.3.12 virtual void LLGL::CommandBuffer::DrawIndexed (std::uint32_t *numIndices*, std::uint32_t *firstIndex*, std::int32_t *vertexOffset*) [pure virtual]

Draws the specified amount of primitives from the currently set vertex- and index buffers.

Parameters

in	*numIndices*	Specifies the number of indices to generate.
in	*firstIndex*	Specifies the zero-based offset of the first index from the index buffer.
in	*vertexOffset*	Specifies the base vertex offset (positive or negative) which is added to each index from the index buffer.

10.19.3.13 virtual void LLGL::CommandBuffer::DrawIndexedInstanced (std::uint32_t *numIndices*, std::uint32_t *numInstances*, std::uint32_t *firstIndex*) [pure virtual]

See also

DrawIndexedInstanced(std::uint32_t, std::uint32_t, std::uint32_t, std::int32_t, std::uint32_t)

10.19.3.14 virtual void LLGL::CommandBuffer::DrawIndexedInstanced (std::uint32_t *numIndices*, std::uint32_t *numInstances*, std::uint32_t *firstIndex*, std::int32_t *vertexOffset*) [pure virtual]

See also

DrawIndexedInstanced(std::uint32_t, std::uint32_t, std::uint32_t, std::int32_t, std::uint32_t)

10.19.3.15 virtual void LLGL::CommandBuffer::DrawIndexedInstanced (std::uint32_t *numIndices*, std::uint32_t *numInstances*, std::uint32_t *firstIndex*, std::int32_t *vertexOffset*, std::uint32_t *firstInstance*) [pure virtual]

Draws the specified amount of instances of primitives from the currently set vertex- and index buffers.

Parameters

`in`	*numIndices*	Specifies the number of indices to generate.
`in`	*numInstances*	Specifies the number of instances to generate.
`in`	*firstIndex*	Specifies the zero-based offset of the first index from the index buffer.
`in`	*vertexOffset*	Specifies the base vertex offset (positive or negative) which is added to each index from the index buffer.
`in`	*firstInstance*	Specifies the zero-based offset of the first instance.

Note

The parameter `firstInstance` modifies the instance ID within the shader pipeline differently for `SV↩_InstanceID` in HLSL and `gl_InstanceID` in GLSL (or `gl_InstanceIndex` for Vulkan), due to rendering API differences. The system value `SV_InstanceID` in HLSL will always start with zero, but the system value `gl_InstanceID` in GLSL (or `gl_InstanceIndex` for Vulkan) will start with the value of `firstInstance`.

10.19.3.16 virtual void LLGL::CommandBuffer::DrawInstanced (std::uint32_t *numVertices*, std::uint32_t *firstVertex*, std::uint32_t *numInstances*) [pure virtual]

See also

DrawInstanced(std::uint32_t, std::uint32_t, std::uint32_t, std::uint32_t)

10.19.3.17 virtual void LLGL::CommandBuffer::DrawInstanced (std::uint32_t *numVertices*, std::uint32_t *firstVertex*, std::uint32_t *numInstances*, std::uint32_t *firstInstance*) [pure virtual]

Draws the specified amount of instances of primitives from the currently set vertex buffer.

Parameters

`in`	*numVertices*	Specifies the number of vertices to generate.
`in`	*firstVertex*	Specifies the zero-based offset of the first vertex from the vertex buffer.
`in`	*numInstances*	Specifies the number of instances to generate.
`in`	*firstInstance*	Specifies the zero-based offset of the first instance.

Note

The parameter `firstVertex` modifies the vertex ID within the shader pipeline differently for `SV_Vertex↩ ID` in HLSL and `gl_VertexID` in GLSL (or `gl_VertexIndex` for Vulkan), due to rendering API differences. The system value `SV_VertexID` in HLSL will always start with zero, but the system value `gl_↩ VertexID` in GLSL (or `gl_VertexIndex` for Vulkan) will start with the value of `firstVertex`. The same holds true for the parameter `firstInstance` and the system values `SV_InstanceID` in HLSL and `gl_InstanceID` in GLSL (or `gl_InstanceIndex` for Vulkan).

10.19.3.18 virtual void LLGL::CommandBuffer::End ( ) `[pure virtual]`

Ends the encoding (also referred to as "recording") of this command buffer.

See also

Begin
CommandQueue::Submit(CommandBuffer&)

10.19.3.19 virtual void LLGL::CommandBuffer::EndQuery (**QueryHeap** & *queryHeap*, std::uint32_t *query* = `0`) `[pure virtual]`

Ends the specified query.

See also

BeginQuery

10.19.3.20 virtual void LLGL::CommandBuffer::EndRenderCondition ( ) `[pure virtual]`

Ends the current render condition.

See also

BeginRenderCondition

10.19.3.21 virtual void LLGL::CommandBuffer::EndRenderPass ( ) `[pure virtual]`

Ends the current render pass.

See also

BeginRenderPass

10.19.3.22 virtual void LLGL::CommandBuffer::EndStreamOutput ( ) `[pure virtual]`

Ends the current stream-output.

See also

BeginStreamOutput

10.19.3.23 virtual void LLGL::CommandBuffer::SetClearColor (const ColorRGBAf & *color*) `[pure virtual]`

Sets the new value to clear the color buffer. By default black (0, 0, 0, 0).

Note

This state is guaranteed to be persistent and can be used outside of command buffer encoding.

See also

Clear

10.19.3.24 virtual void LLGL::CommandBuffer::SetClearDepth (float *depth*) `[pure virtual]`

Sets the new value to clear the depth buffer with. By default 1.0.

Note

This state is guaranteed to be persistent and can be used outside of command buffer encoding.

See also

Clear

10.19.3.25 virtual void LLGL::CommandBuffer::SetClearStencil (std::uint32_t *stencil*) `[pure virtual]`

Sets the new value to clear the stencil buffer. By default 0.

Parameters

`in`	*stencil*	Specifies the value to clear the stencil buffer. This value is masked with `2^m-1`, where `m` is the number of bits in the stencil buffer (e.g. `stencil & 0xFF` for an 8-bit stencil buffer).

Note

This state is guaranteed to be persistent and can be used outside of command buffer encoding.

See also

Clear

10.19.3.26 virtual void LLGL::CommandBuffer::SetComputePipeline (**ComputePipeline** & *computePipeline*) [pure virtual]

Sets the active compute pipeline state.

Parameters

in	*computePipeline*	Specifies the compupite pipeline state to set.

Remarks

This will set the compute shader states. A valid compute pipeline must always be set before any compute operation can be performed.

See also

RenderSystem::CreateComputePipeline

10.19.3.27 virtual void LLGL::CommandBuffer::SetComputeResourceHeap (**ResourceHeap** & *resourceHeap*, std::uint32_t *firstSet* = 0) [pure virtual]

Binds the specified resource heap to the compute pipeline.

Parameters

in	*resourceHeap*	Specifies the resource heap that contains all shader resources that will be bound to the shader pipeline.
in	*firstSet*	Specifies the set number of the first layout descriptor.

Remarks

This may invalidate the previously bound resource heap for both the graphics and compute pipeline.

Note

Parameter 'firstSet' is only supported with: Vulkan.

10.19.3.28 virtual void LLGL::CommandBuffer::SetGraphicsAPIDependentState (const void ∗ *stateDesc*, std::size_t *stateDescSize*) [pure virtual]

Sets a few low-level graphics API dependent states.

Parameters

in	*stateDesc*	Specifies a pointer to the renderer spcific state descriptor. If this is a null pointer, the function has no effect.
in	*stateDescSize*	Specifies the size (in bytes) of the renderer spcific state descriptor structure. If this value is not equal to the state descriptor structure that is required for the respective renderer, the function has no effect.

Remarks

This can be used to work around several differences between the low-level graphics APIs, e.g. for a uniform render target behavior between OpenGL and Direct3D. Here is a usage example:

```
LLGL::OpenGLDependentStateDescriptor myOpenGLStateDesc;
myOpenGLStateDesc.invertFrontFace = true;
myCommandBuffer->SetGraphicsAPIDependentState(&myOpenGLStateDesc, sizeof(myOpenGLStateDesc));
```

Note

Invalid arguments are ignored by this function silently (except for corrupted pointers).

See also

OpenGLDependentStateDescriptor

10.19.3.29 virtual void LLGL::CommandBuffer::SetGraphicsPipeline (GraphicsPipeline & *graphicsPipeline*) [pure virtual]

Sets the active graphics pipeline state.

Parameters

in	*graphicsPipeline*	Specifies the graphics pipeline state to set.

Remarks

This will set all blending-, rasterizer-, depth-, stencil-, and shader states. A valid graphics pipeline must always be set before any drawing operation can be performed, and a graphics pipeline can only be set inside a render pass.

```
// First set render target
myCmdBuffer->BeginRenderPass(...);
{
    // Then set graphics pipeline
    myCmdBuffer->SetGraphicsPipeline(...);

    // Then perform drawing operations
    myCmdBuffer->SetGraphicsResourceHeap(...);
    myCmdBuffer->Draw(...);
}
myCmdBuffer->EndRenderPass();
```

See also

RenderSystem::CreateGraphicsPipeline

10.19.3.30 virtual void LLGL::CommandBuffer::SetGraphicsResourceHeap (ResourceHeap & *resourceHeap*, std::uint32_t *firstSet* = 0) [pure virtual]

Binds the specified resource heap to the graphics pipeline.

Parameters

in	*resourceHeap*	Specifies the resource heap that contains all shader resources that will be bound to the shader pipeline.
in	*firstSet*	Specifies the set number of the first layout descriptor.

Remarks

This may invalidate the previously bound resource heap for both the graphics and compute pipeline.

Note

Parameter 'firstSet' is only supported with: Vulkan.

10.19.3.31 virtual void LLGL::CommandBuffer::SetIndexBuffer (Buffer & *buffer*) [pure virtual]

Sets the active index buffer for subsequent drawing operations.

Parameters

in	*buffer*	Specifies the index buffer to set. This buffer must have been created with the buffer type: BufferType::Index. This must not be an unspecified index buffer, i.e. it must be initialized with either the initial data in the "RenderSystem::CreateBuffer" function or with the "RenderSystem::WriteBuffer" function.

Remarks

An active index buffer is only required for any "DrawIndexed" or "DrawIndexedInstanced" draw call.

See also

RenderSystem::WriteIndexBuffer

10.19.3.32 virtual void LLGL::CommandBuffer::SetScissor (const Scissor & *scissor*) [pure virtual]

Sets a single scissor rectangle.

Remarks

Similar to SetScissors but only a single scissor rectangle is set.

See also

SetScissors

10.19.3.33 virtual void LLGL::CommandBuffer::SetScissors (std::uint32_t *numScissors*, const Scissor ∗ *scissors*) [pure virtual]

Sets an array of scissor rectangles, but only if the scissor test was enabled in the previously set graphics pipeline (otherwise, this function has no effect).

Parameters

in	*numScissors*	Specifies the number of scissor rectangles to set.
in	*scissors*	Pointer to the array of scissor rectangles. This must not be null!

Remarks

This function behaves differently on the OpenGL render system, depending on the state configured with the "SetGraphicsAPIDependentState" function. If 'stateOpenGL.screenSpaceOriginLowerLeft' is false, the origin of each scissor rectangle is on the upper-left (like for all other render systems). If 'stateOpenGL.screen↩SpaceOriginLowerLeft' is true, the origin of each scissor rectangle is on the lower-left.

See also

SetGraphicsAPIDependentState
RasterizerDescriptor::scissorTestEnabled

10.19.3.34 virtual void LLGL::CommandBuffer::SetStreamOutputBuffer (Buffer & *buffer*) [pure virtual]

Sets the active stream-output buffer to the stream-output stage.

Parameters

in	*buffer*	Specifies the stream-output buffer to set. This buffer must have been created with the buffer type: BufferType::StreamOutput.

See also

RenderSystem::MapBuffer
RenderSystem::UnmapBuffer

10.19.3.35 virtual void LLGL::CommandBuffer::SetStreamOutputBufferArray (BufferArray & *bufferArray*) [pure virtual]

Sets the active array of stream-output buffers.

Parameters

in	*bufferArray*	Specifies the stream-output buffer array to set.

See also

RenderSystem::CreateBufferArray
SetStreamOutputBuffer

10.19.3.36 virtual void LLGL::CommandBuffer::SetVertexBuffer (**Buffer** & *buffer*) [pure virtual]

Sets the specified vertex buffer for subsequent drawing operations.

Parameters

in	*buffer*	Specifies the vertex buffer to set. This buffer must have been created with the buffer type: BufferType::Vertex. This must not be an unspecified vertex buffer, i.e. it must be initialized with either the initial data in the "RenderSystem::CreateBuffer" function or with the "RenderSystem::WriteBuffer" function.

See also

RenderSystem::CreateBuffer
RenderSystem::WriteBuffer
SetVertexBufferArray

10.19.3.37 virtual void LLGL::CommandBuffer::SetVertexBufferArray (**BufferArray** & *bufferArray*) [pure virtual]

Sets the specified array of vertex buffers for subsequent drawing operations.

Parameters

in	*bufferArray*	Specifies the vertex buffer array to set.

See also

RenderSystem::CreateBufferArray
SetVertexBuffer

10.19.3.38 virtual void LLGL::CommandBuffer::SetViewport (const **Viewport** & *viewport*) [pure virtual]

Sets a single viewport.

Remarks

Similar to SetViewports but only a single viewport is set.

See also

SetViewports

10.19.3.39 virtual void LLGL::CommandBuffer::SetViewports (std::uint32_t *numViewports*, const **Viewport** ∗ *viewports*) [pure virtual]

Sets an array of viewports.

Parameters

in	*numViewports*	Specifies the number of viewports to set. Most render system have a limit of 16 viewports.
in	*viewports*	Pointer to the array of viewports. This must not be null!

Remarks

This function behaves differently on the OpenGL render system, depending on the state configured with the "SetGraphicsAPIDependentState" function. If 'stateOpenGL.screenSpaceOriginLowerLeft' is false, the origin of each viewport is on the upper-left (like for all other render systems). If 'stateOpenGL.screenSpaceOrigin↩LowerLeft' is true, the origin of each viewport is on the lower-left.

Note

This state is guaranteed to be persistent.

See also

SetGraphicsAPIDependentState
RenderingLimits::maxViewports

10.19.3.40 virtual void LLGL::CommandBuffer::UpdateBuffer (Buffer & *dstBuffer,* std::uint64_t *dstOffset,* const void ∗ *data,* std::uint16_t *dataSize*) `[pure virtual]`

Updates the data of the specified buffer during encoding the command buffer.

Parameters

in	*dstBuffer*	Specifies the destination buffer whose data is to be updated.
in	*dstOffset*	Specifies the destination offset (in bytes) at which the buffer is to be updated. This offset plus the data block size (i.e. `dstOffset + dataSize`) must be less than or equal to the size of the buffer.
in	*data*	Raw pointer to the data with which the buffer is to be updated. This must not be null!
in	*dataSize*	Specifies the size (in bytes) of the data block which is to be updated. This is limited to 2^16 = 65536 bytes, because it may be written to the command buffer itself before it is copied to the destination buffer (depending on the backend).

Remarks

To update buffers larger than 65536 bytes, use RenderSystem::WriteBuffer or RenderSystem::MapBuffer. It is recommended to call this outside of a render pass. Otherwise, LLGL needs to pause and resume the render pass for the Vulkan backend via a secondary render pass object.

The documentation for this class was generated from the following file:

- CommandBuffer.h

10.20 LLGL::CommandBufferDescriptor Struct Reference

Command buffer descriptor structure.

`#include <CommandBufferFlags.h>`

Public Attributes

- long flags = 0

  Specifies the creation flags for the command buffer. By default 0.
- std::uint32_t numNativeBuffers = 2

  Specifies the number of internal native command buffers. By default 2.

10.20.1 Detailed Description

Command buffer descriptor structure.

See also

RenderSystem::CreateCommandBuffer

10.20.2 Member Data Documentation

10.20.2.1 long LLGL::CommandBufferDescriptor::flags = 0

Specifies the creation flags for the command buffer. By default 0.

Remarks

If no flags are specified (i.e. the default value), the command buffer must be encoded again after it has been submitted to the command queue.

See also

CommandBufferFlags

10.20.2.2 std::uint32_t LLGL::CommandBufferDescriptor::numNativeBuffers = 2

Specifies the number of internal native command buffers. By default 2.

Remarks

This is only a hint to the framework, since not all rendering APIs support command buffers natively. For those that do, however, this member specifies how many native command buffers are to be allocated internally. These native command buffers are then switched everytime encoding begins with the CommandBuffer::Begin function. The benefit of having multiple native command buffers is that it reduces the time the GPU is idle because it waits for a command buffer to be completed before it can be reused.

See also

CommandBuffer::Begin

The documentation for this struct was generated from the following file:

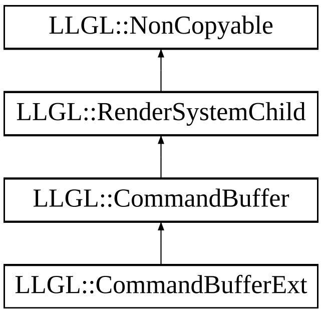
- CommandBufferFlags.h

10.21 LLGL::CommandBufferExt Class Reference

Extended command buffer interface with dynamic state access for shader resources (i.e. Constant Buffers, Storage Buffers, Textures, and Samplers).

```
#include <CommandBufferExt.h>
```

Inheritance diagram for LLGL::CommandBufferExt:



Public Member Functions

- virtual void SetConstantBuffer (Buffer &buffer, std::uint32_t slot, long stageFlags=StageFlags::AllStages)=0

    Sets the active constant buffer at the specified slot index for subsequent drawing and compute operations.
- virtual void SetStorageBuffer (Buffer &buffer, std::uint32_t slot, long stageFlags=StageFlags::AllStages)=0

    Sets the active storage buffer of the specified slot index for subsequent drawing and compute operations.
- virtual void SetTexture (Texture &texture, std::uint32_t slot, long stageFlags=StageFlags::AllStages)=0

    Sets the active texture of the specified slot index for subsequent drawing and compute operations.
- virtual void SetSampler (Sampler &sampler, std::uint32_t slot, long stageFlags=StageFlags::AllStages)=0

    Sets the active sampler of the specified slot index for subsequent drawing and compute operations.
- virtual void ResetResourceSlots (const ResourceType resourceType, std::uint32_t firstSlot, std::uint32_↩ t numSlots, long stageFlags=StageFlags::AllStages)=0

    Resets the binding slots for the specified resources.

Protected Member Functions

- CommandBufferExt ()=default

10.21.1 Detailed Description

Extended command buffer interface with dynamic state access for shader resources (i.e. Constant Buffers, Storage Buffers, Textures, and Samplers).

Remarks

This is an extended command interface for the legacy graphics APIs such as OpenGL and Direct3D 11 to dynamically change bounded shader resources.

Note

Only supported with: OpenGL, Direct3D 11.

10.21.2 Constructor & Destructor Documentation

10.21.2.1 LLGL::CommandBufferExt::CommandBufferExt ( ) `[protected]`, `[default]`

10.21.3 Member Function Documentation

10.21.3.1 virtual void LLGL::CommandBufferExt::ResetResourceSlots (const ResourceType *resourceType*, std::uint32_t *firstSlot*, std::uint32_t *numSlots*, long *stageFlags* = StageFlags::AllStages) `[pure virtual]`

Resets the binding slots for the specified resources.

Remarks

This should be called when a resource is currently bound as shader output and will be bound as shader input for the next draw or compute commands.

Parameters

`in`	*resourceType*	Specifies the type of resources to unbind.
`in`	*firstSlot*	Specifies the first binding slot beginning with zero. This must be zero for the following resource types: ResourceType::IndexBuffer, ResourceType::StreamOutputBuffer.
`in`	*numSlots*	Specifies the number of bindings slots to reset. If this is zero, the function has no effect.
`in`	*stageFlags*	Specifies which shader stages are affected. This can be a bitwise OR combination of the StageFlags entries. By default StageFlags::AllStages.

See also

StageFlags

10.21.3.2 virtual void LLGL::CommandBufferExt::SetConstantBuffer (Buffer & *buffer*, std::uint32_t *slot*, long *stageFlags* = StageFlags::AllStages) `[pure virtual]`

Sets the active constant buffer at the specified slot index for subsequent drawing and compute operations.

Parameters

`in`	*buffer*	Specifies the constant buffer to set. This buffer must have been created with the buffer type: BufferType::Constant. This must not be an unspecified constant buffer, i.e. it must be initialized with either the initial data in the "RenderSystem::CreateBuffer" function or with the "RenderSystem::WriteBuffer" function.
`in`	*slot*	Specifies the slot index where to put the constant buffer.
`in`	*stageFlags*	Specifies at which shader stages the constant buffer is to be set. By default all shader stages are affected.

See also

RenderSystem::WriteBuffer
StageFlags

10.21.3.3 virtual void LLGL::CommandBufferExt::SetSampler (**Sampler** & *sampler*, std::uint32_t *slot*, long *stageFlags* = **StageFlags::AllStages**) [pure virtual]

Sets the active sampler of the specified slot index for subsequent drawing and compute operations.

Parameters

in	*sampler*	Specifies the sampler to set.
in	*slot*	Specifies the slot index where to put the sampler.

See also

RenderSystem::CreateSampler

10.21.3.4 virtual void LLGL::CommandBufferExt::SetStorageBuffer (**Buffer** & *buffer*, std::uint32_t *slot*, long *stageFlags* = **StageFlags::AllStages**) [pure virtual]

Sets the active storage buffer of the specified slot index for subsequent drawing and compute operations.

Parameters

in	*buffer*	Specifies the storage buffer to set. This buffer must have been created with the buffer type: BufferType::Storage.
in	*slot*	Specifies the slot index where to put the storage buffer.
in	*stageFlags*	Specifies at which shader stages the storage buffer is to be set and which resource views are to be set. By default all shader stages and all resource views are affected.

See also

RenderSystem::MapBuffer
RenderSystem::UnmapBuffer
StageFlags::ReadOnlyResource

10.21.3.5 virtual void LLGL::CommandBufferExt::SetTexture (**Texture** & *texture*, std::uint32_t *slot*, long *stageFlags* = **StageFlags::AllStages**) [pure virtual]

Sets the active texture of the specified slot index for subsequent drawing and compute operations.

Parameters

in	*texture*	Specifies the texture to set.
in	*slot*	Specifies the slot index where to put the texture.

The documentation for this class was generated from the following file:

- CommandBufferExt.h

10.22 LLGL::CommandBufferFlags Struct Reference

Command buffer creation flags.

```
#include <CommandBufferFlags.h>
```

Public Types

- enum { DeferredSubmit = (1 << 0) }

10.22.1 Detailed Description

Command buffer creation flags.

See also

CommandBufferDescriptor::flags

10.22.2 Member Enumeration Documentation

10.22.2.1 anonymous enum

Enumerator

DeferredSubmit Specifies that the encoded command buffer can be submitted multiple times.

Remarks

If this is not specified, the command buffer must be encoded again after it has been submitted to the command queue.

The documentation for this struct was generated from the following file:

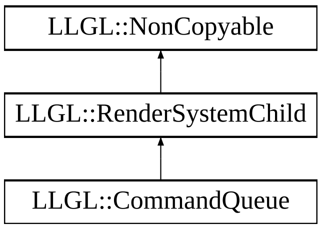
- CommandBufferFlags.h

10.23 LLGL::CommandQueue Class Reference

Command queue interface.

```
#include <CommandQueue.h>
```

Inheritance diagram for LLGL::CommandQueue:



Public Member Functions

- virtual void Submit (CommandBuffer &commandBuffer)=0

  Submits the specified command buffer to the command queue.
- virtual bool QueryResult (QueryHeap &queryHeap, std::uint32_t firstQuery, std::uint32_t numQueries, void ∗data, std::size_t dataSize)=0

  Retrieves the result of the specified query objects.
- virtual void Submit (Fence &fence)=0

  Submits the specified fence to the command queue for CPU/GPU synchronization.
- virtual bool WaitFence (Fence &fence, std::uint64_t timeout)=0

  Blocks the CPU execution until the specified fence has been signaled.
- virtual void WaitIdle ()=0

  Blocks the CPU execution until the entire GPU command queue has been completed.

Protected Member Functions

- CommandQueue ()=default

10.23.1 Detailed Description

Command queue interface.

Remarks

This class is mainly used for modern rendering APIs (such as Direct3D 12 and Vulkan) to submit one ore more command buffers (or command lists) into the command queue. For older rendering APIs (such as Direct3D 11 and OpenGL) submitting a command buffer has no effect. It also provides the functionality to submit small sized objects such as fences into the command queue.

10.23.2 Constructor & Destructor Documentation

10.23.2.1 LLGL::CommandQueue::CommandQueue ( ) `[protected]`, `[default]`

10.23.3 Member Function Documentation

10.23.3.1 virtual bool LLGL::CommandQueue::QueryResult (QueryHeap & *queryHeap*, std::uint32_t *firstQuery*, std::uint32_t *numQueries*, void ∗ *data*, std::size_t *dataSize*) `[pure virtual]`

Retrieves the result of the specified query objects.

Parameters

`in`	*queryHeap*	Specifies the query heap.
`in`	*firstQuery*	Specifies the zero-based index of the first query within the heap. This must be in the half-open range [0, QueryHeapDescriptor::numQueries).
`in`	*numQueries*	Specifies the number of queries to retrieve the result from. This must be less than or equal to (QueryHeapDescriptor::numQueries - firstQuery) and it must not be zero.
`out`	*data*	Specifies the pointer to the output data. This must be a valid pointer to an array of `numQueries` entries. The array entries must have one of the following types:
		• std::uint32_t • std::uint64_t • QueryPipelineStatistics If the function return false, the content of this array is

Returns

True, if all results are available. Otherwise, the results are (partially) unavailable and the content of the output data is undefined.

Remarks

Here is a usage example:

```
// Get results of 10 occlusion queries
std::uint64_t occlusionQueryResults[10] = {};
myCmdQueue->QueryResult(*myOcclusionQuery, 0, 10, occlusionQueryResults, sizeof(occlusionQueryResults));

// Get result of a pipeline statistics query
LLGL::QueryPipelineStatistics stats;
myCmdQueue->QueryResult(*myPipelineStatsQuery, 0, 1, &stats, sizeof(stats));
```

10.23.3.2 virtual void LLGL::CommandQueue::Submit (**CommandBuffer** & *commandBuffer*) [pure virtual]

Submits the specified command buffer to the command queue.

Remarks

This must only be called with a command buffer that has already been encoded via the `Begin` and `End` functions:

```
myCmdBuffer->Begin();
// Encode/record command buffer ...
myCmdBuffer->End();
myCmdQueue->Submit(*myCmdBuffer);
```

See also

CommandBuffer::Begin
CommandBuffer::End
Submit(std::uint32_t, CommandBuffer∗ const ∗)

10.23.3.3 virtual void LLGL::CommandQueue::Submit (**Fence** & *fence*) [pure virtual]

Submits the specified fence to the command queue for CPU/GPU synchronization.

10.23.3.4 virtual bool LLGL::CommandQueue::WaitFence (**Fence** & *fence*, std::uint64_t *timeout*) [pure virtual]

Blocks the CPU execution until the specified fence has been signaled.

Parameters

in	*fence*	Specifies the fence for which the CPU needs to wait to be signaled.
in	*timeout*	Specifies the waiting timeout (in nanoseconds).

Returns

True on success, or false if the fence has a timeout (in nanoseconds) or the device is lost.

Remarks

To wait for the completion of the entire GPU command queue, use 'WaitIdle'.

See also

WaitIdle

10.23.3.5 virtual void LLGL::CommandQueue::WaitIdle ( ) [pure virtual]

Blocks the CPU execution until the entire GPU command queue has been completed.

Remarks

To wait for a specific point in the command queue, use fences. Waiting for the queue to be become idle is equivalent to submitting a fence and waiting for that fence to be signaled:

```
myCmdQueue->Submit(myFence);
myCmdQueue->WaitFence(myFence, ~0);
```

See also

WaitFence

The documentation for this class was generated from the following file:

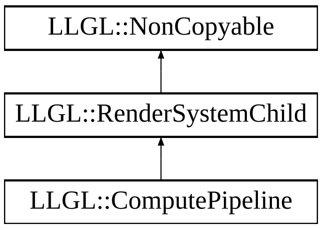
- CommandQueue.h

10.24 LLGL::ComputePipeline Class Reference

Compute pipeline interface.

`#include <ComputePipeline.h>`

Inheritance diagram for LLGL::ComputePipeline:



Additional Inherited Members

10.24.1 Detailed Description

Compute pipeline interface.

The documentation for this class was generated from the following file:

- ComputePipeline.h

10.25 LLGL::ComputePipelineDescriptor Struct Reference

Compute pipeline descriptor structure.

`#include <ComputePipelineFlags.h>`

Public Member Functions

- ComputePipelineDescriptor ()=default
- ComputePipelineDescriptor (ShaderProgram ∗shaderProgram, PipelineLayout ∗pipelineLayout=nullptr)

  Constructor to initialize the entire descriptor.

Public Attributes

- ShaderProgram ∗ shaderProgram = nullptr

  Pointer to the shader program for the compute pipeline.
- PipelineLayout ∗ pipelineLayout = nullptr

  Pointer to an optional pipeline layout for the graphics pipeline.

10.25.1 Detailed Description

Compute pipeline descriptor structure.

10.25.2 Constructor & Destructor Documentation

10.25.2.1 LLGL::ComputePipelineDescriptor::ComputePipelineDescriptor ( ) `[default]`

10.25.2.2 LLGL::ComputePipelineDescriptor::ComputePipelineDescriptor (**ShaderProgram** ∗ *shaderProgram*, **PipelineLayout** ∗ *pipelineLayout* = `nullptr`) `[inline]`

Constructor to initialize the entire descriptor.

10.25.3 Member Data Documentation

10.25.3.1 PipelineLayout∗ LLGL::ComputePipelineDescriptor::pipelineLayout = nullptr

Pointer to an optional pipeline layout for the graphics pipeline.

Remarks

This layout determines at which slots buffer resources can be bound. This is ignored by render systems which do not support pipeline layouts.

Note

Only supported with: Vulkan, Direct3D 12

10.25.3.2 ShaderProgram∗ LLGL::ComputePipelineDescriptor::shaderProgram = nullptr

Pointer to the shader program for the compute pipeline.

Remarks

This must never be null when "RenderSystem::CreateComputePipeline" is called with this structure.

See also

RenderSystem::CreateComputePipeline
RenderSystem::CreateShaderProgram

The documentation for this struct was generated from the following file:

- ComputePipelineFlags.h

10.26 LLGL::DepthBiasDescriptor Struct Reference

Depth bias descriptor structure to control fragment depth values.

```
#include <GraphicsPipelineFlags.h>
```

Public Attributes

- float constantFactor = 0.0f

  Specifies a scalar factor controlling the constant depth value added to each fragment. By default 0.0.
- float slopeFactor = 0.0f

  Specifies a scalar factor applied to a fragment's slope in depth bias calculations. By default 0.0.
- float clamp = 0.0f

  Specifies the maximum (or minimum) depth bias of a fragment. By default 0.0.

10.26.1 Detailed Description

Depth bias descriptor structure to control fragment depth values.

10.26.2 Member Data Documentation

10.26.2.1 float LLGL::DepthBiasDescriptor::clamp = 0.0f

Specifies the maximum (or minimum) depth bias of a fragment. By default 0.0.

Note

For OpenGL, this is only supported if the extension `GL_ARB_polygon_offset_clamp` is available (see `https://www.khronos.org/registry/OpenGL/extensions/ARB/ARB_polygon_↩ offset_clamp.txt`).

10.26.2.2 float LLGL::DepthBiasDescriptor::constantFactor = 0.0f

Specifies a scalar factor controlling the constant depth value added to each fragment. By default 0.0.

Note

The actual constant factor being added to each fragment is implementation dependent of the respective rendering API. Direct3D 12 for instance only considers the integral part.

10.26.2.3 float LLGL::DepthBiasDescriptor::slopeFactor = 0.0f

Specifies a scalar factor applied to a fragment's slope in depth bias calculations. By default 0.0.

The documentation for this struct was generated from the following file:

- GraphicsPipelineFlags.h

10.27 LLGL::DepthDescriptor Struct Reference

Depth state descriptor structure.

`#include <GraphicsPipelineFlags.h>`

Public Attributes

- bool testEnabled = false

  Specifies whether the depth test is enabled or disabled. By default disabled.
- bool writeEnabled = false

  Specifies whether writing to the depth buffer is enabled or disabled. By default disabled.
- CompareOp compareOp = CompareOp::Less

  Specifies the depth test comparison function. By default CompareOp::Less.

10.27.1 Detailed Description

Depth state descriptor structure.

See also

GraphicsPipelineDescriptor::depth

10.27.2 Member Data Documentation

10.27.2.1 CompareOp LLGL::DepthDescriptor::compareOp = CompareOp::Less

Specifies the depth test comparison function. By default CompareOp::Less.

10.27.2.2 bool LLGL::DepthDescriptor::testEnabled = false

Specifies whether the depth test is enabled or disabled. By default disabled.

Remarks

If no pixel shader is used in the graphics pipeline, the depth test must be disabled.

10.27.2.3 bool LLGL::DepthDescriptor::writeEnabled = false

Specifies whether writing to the depth buffer is enabled or disabled. By default disabled.

The documentation for this struct was generated from the following file:

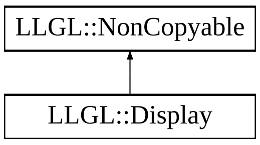
- GraphicsPipelineFlags.h

10.28 LLGL::Display Class Reference

Display interface to query the attributes of all connected displays/monitors.

```
#include <Display.h>
```

Inheritance diagram for LLGL::Display:



Public Member Functions

- virtual bool IsPrimary () const =0

  Returns true if this is the primary display, as configured by the host system.
- virtual std::wstring GetDeviceName () const =0

  Returns the device name of this display. This may also be empty, if the platform does not support display names.
- virtual Offset2D GetOffset () const =0

  Returns the 2D offset relative to the primary display.
- virtual bool ResetDisplayMode ()=0

  Resets the display mode to its default value depending on the host system configuration.
- virtual bool SetDisplayMode (const DisplayModeDescriptor &displayModeDesc)=0

  Sets the new display mode for this display.
- virtual DisplayModeDescriptor GetDisplayMode () const =0

  Returns the current display mode of this display.
- virtual std::vector< DisplayModeDescriptor > QuerySupportedDisplayModes () const =0

  Returns a list of all modes that are supported by this display.

Static Public Member Functions

- static std::vector< std::unique_ptr< Display > > QueryList ()

  Queries the list of all connected displays.
- static std::unique_ptr< Display > QueryPrimary ()

  Queries the primary display.
- static bool ShowCursor (bool show)

  Shows or hides the cursor for the running application from all displays.
- static bool IsCursorShown ()

  Returns true if the cursor is currently being shown on any display.

Static Protected Member Functions

- static void FinalizeDisplayModes (std::vector< DisplayModeDescriptor > &displayModeDescs)

  Sorts the specified list of display modes as described in the QuerySupportedDisplayModes function, and removes duplicate entries.

Additional Inherited Members

10.28.1 Detailed Description

Display interface to query the attributes of all connected displays/monitors.

Remarks

Here is an example to print the attributes of all displays:

```
auto myDisplayList = LLGL::Display::QueryList();
for (const auto& myDisplay : myDisplayList) {
    auto myDisplayOffset = myDisplay->GetOffset();
    auto myDisplayMode   = myDisplay->GetDisplayMode();
    std::wcout << L"Display: \""  << myDisplay->GetDeviceName() << L"\"" << std::endl;
    std::cout << "|-Primary = " << std::boolalpha << myDisplay->IsPrimary() << std::endl;
    std::cout << "|-X       = " << myDisplayOffset.x << std::endl;
    std::cout << "|-Y       = " << myDisplayOffset.y << std::endl;
    std::cout << "|-Width   = " << myDisplayMode.resolution.width << std::endl;
    std::cout << "|-Height  = " << myDisplayMode.resolution.height << std::endl;
    std::cout << "`-Hz      = " << myDisplayMode.refreshRate << std::endl;
}
```

10.28.2 Member Function Documentation

10.28.2.1 static void LLGL::Display::FinalizeDisplayModes (std::vector< DisplayModeDescriptor > & *displayModeDescs*) [static], [protected]

Sorts the specified list of display modes as described in the QuerySupportedDisplayModes function, and removes duplicate entries.

See also

QuerySupportedDisplayModes

10.28.2.2 virtual std::wstring LLGL::Display::GetDeviceName ( ) const [pure virtual]

Returns the device name of this display. This may also be empty, if the platform does not support display names.

10.28.2.3 virtual DisplayModeDescriptor LLGL::Display::GetDisplayMode ( ) const [pure virtual]

Returns the current display mode of this display.

See also

SetDisplayMode

10.28.2.4 virtual Offset2D LLGL::Display::GetOffset ( ) const [pure virtual]

Returns the 2D offset relative to the primary display.

Remarks

This can be used to position your windows accordingly to your displays.

See also

Window::SetPosition

10.28.2.5 static bool LLGL::Display::IsCursorShown ( ) [static]

Returns true if the cursor is currently being shown on any display.

See also

ShowCursor

10.28.2.6 virtual bool LLGL::Display::IsPrimary ( ) const [pure virtual]

Returns true if this is the primary display, as configured by the host system.

10.28.2.7 static std::vector<std::unique_ptr<Display> > LLGL::Display::QueryList ( ) [static]

Queries the list of all connected displays.

10.28.2.8 static std::unique_ptr<Display> LLGL::Display::QueryPrimary ( ) [static]

Queries the primary display.

Returns

Unique pointer to a Display instance that represents the primary display, or null on failure.

10.28.2.9 virtual std::vector<DisplayModeDescriptor> LLGL::Display::QuerySupportedDisplayModes ( ) const [pure virtual]

Returns a list of all modes that are supported by this display.

Remarks

This list is always sorted in the following manner: The first sorting criterion is the number of pixels (resolution width times resolution height) in ascending order, and the second sorting criterion is the refresh rate in ascending order. To get only the currently active display mode, use GetDisplayMode.

See also

GetDisplayMode

10.28.2.10 virtual bool LLGL::Display::ResetDisplayMode ( ) [pure virtual]

Resets the display mode to its default value depending on the host system configuration.

See also

SetDisplayMode

10.28.2.11 virtual bool LLGL::Display::SetDisplayMode (const DisplayModeDescriptor & *displayModeDesc*) [pure virtual]

Sets the new display mode for this display.

Parameters

`in`	*displayModeDesc*	Specifies the descriptor of the new display mode.

Returns

True on success, otherwise the specified display mode is not supported by this display and the function has no effect.

See also

GetDisplayMode

10.28.2.12 static bool LLGL::Display::ShowCursor (bool *show*) `[static]`

Shows or hides the cursor for the running application from all displays.

Parameters

`in`	*show*	Specifies whether to show or hide the cursor.

Remarks

In contrast to the Win32 API, this function only shows or hides the cursor, while the Win32 API function with the same name either increments or decrements an internal visibility counter for the cursor.

Returns

True on success, otherwise cursor visibility changes are not supported.

See also

IsCursorShown

The documentation for this class was generated from the following file:

- Display.h

10.29 LLGL::DisplayModeDescriptor Struct Reference

Display mode descriptor structure.

```
#include <DisplayFlags.h>
```

Public Attributes

- Extent2D resolution

  Display resolution (in pixels).
- std::uint32_t refreshRate = 0

  Display refresh rate (in Hz).

10.29.1 Detailed Description

Display mode descriptor structure.

Remarks

Describes the attributes of a physical display. The counterpart for a virtual video mode is the VideoMode↩ Descriptor structure.

See also

VideoOutputDescriptor::displayModes
VideoModeDescriptor

10.29.2 Member Data Documentation

10.29.2.1 std::uint32_t LLGL::DisplayModeDescriptor::refreshRate = 0

Display refresh rate (in Hz).

10.29.2.2 Extent2D LLGL::DisplayModeDescriptor::resolution

Display resolution (in pixels).

The documentation for this struct was generated from the following file:

- DisplayFlags.h

10.30 LLGL::DstImageDescriptor Struct Reference

Descriptor structure for an image that is used as destination for writing the image data.

```
#include <ImageFlags.h>
```

Public Member Functions

- DstImageDescriptor ()=default
- DstImageDescriptor (const DstImageDescriptor &)=default
- DstImageDescriptor (ImageFormat format, DataType dataType, void ∗data, std::size_t dataSize)

  Constructor to initialize all attributes.

Public Attributes

- ImageFormat format = ImageFormat::RGBA

  Specifies the image format. By default ImageFormat::RGBA.
- DataType dataType = DataType::UInt8

  Specifies the image data type. This must be DataType::UInt8 for compressed images. By default DataType::UInt8.
- void ∗ data = nullptr

  Pointer to the read/write image data.
- std::size_t dataSize = 0

  Specifies the size (in bytes) of the image data. This is primarily used for compressed images and serves for robustness.

10.30.1 Detailed Description

Descriptor structure for an image that is used as destination for writing the image data.

Remarks

This kind of 'Image' is mainly used to fill the image data of a hardware texture.

See also

SrcImageDescriptor
ConvertImageBuffer
RenderSystem::ReadTexture

10.30.2 Constructor & Destructor Documentation

10.30.2.1 LLGL::DstImageDescriptor::DstImageDescriptor ( ) [default]

10.30.2.2 LLGL::DstImageDescriptor::DstImageDescriptor (const DstImageDescriptor &) [default]

10.30.2.3 LLGL::DstImageDescriptor::DstImageDescriptor (ImageFormat *format*, DataType *dataType*, void ∗ *data*, std::size_t *dataSize*) [inline]

Constructor to initialize all attributes.

10.30.3 Member Data Documentation

10.30.3.1 void∗ LLGL::DstImageDescriptor::data = nullptr

Pointer to the read/write image data.

10.30.3.2 std::size_t LLGL::DstImageDescriptor::dataSize = 0

Specifies the size (in bytes) of the image data. This is primarily used for compressed images and serves for robustness.

10.30.3.3 DataType LLGL::DstImageDescriptor::dataType = DataType::UInt8

Specifies the image data type. This must be DataType::UInt8 for compressed images. By default DataType::UInt8.

10.30.3.4 ImageFormat LLGL::DstImageDescriptor::format = ImageFormat::RGBA

Specifies the image format. By default ImageFormat::RGBA.

The documentation for this struct was generated from the following file:

- ImageFlags.h

10.31 LLGL::Canvas::EventListener Class Reference

Interface for all canvas event listeners.

`#include <Canvas.h>`

Public Member Functions

- virtual ∼EventListener ()=default

Protected Member Functions

- virtual void OnProcessEvents (Canvas &sender)

  Send when the canvas events are about to be polled. The event listeners receive this event before the canvas itself.

Friends

- class Canvas

10.31.1 Detailed Description

Interface for all canvas event listeners.

10.31.2 Constructor & Destructor Documentation

10.31.2.1 virtual LLGL::Canvas::EventListener::∼EventListener ( ) `[virtual]`, `[default]`

10.31.3 Member Function Documentation

10.31.3.1 virtual void LLGL::Canvas::EventListener::OnProcessEvents (Canvas & *sender*) `[protected]`, `[virtual]`

Send when the canvas events are about to be polled. The event listeners receive this event before the canvas itself.

See also

Canvas::OnProcessEvents

10.31.4 Friends And Related Function Documentation

10.31.4.1 friend class Canvas `[friend]`

The documentation for this class was generated from the following file:

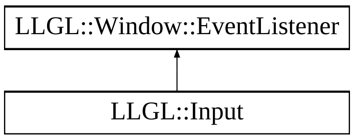
- Canvas.h

10.32 LLGL::Window::EventListener Class Reference

Interface for all window event listeners.

`#include <Window.h>`

Inheritance diagram for LLGL::Window::EventListener:



Public Member Functions

- virtual ∼EventListener ()=default

Protected Member Functions

- virtual void OnProcessEvents (Window &sender)

  Send when the window events are about to be polled. The event listeners receive this event before the window itself.
- virtual void OnKeyDown (Window &sender, Key keyCode)

  Send when a key (from keyboard or mouse) has been pushed.
- virtual void OnKeyUp (Window &sender, Key keyCode)

  Send when a key (from keyboard or mouse) has been released.
- virtual void OnDoubleClick (Window &sender, Key keyCode)

  Send when a mouse button has been double clicked.
- virtual void OnChar (Window &sender, wchar_t chr)

  Send when a character specific key has been typed on the sender window. This will repeat depending on the OS keyboard settings.
- virtual void OnWheelMotion (Window &sender, int motion)

  Send when the mouse wheel has been moved on the sender window.
- virtual void OnLocalMotion (Window &sender, const Offset2D &position)

  Send when the mouse has been moved on the sender window.
- virtual void OnGlobalMotion (Window &sender, const Offset2D &motion)

  Send when the global mouse position has changed. This is a raw input and independent of the screen resolution.
- virtual void OnResize (Window &sender, const Extent2D &clientAreaSize)

  Send when the window has been resized.
- virtual void OnGetFocus (Window &sender)

  Send when the window gets the keyboard focus.
- virtual void OnLoseFocus (Window &sender)

  Send when the window loses the keyboard focus.
- virtual bool OnQuit (Window &sender)

  Send when the window is about to be quit.
- virtual void OnTimer (Window &sender, std::uint32_t timerID)

  Send when the window received a timer event with the specified timer ID number.

Friends

- class Window

10.32.1 Detailed Description

Interface for all window event listeners.

Remarks

This is a design exception compared to most other interfaces in LLGL, because it does not inherit from the NonCopyable interface. This is because there is no hidden implementation, so copying an instance of this interface is allowed.

See also

Input

10.32.2 Constructor & Destructor Documentation

10.32.2.1 virtual LLGL::Window::EventListener::∼EventListener ( ) `[virtual]`, `[default]`

10.32.3 Member Function Documentation

10.32.3.1 virtual void LLGL::Window::EventListener::OnChar (Window & *sender*, wchar_t *chr*) `[protected]`, `[virtual]`

Send when a character specific key has been typed on the sender window. This will repeat depending on the OS keyboard settings.

Reimplemented in LLGL::Input.

10.32.3.2 virtual void LLGL::Window::EventListener::OnDoubleClick (Window & *sender*, Key *keyCode*) `[protected]`, `[virtual]`

Send when a mouse button has been double clicked.

Reimplemented in LLGL::Input.

10.32.3.3 virtual void LLGL::Window::EventListener::OnGetFocus (Window & *sender*) `[protected]`, `[virtual]`

Send when the window gets the keyboard focus.

10.32.3.4 virtual void LLGL::Window::EventListener::OnGlobalMotion (Window & *sender*, const Offset2D & *motion*) `[protected]`, `[virtual]`

Send when the global mouse position has changed. This is a raw input and independent of the screen resolution.

Reimplemented in LLGL::Input.

10.32.3.5 virtual void LLGL::Window::EventListener::OnKeyDown (**Window** & *sender*, **Key** *keyCode*) `[protected]`, `[virtual]`

Send when a key (from keyboard or mouse) has been pushed.

Reimplemented in LLGL::Input.

10.32.3.6 virtual void LLGL::Window::EventListener::OnKeyUp (**Window** & *sender*, **Key** *keyCode*) `[protected]`, `[virtual]`

Send when a key (from keyboard or mouse) has been released.

Reimplemented in LLGL::Input.

10.32.3.7 virtual void LLGL::Window::EventListener::OnLocalMotion (**Window** & *sender*, const **Offset2D** & *position*) `[protected]`, `[virtual]`

Send when the mouse has been moved on the sender window.

Reimplemented in LLGL::Input.

10.32.3.8 virtual void LLGL::Window::EventListener::OnLoseFocus (**Window** & *sender*) `[protected]`, `[virtual]`

Send when the window loses the keyboard focus.

Reimplemented in LLGL::Input.

10.32.3.9 virtual void LLGL::Window::EventListener::OnProcessEvents (**Window** & *sender*) `[protected]`, `[virtual]`

Send when the window events are about to be polled. The event listeners receive this event before the window itself.

See also

Window::OnProcessEvents

Reimplemented in LLGL::Input.

10.32.3.10 virtual bool LLGL::Window::EventListener::OnQuit (**Window** & *sender*) `[protected]`, `[virtual]`

Send when the window is about to be quit.

Returns

True if the sender window can quit. In this case "ProcessEvents" returns false from now on. Otherwise the quit can be prevented. Returns true by default.

See also

Window::ProcessEvents

10.32.3.11 virtual void LLGL::Window::EventListener::OnResize (**Window** & *sender,* const **Extent2D** & *clientAreaSize*) [protected], [virtual]

Send when the window has been resized.

10.32.3.12 virtual void LLGL::Window::EventListener::OnTimer (**Window** & *sender,* std::uint32_t *timerID*) [protected], [virtual]

Send when the window received a timer event with the specified timer ID number.

Note

Only supported on: MS. Windows.

10.32.3.13 virtual void LLGL::Window::EventListener::OnWheelMotion (**Window** & *sender,* int *motion*) [protected], [virtual]

Send when the mouse wheel has been moved on the sender window.

Reimplemented in LLGL::Input.

10.32.4 Friends And Related Function Documentation

10.32.4.1 friend class **Window** [friend]

The documentation for this class was generated from the following file:

- Window.h

10.33 LLGL::Extent2D Struct Reference

2-Dimensional extent structure.

```
#include <Types.h>
```

Public Member Functions

- Extent2D ()=default
- Extent2D (const Extent2D &)=default
- Extent2D (std::uint32_t width, std::uint32_t height)

Public Attributes

- std::uint32_t width = 0

  Extent X axis, i.e. width.
- std::uint32_t height = 0

  Extent Y axis, i.e. height.

10.33.1 Detailed Description

2-Dimensional extent structure.

Remarks

Used for unsigned integral 2D extents (for sizes in window-space, screen-space, and texture-space).

10.33.2 Constructor & Destructor Documentation

10.33.2.1 LLGL::Extent2D::Extent2D ( ) `[default]`

10.33.2.2 LLGL::Extent2D::Extent2D (const Extent2D &) `[default]`

10.33.2.3 LLGL::Extent2D::Extent2D (std::uint32_t *width*, std::uint32_t *height*) `[inline]`

10.33.3 Member Data Documentation

10.33.3.1 std::uint32_t LLGL::Extent2D::height = 0

Extent Y axis, i.e. height.

10.33.3.2 std::uint32_t LLGL::Extent2D::width = 0

Extent X axis, i.e. width.

The documentation for this struct was generated from the following file:

- Types.h

10.34 LLGL::Extent3D Struct Reference

3-Dimensional extent structure.

`#include <Types.h>`

Public Member Functions

- Extent3D ()=default
- Extent3D (const Extent3D &)=default
- Extent3D (std::uint32_t width, std::uint32_t height, std::uint32_t depth)

Public Attributes

- std::uint32_t width = 0

  Extent X axis, i.e. width.
- std::uint32_t height = 0

  Extent Y axis, i.e. height.
- std::uint32_t depth = 0

  Extent Z axis, i.e. depth.

10.34.1 Detailed Description

3-Dimensional extent structure.

Remarks

Used for unsigned integral 3D extents (for sizes in texture-space).

10.34.2 Constructor & Destructor Documentation

10.34.2.1 LLGL::Extent3D::Extent3D ( ) [default]

10.34.2.2 LLGL::Extent3D::Extent3D (const Extent3D &) [default]

10.34.2.3 LLGL::Extent3D::Extent3D (std::uint32_t *width*, std::uint32_t *height*, std::uint32_t *depth*) [inline]

10.34.3 Member Data Documentation

10.34.3.1 std::uint32_t LLGL::Extent3D::depth = 0

Extent Z axis, i.e. depth.

10.34.3.2 std::uint32_t LLGL::Extent3D::height = 0

Extent Y axis, i.e. height.

10.34.3.3 std::uint32_t LLGL::Extent3D::width = 0

Extent X axis, i.e. width.

The documentation for this struct was generated from the following file:

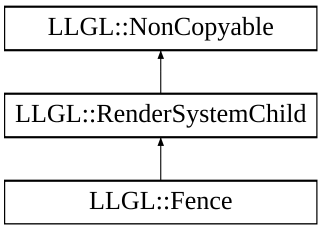
- Types.h

10.35 LLGL::Fence Class Reference

Fence interface for CPU/GPU synchronization.

```
#include <Fence.h>
```

Inheritance diagram for LLGL::Fence:



Additional Inherited Members

10.35.1 Detailed Description

Fence interface for CPU/GPU synchronization.

See also

RenderSystem::CreateFence
CommandQueue::Submit(Fence&)
CommandQueue::WaitFence

The documentation for this class was generated from the following file:

- Fence.h

10.36 LLGL::FrameProfile Struct Reference

Profile of a rendered frame.

```
#include <RenderingProfiler.h>
```

Public Member Functions

- FrameProfile ()
  Default constructor that initializes all counter values to zero.
- void Clear ()
  Clears all counter values.
- void Accumulate (const FrameProfile &rhs)
  Accumulates the specified profile with this profile.

Public Attributes

- union {
  struct {
    std::uint32_t mipMapsGenerations
      Counter for all MIP-map generations.
    std::uint32_t vertexBufferBindings
      Counter for all vertex buffer and vertex buffer array bindings.
    std::uint32_t indexBufferBindings
      Counter for all index buffer bindings.
    std::uint32_t streamOutputBufferBindings
      Counter for all stream-output buffer and stream-output buffer array bindings.
    std::uint32_t constantBufferBindings
      Counter for all individual constant buffer bindings (i.e. without a ResourceHeap).
    std::uint32_t storageBufferBindings
      Counter for all individual storage buffer bindings (i.e. without a ResourceHeap).
    std::uint32_t textureBindings
      Counter for all individual texture bindings (i.e. without a ResourceHeap).
    std::uint32_t samplerBindings
      Counter for all individual sampler bindings (i.e. without a ResourceHeap).
    std::uint32_t graphicsResourceHeapBindings
      Counter for all resource heap bindings on the graphics pipeline.
    std::uint32_t computeResourceHeapBindings
      Counter for all resource heap bindings on the compute pipeline.
    std::uint32_t graphicsPipelineBindings
      Counter for all graphics pipeline bindings.
    std::uint32_t computePipelineBindings
      Counter for all compute pipeline bindings.
    std::uint32_t attachmentClears
      Counter for all framebuffer attachment clear operations.
    std::uint32_t bufferUpdates
      Counter for all buffer updates during command encoding.
    std::uint32_t bufferCopies
      Counter for all buffer copies during command encoding.
    std::uint32_t bufferWrites
      Counter for all buffer write operations outside of command encoding.
    std::uint32_t bufferReads
      Counter for all buffer write operations outside of command encoding.
    std::uint32_t bufferMappings
      Counter for all buffer map/unmap operations outside of command encoding.
    std::uint32_t textureCopies
      Counter for all texture copies during command encoding.
    std::uint32_t textureWrites
      Counter for all texture write operations outside of command encoding.
    std::uint32_t textureReads
      Counter for all texture write operations outside of command encoding.
    std::uint32_t textureMappings
      Counter for all texture write operations outside of command encoding.
    std::uint32_t renderPassSections
      Counter for all command buffer sections that are enclosed by a call to `BeginRenderPass` and `EndRenderPass`.
    std::uint32_t streamOutputSections
      Counter for all command buffer sections that are enclosed by a call to `BeginStreamOutput` and `EndStreamOut`
    std::uint32_t querySections
      Counter for all command buffer sections that are enclosed by a call to `BeginQuery` and `EndQuery`.
    std::uint32_t renderConditionSections
      Counter for all command buffer sections that are enclosed by a call to `BeginRenderCondition` and `EndRender`
    std::uint32_t drawCommands
      Counter for all draw commands.
    std::uint32_t dispatchCommands

Counter for dispatch compute commands.
std::uint32_t commandBufferSubmittions
Counter for all command buffers that were submitted to the queue.
std::uint32_t commandBufferEncodings
Counter for all command buffer encodings that are enclosed by a call to `Begin` and `End`.
std::uint32_t fenceSubmissions
Counter for all fences that were submitted to the queue.
}
std::uint32_t values [31]
All proflile values as linear array.
};

10.36.1 Detailed Description

Profile of a rendered frame.

See also

RenderingProfiler::NextFrame

10.36.2 Constructor & Destructor Documentation

10.36.2.1 LLGL::FrameProfile::FrameProfile ( ) [inline]

Default constructor that initializes all counter values to zero.

10.36.3 Member Function Documentation

10.36.3.1 void LLGL::FrameProfile::Accumulate (const FrameProfile & *rhs*) [inline]

Accumulates the specified profile with this profile.

10.36.3.2 void LLGL::FrameProfile::Clear ( ) [inline]

Clears all counter values.

10.36.4 Member Data Documentation

10.36.4.1 union { ... }

10.36.4.2 std::uint32_t LLGL::FrameProfile::attachmentClears

Counter for all framebuffer attachment clear operations.

See also

CommandBuffer::Clear
CommandBuffer::ClearAttachments

10.36.4.3 std::uint32_t LLGL::FrameProfile::bufferCopies

Counter for all buffer copies during command encoding.

See also

CommandBuffer::CopyBuffer

10.36.4.4 std::uint32_t LLGL::FrameProfile::bufferMappings

Counter for all buffer map/unmap operations outside of command encoding.

See also

RenderSystem::MapBuffer.
RenderSystem::UnmapBuffer.

10.36.4.5 std::uint32_t LLGL::FrameProfile::bufferReads

Counter for all buffer write operations outside of command encoding.

Todo Not available yet.

10.36.4.6 std::uint32_t LLGL::FrameProfile::bufferUpdates

Counter for all buffer updates during command encoding.

See also

CommandBuffer::UpdateBuffer

10.36.4.7 std::uint32_t LLGL::FrameProfile::bufferWrites

Counter for all buffer write operations outside of command encoding.

See also

RenderSystem::WriteBuffer

10.36.4.8 std::uint32_t LLGL::FrameProfile::commandBufferEncodings

Counter for all command buffer encodings that are enclosed by a call to `Begin` and `End`.

See also

CommandBuffer::Begin
CommandBuffer::End

10.36.4.9 std::uint32_t LLGL::FrameProfile::commandBufferSubmittions

Counter for all command buffers that were submitted to the queue.

See also

CommandQueue::Submit(CommandBuffer&)
CommandQueue::Submit(std::uint32_t, CommandBuffer∗ const ∗)

10.36.4.10 std::uint32_t LLGL::FrameProfile::computePipelineBindings

Counter for all compute pipeline bindings.

See also

CommandBuffer::SetComputePipeline

10.36.4.11 std::uint32_t LLGL::FrameProfile::computeResourceHeapBindings

Counter for all resource heap bindings on the compute pipeline.

See also

CommandBuffer::SetComputeResourceHeap

10.36.4.12 std::uint32_t LLGL::FrameProfile::constantBufferBindings

Counter for all individual constant buffer bindings (i.e. without a ResourceHeap).

See also

CommandBufferExt::SetConstantBuffer

10.36.4.13 std::uint32_t LLGL::FrameProfile::dispatchCommands

Counter for dispatch compute commands.

See also

CommandBuffer::Dispatch

10.36.4.14 std::uint32_t LLGL::FrameProfile::drawCommands

Counter for all draw commands.

See also

CommandBuffer::Draw
CommandBuffer::DrawIndexed
CommandBuffer::DrawInstanced
CommandBuffer::DrawIndexedInstanced

10.36.4.15 std::uint32_t LLGL::FrameProfile::fenceSubmissions

Counter for all fences that were submitted to the queue.

See also

CommandQueue::Submit(Fence&)

10.36.4.16 std::uint32_t LLGL::FrameProfile::graphicsPipelineBindings

Counter for all graphics pipeline bindings.

See also

CommandBuffer::SetGraphicsPipeline

10.36.4.17 std::uint32_t LLGL::FrameProfile::graphicsResourceHeapBindings

Counter for all resource heap bindings on the graphics pipeline.

See also

CommandBuffer::SetGraphicsResourceHeap

10.36.4.18 std::uint32_t LLGL::FrameProfile::indexBufferBindings

Counter for all index buffer bindings.

See also

CommandBuffer::SetIndexBuffer

10.36.4.19 std::uint32_t LLGL::FrameProfile::mipMapsGenerations

Counter for all MIP-map generations.

See also

RenderSystem::GenerateMips

10.36.4.20 std::uint32_t LLGL::FrameProfile::querySections

Counter for all command buffer sections that are enclosed by a call to `BeginQuery` and `EndQuery`.

See also

CommandBuffer::BeginQuery
CommandBuffer::EndQuery

10.36.4.21 std::uint32_t LLGL::FrameProfile::renderConditionSections

Counter for all command buffer sections that are enclosed by a call to `BeginRenderCondition` and `End↩RenderCondition`.

See also

CommandBuffer::BeginRenderCondition
CommandBuffer::EndRenderCondition

10.36.4.22 std::uint32_t LLGL::FrameProfile::renderPassSections

Counter for all command buffer sections that are enclosed by a call to `BeginRenderPass` and `EndRender↩Pass`.

See also

CommandBuffer::BeginRenderPass
CommandBuffer::EndRenderPass

10.36.4.23 std::uint32_t LLGL::FrameProfile::samplerBindings

Counter for all individual sampler bindings (i.e. without a ResourceHeap).

See also

CommandBufferExt::SetSampler

10.36.4.24 std::uint32_t LLGL::FrameProfile::storageBufferBindings

Counter for all individual storage buffer bindings (i.e. without a ResourceHeap).

See also

CommandBufferExt::SetStorageBuffer

10.36.4.25 std::uint32_t LLGL::FrameProfile::streamOutputBufferBindings

Counter for all stream-output buffer and stream-output buffer array bindings.

See also

CommandBuffer::SetStreamOutputBuffer
CommandBuffer::SetStreamOutputBufferArray

10.36.4.26 std::uint32_t LLGL::FrameProfile::streamOutputSections

Counter for all command buffer sections that are enclosed by a call to `BeginStreamOutput` and `EndStream←Output`.

See also

CommandBuffer::BeginStreamOutput
CommandBuffer::EndStreamOutput

10.36.4.27 std::uint32_t LLGL::FrameProfile::textureBindings

Counter for all individual texture bindings (i.e. without a ResourceHeap).

See also

CommandBufferExt::SetTexture

10.36.4.28 std::uint32_t LLGL::FrameProfile::textureCopies

Counter for all texture copies during command encoding.

Todo Not available yet.

10.36.4.29 std::uint32_t LLGL::FrameProfile::textureMappings

Counter for all texture write operations outside of command encoding.

Todo Not available yet.

10.36.4.30 std::uint32_t LLGL::FrameProfile::textureReads

Counter for all texture write operations outside of command encoding.

See also

RenderSystem::ReadTexture.

10.36.4.31 std::uint32_t LLGL::FrameProfile::textureWrites

Counter for all texture write operations outside of command encoding.

See also

RenderSystem::WriteTexture.

10.36.4.32 std::uint32_t LLGL::FrameProfile::values[31]

All proflile values as linear array.

10.36.4.33 std::uint32_t LLGL::FrameProfile::vertexBufferBindings

Counter for all vertex buffer and vertex buffer array bindings.

See also

CommandBuffer::SetVertexBuffer
CommandBuffer::SetVertexBufferArray

The documentation for this struct was generated from the following file:

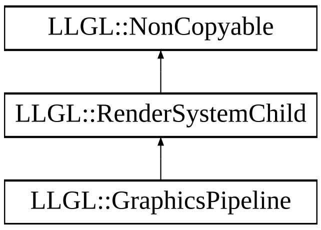
- RenderingProfiler.h

10.37 LLGL::GraphicsPipeline Class Reference

Graphics pipeline interface.

`#include <GraphicsPipeline.h>`

Inheritance diagram for LLGL::GraphicsPipeline:



Additional Inherited Members

10.37.1 Detailed Description

Graphics pipeline interface.

See also

RenderSystem::CreateGraphicsPipeline
CommandBuffer::SetGraphicsPipeline

The documentation for this class was generated from the following file:

- GraphicsPipeline.h

10.38 LLGL::GraphicsPipelineDescriptor Struct Reference

Graphics pipeline descriptor structure.

`#include <GraphicsPipelineFlags.h>`

Public Attributes

- const ShaderProgram ∗ shaderProgram = nullptr

  Pointer to the shader program for the graphics pipeline. By default null.
- const RenderPass ∗ renderPass = nullptr

  Pointer to a RenderPass object. By default null.
- const PipelineLayout ∗ pipelineLayout = nullptr

  Pointer to an optional pipeline layout for the graphics pipeline. By default null.
- PrimitiveTopology primitiveTopology = PrimitiveTopology::TriangleList

  Specifies the primitive topology and ordering of the primitive data. By default PrimitiveTopology::TriangleList.
- std::vector< Viewport > viewports

  Specifies an optional list of viewports. If empty, the viewports must be set dynamically with the command buffer.
- std::vector< Scissor > scissors

  Specifies an optional list of scissor rectangles. If empty, the scissors must be set dynamically with the command buffer.
- DepthDescriptor depth

  Specifies the depth state for the depth-stencil stage.
- StencilDescriptor stencil

  Specifies the stencil state for the depth-stencil stage.
- RasterizerDescriptor rasterizer

  Specifies the state for the rasterizer stage.
- BlendDescriptor blend

  Specifies the state descriptor for the blend stage.

10.38.1 Detailed Description

Graphics pipeline descriptor structure.

Remarks

This structure describes the entire graphics pipeline: shader stages, depth-/ stencil-/ rasterizer-/ blend states etc.

See also

RenderSystem::CreateGraphicsPipeline

10.38.2 Member Data Documentation

10.38.2.1 BlendDescriptor LLGL::GraphicsPipelineDescriptor::blend

Specifies the state descriptor for the blend stage.

10.38.2.2 DepthDescriptor LLGL::GraphicsPipelineDescriptor::depth

Specifies the depth state for the depth-stencil stage.

10.38.2.3 const PipelineLayout∗ LLGL::GraphicsPipelineDescriptor::pipelineLayout = nullptr

Pointer to an optional pipeline layout for the graphics pipeline. By default null.

Remarks

This layout determines at which slots buffer resources can be bound. This is ignored by render systems which do not support pipeline layouts.

10.38.2.4 PrimitiveTopology LLGL::GraphicsPipelineDescriptor::primitiveTopology = PrimitiveTopology::TriangleList

Specifies the primitive topology and ordering of the primitive data. By default PrimitiveTopology::TriangleList.

See also

PrimitiveTopology

10.38.2.5 RasterizerDescriptor LLGL::GraphicsPipelineDescriptor::rasterizer

Specifies the state for the rasterizer stage.

10.38.2.6 const RenderPass∗ LLGL::GraphicsPipelineDescriptor::renderPass = nullptr

Pointer to a RenderPass object. By default null.

Remarks

If this is null, the render pass of the RenderContext that was first created is used. This render pass must be compatible with the one passed to the CommandBuffer::BeginRenderPass function in which the graphics pipeline will be used.

See also

CommandBuffer::BeginRenderPass

10.38.2.7 std::vector<Scissor> LLGL::GraphicsPipelineDescriptor::scissors

Specifies an optional list of scissor rectangles. If empty, the scissors must be set dynamically with the command buffer.

Remarks

This list must have the same number of entries as `viewports`, unless one of the lists is empty.

See also

CommandBuffer::SetScissor
CommandBuffer::SetScissors

10.38.2.8 const ShaderProgram* LLGL::GraphicsPipelineDescriptor::shaderProgram = nullptr

Pointer to the shader program for the graphics pipeline. By default null.

Remarks

This must never be null when RenderSystem::CreateGraphicsPipeline is called with this structure.

See also

RenderSystem::CreateShaderProgram

10.38.2.9 StencilDescriptor LLGL::GraphicsPipelineDescriptor::stencil

Specifies the stencil state for the depth-stencil stage.

10.38.2.10 std::vector<Viewport> LLGL::GraphicsPipelineDescriptor::viewports

Specifies an optional list of viewports. If empty, the viewports must be set dynamically with the command buffer.

Remarks

This list must have the same number of entries as `scissors`, unless one of the lists is empty.

See also

CommandBuffer::SetViewport
CommandBuffer::SetViewports

The documentation for this struct was generated from the following file:

- GraphicsPipelineFlags.h

10.39 LLGL::Image Class Reference

Utility class to manage the storage and attributes of an image.

```
#include <Image.h>
```

Public Member Functions

- Image ()=default
- Image (const Extent3D &extent, const ImageFormat format, const DataType dataType)

  Constructor to initialize the image with a format, data type, and extent.
- Image (const Extent3D &extent, const ImageFormat format, const DataType dataType, const ColorRGBAd &fillColor)

  Constructor to initialize the image with a format, data type, and extent. The image buffer will be filled with the specified color.
- Image (const Extent3D &extent, const ImageFormat format, const DataType dataType, ByteBuffer &&data)

  Constructor to initialize the image with all atributes, including the image buffer specified by the 'data' parameter.
- Image (const Image &rhs)

  Copy constructor which copies the entire image buffer from the specified source image.
- Image (Image &&rhs)

  Move constructor which takes the ownership of the specified source image.
- Image & operator= (const Image &rhs)

  Copy operator which copies the entire image buffer and attributes.
- Image & operator= (Image &&rhs)

  Move operator which takes the ownership of the image buffer.
- void Convert (const ImageFormat format, const DataType dataType, std::size_t threadCount=0)

  Converts the image format and data type.
- void Resize (const Extent3D &extent)

  Resizes the image and resets the image buffer.
- void Resize (const Extent3D &extent, const ColorRGBAd &fillColor)

  Resizes the image and initializes the new pixels with the specified color.
- void Resize (const Extent3D &extent, const ColorRGBAd &fillColor, const Offset3D &offset)

  Resizes the image, moves the previous pixels by an offset, and initializes the new pixels outside the previous extent with the specified color.
- void Resize (const Extent3D &extent, const SamplerFilter filter)

  Resizes the image and resamples the pixels from the previous image buffer.
- void Swap (Image &rhs)

  Swaps all attributes with the specified image.
- void Reset ()

  Resets all image attributes to its default values.
- void Reset (const Extent3D &extent, const ImageFormat format, const DataType dataType, ByteBuffer &&data)

  Resets all image attributes to the specified values.
- ByteBuffer Release ()

  Releases the ownership of the image buffer and resets all attributes.
- void Blit (Offset3D dstRegionOffset, const Image &srcImage, Offset3D srcRegionOffset, Extent3D src←
RegionExtent)

  Copies a region of the specified source image into this image.
- void Fill (Offset3D offset, Extent3D extent, const ColorRGBAd &fillColor)

  Fills a region of this image by the specified color.
- void ReadPixels (const Offset3D &offset, const Extent3D &extent, const DstImageDescriptor &imageDesc, std::size_t threadCount=0) const

  Reads a region of pixels from this image into the destination image buffer specified by 'imageDesc'.
- void WritePixels (const Offset3D &offset, const Extent3D &extent, const SrcImageDescriptor &imageDesc, std::size_t threadCount=0)

  Writes a region of pixels to this image from the source image buffer specified by 'imageDesc'.
- void MirrorYZPlane ()

  Mirrors the image at the YZ plane.

- void MirrorXZPlane ()

  Mirrors the image at the XZ plane.
- void MirrorXYPlane ()

  Mirrors the image at the XY plane.
- SrcImageDescriptor QuerySrcDesc () const

  Returns a source image descriptor for this image with read-only access to the image data.
- DstImageDescriptor QueryDstDesc ()

  Returns a destination image descriptor for this image with read/write access to the image data.
- const Extent3D & GetExtent () const

  Returns the extent of the image as 3D vector.
- ImageFormat GetFormat () const

  Returns the format for each pixel. By default ImageFormat::RGBA.
- DataType GetDataType () const

  Returns the data type for each pixel component. By default DataType::UInt8.
- const void ∗ GetData () const

  Returns the image data buffer as constant raw pointer.
- void ∗ GetData ()

  Returns the image data buffer as raw pointer.
- std::uint32_t GetBytesPerPixel () const

  Returns the size (in bytes) for each pixel.
- std::uint32_t GetRowStride () const

  Returns the stride (in bytes) for each row.
- std::uint32_t GetDepthStride () const

  Returns the stride (in bytes) for each depth slice.
- std::uint32_t GetNumPixels () const

  Returns the number of pixels this image has.
- std::uint32_t GetDataSize () const

  Returns the size (in bytes) of the image buffer.
- bool IsRegionInside (const Offset3D &offset, const Extent3D &extent) const

  Returns true if the specified sub-image region is inside the image.

10.39.1 Detailed Description

Utility class to manage the storage and attributes of an image.

This class is not required for any interaction with the render system. It can be used as utility to handle 2D and 3D image data before passing it to a hardware texture.

Remarks

This class holds the ownership of an image buffer and its attributes. The primary functions are implemented as global functions like `GenerateImageBuffer` for instance.

Note

All image operations of this class do NOT make use of hardware acceleration.

See also

GenerateImageBuffer
ConvertImageBuffer

10.39.2 Constructor & Destructor Documentation

10.39.2.1 LLGL::Image::Image ( ) `[default]`

10.39.2.2 LLGL::Image::Image (const **Extent3D** & *extent*, const **ImageFormat** *format*, const **DataType** *dataType*)

Constructor to initialize the image with a format, data type, and extent.

Note

The image buffer will be uninitialized!

See also

Fill

10.39.2.3 LLGL::Image::Image (const **Extent3D** & *extent*, const **ImageFormat** *format*, const **DataType** *dataType*, const **ColorRGBAd** & *fillColor*)

Constructor to initialize the image with a format, data type, and extent. The image buffer will be filled with the specified color.

See also

GenerateImageBuffer

10.39.2.4 LLGL::Image::Image (const **Extent3D** & *extent*, const **ImageFormat** *format*, const **DataType** *dataType*, **ByteBuffer** && *data*)

Constructor to initialize the image with all atributes, including the image buffer specified by the 'data' parameter.

Note

If the specified data does not manage an image buffer of the specified extent and format, the behavior is undefined.

See also

Reset(const Extent3D&, const ImageFormat, const DataType, ByteBuffer&&)

10.39.2.5 LLGL::Image::Image (const **Image** & *rhs*)

Copy constructor which copies the entire image buffer from the specified source image.

10.39.2.6 LLGL::Image::Image (**Image** && *rhs*)

Move constructor which takes the ownership of the specified source image.

10.39.3 Member Function Documentation

10.39.3.1 void LLGL::Image::Blit (**Offset3D** *dstRegionOffset*, const **Image** & *srcImage*, **Offset3D** *srcRegionOffset*, **Extent3D** *srcRegionExtent*)

Copies a region of the specified source image into this image.

Parameters

in	*dstRegionOffset*	Specifies the offset within the destination image (i.e. this Image instance). This can also be outside of the image area.
in	*srcImage*	Specifies the source image whose region is to be copied. This must have the same format and data type as this image. If the source image is the same object as this image and the destination and source regions overlap, an internal temporary copy is allocated for reading the data.
in	*srcRegionOffset*	Specifies the offset within the source image. This will be clamped if it exceeds the source image area.
in	*srcRegionExtent*	Specifies the extent of the region to copy. This will be clamped if it exceeds the source or destination image area.

Remarks

If one of the region offsets is clamped, the region extent will be adjusted respectively. If the source image has a different format or data type compared to this image, the function has no effect.

See also

ConvertImageBuffer

10.39.3.2 void LLGL::Image::Convert (const ImageFormat *format*, const DataType *dataType*, std::size_t *threadCount* = `0`)

Converts the image format and data type.

See also

ConvertImageBuffer

10.39.3.3 void LLGL::Image::Fill (Offset3D *offset*, Extent3D *extent*, const ColorRGBAd & *fillColor*)

Fills a region of this image by the specified color.

Parameters

in	*offset*	Specifies the offset where the region begins.
in	*extent*	Specifies the extent of the region.
in	*fillColor*	Specifies the color to fill the region with.

Todo Not implemented yet.

10.39.3.4 std::uint32_t LLGL::Image::GetBytesPerPixel ( ) const

Returns the size (in bytes) for each pixel.

See also

GetFormat
ImageFormatSize
GetDataType
DataTypeSize

10.39.3.5 const void* LLGL::Image::GetData ( ) const [inline]

Returns the image data buffer as constant raw pointer.

10.39.3.6 void* LLGL::Image::GetData ( ) [inline]

Returns the image data buffer as raw pointer.

10.39.3.7 std::uint32_t LLGL::Image::GetDataSize ( ) const

Returns the size (in bytes) of the image buffer.

See also

GetBytesPerPixel
GetNumPixels

10.39.3.8 DataType LLGL::Image::GetDataType ( ) const [inline]

Returns the data type for each pixel component. By default DataType::UInt8.

10.39.3.9 std::uint32_t LLGL::Image::GetDepthStride ( ) const

Returns the stride (in bytes) for each depth slice.

10.39.3.10 const Extent3D& LLGL::Image::GetExtent ( ) const [inline]

Returns the extent of the image as 3D vector.

10.39.3.11 ImageFormat LLGL::Image::GetFormat ( ) const [inline]

Returns the format for each pixel. By default ImageFormat::RGBA.

10.39.3.12 std::uint32_t LLGL::Image::GetNumPixels ( ) const

Returns the number of pixels this image has.

Remarks

This is equivalent to the following code example:

```
const auto& extent = myImage.GetExtent();
return extent.width * extent.height * extent.depth;
```

See also

GetExtent

10.39.3.13 std::uint32_t LLGL::Image::GetRowStride ( ) const

Returns the stride (in bytes) for each row.

10.39.3.14 bool LLGL::Image::IsRegionInside (const Offset3D & *offset,* const Extent3D & *extent*) const

Returns true if the specified sub-image region is inside the image.

10.39.3.15 void LLGL::Image::MirrorXYPlane ( )

Mirrors the image at the XY plane.

Todo Not implemented yet

10.39.3.16 void LLGL::Image::MirrorXZPlane ( )

Mirrors the image at the XZ plane.

Todo Not implemented yet

10.39.3.17 void LLGL::Image::MirrorYZPlane ( )

Mirrors the image at the YZ plane.

Todo Not implemented yet

10.39.3.18 Image& LLGL::Image::operator= (const Image & *rhs*)

Copy operator which copies the entire image buffer and attributes.

10.39.3.19 Image& LLGL::Image::operator= (Image && *rhs*)

Move operator which takes the ownership of the image buffer.

10.39.3.20 DstImageDescriptor LLGL::Image::QueryDstDesc ( )

Returns a destination image descriptor for this image with read/write access to the image data.

10.39.3.21 SrcImageDescriptor LLGL::Image::QuerySrcDesc ( ) const

Returns a source image descriptor for this image with read-only access to the image data.

10.39.3.22 void LLGL::Image::ReadPixels (const Offset3D & *offset,* const Extent3D & *extent,* const DstImageDescriptor & *imageDesc,* std::size_t *threadCount* = 0) const

Reads a region of pixels from this image into the destination image buffer specified by 'imageDesc'.

Parameters

in	*offset*	Specifies the region offset within this image to read from.
in	*extent*	Specifies the region extent within this image to read from.
in	*imageDesc*	Specifies the destination image descriptor to write the region to. If the 'data' member of this descriptor is null or if the sub-image region is not inside the image, this function has no effect.
in	*threadCount*	Specifies the number of threads to use if the data needs to be converted (see ConvertImageBuffer for more details). By default 0.

Remarks

To read a single pixel, use the following code example:

```
LLGL::ColorRGBAub ReadSinglePixelRGBAub(const LLGL::Image& image, const
      LLGL::Offset3D& position) {
    LLGL::ColorRGBAub pixelColor;
    const DstImageDescriptor imageDesc { LLGL::ImageFormat::RGBA,
      LLGL::DataType::UInt8, &pixelColor, sizeof(pixelColor) };
    image.ReadPixels(position, { 1, 1, 1 }, imageDesc);
    return pixelColor;
}
```

Exceptions

std::invalid_argument	If the 'data' member of the image descriptor is non-null, the sub-image region is inside the image, but the 'dataSize' member of the image descriptor is too small.

See also

IsRegionInside
ConvertImageBuffer

10.39.3.23 ByteBuffer LLGL::Image::Release ( )

Releases the ownership of the image buffer and resets all attributes.

10.39.3.24 void LLGL::Image::Reset ( )

Resets all image attributes to its default values.

10.39.3.25 void LLGL::Image::Reset (const Extent3D & *extent,* const ImageFormat *format,* const DataType *dataType,* ByteBuffer && *data*)

Resets all image attributes to the specified values.

Note

If the specified data does not manage an image buffer of the specified extent and format, the behavior is undefined.

See also

GenerateImageBuffer
GenerateEmptyByteBuffer

10.39.3.26 void LLGL::Image::Resize (const Extent3D & *extent*)

Resizes the image and resets the image buffer.

Parameters

`in`	*extent*	Specifies the new image size.

Note

The new image buffer will be uninitialized!

10.39.3.27 void LLGL::Image::Resize (const Extent3D & *extent,* const ColorRGBAd & *fillColor*)

Resizes the image and initializes the new pixels with the specified color.

Parameters

in	*extent*	Specifies the new image size.
in	*fillColor*	Specifies the color to fill the pixels with. GenerateImageBuffer

10.39.3.28 void LLGL::Image::Resize (const Extent3D & *extent*, const ColorRGBAd & *fillColor*, const Offset3D & *offset*)

Resizes the image, moves the previous pixels by an offset, and initializes the new pixels outside the previous extent with the specified color.

Parameters

in	*extent*	Specifies the new image size.
in	*fillColor*	Specifies the color to fill the pixels with that are outside the previous extent.
in	*offset*	Specifies the offset to move the previous pixels to. This will be clamped if it exceeds the image area. GenerateImageBuffer

10.39.3.29 void LLGL::Image::Resize (const Extent3D & *extent*, const SamplerFilter *filter*)

Resizes the image and resamples the pixels from the previous image buffer.

Parameters

in	*extent*	Specifies the new image size.
in	*filter*	Specifies the sampling filter. GenerateImageBuffer

Todo Not implemented yet.

10.39.3.30 void LLGL::Image::Swap (Image & *rhs*)

Swaps all attributes with the specified image.

10.39.3.31 void LLGL::Image::WritePixels (const Offset3D & *offset*, const Extent3D & *extent*, const SrcImageDescriptor & *imageDesc*, std::size_t *threadCount* = 0)

Writes a region of pixels to this image from the source image buffer specified by 'imageDesc'.

Parameters

in	*offset*	Specifies the region offset within this image to write to.
in	*extent*	Specifies the region extent within this image to write to.
in	*imageDesc*	Specifies the source image descriptor to read the region from. If the 'data' member of this descriptor is null or if the sub-image region is not inside the image, this function has no effect.
in	*threadCount*	Specifies the number of threads to use if the data needs to be converted (see ConvertImageBuffer for more details). By default 0.

See also

IsRegionInside
ConvertImageBuffer

The documentation for this class was generated from the following file:

- Image.h

10.40 LLGL::ImageInitialization Struct Reference

Structure of image initialization for textures without initial image data.

```
#include <RenderSystemFlags.h>
```

Public Attributes

- bool enabled = true

  Enables or disables the default initialization of texture images. By default true.
- ClearValue clearValue

  Specifies the default value to clear uninitialized textures.

10.40.1 Detailed Description

Structure of image initialization for textures without initial image data.

10.40.2 Member Data Documentation

10.40.2.1 ClearValue LLGL::ImageInitialization::clearValue

Specifies the default value to clear uninitialized textures.

Todo Currently only supports initialization of color and depth. Default initialization of stencil values is not supported yet.

10.40.2.2 bool LLGL::ImageInitialization::enabled = true

Enables or disables the default initialization of texture images. By default true.

Remarks

This will be used when a texture is created and no initial image data is specified. If this is false and a texture is created without initial image data, the texture remains uninitialized.

Note

Reading or sampling uninitialized textures is undefined behavior.

The documentation for this struct was generated from the following file:

- RenderSystemFlags.h

10.41 LLGL::BufferDescriptor::IndexBuffer Struct Reference

Index buffer specific descriptor structure.

```
#include <BufferFlags.h>
```

Public Attributes

- IndexFormat format

  Specifies the index format layout, which is basically only the data type of each index.

10.41.1 Detailed Description

Index buffer specific descriptor structure.

10.41.2 Member Data Documentation

10.41.2.1 IndexFormat LLGL::BufferDescriptor::IndexBuffer::format

Specifies the index format layout, which is basically only the data type of each index.

Remarks

The only valid format types for an index buffer are: DataType::UByte, DataType::UShort, and DataType::UInt.

See also

DataType

The documentation for this struct was generated from the following file:

- BufferFlags.h

10.42 LLGL::IndexFormat Class Reference

Index buffer format class.

```
#include <IndexFormat.h>
```

Public Member Functions

- IndexFormat ()=default
- IndexFormat (const IndexFormat &)=default
- IndexFormat & operator= (const IndexFormat &)=default
- IndexFormat (const DataType dataType)

    Constructor to initialize the index format with the specified data type.
- DataType GetDataType () const

    Returns the data type of this index format.
- std::uint32_t GetFormatSize () const

    Returns the size of this vertex format (in bytes).

10.42.1 Detailed Description

Index buffer format class.

See also

BufferDescriptor::IndexBuffer

10.42.2 Constructor & Destructor Documentation

10.42.2.1 LLGL::IndexFormat::IndexFormat ( ) [default]

10.42.2.2 LLGL::IndexFormat::IndexFormat (const IndexFormat &) [default]

10.42.2.3 LLGL::IndexFormat::IndexFormat (const DataType *dataType*)

Constructor to initialize the index format with the specified data type.

Remarks

This will automatically determine the format size.

See also

GetFormatSize

10.42.3 Member Function Documentation

10.42.3.1 DataType LLGL::IndexFormat::GetDataType ( ) const [inline]

Returns the data type of this index format.

10.42.3.2 std::uint32_t LLGL::IndexFormat::GetFormatSize ( ) const [inline]

Returns the size of this vertex format (in bytes).

10.42.3.3 IndexFormat& LLGL::IndexFormat::operator= (const IndexFormat &) [default]

The documentation for this class was generated from the following file:

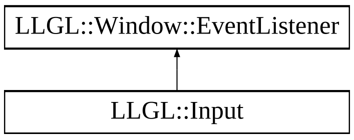
- IndexFormat.h

10.43 LLGL::Input Class Reference

Default window event listener to receive user input.

`#include <Input.h>`

Inheritance diagram for LLGL::Input:



Public Member Functions

- Input ()
- bool KeyPressed (Key keyCode) const

  Returns true if the specified key is currently being pressed down.
- bool KeyDown (Key keyCode) const

  Returns true if the specified key was pressed down in the previous event processing.
- bool KeyDownRepeated (Key keyCode) const

  Returns true if the specified key was pressed down in the previous event processing (this event will be repeated, depending on the paltform settings).
- bool KeyUp (Key keyCode) const

  Returns true if the specified key was released in the previous event processing.
- bool KeyDoubleClick (Key keyCode) const

  Returns true if the specified key was double clicked.
- const Offset2D & GetMousePosition () const

  Returns the local mouse position.
- const Offset2D & GetMouseMotion () const

  Returns the global mouse motion.
- int GetWheelMotion () const

  Returns the mouse wheel motion.
- const std::wstring & GetEnteredChars () const

  Returns the entered characters.
- std::size_t GetAnyKeyCount () const

  Returns the number of any keys being pressed.

Protected Member Functions

- void OnProcessEvents (Window &sender) override

  Send when the window events are about to be polled. The event listeners receive this event before the window itself.
- void OnKeyDown (Window &sender, Key keyCode) override

  Send when a key (from keyboard or mouse) has been pushed.
- void OnKeyUp (Window &sender, Key keyCode) override

  Send when a key (from keyboard or mouse) has been released.
- void OnDoubleClick (Window &sender, Key keyCode) override

  Send when a mouse button has been double clicked.
- void OnChar (Window &sender, wchar_t chr) override

  Send when a character specific key has been typed on the sender window. This will repeat depending on the OS keyboard settings.
- void OnWheelMotion (Window &sender, int motion) override

  Send when the mouse wheel has been moved on the sender window.
- void OnLocalMotion (Window &sender, const Offset2D &position) override

  Send when the mouse has been moved on the sender window.
- void OnGlobalMotion (Window &sender, const Offset2D &motion) override

  Send when the global mouse position has changed. This is a raw input and independent of the screen resolution.
- void OnLoseFocus (Window &sender) override

  Send when the window loses the keyboard focus.

10.43.1 Detailed Description

Default window event listener to receive user input.

Remarks

This class stores all received user input for a simple evaluation. However, for efficient evaluation, write your own sub class and only respond to user input when the appropriate callback is invoked. Here is an example usage:

```
auto myInput = std::make_shared<LLGL::Input>();
myWindow->AddEventListener(myInput);
while (myWindow->ProcessEvents()) {
    // Quit main loop when user hit the escape key.
    if (myInput->KeyDown(LLGL::Key::Escape))
        break;

    // Rendering goes here ...
}
```

10.43.2 Constructor & Destructor Documentation

10.43.2.1 LLGL::Input::Input ( )

10.43.3 Member Function Documentation

10.43.3.1 std::size_t LLGL::Input::GetAnyKeyCount ( ) const [inline]

Returns the number of any keys being pressed.

10.43.3.2 const std::wstring& LLGL::Input::GetEnteredChars ( ) const [inline]

Returns the entered characters.

10.43.3.3 const Offset2D& LLGL::Input::GetMouseMotion ( ) const [inline]

Returns the global mouse motion.

10.43.3.4 const Offset2D& LLGL::Input::GetMousePosition ( ) const [inline]

Returns the local mouse position.

10.43.3.5 int LLGL::Input::GetWheelMotion ( ) const [inline]

Returns the mouse wheel motion.

10.43.3.6 bool LLGL::Input::KeyDoubleClick (Key *keyCode*) const

Returns true if the specified key was double clicked.

Remarks

This can only be true for the key codes: Key::LButton, Key::RButton, and Key::MButton.

10.43.3.7 bool LLGL::Input::KeyDown (Key *keyCode*) const

Returns true if the specified key was pressed down in the previous event processing.

10.43.3.8 bool LLGL::Input::KeyDownRepeated (Key *keyCode*) const

Returns true if the specified key was pressed down in the previous event processing (this event will be repeated, depending on the paltform settings).

10.43.3.9 bool LLGL::Input::KeyPressed (Key *keyCode*) const

Returns true if the specified key is currently being pressed down.

10.43.3.10 bool LLGL::Input::KeyUp (Key *keyCode*) const

Returns true if the specified key was released in the previous event processing.

10.43.3.11 void LLGL::Input::OnChar (Window & *sender*, wchar_t *chr*) [override], [protected], [virtual]

Send when a character specific key has been typed on the sender window. This will repeat depending on the OS keyboard settings.

Reimplemented from LLGL::Window::EventListener.

10.43.3.12 void LLGL::Input::OnDoubleClick (Window & *sender*, Key *keyCode*) [override], [protected], [virtual]

Send when a mouse button has been double clicked.

Reimplemented from LLGL::Window::EventListener.

10.43.3.13 void LLGL::Input::OnGlobalMotion (Window & *sender*, const Offset2D & *motion*) [override], [protected], [virtual]

Send when the global mouse position has changed. This is a raw input and independent of the screen resolution.

Reimplemented from LLGL::Window::EventListener.

10.43.3.14 void LLGL::Input::OnKeyDown (Window & *sender*, Key *keyCode*) [override], [protected], [virtual]

Send when a key (from keyboard or mouse) has been pushed.

Reimplemented from LLGL::Window::EventListener.

10.43.3.15 void LLGL::Input::OnKeyUp (Window & *sender*, Key *keyCode*) [override], [protected], [virtual]

Send when a key (from keyboard or mouse) has been released.

Reimplemented from LLGL::Window::EventListener.

10.43.3.16 void LLGL::Input::OnLocalMotion (Window & *sender*, const Offset2D & *position*) [override], [protected], [virtual]

Send when the mouse has been moved on the sender window.

Reimplemented from LLGL::Window::EventListener.

10.43.3.17 void LLGL::Input::OnLoseFocus (Window & *sender*) [override], [protected], [virtual]

Send when the window loses the keyboard focus.

Reimplemented from LLGL::Window::EventListener.

10.43.3.18 void LLGL::Input::OnProcessEvents (Window & *sender*) [override], [protected], [virtual]

Send when the window events are about to be polled. The event listeners receive this event before the window itself.

See also

Window::OnProcessEvents

Reimplemented from LLGL::Window::EventListener.

10.43.3.19 void LLGL::Input::OnWheelMotion (Window & *sender,* int *motion*) [override], [protected], [virtual]

Send when the mouse wheel has been moved on the sender window.

Reimplemented from LLGL::Window::EventListener.

The documentation for this class was generated from the following file:

- Input.h

10.44 LLGL::RenderingDebugger::Message Class Reference

Rendering debugger message class.

```
#include <RenderingDebugger.h>
```

Public Member Functions

- Message ()=default
- Message (const Message &)=default
- Message & operator= (const Message &)=default
- Message (const std::string &text, const std::string &source)
- void Block ()

  Blocks further occurrences of this message.
- void BlockAfter (std::size_t occurrences)

  Blocks further occurrences of this message after the specified amount of messages have been occurred.
- const std::string & GetText () const

  Returns the message text.
- const std::string & GetSource () const

  Returns the source function where this message occurred.
- std::size_t GetOccurrences () const

  Returns the number of occurrences of this message.
- bool IsBlocked () const

  Returns true if this message has already been blocked.

Protected Member Functions

- void IncOccurrence ()

Friends

- class RenderingDebugger

10.44.1 Detailed Description

Rendering debugger message class.

10.44.2 Constructor & Destructor Documentation

10.44.2.1 LLGL::RenderingDebugger::Message::Message ( ) `[default]`

10.44.2.2 LLGL::RenderingDebugger::Message::Message (const Message &) `[default]`

10.44.2.3 LLGL::RenderingDebugger::Message::Message (const std::string & *text*, const std::string & *source*)

10.44.3 Member Function Documentation

10.44.3.1 void LLGL::RenderingDebugger::Message::Block ( )

Blocks further occurrences of this message.

10.44.3.2 void LLGL::RenderingDebugger::Message::BlockAfter (std::size_t *occurrences*)

Blocks further occurrences of this message after the specified amount of messages have been occurred.

10.44.3.3 std::size_t LLGL::RenderingDebugger::Message::GetOccurrences ( ) const `[inline]`

Returns the number of occurrences of this message.

10.44.3.4 const std::string& LLGL::RenderingDebugger::Message::GetSource ( ) const `[inline]`

Returns the source function where this message occurred.

10.44.3.5 const std::string& LLGL::RenderingDebugger::Message::GetText ( ) const `[inline]`

Returns the message text.

10.44.3.6 void LLGL::RenderingDebugger::Message::IncOccurrence ( ) [protected]

10.44.3.7 bool LLGL::RenderingDebugger::Message::IsBlocked ( ) const [inline]

Returns true if this message has already been blocked.

10.44.3.8 Message& LLGL::RenderingDebugger::Message::operator= (const Message &) [default]

10.44.4 Friends And Related Function Documentation

10.44.4.1 friend class RenderingDebugger [friend]

The documentation for this class was generated from the following file:

- RenderingDebugger.h

10.45 LLGL::MultiSamplingDescriptor Struct Reference

Multi-sampling descriptor structure.

`#include <GraphicsPipelineFlags.h>`

Public Member Functions

- MultiSamplingDescriptor ()=default
- MultiSamplingDescriptor (std::uint32_t samples, std::uint32_t sampleMask=∼0)

  Constructor to initialize the sample.
- std::uint32_t SampleCount () const

  Returns the sample count for the state of this multi-sampling descriptor.

Public Attributes

- bool enabled = false

  Specifies whether multi-sampling is enabled or disabled. By default disabled.
- std::uint32_t samples = 1

  Number of samples used for multi-sampling. By default 1.
- std::uint32_t sampleMask = ∼0

  Specifies the bitmask for sample coverage. By default `0xFFFFFFFF`.

10.45.1 Detailed Description

Multi-sampling descriptor structure.

See also

RasterizerDescriptor::multiSampling

10.45.2 Constructor & Destructor Documentation

10.45.2.1 LLGL::MultiSamplingDescriptor::MultiSamplingDescriptor ( ) [default]

10.45.2.2 LLGL::MultiSamplingDescriptor::MultiSamplingDescriptor (std::uint32_t *samples*, std::uint32_t *sampleMask* = ∼0) [inline]

Constructor to initialize the sample.

Parameters

`in`	*samples*	Specifies the number of samples used for multi-sampling. If this is greater than 1, multi-sampling is enabled.
`in`	*sampleMask*	Specifies the bitmask for sample coverage.

10.45.3 Member Function Documentation

10.45.3.1 std::uint32_t LLGL::MultiSamplingDescriptor::SampleCount ( ) const `[inline]`

Returns the sample count for the state of this multi-sampling descriptor.

Returns

`max{ 1, samples }` if multi-sampling is enabled, otherwise 1.

10.45.4 Member Data Documentation

10.45.4.1 bool LLGL::MultiSamplingDescriptor::enabled = false

Specifies whether multi-sampling is enabled or disabled. By default disabled.

10.45.4.2 std::uint32_t LLGL::MultiSamplingDescriptor::sampleMask = ∼0

Specifies the bitmask for sample coverage. By default `0xFFFFFFFF`.

10.45.4.3 std::uint32_t LLGL::MultiSamplingDescriptor::samples = 1

Number of samples used for multi-sampling. By default 1.

Remarks

The equivalent member for multi-sampled textures is TextureDescriptor::samples.

See also

TextureDescriptor::samples

The documentation for this struct was generated from the following file:

- GraphicsPipelineFlags.h

10.46 LLGL::NativeContextHandle Struct Reference

iOS native context handle structure.

`#include <IOSNativeHandle.h>`

Public Attributes

- UIView ∗ parentView
- ::Display ∗ display
- ::Window parentWindow
- ::XVisualInfo ∗ visual
- ::Colormap colorMap
- int screen
- NSWindow ∗ parentWindow
- HWND parentWindow

10.46.1 Detailed Description

iOS native context handle structure.

Win32 native context handle structure.

MacOS native context handle structure.

Linux native context handle structure.

Remarks

This must be a POD (Plain-Old-Data) structure, so no default initialization is provided!

10.46.2 Member Data Documentation

10.46.2.1 ::Colormap LLGL::NativeContextHandle::colorMap

10.46.2.2 ::Display∗ LLGL::NativeContextHandle::display

10.46.2.3 UIView∗ LLGL::NativeContextHandle::parentView

10.46.2.4 NSWindow∗ LLGL::NativeContextHandle::parentWindow

10.46.2.5 ::Window LLGL::NativeContextHandle::parentWindow

10.46.2.6 HWND LLGL::NativeContextHandle::parentWindow

10.46.2.7 int LLGL::NativeContextHandle::screen

10.46.2.8 ::XVisualInfo∗ LLGL::NativeContextHandle::visual

The documentation for this struct was generated from the following files:

- IOSNativeHandle.h
- LinuxNativeHandle.h
- MacOSNativeHandle.h
- Win32NativeHandle.h

10.47 LLGL::NativeHandle Struct Reference

iOS native handle structure.

```
#include <IOSNativeHandle.h>
```

Public Attributes

- UIView ∗ view
- ::Display ∗ display
- ::Window window
- ::XVisualInfo ∗ visual
- NSWindow ∗ window
- HWND window

10.47.1 Detailed Description

iOS native handle structure.

Win32 native handle structure.

MacOS native handle structure.

Linux native handle structure.

Remarks

This must be a POD (Plain-Old-Data) structure, so no default initialization is provided!

10.47.2 Member Data Documentation

10.47.2.1 ::Display∗ LLGL::NativeHandle::display

10.47.2.2 UIView∗ LLGL::NativeHandle::view

10.47.2.3 ::XVisualInfo∗ LLGL::NativeHandle::visual

10.47.2.4 NSWindow∗ LLGL::NativeHandle::window

10.47.2.5 ::Window LLGL::NativeHandle::window

10.47.2.6 HWND LLGL::NativeHandle::window

The documentation for this struct was generated from the following files:

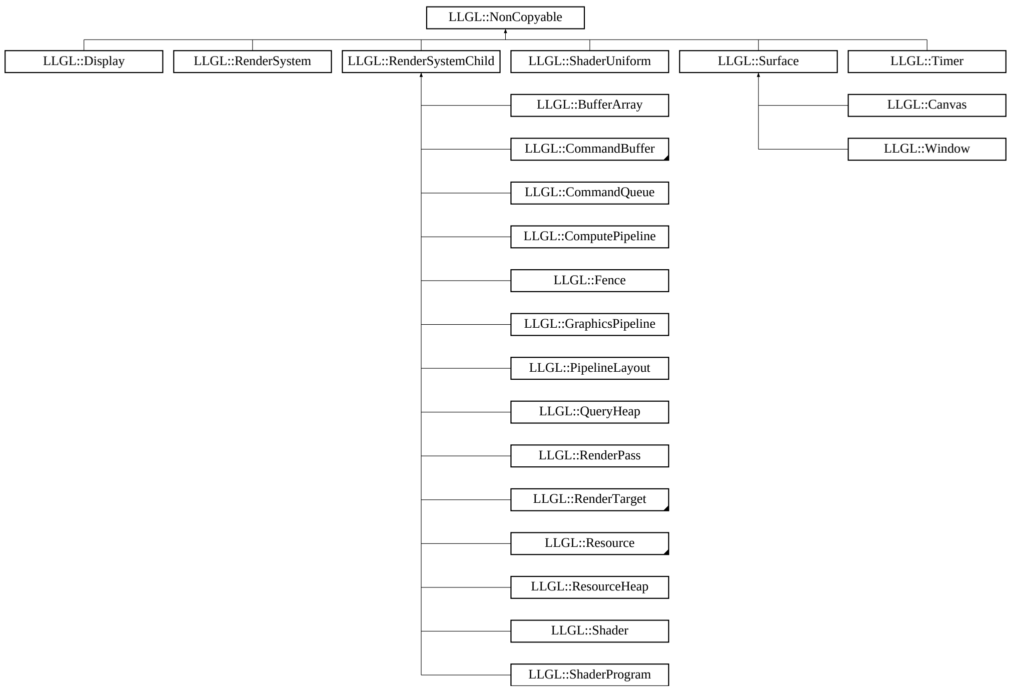
- IOSNativeHandle.h
- LinuxNativeHandle.h
- MacOSNativeHandle.h
- Win32NativeHandle.h

10.48 LLGL::NonCopyable Class Reference

Base class for all interfaces in LLGL.

`#include <NonCopyable.h>`

Inheritance diagram for LLGL::NonCopyable:



Public Member Functions

- NonCopyable (const NonCopyable &)=delete
- NonCopyable & operator= (const NonCopyable &)=delete
- virtual ∼NonCopyable ()=default

Protected Member Functions

- NonCopyable ()=default

10.48.1 Detailed Description

Base class for all interfaces in LLGL.

Remarks

Sub classes of this interface cannot be copied on its own, since its copy constructor and copy operator are deleted functions.

See also

Display
RenderSystem
RenderSystemChild
ShaderUniform
Surface
Timer

10.48.2 Constructor & Destructor Documentation

10.48.2.1 LLGL::NonCopyable::NonCopyable (const NonCopyable &) `[delete]`

10.48.2.2 virtual LLGL::NonCopyable::∼NonCopyable ( ) `[virtual], [default]`

10.48.2.3 LLGL::NonCopyable::NonCopyable ( ) `[protected], [default]`

10.48.3 Member Function Documentation

10.48.3.1 NonCopyable& LLGL::NonCopyable::operator= (const NonCopyable &) `[delete]`

The documentation for this class was generated from the following file:

- NonCopyable.h

10.49 LLGL::Offset2D Struct Reference

2-Dimensional offset structure.

`#include <Types.h>`

Public Member Functions

- Offset2D ()=default
- Offset2D (const Offset2D &)=default
- Offset2D (std::int32_t x, std::int32_t y)

Public Attributes

- std::int32_t x = 0

  Offset X axis.
- std::int32_t y = 0

  Offset Y axis.

10.49.1 Detailed Description

2-Dimensional offset structure.

Remarks

Used for signed integral 2D offsets (for coordinates in window-space, screen-space, and texture-space).

10.49.2 Constructor & Destructor Documentation

10.49.2.1 LLGL::Offset2D::Offset2D ( ) [default]

10.49.2.2 LLGL::Offset2D::Offset2D (const Offset2D &) [default]

10.49.2.3 LLGL::Offset2D::Offset2D (std::int32_t *x*, std::int32_t *y*) [inline]

10.49.3 Member Data Documentation

10.49.3.1 std::int32_t LLGL::Offset2D::x = 0

Offset X axis.

10.49.3.2 std::int32_t LLGL::Offset2D::y = 0

Offset Y axis.

The documentation for this struct was generated from the following file:

- Types.h

10.50 LLGL::Offset3D Struct Reference

3-Dimensional offset structure.

`#include <Types.h>`

Public Member Functions

- Offset3D ()=default
- Offset3D (const Offset3D &)=default
- Offset3D (std::int32_t x, std::int32_t y, std::int32_t z)

Public Attributes

- std::int32_t x = 0

  Offset X axis.
- std::int32_t y = 0

  Offset Y axis.
- std::int32_t z = 0

  Offset Z axis.

10.50.1 Detailed Description

3-Dimensional offset structure.

Remarks

Used for signed integral 3D offsets (for coordinates in texture-space).

10.50.2 Constructor & Destructor Documentation

10.50.2.1 LLGL::Offset3D::Offset3D ( ) `[default]`

10.50.2.2 LLGL::Offset3D::Offset3D (const Offset3D &) `[default]`

10.50.2.3 LLGL::Offset3D::Offset3D (std::int32_t *x*, std::int32_t *y*, std::int32_t *z*) `[inline]`

10.50.3 Member Data Documentation

10.50.3.1 std::int32_t LLGL::Offset3D::x = 0

Offset X axis.

10.50.3.2 std::int32_t LLGL::Offset3D::y = 0

Offset Y axis.

10.50.3.3 std::int32_t LLGL::Offset3D::z = 0

Offset Z axis.

The documentation for this struct was generated from the following file:

- Types.h

10.51 LLGL::OpenGLDependentStateDescriptor Struct Reference

Graphics API dependent state descriptor for the OpenGL renderer.

```
#include <CommandBufferFlags.h>
```

Public Attributes

- bool originLowerLeft = false

  Specifies whether the screen-space origin is on the lower-left. By default false.
- bool invertFrontFace = false

  Specifies whether to invert front-facing. By default false.

10.51.1 Detailed Description

Graphics API dependent state descriptor for the OpenGL renderer.

Remarks

This descriptor is used to compensate a few differences between OpenGL and the other rendering APIs.

See also

RenderContext::SetGraphicsAPIDependentState

10.51.2 Member Data Documentation

10.51.2.1 bool LLGL::OpenGLDependentStateDescriptor::invertFrontFace = false

Specifies whether to invert front-facing. By default false.

Remarks

If this is true, the front facing (either GL_CW or GL_CCW) will be inverted, i.e. CCW becomes CW, and CW becomes CCW.

10.51.2.2 bool LLGL::OpenGLDependentStateDescriptor::originLowerLeft = false

Specifies whether the screen-space origin is on the lower-left. By default false.

Remarks

If this is true, the viewports and scissor rectangles of OpenGL are NOT emulated to the upper-left, which is the default to be uniform with other rendering APIs such as Direct3D and Vulkan.

The documentation for this struct was generated from the following file:

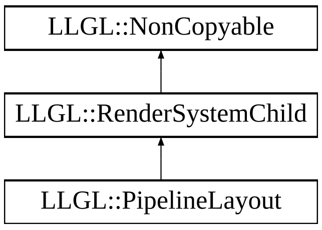
- CommandBufferFlags.h

10.52 LLGL::PipelineLayout Class Reference

Pipeline layout interface.

```
#include <PipelineLayout.h>
```

Inheritance diagram for LLGL::PipelineLayout:



Additional Inherited Members

10.52.1 Detailed Description

Pipeline layout interface.

Remarks

An instance of this interface provides all descriptor sets (as called in Vulkan) or descriptor heaps (as called in Direct3D 12) for graphics and compute pipelines.

See also

RenderSystem::CreatePipelineLayout
GraphicsPipelineDescriptor::pipelineLayout
ResourceHeapDescriptor::pipelineLayout

The documentation for this class was generated from the following file:

- PipelineLayout.h

10.53 LLGL::PipelineLayoutDescriptor Struct Reference

Pipeline layout descritpor structure.

```
#include <PipelineLayoutFlags.h>
```

Public Attributes

- std::vector< BindingDescriptor > bindings

  List of layout resource bindings.

10.53.1 Detailed Description

Pipeline layout descritpor structure.

Remarks

Contains all layout bindings that will be used by graphics and compute pipelines.

10.53.2 Member Data Documentation

10.53.2.1 std::vector<BindingDescriptor> LLGL::PipelineLayoutDescriptor::bindings

List of layout resource bindings.

The documentation for this struct was generated from the following file:

- PipelineLayoutFlags.h

10.54 LLGL::ProfileOpenGLDescriptor Struct Reference

OpenGL profile descriptor structure.

```
#include <RenderContextFlags.h>
```

Public Attributes

- OpenGLContextProfile contextProfile = OpenGLContextProfile::CompatibilityProfile

  Specifies the requested OpenGL context profile. By default OpenGLContextProfile::CompatibilityProfile.
- int majorVersion = -1

  Specifies the requested OpenGL context major version. By default -1 to indicate to use the highest version possible.
- int minorVersion = -1

  Specifies the requested OpenGL context minor version. By default -1 to indicate to use the highest version possible.

10.54.1 Detailed Description

OpenGL profile descriptor structure.

Note

On MacOS the only supported OpenGL profiles are compatibility profile (for lagecy OpenGL before 3.0), 3.2 core profile, or 4.1 core profile.

10.54.2 Member Data Documentation

10.54.2.1 OpenGLContextProfile LLGL::ProfileOpenGLDescriptor::contextProfile = OpenGLContextProfile::↩ CompatibilityProfile

Specifies the requested OpenGL context profile. By default OpenGLContextProfile::CompatibilityProfile.

10.54.2.2 int LLGL::ProfileOpenGLDescriptor::majorVersion = -1

Specifies the requested OpenGL context major version. By default -1 to indicate to use the highest version possible.

Remarks

This member is ignored if 'contextProfile' is 'OpenGLContextProfile::CompatibilityProfile'.

10.54.2.3 int LLGL::ProfileOpenGLDescriptor::minorVersion = -1

Specifies the requested OpenGL context minor version. By default -1 to indicate to use the highest version possible.

Remarks

This member is ignored if 'contextProfile' is 'OpenGLContextProfile::CompatibilityProfile'.

The documentation for this struct was generated from the following file:

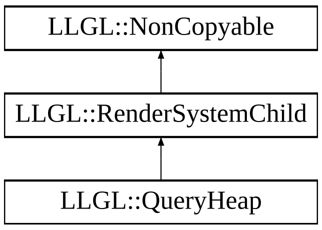
- RenderContextFlags.h

10.55 LLGL::QueryHeap Class Reference

Query heap interface that holds a certain number of queries that are all of the same type.

`#include <QueryHeap.h>`

Inheritance diagram for LLGL::QueryHeap:



Public Member Functions

- QueryType GetType () const

  Returns the type of queries within this heap.

Protected Member Functions

- QueryHeap (const QueryType type)

10.55.1 Detailed Description

Query heap interface that holds a certain number of queries that are all of the same type.

See also

RenderSystem::CreateQueryHeap
CommandBuffer::BeginQuery
CommandBuffer::BeginRenderCondition
CommandQueue::QueryResult

10.55.2 Constructor & Destructor Documentation

10.55.2.1 LLGL::QueryHeap::QueryHeap (const QueryType *type*) `[protected]`

10.55.3 Member Function Documentation

10.55.3.1 QueryType LLGL::QueryHeap::GetType ( ) const `[inline]`

Returns the type of queries within this heap.

The documentation for this class was generated from the following file:

- QueryHeap.h

10.56 LLGL::QueryHeapDescriptor Struct Reference

Query heap descriptor structure.

```
#include <QueryHeapFlags.h>
```

Public Attributes

- QueryType type = QueryType::SamplesPassed

  Specifies the type of queries in the heap. By default QueryType::SamplesPassed.
- std::uint32_t numQueries = 1

  Specifies the number of queries in the heap. This must be greater than zero. By default 1.
- bool renderCondition = false

  Specifies whether the queries are to be used as render conditions. By default false.

10.56.1 Detailed Description

Query heap descriptor structure.

See also

RenderSystem::CreateQueryHeap

10.56.2 Member Data Documentation

10.56.2.1 std::uint32_t LLGL::QueryHeapDescriptor::numQueries = 1

Specifies the number of queries in the heap. This must be greater than zero. By default 1.

10.56.2.2 bool LLGL::QueryHeapDescriptor::renderCondition = false

Specifies whether the queries are to be used as render conditions. By default false.

Remarks

If this is true, the results of the queries cannot be retrieved by CommandBuffer::QueryResult and the member `type` can only have one of the following values:

- QueryType::SamplesPassed
- QueryType::AnySamplesPassed
- QueryType::AnySamplesPassedConservative
- QueryType::StreamOutOverflow

Render conditions can be used to render complex geometry under the condition that a previous (commonly significantly smaller) geometry has passed the depth and stencil tests.

See also

CommandBuffer::BeginRenderCondition
CommandBuffer::EndRenderCondition

Note

Only supported with: OpenGL, Direct3D 11, Direct3D 12.

10.56.2.3 QueryType LLGL::QueryHeapDescriptor::type = QueryType::SamplesPassed

Specifies the type of queries in the heap. By default QueryType::SamplesPassed.

The documentation for this struct was generated from the following file:

- QueryHeapFlags.h

10.57 LLGL::QueryPipelineStatistics Struct Reference

Query data structure for pipeline statistics.

```
#include <QueryHeapFlags.h>
```

Public Attributes

- std::uint64_t inputAssemblyVertices = 0

    Number of vertices submitted to the input-assembly.
- std::uint64_t inputAssemblyPrimitives = 0

    Number of primitives submitted to the input-assembly.
- std::uint64_t vertexShaderInvocations = 0

    Number of vertex shader invocations.
- std::uint64_t geometryShaderInvocations = 0

    Number of geometry shader invocations.
- std::uint64_t geometryShaderPrimitives = 0

    Number of primitives generated by the geometry shader.
- std::uint64_t clippingInvocations = 0

    Number of primitives that reached the primitive clipping stage.
- std::uint64_t clippingPrimitives = 0

    Number of primitives that passed the primitive clipping stage.
- std::uint64_t fragmentShaderInvocations = 0

    Number of fragment shader invocations.
- std::uint64_t tessControlShaderInvocations = 0

    Number of tessellation-control shader invocations.
- std::uint64_t tessEvaluationShaderInvocations = 0

    Number of tessellation-evaluation shader invocations.
- std::uint64_t computeShaderInvocations = 0

    Number of compute shader invocations.

10.57.1 Detailed Description

Query data structure for pipeline statistics.

Remarks

This structure is designed to be compatible to the equivalent in Direct3D 11 (i.e. `D3D11_QUERY_DATA_PIPELINE_STATISTICS`), Direct3D 12 (i.e. `D3D12_QUERY_DATA_PIPELINE_STATISTICS`), and Vulkan (i.e. `VkQueryPipelineStatisticFlagBits`).

See also

QueryType::PipelineStatistics
CommandQueue::QueryResult
RenderingFeatures::hasPipelineStatistics
`https://docs.microsoft.com/en-us/windows/desktop/api/d3d11/ns-d3d11-d3d11_query_data_pipeline_statistics`
`https://docs.microsoft.com/en-us/windows/desktop/api/d3d12/ns-d3d12-d3d12_query_data_pipeline_statistics`
`https://www.khronos.org/registry/vulkan/specs/1.1-extensions/man/html/VkQueryPipelineStatisticFlagBits.html`

10.57.2 Member Data Documentation

10.57.2.1 std::uint64_t LLGL::QueryPipelineStatistics::clippingInvocations = 0

Number of primitives that reached the primitive clipping stage.

10.57.2.2 std::uint64_t LLGL::QueryPipelineStatistics::clippingPrimitives = 0

Number of primitives that passed the primitive clipping stage.

10.57.2.3 std::uint64_t LLGL::QueryPipelineStatistics::computeShaderInvocations = 0

Number of compute shader invocations.

10.57.2.4 std::uint64_t LLGL::QueryPipelineStatistics::fragmentShaderInvocations = 0

Number of fragment shader invocations.

10.57.2.5 std::uint64_t LLGL::QueryPipelineStatistics::geometryShaderInvocations = 0

Number of geometry shader invocations.

10.57.2.6 std::uint64_t LLGL::QueryPipelineStatistics::geometryShaderPrimitives = 0

Number of primitives generated by the geometry shader.

10.57.2.7 std::uint64_t LLGL::QueryPipelineStatistics::inputAssemblyPrimitives = 0

Number of primitives submitted to the input-assembly.

10.57.2.8 std::uint64_t LLGL::QueryPipelineStatistics::inputAssemblyVertices = 0

Number of vertices submitted to the input-assembly.

10.57.2.9 std::uint64_t LLGL::QueryPipelineStatistics::tessControlShaderInvocations = 0

Number of tessellation-control shader invocations.

10.57.2.10 std::uint64_t LLGL::QueryPipelineStatistics::tessEvaluationShaderInvocations = 0

Number of tessellation-evaluation shader invocations.

10.57.2.11 std::uint64_t LLGL::QueryPipelineStatistics::vertexShaderInvocations = 0

Number of vertex shader invocations.

The documentation for this struct was generated from the following file:

- QueryHeapFlags.h

10.58 LLGL::RasterizerDescriptor Struct Reference

Rasterizer state descriptor structure.

```
#include <GraphicsPipelineFlags.h>
```

Public Attributes

- PolygonMode polygonMode = PolygonMode::Fill

  Polygon render mode. By default PolygonMode::Fill.
- CullMode cullMode = CullMode::Disabled

  Polygon face culling mode. By default CullMode::Disabled.
- DepthBiasDescriptor depthBias

  Specifies the parameters to bias fragment depth values.
- MultiSamplingDescriptor multiSampling

  (Multi-)sampling descriptor.
- bool frontCCW = false

  If enabled, front facing polygons are in counter-clock-wise winding, otherwise in clock-wise winding. By default disabled.
- bool discardEnabled = false

If enabled, primitives are discarded after optional stream-outputs but before the rasterization stage. By default disabled.

- bool depthClampEnabled = false

  If enabled, there is effectively no near and far clipping plane. By default disabled.
- bool scissorTestEnabled = false

  Specifies whether scissor test is enabled or disabled. By default disabled.
- bool antiAliasedLineEnabled = false

  Specifies whether lines are rendered with or without anti-aliasing. By default disabled.
- bool conservativeRasterization = false

  If true, conservative rasterization is enabled. By default disabled.
- float lineWidth = 1.0f

  Specifies the width of all generated line primitives. By default 1.0.

10.58.1 Detailed Description

Rasterizer state descriptor structure.

See also

GraphicsPipelineDescriptor::rasterizer

10.58.2 Member Data Documentation

10.58.2.1 bool LLGL::RasterizerDescriptor::antiAliasedLineEnabled = false

Specifies whether lines are rendered with or without anti-aliasing. By default disabled.

10.58.2.2 bool LLGL::RasterizerDescriptor::conservativeRasterization = false

If true, conservative rasterization is enabled. By default disabled.

Note

Only supported with: Direct3D 12, Direct3D 11.3, OpenGL (if the extension `GL_NV_conservative_↩ raster` or `GL_INTEL_conservative_rasterization` is supported).

See also

`https://www.opengl.org/registry/specs/NV/conservative_raster.txt`
`https://www.opengl.org/registry/specs/INTEL/conservative_rasterization.↩ txt`
RenderingFeatures::hasConservativeRasterization

10.58.2.3 CullMode LLGL::RasterizerDescriptor::cullMode = CullMode::Disabled

Polygon face culling mode. By default CullMode::Disabled.

10.58.2.4 DepthBiasDescriptor LLGL::RasterizerDescriptor::depthBias

Specifies the parameters to bias fragment depth values.

10.58.2.5 bool LLGL::RasterizerDescriptor::depthClampEnabled = false

If enabled, there is effectively no near and far clipping plane. By default disabled.

10.58.2.6 bool LLGL::RasterizerDescriptor::discardEnabled = false

If enabled, primitives are discarded after optional stream-outputs but before the rasterization stage. By default disabled.

Note

Only supported with: OpenGL, Vulkan.

10.58.2.7 bool LLGL::RasterizerDescriptor::frontCCW = false

If enabled, front facing polygons are in counter-clock-wise winding, otherwise in clock-wise winding. By default disabled.

10.58.2.8 float LLGL::RasterizerDescriptor::lineWidth = 1.0f

Specifies the width of all generated line primitives. By default 1.0.

Remarks

The minimum and maximum supported line width can be determined by the `lineWidthRange` member in the RenderingCapabilities structure. If this line width is out of range, it will be clamped silently during graphics pipeline creation.

Note

Only supported with: OpenGL, Vulkan.

See also

RenderingLimits::lineWidthRange

10.58.2.9 MultiSamplingDescriptor LLGL::RasterizerDescriptor::multiSampling

(Multi-)sampling descriptor.

10.58.2.10 PolygonMode LLGL::RasterizerDescriptor::polygonMode = PolygonMode::Fill

Polygon render mode. By default PolygonMode::Fill.

10.58.2.11 bool LLGL::RasterizerDescriptor::scissorTestEnabled = false

Specifies whether scissor test is enabled or disabled. By default disabled.

See also

CommandBuffer::SetScissor
CommandBuffer::SetScissors

The documentation for this struct was generated from the following file:

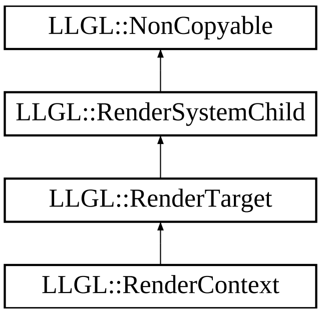
- GraphicsPipelineFlags.h

10.59 LLGL::RenderContext Class Reference

Render context interface.

```
#include <RenderContext.h>
```

Inheritance diagram for LLGL::RenderContext:



Public Member Functions

- bool IsRenderContext () const final

  Returns true.
- Extent2D GetResolution () const final

  Returns the resolution of the current video mode.
- std::uint32_t GetNumColorAttachments () const final

  Returns 1, since each render context has always a single color attachment.
- bool HasDepthAttachment () const final

  Returns true if this render context has a depth format.
- bool HasStencilAttachment () const final

  Returns true if this render context has a stencil format.
- virtual void Present ()=0

Swaps the back buffer with the front buffer to present it on the screen (or rather on this render context).

- virtual Format QueryColorFormat () const =0

  Returns the color format of this render context.
- virtual Format QueryDepthStencilFormat () const =0

  Returns the depth-stencil format of this render context.
- Surface & GetSurface () const

  Returns the surface which is used to present the content on the screen.
- bool SetVideoMode (const VideoModeDescriptor &videoModeDesc)

  Sets the new video mode for this render context.
- const VideoModeDescriptor & GetVideoMode () const

  Returns the video mode for this render context.
- bool SetVsync (const VsyncDescriptor &vsyncDesc)

  Sets the new vertical-sychronization (V-sync) configuration for this render context.
- const VsyncDescriptor & GetVsync () const

  Returns the V-snyc configuration for this render context.

Protected Member Functions

- RenderContext ()=default

  Default constructor with no effect.
- RenderContext (const VideoModeDescriptor &initialVideoMode, const VsyncDescriptor &initialVsync)

  Constructor to initialize the render context with the specified video mode and V-sync.
- virtual bool OnSetVideoMode (const VideoModeDescriptor &videoModeDesc)=0

  Callback when the video mode is about to get changed.
- virtual bool OnSetVsync (const VsyncDescriptor &vsyncDesc)=0

  Callback when the V-sync is about to get changed.
- void SetOrCreateSurface (const std::shared_ptr< Surface > &surface, VideoModeDescriptor videoMode↩ Desc, const void ∗windowContext)

  Sets the render context surface or creates one if 'surface' is null, and switches to fullscreen mode if enabled.
- void ShareSurfaceAndConfig (RenderContext &other)

  Shares the surface and video mode with another render context.
- bool SetDisplayModeByVideoMode (Display &display, const VideoModeDescriptor &videoModeDesc)

  Sets the display mode for the specified display by the parameters of the video mode descriptor.
- bool SwitchFullscreenMode (const VideoModeDescriptor &videoModeDesc)

10.59.1 Detailed Description

Render context interface.

Remarks

Each render context has its own surface and back buffer (or rather swap-chain) to draw into.

See also

RenderSystem::CreateRenderContext
CommandBuffer::SetRenderTarget(RenderContext&)

10.59.2 Constructor & Destructor Documentation

10.59.2.1 LLGL::RenderContext::RenderContext ( ) [protected], [default]

Default constructor with no effect.

10.59.2.2 LLGL::RenderContext::RenderContext (const VideoModeDescriptor & *initialVideoMode,* const VsyncDescriptor & *initialVsync*) [protected]

Constructor to initialize the render context with the specified video mode and V-sync.

10.59.3 Member Function Documentation

10.59.3.1 std::uint32_t LLGL::RenderContext::GetNumColorAttachments ( ) const [final], [virtual]

Returns 1, since each render context has always a single color attachment.

Implements LLGL::RenderTarget.

10.59.3.2 Extent2D LLGL::RenderContext::GetResolution ( ) const [final], [virtual]

Returns the resolution of the current video mode.

See also

GetVideoMode

Implements LLGL::RenderTarget.

10.59.3.3 Surface& LLGL::RenderContext::GetSurface ( ) const [inline]

Returns the surface which is used to present the content on the screen.

Remarks

On desktop platforms, this can be statically casted to 'LLGL::Window&', and on mobile platforms, this can be statically casted to 'LLGL::Canvas&':

```
auto& myWindow = static_cast<LLGL::Window&>(myRenderContext->GetSurface());
```

10.59.3.4 const VideoModeDescriptor& LLGL::RenderContext::GetVideoMode ( ) const [inline]

Returns the video mode for this render context.

10.59.3.5 const VsyncDescriptor& LLGL::RenderContext::GetVsync ( ) const [inline]

Returns the V-snyc configuration for this render context.

10.59.3.6 bool LLGL::RenderContext::HasDepthAttachment ( ) const [final], [virtual]

Returns true if this render context has a depth format.

See also

QueryDepthStencilFormat
IsDepthFormat

Implements LLGL::RenderTarget.

10.59.3.7 bool LLGL::RenderContext::HasStencilAttachment ( ) const [final], [virtual]

Returns true if this render context has a stencil format.

See also

QueryDepthStencilFormat
IsStencilFormat

Implements LLGL::RenderTarget.

10.59.3.8 bool LLGL::RenderContext::IsRenderContext ( ) const [final], [virtual]

Returns true.

Reimplemented from LLGL::RenderTarget.

10.59.3.9 virtual bool LLGL::RenderContext::OnSetVideoMode (const VideoModeDescriptor & *videoModeDesc*) [protected], [pure virtual]

Callback when the video mode is about to get changed.

Parameters

in	*videoModeDesc*	Specifies the descriptor of the new video mode.

Returns

True on success, otherwise the previous video mode remains.

Remarks

Only if the function returns true, the new video mode will be stored in the member returned by 'GetVideoMode'. This callback is only called when the parameter of 'SetVideoMode' differs from the previous video mode.

Note

This video mode may differ from the one passed by 'SetVideoMode' if the platform specific 'Surface' object has modified it for its requirements.

See also

SetVideoMode
GetVideoMode
Surface::AdaptForVideoMode

10.59.3.10 virtual bool LLGL::RenderContext::OnSetVsync (const VsyncDescriptor & *vsyncDesc*) [protected], [pure virtual]

Callback when the V-sync is about to get changed.

Parameters

in	*vsyncDesc*	Specifies the descriptor of the new V-sync configuration.

Returns

True on success, otherwise the previous V-sync configuration remains.

10.59.3.11 virtual void LLGL::RenderContext::Present ( ) [pure virtual]

Swaps the back buffer with the front buffer to present it on the screen (or rather on this render context).

10.59.3.12 virtual Format LLGL::RenderContext::QueryColorFormat ( ) const [pure virtual]

Returns the color format of this render context.

Remarks

This may depend on the settings specified for the video mode. A common value for a render context color format is Format::BGRA8UNorm.

See also

SetVideoMode
AttachmentFormatDescriptor::format
Format

10.59.3.13 virtual Format LLGL::RenderContext::QueryDepthStencilFormat ( ) const [pure virtual]

Returns the depth-stencil format of this render context.

Remarks

This may depend on the settings specified for the video mode.

See also

SetVideoMode
AttachmentFormatDescriptor::format
Format

10.59.3.14 bool LLGL::RenderContext::SetDisplayModeByVideoMode (Display & *display*, const VideoModeDescriptor & *videoModeDesc*) [protected]

Sets the display mode for the specified display by the parameters of the video mode descriptor.

Returns

Return value of the Display::SetDisplayMode function.

See also

Display::SetDisplayMode

10.59.3.15 void LLGL::RenderContext::SetOrCreateSurface (const std::shared_ptr< Surface > & *surface*, VideoModeDescriptor *videoModeDesc*, const void * *windowContext*) [protected]

Sets the render context surface or creates one if 'surface' is null, and switches to fullscreen mode if enabled.

Parameters

in	*surface*	Optional shared pointer to a surface which will be used as main render target. If this is null, a new surface is created for this render context.
in	*videoModeDesc*	Specifies the video mode descriptor. The resolution of this video mode is only used if 'surface' is null, otherwise the resolution is determined by the content size of the specified surface (i.e. with the Surface::GetContentSize function). To determine the final video mode, use the GetVideoMode function.
in	*Optional*	pointer to a NativeContextHandle structure. This is only used for desktop platforms.

See also

WindowDescriptor::windowContext
Surface::GetContentSize
GetVideoMode
SwitchFullscreenMode

10.59.3.16 bool LLGL::RenderContext::SetVideoMode (const VideoModeDescriptor & *videoModeDesc*)

Sets the new video mode for this render context.

Parameters

in	*videoModeDesc*	Specifies the descriptor of the new video mode.

Returns

True on success, otherwise the specified video mode was invalid (e.g. if the resolution contains a zero).

Remarks

When the video mode is changed from fullscreen to non-fullscreen, the previous surface position is restored.

Note

This may invalidate the currently set render target if the back buffer is required, so a subsequent call to "↩ CommandBuffer::SetRenderTarget" is necessary!

See also

CommandBuffer::SetRenderTarget(RenderContext&)

10.59.3.17 bool LLGL::RenderContext::SetVsync (const VsyncDescriptor & *vsyncDesc*)

Sets the new vertical-sychronization (V-sync) configuration for this render context.

Parameters

in	*vsyncDesc*	Specifies the descriptor of the new V-sync configuration.

Returns

True on success, otherwise the specified V-sync is invalid.

10.59.3.18 void LLGL::RenderContext::ShareSurfaceAndConfig (RenderContext & *other*) [protected]

Shares the surface and video mode with another render context.

Note

This is only used by the renderer debug layer.

10.59.3.19 bool LLGL::RenderContext::SwitchFullscreenMode (const VideoModeDescriptor & *videoModeDesc*) [protected]

Switches the fullscreen mode for the primary display if the specified fullscreen mode is different to the current fullscreen setting.

See also

SetDisplayModeByVideoMode
GetVideoMode

The documentation for this class was generated from the following file:

- RenderContext.h

10.60 LLGL::RenderContextDescriptor Struct Reference

Render context descriptor structure.

`#include <RenderContextFlags.h>`

Public Attributes

- VsyncDescriptor vsync

  Vertical-synchronization (Vsync) descriptor.
- MultiSamplingDescriptor multiSampling

  Multi-sampling descriptor.
- VideoModeDescriptor videoMode

  Video mode descriptor.
- ProfileOpenGLDescriptor profileOpenGL

  OpenGL profile descriptor (to switch between compatability or core profile).
- DebugCallback debugCallback

  Debuging callback function object.

10.60.1 Detailed Description

Render context descriptor structure.

10.60.2 Member Data Documentation

10.60.2.1 DebugCallback LLGL::RenderContextDescriptor::debugCallback

Debuging callback function object.

10.60.2.2 MultiSamplingDescriptor LLGL::RenderContextDescriptor::multiSampling

Multi-sampling descriptor.

10.60.2.3 ProfileOpenGLDescriptor LLGL::RenderContextDescriptor::profileOpenGL

OpenGL profile descriptor (to switch between compatability or core profile).

10.60.2.4 VideoModeDescriptor LLGL::RenderContextDescriptor::videoMode

Video mode descriptor.

10.60.2.5 VsyncDescriptor LLGL::RenderContextDescriptor::vsync

Vertical-synchronization (Vsync) descriptor.

The documentation for this struct was generated from the following file:

- RenderContextFlags.h

10.61 LLGL::RendererID Struct Reference

Renderer identification number enumeration.

```
#include <RenderSystemFlags.h>
```

Static Public Attributes

- static const int Undefined = 0x00000000

  Undefined ID number.
- static const int OpenGL = 0x00000001

  ID number for an OpenGL renderer.
- static const int OpenGLES1 = 0x00000002

  ID number for an OpenGL ES 1 renderer.
- static const int OpenGLES2 = 0x00000003

  ID number for an OpenGL ES 2 renderer.
- static const int OpenGLES3 = 0x00000004

  ID number for an OpenGL ES 3 renderer.
- static const int Direct3D9 = 0x00000005

  ID number for a Direct3D 9 renderer.
- static const int Direct3D10 = 0x00000006

  ID number for a Direct3D 10 renderer.
- static const int Direct3D11 = 0x00000007

  ID number for a Direct3D 11 renderer.
- static const int Direct3D12 = 0x00000008

  ID number for a Direct3D 12 renderer.
- static const int Vulkan = 0x00000009

  ID number for a Vulkan renderer.
- static const int Metal = 0x0000000a

  ID number for a Metal renderer.
- static const int Reserved = 0x000000ff

  Highest ID number for reserved future renderers. Value is 0x000000ff.

10.61.1 Detailed Description

Renderer identification number enumeration.

Remarks

There are several IDs for reserved future renderes, which are currently not supported (and maybe never supported). You can use an ID greater than 'RendererID::Reserved' (which has a value of 0x000000ff) for your own renderer. Or use one of the pre-defined IDs if you want to implement your own OpenGL/ Direct3D or whatever renderer.

See also

RendererInfo::rendererID

10.61.2 Member Data Documentation

10.61.2.1 const int LLGL::RendererID::Direct3D10 = 0x00000006 `[static]`

ID number for a Direct3D 10 renderer.

10.61.2.2 const int LLGL::RendererID::Direct3D11 = 0x00000007 `[static]`

ID number for a Direct3D 11 renderer.

10.61.2.3 const int LLGL::RendererID::Direct3D12 = 0x00000008 `[static]`

ID number for a Direct3D 12 renderer.

10.61.2.4 const int LLGL::RendererID::Direct3D9 = 0x00000005 `[static]`

ID number for a Direct3D 9 renderer.

10.61.2.5 const int LLGL::RendererID::Metal = 0x0000000a `[static]`

ID number for a Metal renderer.

10.61.2.6 const int LLGL::RendererID::OpenGL = 0x00000001 `[static]`

ID number for an OpenGL renderer.

10.61.2.7 const int LLGL::RendererID::OpenGLES1 = 0x00000002 `[static]`

ID number for an OpenGL ES 1 renderer.

10.61.2.8 const int LLGL::RendererID::OpenGLES2 = 0x00000003 [static]

ID number for an OpenGL ES 2 renderer.

10.61.2.9 const int LLGL::RendererID::OpenGLES3 = 0x00000004 [static]

ID number for an OpenGL ES 3 renderer.

10.61.2.10 const int LLGL::RendererID::Reserved = 0x000000ff [static]

Highest ID number for reserved future renderers. Value is 0x000000ff.

10.61.2.11 const int LLGL::RendererID::Undefined = 0x00000000 [static]

Undefined ID number.

10.61.2.12 const int LLGL::RendererID::Vulkan = 0x00000009 [static]

ID number for a Vulkan renderer.

The documentation for this struct was generated from the following file:

- RenderSystemFlags.h

10.62 LLGL::RendererInfo Struct Reference

Renderer basic information structure.

```
#include <RenderSystemFlags.h>
```

Public Attributes

- std::string rendererName

  Rendering API name and version (e.g. "OpenGL 4.6").
- std::string deviceName

  Renderer device name (e.g. "GeForce GTX 1070/PCIe/SSE2").
- std::string vendorName

  Vendor name of the renderer device (e.g. "NVIDIA Corporation").
- std::string shadingLanguageName

  Shading language version (e.g. "GLSL 4.50").

10.62.1 Detailed Description

Renderer basic information structure.

10.62.2 Member Data Documentation

10.62.2.1 std::string LLGL::RendererInfo::deviceName

Renderer device name (e.g. "GeForce GTX 1070/PCIe/SSE2").

10.62.2.2 std::string LLGL::RendererInfo::rendererName

Rendering API name and version (e.g. "OpenGL 4.6").

10.62.2.3 std::string LLGL::RendererInfo::shadingLanguageName

Shading language version (e.g. "GLSL 4.50").

10.62.2.4 std::string LLGL::RendererInfo::vendorName

Vendor name of the renderer device (e.g. "NVIDIA Corporation").

The documentation for this struct was generated from the following file:

- RenderSystemFlags.h

10.63 LLGL::RenderingCapabilities Struct Reference

Structure with all attributes describing the rendering capabilities of the render system.

```
#include <RenderSystemFlags.h>
```

Public Attributes

- ScreenOrigin screenOrigin = ScreenOrigin::UpperLeft

  Screen coordinate system origin.
- ClippingRange clippingRange = ClippingRange::ZeroToOne

  Specifies the clipping depth range.
- std::vector< ShadingLanguage > shadingLanguages

  Specifies the list of supported shading languages.
- std::vector< Format > textureFormats

  Specifies the list of supported texture formats.
- RenderingFeatures features

  Specifies all supported hardware features.
- RenderingLimits limits

  Specifies all rendering limitations.

10.63.1 Detailed Description

Structure with all attributes describing the rendering capabilities of the render system.

See also

RenderSystem::GetRenderingCaps

10.63.2 Member Data Documentation

10.63.2.1 ClippingRange LLGL::RenderingCapabilities::clippingRange = ClippingRange::ZeroToOne

Specifies the clipping depth range.

10.63.2.2 RenderingFeatures LLGL::RenderingCapabilities::features

Specifies all supported hardware features.

Remarks

Especially with OpenGL these features can vary between different hardware and GL versions.

10.63.2.3 RenderingLimits LLGL::RenderingCapabilities::limits

Specifies all rendering limitations.

Remarks

Especially with OpenGL these features can vary between different hardware and GL versions.

10.63.2.4 ScreenOrigin LLGL::RenderingCapabilities::screenOrigin = ScreenOrigin::UpperLeft

Screen coordinate system origin.

Remarks

This determines the coordinate space of viewports, scissors, and framebuffers.

10.63.2.5 std::vector<ShadingLanguage> LLGL::RenderingCapabilities::shadingLanguages

Specifies the list of supported shading languages.

Remarks

This also specifies whether shaders can be loaded in source or binary form (using "Compile" or "LoadBinary" functions of the "Shader" interface).

See also

Shader::Compile
Shader::LoadBinary

10.63.2.6 std::vector<Format> LLGL::RenderingCapabilities::textureFormats

Specifies the list of supported texture formats.

See also

Format

The documentation for this struct was generated from the following file:

- RenderSystemFlags.h

10.64 LLGL::RenderingDebugger Class Reference

Rendering debugger interface.

```
#include <RenderingDebugger.h>
```

Classes

- class Message

  Rendering debugger message class.

Public Member Functions

- virtual ∼RenderingDebugger ()
- void SetSource (const char ∗source)

  Sets the new source function name.
- void PostError (const ErrorType type, const std::string &message)

  Posts an error message.
- void PostWarning (const WarningType type, const std::string &message)

  Posts a warning message.

Protected Member Functions

- virtual void OnError (ErrorType type, Message &message)

  Callback function when an error was posted.
- virtual void OnWarning (WarningType type, Message &message)

  Callback function when a warning was posted.

10.64.1 Detailed Description

Rendering debugger interface.

Remarks

This can be used to profile the renderer draw calls and buffer updates.

10.64.2 Constructor & Destructor Documentation

10.64.2.1 virtual LLGL::RenderingDebugger::∼RenderingDebugger ( ) [virtual]

10.64.3 Member Function Documentation

10.64.3.1 virtual void LLGL::RenderingDebugger::OnError (ErrorType *type*, Message & *message*) [protected], [virtual]

Callback function when an error was posted.

Remarks

Use the 'message' parameter to block further occurences of this error if you like. The following example shows a custom implementation that is equivalent to the default implementation:

```
class MyDebugger : public LLGL::RenderingDebugger {
    void OnError(ErrorType type, Message& message) override {
        LLGL::Log::PostReport(
            LLGL::Log::ReportType::Error,
            "ERROR (" + std::string(LLGL::ToString(type)) + "): in '" + message.GetSource() +
       "': " + message.GetText()
        );
        message.Block();
    }
};
```

See also

RenderingDebugger::PostError
OnWarning

10.64.3.2 virtual void LLGL::RenderingDebugger::OnWarning (WarningType *type*, Message & *message*) [protected], [virtual]

Callback function when a warning was posted.

See also

RenderingDebugger::PostWarning
OnError

10.64.3.3 void LLGL::RenderingDebugger::PostError (const ErrorType *type*, const std::string & *message*)

Posts an error message.

Parameters

in	*type*	Specifies the type of error.
in	*message*	Specifies the string which describes the failure.
in	*source*	Specifies the string which describes the source (typically the function where the failure happend).

10.64.3.4 void LLGL::RenderingDebugger::PostWarning (const WarningType *type*, const std::string & *message*)

Posts a warning message.

Parameters

in	*type*	Specifies the type of error.
in	*message*	Specifies the string which describes the warning.
in	*source*	Specifies the string which describes the source (typically the function where the failure happend).

10.64.3.5 void LLGL::RenderingDebugger::SetSource (const char ∗ *source*)

Sets the new source function name.

The documentation for this class was generated from the following file:

- RenderingDebugger.h

10.65 LLGL::RenderingFeatures Struct Reference

Contains the attributes for all supported rendering features.

```
#include <RenderSystemFlags.h>
```

Public Attributes

- bool hasCommandBufferExt = false

  Specifies whether the render system supports extended command buffers with dynamic state access for shader resources.
- bool hasRenderTargets = false

  Specifies whether render targets (also "framebuffer objects") are supported.
- bool has3DTextures = false

  Specifies whether 3D textures are supported.
- bool hasCubeTextures = false

  Specifies whether cube textures are supported.
- bool hasArrayTextures = false

  Specifies whether 1D- and 2D array textures are supported.
- bool hasCubeArrayTextures = false

  Specifies whether cube array textures are supported.
- bool hasMultiSampleTextures = false

  Specifies whether multi-sample textures are supported.
- bool hasSamplers = false

  Specifies whether samplers are supported.
- bool hasConstantBuffers = false

  Specifies whether constant buffers (also "uniform buffer objects") are supported.
- bool hasStorageBuffers = false

Specifies whether storage buffers (also "read/write buffers") are supported.

- bool hasUniforms = false

  Specifies whether individual shader uniforms are supported (typically only for OpenGL 2.0+).
- bool hasGeometryShaders = false

  Specifies whether geometry shaders are supported.
- bool hasTessellationShaders = false

  Specifies whether tessellation shaders are supported.
- bool hasComputeShaders = false

  Speciifes whether compute shaders are supported.
- bool hasInstancing = false

  Specifies whether hardware instancing is supported.
- bool hasOffsetInstancing = false

  Specifies whether hardware instancing with instance offsets is supported.
- bool hasViewportArrays = false

  Specifies whether multiple viewports, depth-ranges, and scissors at once are supported.
- bool hasConservativeRasterization = false

  Specifies whether conservative rasterization is supported.
- bool hasStreamOutputs = false

  Specifies whether stream-output is supported.
- bool hasLogicOp = false

  Specifies whether logic fragment operations are supported.
- bool hasPipelineStatistics = false

  Specifies whether queries for pipeline statistics are supported.
- bool hasRenderCondition = false

  Specifies whether queries for conditional rendering are supported.

10.65.1 Detailed Description

Contains the attributes for all supported rendering features.

See also

RenderingCapabilities

10.65.2 Member Data Documentation

10.65.2.1 bool LLGL::RenderingFeatures::has3DTextures = false

Specifies whether 3D textures are supported.

See also

TextureType::Texture3D

10.65.2.2 bool LLGL::RenderingFeatures::hasArrayTextures = false

Specifies whether 1D- and 2D array textures are supported.

See also

TextureType::Texture1DArray
TextureType::Texture2DArray

10.65.2.3 bool LLGL::RenderingFeatures::hasCommandBufferExt = false

Specifies whether the render system supports extended command buffers with dynamic state access for shader resources.

Remarks

This is only supported by older graphics APIs such as OpenGL and Direct3D 11.

See also

RenderSystem::CreateCommandBufferExt
CommandBufferExt

10.65.2.4 bool LLGL::RenderingFeatures::hasComputeShaders = false

Speciifes whether compute shaders are supported.

10.65.2.5 bool LLGL::RenderingFeatures::hasConservativeRasterization = false

Specifies whether conservative rasterization is supported.

See also

RasterizerDescriptor::conservativeRasterization

10.65.2.6 bool LLGL::RenderingFeatures::hasConstantBuffers = false

Specifies whether constant buffers (also "uniform buffer objects") are supported.

See also

BufferType::Constant

10.65.2.7 bool LLGL::RenderingFeatures::hasCubeArrayTextures = false

Specifies whether cube array textures are supported.

See also

TextureType::TextureCubeArray

10.65.2.8 bool LLGL::RenderingFeatures::hasCubeTextures = false

Specifies whether cube textures are supported.

See also

TextureType::TextureCube

10.65.2.9 bool LLGL::RenderingFeatures::hasGeometryShaders = false

Specifies whether geometry shaders are supported.

10.65.2.10 bool LLGL::RenderingFeatures::hasInstancing = false

Specifies whether hardware instancing is supported.

See also

CommandBuffer::DrawInstanced(std::uint32_t, std::uint32_t, std::uint32_t)
CommandBuffer::DrawIndexedInstanced(std::uint32_t, std::uint32_t, std::uint32_t)
CommandBuffer::DrawIndexedInstanced(std::uint32_t, std::uint32_t, std::uint32_t, std::int32_t)

10.65.2.11 bool LLGL::RenderingFeatures::hasLogicOp = false

Specifies whether logic fragment operations are supported.

Note

For Direct3D 11, feature level 11.1 is required.

See also

BlendDescriptor::logicOp

10.65.2.12 bool LLGL::RenderingFeatures::hasMultiSampleTextures = false

Specifies whether multi-sample textures are supported.

See also

TextureType::Texture2DMS
TextureType::Texture2DMSArray

10.65.2.13 bool LLGL::RenderingFeatures::hasOffsetInstancing = false

Specifies whether hardware instancing with instance offsets is supported.

See also

CommandBuffer::DrawInstanced(std::uint32_t, std::uint32_t, std::uint32_t, std::uint32_t)
CommandBuffer::DrawIndexedInstanced(std::uint32_t, std::uint32_t, std::uint32_t, std::int32_t, std::uint32_t)

10.65.2.14 bool LLGL::RenderingFeatures::hasPipelineStatistics = false

Specifies whether queries for pipeline statistics are supported.

See also

QueryType::PipelineStatistics
QueryPipelineStatistics

10.65.2.15 bool LLGL::RenderingFeatures::hasRenderCondition = false

Specifies whether queries for conditional rendering are supported.

See also

QueryHeapDescriptor::renderCondition
CommandBuffer:BeginRenderCondition

10.65.2.16 bool LLGL::RenderingFeatures::hasRenderTargets = false

Specifies whether render targets (also "framebuffer objects") are supported.

10.65.2.17 bool LLGL::RenderingFeatures::hasSamplers = false

Specifies whether samplers are supported.

10.65.2.18 bool LLGL::RenderingFeatures::hasStorageBuffers = false

Specifies whether storage buffers (also "read/write buffers") are supported.

See also

BufferType::Storage

10.65.2.19 bool LLGL::RenderingFeatures::hasStreamOutputs = false

Specifies whether stream-output is supported.

See also

ShaderSource::streamOutput
CommandBuffer::BeginStreamOutput

10.65.2.20 bool LLGL::RenderingFeatures::hasTessellationShaders = false

Specifies whether tessellation shaders are supported.

10.65.2.21 bool LLGL::RenderingFeatures::hasUniforms = false

Specifies whether individual shader uniforms are supported (typically only for OpenGL 2.0+).

See also

ShaderProgram::LockShaderUniform

10.65.2.22 bool LLGL::RenderingFeatures::hasViewportArrays = false

Specifies whether multiple viewports, depth-ranges, and scissors at once are supported.

See also

RenderingLimits::maxViewports

The documentation for this struct was generated from the following file:

- RenderSystemFlags.h

10.66 LLGL::RenderingLimits Struct Reference

Contains all rendering limitations such as maximum buffer size, maximum texture resolution etc.

```
#include <RenderSystemFlags.h>
```

Public Attributes

- float lineWidthRange [2] = { 1.0f, 1.0f }

  Specifies the range for rasterizer line widths. By default [1, 1].
- std::uint32_t maxTextureArrayLayers = 0

  Specifies the maximum number of texture array layers (for 1D-, 2D-, and cube textures).
- std::uint32_t maxColorAttachments = 0

  Specifies the maximum number of color attachments for each render target.
- std::uint32_t maxPatchVertices = 0

  Specifies the maximum number of patch control points.
- std::uint32_t max1DTextureSize = 0

  Specifies the maximum size of each 1D texture.
- std::uint32_t max2DTextureSize = 0

  Specifies the maximum size of each 2D texture (for width and height).
- std::uint32_t max3DTextureSize = 0

  Specifies the maximum size of each 3D texture (for width, height, and depth).
- std::uint32_t maxCubeTextureSize = 0

  Specifies the maximum size of each cube texture (for width and height).
- std::uint32_t maxAnisotropy = 0

  Specifies the maximum anisotropy texture filter.
- std::uint32_t maxComputeShaderWorkGroups [3] = { 0, 0, 0 }

  Specifies the maximum number of work groups in a compute shader.
- std::uint32_t maxComputeShaderWorkGroupSize [3] = { 0, 0, 0 }

  Specifies the maximum work group size in a compute shader.
- std::uint32_t maxViewports = 0

  Specifies the maximum number of viewports and scissor rectangles. Most render systems have a maximum of 16.
- std::uint32_t maxViewportSize [2] = { 0, 0 }

  Specifies the maximum width and height of each viewport and scissor rectangle.
- std::uint64_t maxBufferSize = 0

  Specifies the maximum size (in bytes) that is supported for hardware buffers (vertex, index, storage buffers).
- std::uint64_t maxConstantBufferSize = 0

  Specifies the maximum size (in bytes) that is supported for hardware constant buffers.

10.66.1 Detailed Description

Contains all rendering limitations such as maximum buffer size, maximum texture resolution etc.

See also

RenderingCapabilities

10.66.2 Member Data Documentation

10.66.2.1 float LLGL::RenderingLimits::lineWidthRange[2] = { 1.0f, 1.0f }

Specifies the range for rasterizer line widths. By default [1, 1].

Note

Only supported with: OpenGL, Vulkan.

See also

RasterizerDescriptor::lineWidth

10.66.2.2 std::uint32_t LLGL::RenderingLimits::max1DTextureSize = 0

Specifies the maximum size of each 1D texture.

See also

TextureDescriptor::extent

10.66.2.3 std::uint32_t LLGL::RenderingLimits::max2DTextureSize = 0

Specifies the maximum size of each 2D texture (for width and height).

See also

TextureDescriptor::extent

10.66.2.4 std::uint32_t LLGL::RenderingLimits::max3DTextureSize = 0

Specifies the maximum size of each 3D texture (for width, height, and depth).

See also

TextureDescriptor::extent

10.66.2.5 std::uint32_t LLGL::RenderingLimits::maxAnisotropy = 0

Specifies the maximum anisotropy texture filter.

See also

SamplerDescriptor::maxAnisotropy

10.66.2.6 std::uint64_t LLGL::RenderingLimits::maxBufferSize = 0

Specifies the maximum size (in bytes) that is supported for hardware buffers (vertex, index, storage buffers).

Remarks

Constant buffers are a special case for which 'maxConstantBufferSize' can be used.

See also

BufferDescriptor::size
maxConstantBufferSize

10.66.2.7 std::uint32_t LLGL::RenderingLimits::maxColorAttachments = 0

Specifies the maximum number of color attachments for each render target.

Remarks

This value must not be greater than 8.

See also

RenderTargetDescriptor::attachments
RenderPassDescriptor::colorAttachments
BlendDescriptor::targets

10.66.2.8 std::uint32_t LLGL::RenderingLimits::maxComputeShaderWorkGroups[3] = { 0, 0, 0 }

Specifies the maximum number of work groups in a compute shader.

See also

CommandBuffer::Dispatch

10.66.2.9 std::uint32_t LLGL::RenderingLimits::maxComputeShaderWorkGroupSize[3] = { 0, 0, 0 }

Specifies the maximum work group size in a compute shader.

10.66.2.10 std::uint64_t LLGL::RenderingLimits::maxConstantBufferSize = 0

Specifies the maximum size (in bytes) that is supported for hardware constant buffers.

Remarks

This is typically a lot smaller than the maximum size for other types of buffers.

See also

BufferDescriptor::size

10.66.2.11 std::uint32_t LLGL::RenderingLimits::maxCubeTextureSize = 0

Specifies the maximum size of each cube texture (for width and height).

See also

TextureDescriptor::extent

10.66.2.12 std::uint32_t LLGL::RenderingLimits::maxPatchVertices = 0

Specifies the maximum number of patch control points.

See also

PrimitiveTopology::Patches1
PrimitiveTopology::Patches32

10.66.2.13 std::uint32_t LLGL::RenderingLimits::maxTextureArrayLayers = 0

Specifies the maximum number of texture array layers (for 1D-, 2D-, and cube textures).

See also

TextureDescriptor::arrayLayers

10.66.2.14 std::uint32_t LLGL::RenderingLimits::maxViewports = 0

Specifies the maximum number of viewports and scissor rectangles. Most render systems have a maximum of 16.

See also

CommandBuffer::SetViewports
CommandBuffer::SetScissors
GraphicsPipelineDescriptor::viewports
GraphicsPipelineDescriptor::scissors
RenderingFeatures::hasViewportArrays

10.66.2.15 std::uint32_t LLGL::RenderingLimits::maxViewportSize[2] = { 0, 0 }

Specifies the maximum width and height of each viewport and scissor rectangle.

See also

Viewport::width
Viewport::height
Scissor::width
Scissor::height

The documentation for this struct was generated from the following file:

- RenderSystemFlags.h

10.67 LLGL::RenderingProfiler Class Reference

Rendering profiler model class.

```
#include <RenderingProfiler.h>
```

Public Member Functions

- void NextProfile (FrameProfile ∗outputProfile=nullptr)

  Returns the current frame profile and resets the counters for the next frame.
- void Accumulate (const FrameProfile &profile)

  Accumulates the specified profile with the current values.

Public Attributes

- FrameProfile frameProfile

  Current frame profile with all counter values.

10.67.1 Detailed Description

Rendering profiler model class.

Remarks

This can be used to profile the renderer draw calls and buffer updates.

Todo Refactor this for the new ResourceHeap and RenderPass interfaces.

10.67.2 Member Function Documentation

10.67.2.1 void LLGL::RenderingProfiler::Accumulate (const **FrameProfile** & *profile*)

Accumulates the specified profile with the current values.

Parameters

`in`	*profile*	Specifies the input profile whose values are to be merged with the current values.

See also

FrameProfile::Accumulate

10.67.2.2 void LLGL::RenderingProfiler::NextProfile (**FrameProfile** ∗ *outputProfile* = `nullptr`)

Returns the current frame profile and resets the counters for the next frame.

Parameters

`out`	*outputProfile*	Optional pointer to an output profile to retrieve the current values. By default null.

10.67.3 Member Data Documentation

10.67.3.1 FrameProfile LLGL::RenderingProfiler::frameProfile

Current frame profile with all counter values.

The documentation for this class was generated from the following file:

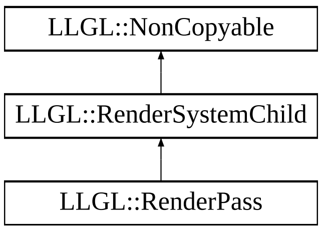
- RenderingProfiler.h

10.68 LLGL::RenderPass Class Reference

Render pass interface.

```
#include <RenderPass.h>
```

Inheritance diagram for LLGL::RenderPass:



Additional Inherited Members

10.68.1 Detailed Description

Render pass interface.

Remarks

A render pass is a high level construct adopted from Vulkan and Metal. It is used to tell the driver the various segments of a frame and which render target attachments are used and which depend on each other.

See also

RenderSystem::CreateRenderPass
CommandBuffer::BeginRenderPass
CommandBuffer::EndRenderPass

The documentation for this class was generated from the following file:

- RenderPass.h

10.69 LLGL::RenderPassDescriptor Struct Reference

Render pass descriptor structure.

```
#include <RenderPassFlags.h>
```

Public Attributes

- std::vector< AttachmentFormatDescriptor > colorAttachments
- AttachmentFormatDescriptor depthAttachment

    Specifies the depth attachment used within the render pass.
- AttachmentFormatDescriptor stencilAttachment

    Specifies the depth attachment used within the render pass.

10.69.1 Detailed Description

Render pass descriptor structure.

Remarks

A render pass object can be used across multiple render targets. Moreover, a render target can be created with a different render pass object than the one used for CommandBuffer::BeginRenderPass as long as they are compatible. Two render passes are considered compatible when all color-, depth-, and stencil attachments are compatible.

See also

RenderSystem::CreateRenderPass
CommandBuffer::BeginRenderPass
AttachmentFormatDescriptor

10.69.2 Member Data Documentation

10.69.2.1 std::vector<**AttachmentFormatDescriptor**> LLGL::RenderPassDescriptor::colorAttachments

Specifies the color attachments used within the render pass.

Remarks

A render context usually uses an BGRA format instead of an RGBA format.

See also

RenderingLimits::maxColorAttachments
Format::BGRA8UNorm
Format::BGRA8sRGB

10.69.2.2 AttachmentFormatDescriptor LLGL::RenderPassDescriptor::depthAttachment

Specifies the depth attachment used within the render pass.

Remarks

The depth attachment and stencil attachment usually share the same format (e.g. Format::D24UNormS8UInt). They are separated here to specify different load and store operations.

10.69.2.3 AttachmentFormatDescriptor LLGL::RenderPassDescriptor::stencilAttachment

Specifies the depth attachment used within the render pass.

Remarks

The depth attachment and stencil attachment usually share the same format (e.g. Format::D24UNormS8UInt). They are separated here to specify different load and store operations.

The documentation for this struct was generated from the following file:

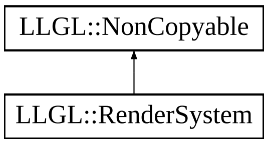
- RenderPassFlags.h

10.70 LLGL::RenderSystem Class Reference

Render system interface.

```
#include <RenderSystem.h>
```

Inheritance diagram for LLGL::RenderSystem:



Public Member Functions

- int GetRendererID () const

  Rendering API identification number.
- const std::string & GetName () const

  Returns the name of this render system.
- const RendererInfo & GetRendererInfo () const

  Returns basic renderer information.
- const RenderingCapabilities & GetRenderingCaps () const

  Returns the rendering capabilities.
- virtual void SetConfiguration (const RenderSystemConfiguration &config)

  Sets the basic configuration.

- const RenderSystemConfiguration & GetConfiguration () const

  Returns the basic configuration.
- virtual RenderContext ∗ CreateRenderContext (const RenderContextDescriptor &desc, const std::shared_↩ ptr< Surface > &surface={})=0

  Creates a new render context and returns the raw pointer.
- virtual void Release (RenderContext &renderContext)=0

  Releases the specified render context. This will all release all resources, that are associated with this render context.
- virtual CommandQueue ∗ GetCommandQueue ()=0

  Returns the single instance of the command queue.
- virtual CommandBuffer ∗ CreateCommandBuffer (const CommandBufferDescriptor &desc={})=0

  Creates a new command buffer.
- virtual CommandBufferExt ∗ CreateCommandBufferExt (const CommandBufferDescriptor &desc={})=0

  Creates a new extended command buffer (if supported) with dynamic state access for shader resources (i.e. Constant Buffers, Storage Buffers, Textures, and Samplers).
- virtual void Release (CommandBuffer &commandBuffer)=0

  Releases the specified command buffer. After this call, the specified object must no longer be used.
- virtual Buffer ∗ CreateBuffer (const BufferDescriptor &desc, const void ∗initialData=nullptr)=0

  Creates a new generic hardware buffer.
- virtual BufferArray ∗ CreateBufferArray (std::uint32_t numBuffers, Buffer ∗const ∗bufferArray)=0

  Creates a new buffer array.
- virtual void Release (Buffer &buffer)=0

  Releases the specified buffer object. After this call, the specified object must no longer be used.
- virtual void Release (BufferArray &bufferArray)=0

  Releases the specified buffer array object. After this call, the specified object must no longer be used.
- virtual void WriteBuffer (Buffer &dstBuffer, std::uint64_t dstOffset, const void ∗data, std::uint64_t dataSize)=0

  Updates the data of the specified buffer.
- virtual void ∗ MapBuffer (Buffer &buffer, const CPUAccess access)=0

  Maps the specified buffer from GPU to CPU memory space.
- virtual void UnmapBuffer (Buffer &buffer)=0

  Unmaps the specified buffer.
- virtual Texture ∗ CreateTexture (const TextureDescriptor &textureDesc, const SrcImageDescriptor ∗image↩ Desc=nullptr)=0

  Creates a new texture.
- virtual void Release (Texture &texture)=0

  Releases the specified texture object. After this call, the specified object must no longer be used.
- virtual void WriteTexture (Texture &texture, const TextureRegion &textureRegion, const SrcImageDescriptor &imageDesc)=0

  Updates the image data of the specified texture.
- virtual void ReadTexture (const Texture &texture, std::uint32_t mipLevel, const DstImageDescriptor &image↩ Desc)=0

  Reads the image data from the specified texture.
- virtual void GenerateMips (Texture &texture)=0

  Generates all MIP-maps for the specified texture.
- virtual void GenerateMips (Texture &texture, std::uint32_t baseMipLevel, std::uint32_t numMipLevels, std↩ ::uint32_t baseArrayLayer=0, std::uint32_t numArrayLayers=1)=0

  Generates the specified range of MIP-maps for the specified texture.
- virtual Sampler ∗ CreateSampler (const SamplerDescriptor &desc)=0

  Creates a new Sampler object.
- virtual void Release (Sampler &sampler)=0

  Releases the specified Sampler object. After this call, the specified object must no longer be used.
- virtual ResourceHeap ∗ CreateResourceHeap (const ResourceHeapDescriptor &desc)=0

Creates a new resource heap.

- virtual void Release (ResourceHeap &resourceHeap)=0

  Releases the specified ResourceHeap object. After this call, the specified object must no longer be used.
- virtual RenderPass ∗ CreateRenderPass (const RenderPassDescriptor &desc)=0

  Creates a new RenderPass object.
- virtual void Release (RenderPass &renderPass)=0

  Releases the specified RenderPass object. After this call, the specified object must no longer be used.
- virtual RenderTarget ∗ CreateRenderTarget (const RenderTargetDescriptor &desc)=0

  Creates a new RenderTarget object.
- virtual void Release (RenderTarget &renderTarget)=0

  Releases the specified RenderTarget object. After this call, the specified object must no longer be used.
- virtual Shader ∗ CreateShader (const ShaderDescriptor &desc)=0

  Creates a new and Shader object and compiles the specified source.
- virtual ShaderProgram ∗ CreateShaderProgram (const ShaderProgramDescriptor &desc)=0

  Creates a new shader program and links all specified shaders.
- virtual void Release (Shader &shader)=0

  Releases the specified Shader object. After this call, the specified object must no longer be used.
- virtual void Release (ShaderProgram &shaderProgram)=0

  Releases the specified ShaderProgram object. After this call, the specified object must no longer be used.
- virtual PipelineLayout ∗ CreatePipelineLayout (const PipelineLayoutDescriptor &desc)=0

  Creates a new and initialized pipeline layout object, if and only if the renderer supports pipeline layouts.
- virtual void Release (PipelineLayout &pipelineLayout)=0

  Releases the specified PipelineLayout object. After this call, the specified object must no longer be used.
- virtual GraphicsPipeline ∗ CreateGraphicsPipeline (const GraphicsPipelineDescriptor &desc)=0

  Creates a new and initialized graphics pipeline state object.
- virtual ComputePipeline ∗ CreateComputePipeline (const ComputePipelineDescriptor &desc)=0

  Creates a new and initialized compute pipeline state object.
- virtual void Release (GraphicsPipeline &graphicsPipeline)=0

  Releases the specified GraphicsPipeline object. After this call, the specified object must no longer be used.
- virtual void Release (ComputePipeline &computePipeline)=0

  Releases the specified ComputePipeline object. After this call, the specified object must no longer be used.
- virtual QueryHeap ∗ CreateQueryHeap (const QueryHeapDescriptor &desc)=0

  Creates a new query heap.
- virtual void Release (QueryHeap &queryHeap)=0

  Releases the specified QueryHeap object. After this call, the specified object must no longer be used.
- virtual Fence ∗ CreateFence ()=0

  Creates a new fence (used for CPU/GPU synchronization).
- virtual void Release (Fence &fence)=0

  Releases the specified Fence object. After this call, the specified object must no longer be used.

Static Public Member Functions

- static std::vector< std::string > FindModules ()

  Returns the list of all available render system modules for the current platform.
- static std::unique_ptr< RenderSystem > Load (const RenderSystemDescriptor &renderSystemDesc, RenderingProfiler ∗profiler=nullptr, RenderingDebugger ∗debugger=nullptr)

  Loads a new render system from the specified module.
- static void Unload (std::unique_ptr< RenderSystem > &&renderSystem)

  Unloads the specified render system and the internal module.

Protected Member Functions

- RenderSystem ()=default
- void SetRendererInfo (const RendererInfo &info)

  Sets the renderer information.
- void SetRenderingCaps (const RenderingCapabilities &caps)

  Sets the rendering capabilities.
- void AssertCreateBuffer (const BufferDescriptor &desc, std::uint64_t maxSize)

  Validates the specified buffer descriptor to be used for buffer creation.
- void AssertCreateBufferArray (std::uint32_t numBuffers, Buffer ∗const ∗bufferArray)

  Validates the specified arguments to be used for buffer array creation.
- void AssertCreateShader (const ShaderDescriptor &desc)

  Validates the specified shader descriptor.
- void AssertCreateShaderProgram (const ShaderProgramDescriptor &desc)

  Validates the specified shader program descriptor.
- void AssertCreateRenderTarget (const RenderTargetDescriptor &desc)

  Validates the specified render target descriptor.
- void AssertCreateRenderPass (const RenderPassDescriptor &desc)

  Validates the specified render pass descriptor.
- void AssertImageDataSize (std::size_t dataSize, std::size_t requiredDataSize, const char ∗info=nullptr)

  Validates the specified image data size against the required size (in bytes).

10.70.1 Detailed Description

Render system interface.

Remarks

This is the main interface for the entire renderer. It manages the ownership of all graphics objects and is used to create, modify, and delete all those objects. The main functions for most graphics objects are "Create...", "Write...", "Read...", "Map...", "Unmap...", and "Release":

```
// Create and initialize vertex buffer
LLGL::BufferDescriptor bufferDesc;
//fill descriptor ...
auto vertexBuffer = renderSystem->CreateBuffer(*buffer, bufferDesc, initialData);

// Modify data
renderSystem->WriteBuffer(*buffer, modificationData, ...);

// Release object
renderSystem->Release(*buffer);
```

10.70.2 Constructor & Destructor Documentation

10.70.2.1 LLGL::RenderSystem::RenderSystem ( ) [protected], [default]

10.70.3 Member Function Documentation

10.70.3.1 void LLGL::RenderSystem::AssertCreateBuffer (const **BufferDescriptor** & *desc*, std::uint64_t *maxSize*) [protected]

Validates the specified buffer descriptor to be used for buffer creation.

10.70.3.2 void LLGL::RenderSystem::AssertCreateBufferArray (std::uint32_t *numBuffers,* Buffer ∗const ∗ *bufferArray*) [protected]

Validates the specified arguments to be used for buffer array creation.

10.70.3.3 void LLGL::RenderSystem::AssertCreateRenderPass (const RenderPassDescriptor & *desc*) [protected]

Validates the specified render pass descriptor.

10.70.3.4 void LLGL::RenderSystem::AssertCreateRenderTarget (const RenderTargetDescriptor & *desc*) [protected]

Validates the specified render target descriptor.

10.70.3.5 void LLGL::RenderSystem::AssertCreateShader (const ShaderDescriptor & *desc*) [protected]

Validates the specified shader descriptor.

10.70.3.6 void LLGL::RenderSystem::AssertCreateShaderProgram (const ShaderProgramDescriptor & *desc*) [protected]

Validates the specified shader program descriptor.

10.70.3.7 void LLGL::RenderSystem::AssertImageDataSize (std::size_t *dataSize,* std::size_t *requiredDataSize,* const char ∗ *info* = nullptr) [protected]

Validates the specified image data size against the required size (in bytes).

10.70.3.8 virtual Buffer∗ LLGL::RenderSystem::CreateBuffer (const BufferDescriptor & *desc,* const void ∗ *initialData* = nullptr) [pure virtual]

Creates a new generic hardware buffer.

Parameters

in	*desc*	Specifies the vertex buffer descriptor.
in	*initialData*	Optional raw pointer to the data with which the buffer is to be initialized. This may also be null, to only initialize the size of the buffer. In this case, the buffer must be initialized with the "WriteBuffer" function before it is used for drawing operations. By default null.

See also

WriteBuffer

10.70.3.9 virtual **BufferArray**∗ LLGL::RenderSystem::CreateBufferArray (std::uint32_t *numBuffers*, **Buffer** ∗const ∗ *bufferArray*) [pure virtual]

Creates a new buffer array.

Parameters

in	*numBuffers*	Specifies the number of buffers in the array. This must be greater than 0.
in	*bufferArray*	Pointer to an array of Buffer object pointers. This must not be null.

Remarks

This array can only contain buffers which are all from the same type, like an array of vertex buffers for instance. The buffers inside this array must persist as long as this buffer array is used, and the individual buffers are still required to read and write its data from and to the GPU.

Exceptions

std::invalid_argument	If 'numBuffers' is 0, if 'bufferArray' is null, if any of the pointers in the array are null, if not all buffers have the same type, or if the buffer array type is not one of these: BufferType::Vertex, BufferType::Constant, BufferType::Storage, or BufferType::StreamOutput.

10.70.3.10 virtual **CommandBuffer**∗ LLGL::RenderSystem::CreateCommandBuffer (const **CommandBufferDescriptor** & *desc* = { }) [pure virtual]

Creates a new command buffer.

Remarks

All render systems can create multiple command buffers, but especially for the legacy graphics APIs such as OpenGL and Direct3D 11, this doesn't provide any benefit, since all graphics and compute commands are submitted sequentially to the GPU.

10.70.3.11 virtual **CommandBufferExt**∗ LLGL::RenderSystem::CreateCommandBufferExt (const **CommandBufferDescriptor** & *desc* = { }) [pure virtual]

Creates a new extended command buffer (if supported) with dynamic state access for shader resources (i.e. Constant Buffers, Storage Buffers, Textures, and Samplers).

Returns

Pointer to the new CommandBufferExt object, or null if the render system does not support extended command buffers.

Remarks

For those render systems that do not support dynamic state access for shader resources, use the Resource↩ Heap interface.

Note

Only supported with: OpenGL, Direct3D 11, Metal.

See also

RenderingCapabilities::hasCommandBufferExt
CreateResourceHeap

10.70.3.12 virtual ComputePipeline∗ LLGL::RenderSystem::CreateComputePipeline (const ComputePipelineDescriptor & *desc*) `[pure virtual]`

Creates a new and initialized compute pipeline state object.

Parameters

`in`	*desc*	Specifies the compute pipeline descriptor. This will describe the shader states. The "shaderProgram" member of the descriptor must never be null!

See also

ComputePipelineDescriptor

10.70.3.13 virtual Fence∗ LLGL::RenderSystem::CreateFence ( ) `[pure virtual]`

Creates a new fence (used for CPU/GPU synchronization).

See also

CommandBuffer::SubmitFence
CommandBuffer::WaitFence

10.70.3.14 virtual GraphicsPipeline∗ LLGL::RenderSystem::CreateGraphicsPipeline (const GraphicsPipelineDescriptor & *desc*) `[pure virtual]`

Creates a new and initialized graphics pipeline state object.

Parameters

`in`	*desc*	Specifies the graphics pipeline descriptor. This will describe the entire pipeline state, i.e. the blending-, rasterizer-, depth-, stencil- and shader states. The "shaderProgram" member of the descriptor must never be null!

See also

GraphicsPipelineDescriptor

10.70.3.15 virtual **PipelineLayout**∗ LLGL::RenderSystem::CreatePipelineLayout (const **PipelineLayoutDescriptor** & *desc*) `[pure virtual]`

Creates a new and initialized pipeline layout object, if and only if the renderer supports pipeline layouts.

Parameters

`in`	*desc*	Specifies the pipeline layout descriptor with all layout bindings.

Remarks

A pipeline layout is required in combination with a ResourceHeap to bind multiple resources at once. For modern graphics APIs (i.e. Direct3D 12 and Vulkan), this is only way to bind shader resources. For legacy graphics APIs (i.e. Direct3D 11 and OpenGL), shader resources can also be bound individually with the extended command buffer.

Returns

Pointer to the new PipelineLayout object or null if the renderer does not support pipeline layouts.

See also

CommandBufferExt
CreateResourceHeap

10.70.3.16 virtual **QueryHeap**∗ LLGL::RenderSystem::CreateQueryHeap (const **QueryHeapDescriptor** & *desc*) `[pure virtual]`

Creates a new query heap.

10.70.3.17 virtual **RenderContext**∗ LLGL::RenderSystem::CreateRenderContext (const **RenderContextDescriptor** & *desc*, const std::shared_ptr< **Surface** > & *surface* = { }) `[pure virtual]`

Creates a new render context and returns the raw pointer.

Parameters

`in`	*desc*	Specifies the render context descriptor, which contains the video mode, vsync, multi-sampling settings etc.
`in`	*surface*	Optional shared pointer to a surface for the render context. If this is null, the render context will create its own platform specific surface, which can be accessed by RenderContext::GetSurface. The default surface is not shown automatically.

See also

RenderContext::GetSurface

10.70.3.18 virtual RenderPass∗ LLGL::RenderSystem::CreateRenderPass (const RenderPassDescriptor & *desc*) `[pure virtual]`

Creates a new RenderPass object.

Returns

Pointer to the new RenderPass object or null if the render system does not use render passes. In the case of the latter, null pointers are allowed for render passes.

See also

RenderTargetDescriptor::renderPass
GraphicsPipelineDescriptor::renderPass
CommandBuffer::BeginRenderPass
CommandBuffer::EndRenderPass

10.70.3.19 virtual RenderTarget∗ LLGL::RenderSystem::CreateRenderTarget (const RenderTargetDescriptor & *desc*) `[pure virtual]`

Creates a new RenderTarget object.

Exceptions

std::runtime_error	If the renderer does not support RenderTarget objects (e.g. if OpenGL 2.1 or lower is used).

10.70.3.20 virtual ResourceHeap∗ LLGL::RenderSystem::CreateResourceHeap (const ResourceHeapDescriptor & *desc*) `[pure virtual]`

Creates a new resource heap.

Parameters

`in`	*desc*	Specifies the descriptor which determines all shader resource.

Remarks

Resources heaps are used in combination with a pipeline layout. The pipeline layout determines to which binding points the resources are bound.

See also

CreatePipelineLayout
CommandBuffer::SetGraphicsResourceHeap
CommandBuffer::SetComputeResourceHeap

10.70.3.21 virtual **Sampler**∗ LLGL::RenderSystem::CreateSampler (const **SamplerDescriptor** & *desc*) `[pure virtual]`

Creates a new Sampler object.

Exceptions

std::runtime_error	If the renderer does not support Sampler objects (e.g. if OpenGL 3.1 or lower is used).

See also

GetRenderingCaps

10.70.3.22 virtual **Shader**∗ LLGL::RenderSystem::CreateShader (const **ShaderDescriptor** & *desc*) `[pure virtual]`

Creates a new and Shader object and compiles the specified source.

Remarks

To check whether the compilation was successful or not, use the `HasErrors` and `QueryInfoLog` functions of the Shader interface.

See also

Shader::HasErrors
Shader::QueryInfoLog
ShaderDescriptor
ShaderDescFromFile

10.70.3.23 virtual **ShaderProgram**∗ LLGL::RenderSystem::CreateShaderProgram (const **ShaderProgramDescriptor** & *desc*) `[pure virtual]`

Creates a new shader program and links all specified shaders.

Remarks

To check whether the linking was successful or not, use the `HasErrors` and `QueryInfoLog` functions of the ShaderProgram interface.

See also

ShaderProgram::HasErrors
ShaderProgram::QueryInfoLog
ShaderProgramDescriptor
ShaderProgramDesc

10.70.3.24 virtual **Texture**∗ LLGL::RenderSystem::CreateTexture (const **TextureDescriptor** & *textureDesc,* const **SrcImageDescriptor** ∗ *imageDesc* = `nullptr`) `[pure virtual]`

Creates a new texture.

Parameters

`in`	*textureDesc*	Specifies the texture descriptor.
`in`	*imageDesc*	Optional pointer to the image data descriptor. If this is null, the texture will be initialized with the currently configured default image color. If this is non-null, it is used to initialize the texture data. This parameter will be ignored if the texture type is a multi-sampled texture (i.e. TextureType::Texture2DMS or TextureType::Texture2DMSArray).

See also

WriteTexture
RenderSystemConfiguration::imageInitialization

10.70.3.25 static std::vector<std::string> LLGL::RenderSystem::FindModules ( ) `[static]`

Returns the list of all available render system modules for the current platform.

Remarks

For example, on Win32 this might be { "OpenGL", "Direct3D11", "Direct3D12" }, but on MacOS it might be only { "OpenGL" }.

10.70.3.26 virtual void LLGL::RenderSystem::GenerateMips (Texture & *texture*) `[pure virtual]`

Generates all MIP-maps for the specified texture.

Parameters

`in,out`	*texture*	Specifies the texture whose MIP-maps are to be generated.

Remarks

To generate only a small amout of MIP levels, use the secondary `GenerateMips` function. To update the MIP levels during encoding a command buffer, use CommandBuffer::GenerateMips.

See also

GenerateMips(Texture&, std::uint32_t, std::uint32_t, std::uint32_t, std::uint32_t)

10.70.3.27 virtual void LLGL::RenderSystem::GenerateMips (Texture & *texture*, std::uint32_t *baseMipLevel*, std::uint32_t *numMipLevels*, std::uint32_t *baseArrayLayer* = `0`, std::uint32_t *numArrayLayers* = `1`) `[pure virtual]`

Generates the specified range of MIP-maps for the specified texture.

Parameters

`in,out`	*texture*	Specifies the texture whose MIP-maps are to be generated.
`in`	*baseMipLevel*	Specifies the zero-based index of the first MIP-map level.
`in`	*numMipLevels*	Specifies the number of MIP-maps to generate. This also includes the base MIP-map level, so a number of less than 2 has no effect.
`in`	*baseArrayLayer*	Specifies the zero-based index of the first array layer (if an array texture is used). By default 0.
`in`	*numArrayLayers*	Specifies the number of array layers. For both array textures and non-array textures this must be at least 1. By default 1.

Remarks

This function only guarantees to generate at least the specified amount of MIP-maps. It may also update all other MIP-maps if the respective rendering API does not support hardware accelerated generation of a sub-range of MIP-maps. To update the MIP levels during encoding a command buffer, use CommandBuffer↩ ::GenerateMips.

Note

Only use this function if the range of MIP-maps is significantly smaller than the entire MIP chain, e.g. only a single slice of a large 2D array texture, and use the primary `GenerateMips` function otherwise.

See also

GenerateMips(Texture&)
NumMipLevels

10.70.3.28 virtual **CommandQueue**∗ LLGL::RenderSystem::GetCommandQueue ( ) `[pure virtual]`

Returns the single instance of the command queue.

10.70.3.29 const **RenderSystemConfiguration**& LLGL::RenderSystem::GetConfiguration ( ) const `[inline]`

Returns the basic configuration.

See also

SetConfiguration

10.70.3.30 const std::string& LLGL::RenderSystem::GetName ( ) const `[inline]`

Returns the name of this render system.

10.70.3.31 int LLGL::RenderSystem::GetRendererID ( ) const [inline]

Rendering API identification number.

Remarks

This can be a value of the RendererID entries. Since the render system is modular, a new render system can have its own ID number.

See also

RendererID

10.70.3.32 const RendererInfo& LLGL::RenderSystem::GetRendererInfo ( ) const [inline]

Returns basic renderer information.

Remarks

The validity of these information is only guaranteed if this function is called after a valid render context has been created. Otherwise the behavior is undefined!

10.70.3.33 const RenderingCapabilities& LLGL::RenderSystem::GetRenderingCaps ( ) const [inline]

Returns the rendering capabilities.

Remarks

The validity of these information is only guaranteed if this function is called after a valid render context has been created. Otherwise the behavior is undefined!

10.70.3.34 static std::unique_ptr<RenderSystem> LLGL::RenderSystem::Load (const RenderSystemDescriptor & *renderSystemDesc*, RenderingProfiler ∗ *profiler* = `nullptr`, RenderingDebugger ∗ *debugger* = `nullptr`) [static]

Loads a new render system from the specified module.

Parameters

in	*renderSystemDesc*	Specifies the render system descriptor structure. The 'moduleName' member of this strucutre must not be empty.
in	*profiler*	Optional pointer to a rendering profiler. This is only supported if LLGL was compiled with the `LLGL_ENABLE_DEBUG_LAYER` flag. If this is used, the counters of the profiler must be reset manually.
in	*debugger*	Optional pointer to a rendering debugger. This is only supported if LLGL was compiled with the `LLGL_ENABLE_DEBUG_LAYER` flag. If the default debugger is used (i.e. no sub class of RenderingDebugger), then all reports will be send to the Log. In order to see any reports from the Log, use either Log::SetReportCallback or Log::SetReportCallbackStd.

Remarks

The descriptor structure can be initialized by only the module name like shown in the following example:

```
// Load the "OpenGL" render system module
auto myRenderSystem = LLGL::RenderSystem::Load("OpenGL");
```

The debugger and profiler can be used like this:

```
// Forward all log reports to the standard output stream for errors
LLGL::Log::SetReportCallbackStd(std::cerr);

// Declare profiler and debugger (these classes can also be extended)
LLGL::RenderingProfiler myProfiler;
LLGL::RenderingDebugger myDebugger;

// Load the "Direct3D11" render system module
auto myRenderSystem = LLGL::RenderSystem::Load("Direct3D11", &myProfiler, &
      myDebugger);
```

Exceptions

std::runtime_error	If loading the render system from the specified module failed.

See also

RenderSystemDescriptor::moduleName

10.70.3.35 virtual void∗ LLGL::RenderSystem::MapBuffer (**Buffer** & *buffer*, const **CPUAccess** *access*) [pure virtual]

Maps the specified buffer from GPU to CPU memory space.

Parameters

in	*buffer*	Specifies the buffer which is to be mapped.
in	*access*	Specifies the CPU buffer access requirement, i.e. if the CPU can read and/or write the mapped memory.

Returns

Raw pointer to the mapped memory block. You should be aware of the storage buffer size, to not cause memory violations.

See also

UnmapBuffer

10.70.3.36 virtual void LLGL::RenderSystem::ReadTexture (const **Texture** & *texture*, std::uint32_t *mipLevel*, const **DstImageDescriptor** & *imageDesc*) [pure virtual]

Reads the image data from the specified texture.

Parameters

in	*texture*	Specifies the texture object to read from.
in	*mipLevel*	Specifies the MIP-level from which to read the texture data.
out	*imageDesc*	Specifies the destination image descriptor to write the texture data to.

Remarks

The required size for a successful texture read operation depends on the image format, data type, and texture size. The Texture::QueryDesc or Texture::QueryMipExtent functions can be used to determine the texture dimensions.

```
// Query texture size attribute
auto myTextureExtent = myTexture->QueryMipExtent(0);

// Allocate image buffer with elements in all dimensions
std::vector<LLGL::ColorRGBAub> myImage(myTextureExtent.width * myTextureExtent.height * myTextureExtent.
      depth);

// Initialize destination image descriptor
const DstImageDescriptor myImageDesc {
    LLGL::ImageFormat::RGBA,                    // RGBA image format, since we used
       LLGL::ColorRGBAub
    LLGL::DataType::UInt8,                      // 8-bit unsigned integral data type:
       <std::uint8_t> or <unsigned char>
    myImage.data(),                             // Output image buffer
    myImage.size() * sizeof(LLGL::ColorRGBAub)  // Image buffer size: number of color
       elements and size of each color element
};

// Read texture data from first MIP-map level (index 0)
myRenderSystem->ReadTexture(*myTexture, 0, myImageDesc);
```

Note

The behavior is undefined if 'imageDesc.data' points to an invalid buffer, or 'imageDesc.data' points to a buffer that is smaller than specified by 'imageDesc.dataSize', or 'imageDesc.dataSize' is less than the required size.

Exceptions

std::invalid_argument	If 'imageDesc.data' is null.

See also

Texture::QueryDesc
Texture::QueryMipExtent

10.70.3.37 virtual void LLGL::RenderSystem::Release (**RenderContext** & *renderContext*) [pure virtual]

Releases the specified render context. This will all release all resources, that are associated with this render context.

10.70.3.38 virtual void LLGL::RenderSystem::Release (**CommandBuffer** & *commandBuffer*) [pure virtual]

Releases the specified command buffer. After this call, the specified object must no longer be used.

Remarks

This can be used for both CommandBuffer and CommandBufferExt objects as the latter one inherits from the former one.

See also

CreateCommandBuffer
CreateCommandBufferExt

10.70.3.39 virtual void LLGL::RenderSystem::Release (**Buffer** & *buffer*) `[pure virtual]`

Releases the specified buffer object. After this call, the specified object must no longer be used.

10.70.3.40 virtual void LLGL::RenderSystem::Release (**BufferArray** & *bufferArray*) `[pure virtual]`

Releases the specified buffer array object. After this call, the specified object must no longer be used.

10.70.3.41 virtual void LLGL::RenderSystem::Release (**Texture** & *texture*) `[pure virtual]`

Releases the specified texture object. After this call, the specified object must no longer be used.

10.70.3.42 virtual void LLGL::RenderSystem::Release (**Sampler** & *sampler*) `[pure virtual]`

Releases the specified Sampler object. After this call, the specified object must no longer be used.

10.70.3.43 virtual void LLGL::RenderSystem::Release (**ResourceHeap** & *resourceHeap*) `[pure virtual]`

Releases the specified ResourceHeap object. After this call, the specified object must no longer be used.

10.70.3.44 virtual void LLGL::RenderSystem::Release (**RenderPass** & *renderPass*) `[pure virtual]`

Releases the specified RenderPass object. After this call, the specified object must no longer be used.

10.70.3.45 virtual void LLGL::RenderSystem::Release (**RenderTarget** & *renderTarget*) `[pure virtual]`

Releases the specified RenderTarget object. After this call, the specified object must no longer be used.

10.70.3.46 virtual void LLGL::RenderSystem::Release (**Shader** & *shader*) `[pure virtual]`

Releases the specified Shader object. After this call, the specified object must no longer be used.

10.70.3.47 virtual void LLGL::RenderSystem::Release (**ShaderProgram** & *shaderProgram*) `[pure virtual]`

Releases the specified ShaderProgram object. After this call, the specified object must no longer be used.

10.70.3.48 virtual void LLGL::RenderSystem::Release (**PipelineLayout** & *pipelineLayout*) `[pure virtual]`

Releases the specified PipelineLayout object. After this call, the specified object must no longer be used.

10.70.3.49 virtual void LLGL::RenderSystem::Release (**GraphicsPipeline** & *graphicsPipeline*) `[pure virtual]`

Releases the specified GraphicsPipeline object. After this call, the specified object must no longer be used.

10.70.3.50 virtual void LLGL::RenderSystem::Release (**ComputePipeline** & *computePipeline*) `[pure virtual]`

Releases the specified ComputePipeline object. After this call, the specified object must no longer be used.

10.70.3.51 virtual void LLGL::RenderSystem::Release (**QueryHeap** & *queryHeap*) `[pure virtual]`

Releases the specified QueryHeap object. After this call, the specified object must no longer be used.

10.70.3.52 virtual void LLGL::RenderSystem::Release (**Fence** & *fence*) `[pure virtual]`

Releases the specified Fence object. After this call, the specified object must no longer be used.

10.70.3.53 virtual void LLGL::RenderSystem::SetConfiguration (const **RenderSystemConfiguration** & *config*) `[virtual]`

Sets the basic configuration.

Remarks

This can be used to change the behavior of default initializion of textures for instance.

See also

RenderSystemConfiguration

10.70.3.54 void LLGL::RenderSystem::SetRendererInfo (const **RendererInfo** & *info*) `[protected]`

Sets the renderer information.

10.70.3.55 void LLGL::RenderSystem::SetRenderingCaps (const RenderingCapabilities & *caps*) [protected]

Sets the rendering capabilities.

10.70.3.56 static void LLGL::RenderSystem::Unload (std::unique_ptr< RenderSystem > && *renderSystem*) [static]

Unloads the specified render system and the internal module.

Remarks

After this call, the specified render system and all the objects associated to it must no longer be used!

10.70.3.57 virtual void LLGL::RenderSystem::UnmapBuffer (Buffer & *buffer*) [pure virtual]

Unmaps the specified buffer.

See also

MapBuffer

10.70.3.58 virtual void LLGL::RenderSystem::WriteBuffer (Buffer & *dstBuffer,* std::uint64_t *dstOffset,* const void * *data,* std::uint64_t *dataSize*) [pure virtual]

Updates the data of the specified buffer.

Parameters

in	*dstBuffer*	Specifies the destination buffer whose data is to be updated.
in	*dstOffset*	Specifies the offset (in bytes) at which the buffer is to be updated. This offset plus the data block size (i.e. `offset + dataSize`) must be less than or equal to the size of the buffer.
in	*data*	Raw pointer to the data with which the buffer is to be updated. This must not be null!
in	*dataSize*	Specifies the size (in bytes) of the data block which is to be updated. This must be less then or equal to the size of the buffer.

Remarks

To update a small buffer (maximum of 65536 bytes) during encoding a command buffer, use Command↩ Buffer::UpdateBuffer.

10.70.3.59 virtual void LLGL::RenderSystem::WriteTexture (Texture & *texture,* const TextureRegion & *textureRegion,* const SrcImageDescriptor & *imageDesc*) [pure virtual]

Updates the image data of the specified texture.

Parameters

in	*texture*	Specifies the texture whose data is to be updated.
in	*textureRegion*	Specifies the texture region where the texture is to be updated.
in	*imageDesc*	Specifies the image data descriptor. Its `data` member must not be null!

Remarks

This function can only be used for non-multi-sample textures, i.e. from types other than TextureType::↩
Texture2DMS and TextureType::Texture2DMSArray.

The documentation for this class was generated from the following file:

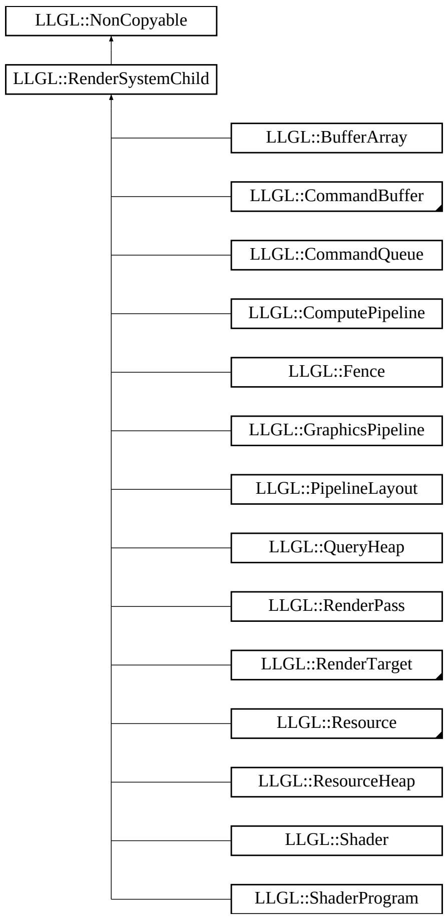
- RenderSystem.h

10.71 LLGL::RenderSystemChild Class Reference

Base class for all interfaces whoes instances are owned by the RenderSystem.

`#include <RenderSystemChild.h>`

Inheritance diagram for LLGL::RenderSystemChild:



Additional Inherited Members

10.71.1 Detailed Description

Base class for all interfaces whoes instances are owned by the RenderSystem.

The documentation for this class was generated from the following file:

- RenderSystemChild.h

10.72 LLGL::RenderSystemConfiguration Struct Reference

Render system configuration structure.

```
#include <RenderSystemFlags.h>
```

Public Attributes

- ImageInitialization imageInitialization

    Image initialization for textures without initial image data.
- std::size_t threadCount = Constants::maxThreadCount

    Specifies the number of threads that will be used internally by the render system. By default Constants::maxThread←Count.

10.72.1 Detailed Description

Render system configuration structure.

10.72.2 Member Data Documentation

10.72.2.1 ImageInitialization LLGL::RenderSystemConfiguration::imageInitialization

Image initialization for textures without initial image data.

10.72.2.2 std::size_t LLGL::RenderSystemConfiguration::threadCount = Constants::maxThreadCount

Specifies the number of threads that will be used internally by the render system. By default Constants::max←ThreadCount.

Remarks

This is mainly used by the Direct3D render systems, e.g. inside the "CreateTexture" and "WriteTexture" functions to convert the image data into the respective hardware texture format. OpenGL does this automatically.

See also

Constants::maxThreadCount

The documentation for this struct was generated from the following file:

- RenderSystemFlags.h

10.73 LLGL::RenderSystemDescriptor Struct Reference

Render system descriptor structure.

```
#include <RenderSystemFlags.h>
```

Public Member Functions

- RenderSystemDescriptor ()=default
- RenderSystemDescriptor (const RenderSystemDescriptor &)=default
- RenderSystemDescriptor & operator= (const RenderSystemDescriptor &)=default
- RenderSystemDescriptor (const std::string &moduleName)

  Constructor to initialize the descriptor with the module name form an std::string.
- RenderSystemDescriptor (const char ∗moduleName)

  Constructor to initialize the descriptor with the module name form a null terminated string.

Public Attributes

- std::string moduleName

  Specifies the name from which the new render system is to be loaded.
- const void ∗ rendererConfig = nullptr

  Optional raw pointer to a renderer specific configuration structure.
- std::size_t rendererConfigSize = 0

  Specifies the size (in bytes) of the structure where the 'rendererConfig' member points to (use 'sizeof' with the respective structure). By default 0.

10.73.1 Detailed Description

Render system descriptor structure.

Remarks

This can be used for some refinements of a specific renderer, e.g. to configure the Vulkan device memory manager.

See also

RenderSystem::Load

10.73.2 Constructor & Destructor Documentation

10.73.2.1 LLGL::RenderSystemDescriptor::RenderSystemDescriptor ( ) [default]

10.73.2.2 LLGL::RenderSystemDescriptor::RenderSystemDescriptor (const RenderSystemDescriptor &) [default]

10.73.2.3 LLGL::RenderSystemDescriptor::RenderSystemDescriptor (const std::string & *moduleName*) [inline]

Constructor to initialize the descriptor with the module name form an std::string.

10.73.2.4 LLGL::RenderSystemDescriptor::RenderSystemDescriptor (const char ∗ *moduleName*) [inline]

Constructor to initialize the descriptor with the module name form a null terminated string.

10.73.3 Member Function Documentation

10.73.3.1 RenderSystemDescriptor& LLGL::RenderSystemDescriptor::operator= (const RenderSystemDescriptor &) [default]

10.73.4 Member Data Documentation

10.73.4.1 std::string LLGL::RenderSystemDescriptor::moduleName

Specifies the name from which the new render system is to be loaded.

Remarks

This denotes a shared library (∗.dll-files on Windows, ∗.so-files on Unix systems). If compiled in debug mode, the postfix "D" is appended to the module name. Moreover, the platform dependent file extension is always added automatically as well as the prefix "LLGL_", i.e. a module name "OpenGL" will be translated to "LLG↩
L_OpenGLD.dll", if compiled on Windows in Debug mode.

10.73.4.2 const void∗ LLGL::RenderSystemDescriptor::rendererConfig = nullptr

Optional raw pointer to a renderer specific configuration structure.

Remarks

This can be used to pass some refinement configurations to the render system when the module is loaded. Example usage (for Vulkan renderer):

```
// Initialize Vulkan specific configurations (e.g. always allocate at least 1GB of VRAM for each device
      memory chunk).
LLGL::VulkanRendererConfiguration config;
config.minDeviceMemoryAllocationSize = 1024*1024*1024;

// Initialize render system descriptor
LLGL::RenderSystemDescriptor rendererDesc;
rendererDesc.moduleName         = "Vulkan";
rendererDesc.rendererConfig     = &config;
rendererDesc.rendererConfigSize = sizeof(config);

// Load Vulkan render system
auto renderer = LLGL::RenderSystem::Load(rendererDesc);
```

See also

rendererConfigSize
VulkanRendererConfiguration

10.73.4.3 std::size_t LLGL::RenderSystemDescriptor::rendererConfigSize = 0

Specifies the size (in bytes) of the structure where the 'rendererConfig' member points to (use 'sizeof' with the respective structure). By default 0.

Remarks

If 'rendererConfig' is null then this member is ignored.

See also

rendererConfig

The documentation for this struct was generated from the following file:

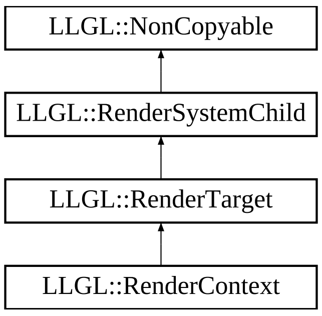
- RenderSystemFlags.h

10.74 LLGL::RenderTarget Class Reference

Render target interface.

```
#include <RenderTarget.h>
```

Inheritance diagram for LLGL::RenderTarget:



Public Member Functions

- virtual bool IsRenderContext () const

  Returns true if this render target is an instance of RenderContext. By default false.
- virtual Extent2D GetResolution () const =0

  Returns the render target resolution.
- virtual std::uint32_t GetNumColorAttachments () const =0

  Returns the number of color attachments of this render target. This can also be zero.
- virtual bool HasDepthAttachment () const =0

  Returns true if this render target has a depth or depth-stencil attachment.
- virtual bool HasStencilAttachment () const =0

  Returns true if this render target has a stencil or depth-stencil attachment.
- virtual const RenderPass ∗ GetRenderPass () const =0

  Returns the RenderPass object this render target is associated with, or null if render passes are optional for the the render system.

Protected Member Functions

- void ValidateResolution (const Extent2D &resolution)

  Applies the specified resolution.
- void ValidateMipResolution (const Texture &texture, std::uint32_t mipLevel)

  Applies the resolution of the texture MIP level.

10.74.1 Detailed Description

Render target interface.

Remarks

A render target in the broader sense is a composition of Texture objects which can be specified as the destination for drawing operations. After a texture has been attached to a render target, its image content is undefined until something has been rendered into the render target. The only interface that inherits from this interface is RenderContext, a special case of render targets used to present the result on the screen.

See also

RenderSystem::CreateRenderTarget
CommandBuffer::SetRenderTarget(RenderTarget&)
RenderContext

10.74.2 Member Function Documentation

10.74.2.1 virtual std::uint32_t LLGL::RenderTarget::GetNumColorAttachments ( ) const [pure virtual]

Returns the number of color attachments of this render target. This can also be zero.

Remarks

For a render context, this will always be 1.

See also

RenderContext::QueryColorFormat

Implemented in LLGL::RenderContext.

10.74.2.2 virtual const RenderPass∗ LLGL::RenderTarget::GetRenderPass ( ) const [pure virtual]

Returns the RenderPass object this render target is associated with, or null if render passes are optional for the the render system.

Remarks

This is either the RenderPass object that was passed to the descriptor when this render target was created, or it is the default RenderPass object that was created by the render target itself.

See also

RenderTargetDescriptor::renderPass

10.74.2.3 virtual Extent2D LLGL::RenderTarget::GetResolution ( ) const [pure virtual]

Returns the render target resolution.

Remarks

This is either determined by the resolution specified in the render target descriptor, or by the video mode of the render context.

See also

RenderContext::GetVideoMode
RenderTargetDescriptor::resolution
VideoModeDescriptor::resolution

Implemented in LLGL::RenderContext.

10.74.2.4 virtual bool LLGL::RenderTarget::HasDepthAttachment ( ) const [pure virtual]

Returns true if this render target has a depth or depth-stencil attachment.

Remarks

The return value depends on whether the rendering API supports depth-stencil formats where the depth and stencil components can be strictly separated. For example, if the render target was created with only a stencil attachment, LLGL may still create a depth-stencil buffer that results in both a depth and stencil component in one attachment.

See also

RenderContext::QueryDepthStencilFormat

Implemented in LLGL::RenderContext.

10.74.2.5 virtual bool LLGL::RenderTarget::HasStencilAttachment ( ) const [pure virtual]

Returns true if this render target has a stencil or depth-stencil attachment.

Remarks

The return value depends on whether the rendering API supports depth-stencil formats where the depth and stencil components can be strictly separated. For example, if the render target was created with only a stencil attachment, LLGL may still create a depth-stencil buffer that results in both a depth and stencil component in one attachment.

See also

RenderContext::QueryDepthStencilFormat

Implemented in LLGL::RenderContext.

10.74.2.6 virtual bool LLGL::RenderTarget::IsRenderContext ( ) const [virtual]

Returns true if this render target is an instance of RenderContext. By default false.

Remarks

Do not override this function. Only the sub class RenderContext is supposed to override it.

See also

RenderContext::IsRenderContext

Reimplemented in LLGL::RenderContext.

10.74.2.7 void LLGL::RenderTarget::ValidateMipResolution (const Texture & *texture,* std::uint32_t *mipLevel*) [protected]

Applies the resolution of the texture MIP level.

See also

Texture::QueryMipExtent
ValidateResolution

10.74.2.8 void LLGL::RenderTarget::ValidateResolution (const Extent2D & *resolution*) [protected]

Applies the specified resolution.

Remarks

This shoudl be called for each attachment.

Exceptions

std::invalid_argument	If one of the resolution components is zero.
std::invalid_argument	If the internal resolution has already been set and the input resolution is not equal to that previous resolution.

The documentation for this class was generated from the following file:

- RenderTarget.h

10.75 LLGL::RenderTargetDescriptor Struct Reference

Render target descriptor structure.

`#include <RenderTargetFlags.h>`

Public Attributes

- const RenderPass ∗ renderPass = nullptr

  Optional render pass object that will be used with the render target. By default null.
- Extent2D resolution

  Specifies the resolution of the render targets.
- MultiSamplingDescriptor multiSampling

  Multi-sampling descriptor. By default, multi-sampling is disabled.
- bool customMultiSampling = false

  Specifies whether custom multi-sampling is used or not. By default false.
- std::vector< AttachmentDescriptor > attachments

  Specifies all render target attachment descriptors.

10.75.1 Detailed Description

Render target descriptor structure.

Remarks

Here is a small example of a render target descriptor with a color attachmnet and an anonymous depth attachment (i.e. without a texture reference, which is only allowed for depth/stencil attachments):

```
LLGL::RenderTargetDescriptor myRenderTargetDesc;

auto myRenderTargetSize = myColorTexture->QueryMipExtent(0);
myRenderTargetDesc.resolution = { myRenderTargetSize.width, myRenderTargetSize.height };

myRenderTargetDesc.attachments = {
    LLGL::AttachmentDescriptor {
      LLGL::AttachmentType::Color, myColorTexture },
    LLGL::AttachmentDescriptor {
      LLGL::AttachmentType::Depth },
};

auto myRenderTarget = myRenderer->CreateRenderTarget(myRenderTargetDesc);
```

See also

RenderSystem::CreateRenderTarget

10.75.2 Member Data Documentation

10.75.2.1 std::vector<AttachmentDescriptor> LLGL::RenderTargetDescriptor::attachments

Specifies all render target attachment descriptors.

Remarks

This container can also be empty, if the respective fragment shader has no direct output but writes into a storage texture instead (e.g. `image3D` in GLSL, or `RWTexture3D<float4>` in HLSL). If the respective rendering API does not support render targets without any attachments, LLGL will generate a dummy texture.

10.75.2.2 bool LLGL::RenderTargetDescriptor::customMultiSampling = false

Specifies whether custom multi-sampling is used or not. By default false.

Remarks

If this is true, only multi-sampled textures can be attached to a render-target, i.e. textures of the following types: Texture2DMS, Texture2DMSArray. If this is false, only non-multi-sampled textures can be attached to a render-target. This field will be ignored if multi-sampling is disabled.

10.75.2.3 MultiSamplingDescriptor LLGL::RenderTargetDescriptor::multiSampling

Multi-sampling descriptor. By default, multi-sampling is disabled.

10.75.2.4 const RenderPass∗ LLGL::RenderTargetDescriptor::renderPass = nullptr

Optional render pass object that will be used with the render target. By default null.

Remarks

If this is null, a default render pass is created for the render target. The default render pass determines the attachment formats by the render target attachments and keeps the load and store operations at its default values.

See also

RenderSystem::CreateRenderPass
AttachmentFormatDescriptor::loadOp
AttachmentFormatDescriptor::storeOp

10.75.2.5 Extent2D LLGL::RenderTargetDescriptor::resolution

Specifies the resolution of the render targets.

Remarks

All attachments with a reference to a texture must have the same resolution, i.e. the specified array layer and MIP-map level must have the same extent.

See also

Texture::QueryMipExtent

The documentation for this struct was generated from the following file:

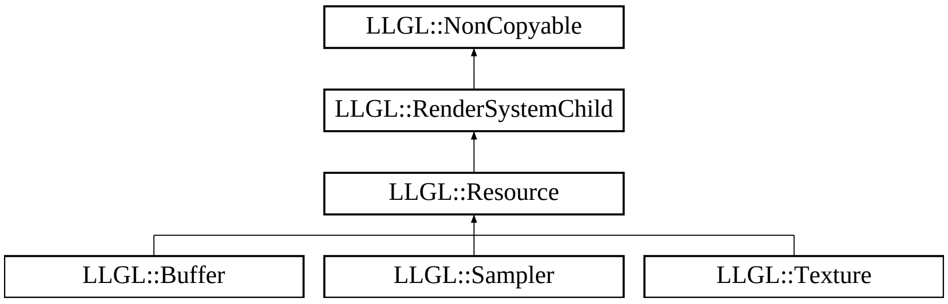
- RenderTargetFlags.h

10.76 LLGL::Resource Class Reference

Base class for all hardware resource interfaces.

`#include <Resource.h>`

Inheritance diagram for LLGL::Resource:



Public Member Functions

- virtual ResourceType QueryResourceType () const =0

  Returns the type of this resource object.

Additional Inherited Members

10.76.1 Detailed Description

Base class for all hardware resource interfaces.

See also

Buffer
Texture
Sampler

10.76.2 Member Function Documentation

10.76.2.1 virtual ResourceType LLGL::Resource::QueryResourceType ( ) const [pure virtual]

Returns the type of this resource object.

Remarks

This is queried by a virtual function call, so the resource type does not need to be stored per instance.

See also

ResourceType

Implemented in LLGL::Texture, LLGL::Buffer, and LLGL::Sampler.

The documentation for this class was generated from the following file:

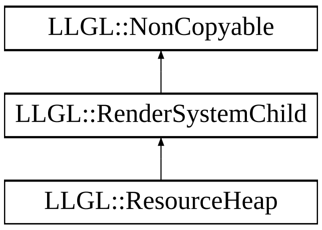
- Resource.h

10.77 LLGL::ResourceHeap Class Reference

Resource heap interface.

```
#include <ResourceHeap.h>
```

Inheritance diagram for LLGL::ResourceHeap:



Additional Inherited Members

10.77.1 Detailed Description

Resource heap interface.

Remarks

An instance of this interface provides a descriptor set (as called in Vulkan) or descriptor heap (as called in Direct3D 12) for graphics and compute pipelines.

See also

RenderSystem::CreateResourceHeap
CommandBuffer::SetGraphicsResourceHeap
CommandBuffer::SetComputeResourceHeap

Todo Maybe rename to "ResourceViewHeap" again?

The documentation for this class was generated from the following file:

- ResourceHeap.h

10.78 LLGL::ResourceHeapDescriptor Struct Reference

Resource heap descriptor structure.

```
#include <ResourceHeapFlags.h>
```

Public Attributes

- PipelineLayout ∗ pipelineLayout = nullptr

  Reference to the pipeline layout. This must not be null, when a resource heap is created.
- std::vector< ResourceViewDescriptor > resourceViews

  List of all resource view descriptors.

10.78.1 Detailed Description

Resource heap descriptor structure.

Remarks

For the render systems of modern graphics APIs (i.e. Vulkan and Direct3D 12), a resource heap is the only way to bind hardware resources to a shader pipeline. The resource heap is a container for one or more resources such as textures, samplers, constant buffers etc.

See also

RenderSystem::CreateResourceHeap

10.78.2 Member Data Documentation

10.78.2.1 PipelineLayout∗ LLGL::ResourceHeapDescriptor::pipelineLayout = nullptr

Reference to the pipeline layout. This must not be null, when a resource heap is created.

10.78.2.2 std::vector<ResourceViewDescriptor> LLGL::ResourceHeapDescriptor::resourceViews

List of all resource view descriptors.

Remarks

These resources must be specified in the same order as they were specified when the pipeline layout was created.

See also

PipelineLayoutDescriptor::bindings

The documentation for this struct was generated from the following file:

- ResourceHeapFlags.h

10.79 LLGL::ShaderReflectionDescriptor::ResourceView Struct Reference

Shader reflection resource view structure.

`#include <ShaderProgramFlags.h>`

Public Attributes

- std::string name

  Name of the shader resource, i.e. the identifier used in the shader.
- ResourceType type = ResourceType::Undefined

  Resource view type for this layout binding. By default ResourceType::Undefined.
- long stageFlags = 0

  Specifies in which shader stages the resource is located. By default 0.
- std::uint32_t slot = 0

  Specifies the zero-based binding slot. By default 0.
- std::uint32_t arraySize = 1

  Specifies the number of binding slots for an array resource. By default 1.
- std::uint32_t constantBufferSize = 0

  Specifies the size (in bytes) for a constant buffer resource.
- StorageBufferType storageBufferType = StorageBufferType::Undefined

  Specifies the sub-type of a storage buffer resource.

10.79.1 Detailed Description

Shader reflection resource view structure.

Remarks

A mapping between this structure and a binding descriptor may look like this:

```
auto myShaderReflectionDesc = myShaderProgram->QueryReflectionDesc();
LLGL::PipelineLayoutDescriptor myPipelineLayoutDesc;
for (const auto& myResourceView : myShaderReflectionDesc) {
    BindingDescriptor myBindingDesc;
    myBindingDesc.type          = myResourceView.type;
    myBindingDesc.stageFlags    = myResourceView.stageFlags;
    myBindingDesc.slot          = myResourceView.slot;
    myBindingDesc.arraySize     = myResourceView.arraySize;
    myPipelineLayoutDesc.bindings.push_back(myBindingDesc);
}
```

See also

BindingDescriptor

10.79.2 Member Data Documentation

10.79.2.1 std::uint32_t LLGL::ShaderReflectionDescriptor::ResourceView::arraySize = 1

Specifies the number of binding slots for an array resource. By default 1.

Note

For Vulkan, this number specifies the size of an array of resources (e.g. an array of uniform buffers).

10.79.2.2 std::uint32_t LLGL::ShaderReflectionDescriptor::ResourceView::constantBufferSize = 0

Specifies the size (in bytes) for a constant buffer resource.

Remarks

Additional attribute exclusively used for constant buffer resources. For all other resources, i.e. when 'type' is not equal to 'ResourceType::ConstantBuffer', this attribute is zero.

See also

ResourceType::ConstantBuffer

10.79.2.3 std::string LLGL::ShaderReflectionDescriptor::ResourceView::name

Name of the shader resource, i.e. the identifier used in the shader.

10.79.2.4 std::uint32_t LLGL::ShaderReflectionDescriptor::ResourceView::slot = 0

Specifies the zero-based binding slot. By default 0.

Remarks

If the binding slot could be not queried by the shader reflection, the value is Constants::invalidSlot.

See also

Constants::invalidSlot

10.79.2.5 long LLGL::ShaderReflectionDescriptor::ResourceView::stageFlags = 0

Specifies in which shader stages the resource is located. By default 0.

Remarks

This can be a bitwise OR combination of the StageFlags bitmasks.

See also

StageFlags

10.79.2.6 StorageBufferType LLGL::ShaderReflectionDescriptor::ResourceView::storageBufferType = StorageBufferType::Undefined

Specifies the sub-type of a storage buffer resource.

Remarks

Additional attribute exclusively used for storage buffer resources.

10.79.2.7 ResourceType LLGL::ShaderReflectionDescriptor::ResourceView::type = ResourceType::Undefined

Resource view type for this layout binding. By default ResourceType::Undefined.

The documentation for this struct was generated from the following file:

- ShaderProgramFlags.h

10.80 LLGL::ResourceViewDescriptor Struct Reference

Resource view descriptor structure.

```
#include <ResourceHeapFlags.h>
```

Public Member Functions

- ResourceViewDescriptor ()=default

  Default constructor to initialize the resource view with a null pointer.
- ResourceViewDescriptor (Resource ∗resource)

  Constructor to initialize the descriptor with a Buffer resource view.

Public Attributes

- Resource ∗ resource = nullptr

  Pointer to the hardware resoudce.

10.80.1 Detailed Description

Resource view descriptor structure.

See also

ResourceHeapDescriptor::resourceViews

10.80.2 Constructor & Destructor Documentation

10.80.2.1 LLGL::ResourceViewDescriptor::ResourceViewDescriptor ( ) [default]

Default constructor to initialize the resource view with a null pointer.

10.80.2.2 LLGL::ResourceViewDescriptor::ResourceViewDescriptor (Resource ∗ *resource*) [inline]

Constructor to initialize the descriptor with a Buffer resource view.

10.80.3 Member Data Documentation

10.80.3.1 Resource∗ LLGL::ResourceViewDescriptor::resource = nullptr

Pointer to the hardware resoudce.

The documentation for this struct was generated from the following file:

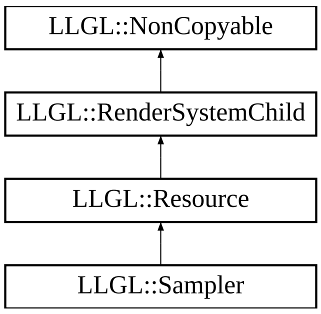
- ResourceHeapFlags.h

10.81 LLGL::Sampler Class Reference

Sampler interface.

```
#include <Sampler.h>
```

Inheritance diagram for LLGL::Sampler:



Public Member Functions

- ResourceType QueryResourceType () const override
  Returns ResourceType::Sampler.

Protected Member Functions

- Sampler ()=default

10.81.1 Detailed Description

Sampler interface.

See also

RenderSystem::CreateSampler

10.81.2 Constructor & Destructor Documentation

10.81.2.1 LLGL::Sampler::Sampler ( ) [protected], [default]

10.81.3 Member Function Documentation

10.81.3.1 ResourceType LLGL::Sampler::QueryResourceType ( ) const [override], [virtual]

Returns ResourceType::Sampler.

Implements LLGL::Resource.

The documentation for this class was generated from the following file:

- Sampler.h

10.82 LLGL::SamplerDescriptor Struct Reference

Texture sampler descriptor structure.

`#include <SamplerFlags.h>`

Public Attributes

- SamplerAddressMode addressModeU = SamplerAddressMode::Repeat

  Sampler address mode in U direction (also X axis). By default SamplerAddressMode::Repeat.
- SamplerAddressMode addressModeV = SamplerAddressMode::Repeat

  Sampler address mode in V direction (also Y axis). By default SamplerAddressMode::Repeat.
- SamplerAddressMode addressModeW = SamplerAddressMode::Repeat

  Sampler address mode in W direction (also Z axis). By default SamplerAddressMode::Repeat.
- SamplerFilter minFilter = SamplerFilter::Linear

  Minification filter. By default SamplerFilter::Linear.
- SamplerFilter magFilter = SamplerFilter::Linear

  Magnification filter. By default SamplerFilter::Linear.
- SamplerFilter mipMapFilter = SamplerFilter::Linear

  MIP-mapping filter. By default SamplerFilter::Linear.
- bool mipMapping = true

  Specifies whether MIP-maps are used or not. By default true.
- float mipMapLODBias = 0.0f

  MIP-mapping level-of-detail (LOD) bias (or rather offset). By default 0.
- float minLOD = 0.0f

  Lower end of the MIP-map range. By default 0.
- float maxLOD = 1000.0f

  Upper end of the MIP-map range. Must be greater than or equal to "minLOD". By default 1000.
- std::uint32_t maxAnisotropy = 1

  Maximal anisotropy in the range [1, 16].
- bool compareEnabled = false

  Specifies whether the compare operation for depth textures is to be used or not. By default false.
- CompareOp compareOp = CompareOp::Less

  Compare operation for depth textures. By default CompareOp::Less.
- ColorRGBAf borderColor = { 0.0f, 0.0f, 0.0f, 0.0f }

  Border color. By default black (0, 0, 0, 0).

10.82.1 Detailed Description

Texture sampler descriptor structure.

10.82.2 Member Data Documentation

10.82.2.1 SamplerAddressMode LLGL::SamplerDescriptor::addressModeU = SamplerAddressMode::Repeat

Sampler address mode in U direction (also X axis). By default SamplerAddressMode::Repeat.

10.82.2.2 SamplerAddressMode LLGL::SamplerDescriptor::addressModeV = SamplerAddressMode::Repeat

Sampler address mode in V direction (also Y axis). By default SamplerAddressMode::Repeat.

10.82.2.3 SamplerAddressMode LLGL::SamplerDescriptor::addressModeW = SamplerAddressMode::Repeat

Sampler address mode in W direction (also Z axis). By default SamplerAddressMode::Repeat.

10.82.2.4 ColorRGBAf LLGL::SamplerDescriptor::borderColor = { 0.0f, 0.0f, 0.0f, 0.0f }

Border color. By default black (0, 0, 0, 0).

Note

For Vulkan and Metal, only three predefined border colors are supported:

- Transparenty black: `{0,0,0,0}`
- Opaque black: `{0,0,0,1}`
- Opaque white: `{1,1,1,1}`

10.82.2.5 bool LLGL::SamplerDescriptor::compareEnabled = false

Specifies whether the compare operation for depth textures is to be used or not. By default false.

10.82.2.6 CompareOp LLGL::SamplerDescriptor::compareOp = CompareOp::Less

Compare operation for depth textures. By default CompareOp::Less.

10.82.2.7 SamplerFilter LLGL::SamplerDescriptor::magFilter = SamplerFilter::Linear

Magnification filter. By default SamplerFilter::Linear.

10.82.2.8 std::uint32_t LLGL::SamplerDescriptor::maxAnisotropy = 1

Maximal anisotropy in the range [1, 16].

10.82.2.9 float LLGL::SamplerDescriptor::maxLOD = 1000.0f

Upper end of the MIP-map range. Must be greater than or equal to "minLOD". By default 1000.

10.82.2.10 SamplerFilter LLGL::SamplerDescriptor::minFilter = SamplerFilter::Linear

Minification filter. By default SamplerFilter::Linear.

10.82.2.11 float LLGL::SamplerDescriptor::minLOD = 0.0f

Lower end of the MIP-map range. By default 0.

10.82.2.12 SamplerFilter LLGL::SamplerDescriptor::mipMapFilter = SamplerFilter::Linear

MIP-mapping filter. By default SamplerFilter::Linear.

10.82.2.13 float LLGL::SamplerDescriptor::mipMapLODBias = 0.0f

MIP-mapping level-of-detail (LOD) bias (or rather offset). By default 0.

10.82.2.14 bool LLGL::SamplerDescriptor::mipMapping = true

Specifies whether MIP-maps are used or not. By default true.

Note

Sampling a texture object that was not created with the 'TextureFlags::GenerateMips' flag while MIP-mapping is enabled is considered undefined behavior.

See also

TextureFlags::GenerateMips
TextureDescriptor::flags

The documentation for this struct was generated from the following file:

- SamplerFlags.h

10.83 LLGL::Scissor Struct Reference

Scissor dimensions.

`#include <GraphicsPipelineFlags.h>`

Public Member Functions

- Scissor ()=default
- Scissor (const Scissor &)=default
- Scissor (std::int32_t x, std::int32_t y, std::int32_t width, std::int32_t height)

  Scissor constructor with parameters for all attributes.
- Scissor (const Offset2D &offset, const Extent2D &extent)

  Scissor constructor with offset and extent parameters.

Public Attributes

- std::int32_t x = 0

  Left-top X coordinate.
- std::int32_t y = 0

  Left-top Y coordinate.
- std::int32_t width = 0

  Right-bottom width.
- std::int32_t height = 0

  Right-bottom height.

10.83.1 Detailed Description

Scissor dimensions.

Remarks

A scissor is in screen coordinates where the origin is in the left-top corner.

See also

CommandBuffer::SetScissor
CommandBuffer::SetScissors
GraphicsPipelineDescriptor::scissors

10.83.2 Constructor & Destructor Documentation

10.83.2.1 LLGL::Scissor::Scissor ( ) `[default]`

10.83.2.2 LLGL::Scissor::Scissor (const Scissor &) `[default]`

10.83.2.3 LLGL::Scissor::Scissor (std::int32_t *x*, std::int32_t *y*, std::int32_t *width*, std::int32_t *height*) `[inline]`

Scissor constructor with parameters for all attributes.

10.83.2.4 LLGL::Scissor::Scissor (const Offset2D & *offset*, const Extent2D & *extent*) [inline]

Scissor constructor with offset and extent parameters.

10.83.3 Member Data Documentation

10.83.3.1 std::int32_t LLGL::Scissor::height = 0

Right-bottom height.

10.83.3.2 std::int32_t LLGL::Scissor::width = 0

Right-bottom width.

10.83.3.3 std::int32_t LLGL::Scissor::x = 0

Left-top X coordinate.

10.83.3.4 std::int32_t LLGL::Scissor::y = 0

Left-top Y coordinate.

The documentation for this struct was generated from the following file:

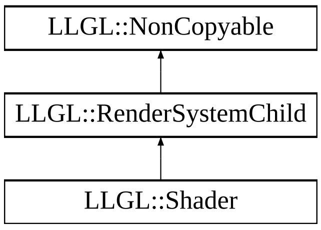
- GraphicsPipelineFlags.h

10.84 LLGL::Shader Class Reference

Shader interface.

```
#include <Shader.h>
```

Inheritance diagram for LLGL::Shader:



Public Member Functions

- virtual bool HasErrors () const =0

  Returns true if this shader has any errors. Otherwise, the compilation was successful.
- virtual std::string Disassemble (int flags=0)=0

  Disassembles the previously compiled shader byte code.
- virtual std::string QueryInfoLog ()=0

  Returns the information log after the shader compilation.
- long GetStageFlags () const

  Returns the shader stage bitmask for this shader object.
- ShaderType GetType () const

  Returns the type of this shader.

Protected Member Functions

- Shader (const ShaderType type)

10.84.1 Detailed Description

Shader interface.

See also

RenderSystem::CreateShader

10.84.2 Constructor & Destructor Documentation

10.84.2.1 LLGL::Shader::Shader (const ShaderType *type*) `[protected]`

10.84.3 Member Function Documentation

10.84.3.1 virtual std::string LLGL::Shader::Disassemble (int *flags* = `0`) `[pure virtual]`

Disassembles the previously compiled shader byte code.

Parameters

`in`	*flags*	Specifies optional disassemble flags. This can be a bitwise OR combination of the 'ShaderDisassembleFlags' enumeration entries. By default 0.

Returns

Disassembled assembler code or an empty string if disassembling was not possible.

Note

Only supported with: Direct3D 11, Direct3D 12.

10.84.3.2 long LLGL::Shader::GetStageFlags ( ) const

Returns the shader stage bitmask for this shader object.

See also

StageFlags

10.84.3.3 ShaderType LLGL::Shader::GetType ( ) const [inline]

Returns the type of this shader.

10.84.3.4 virtual bool LLGL::Shader::HasErrors ( ) const [pure virtual]

Returns true if this shader has any errors. Otherwise, the compilation was successful.

Remarks

If the compilation failed, this shader can not be used for a graphics or compute pipeline. However, the details about the failure can be queried by the QueryInfoLog function.

See also

QueryInfoLog

10.84.3.5 virtual std::string LLGL::Shader::QueryInfoLog ( ) [pure virtual]

Returns the information log after the shader compilation.

The documentation for this class was generated from the following file:

- Shader.h

10.85 LLGL::ShaderCompileFlags Struct Reference

Shader compilation flags enumeration.

`#include <ShaderFlags.h>`

Public Types

- enum {
  Debug = (1 << 0), O1 = (1 << 1), O2 = (1 << 2), O3 = (1 << 3),
  WarnError = (1 << 4) }

10.85.1 Detailed Description

Shader compilation flags enumeration.

Note

Only supported with: Direct3D 11, Direct3D 12.

10.85.2 Member Enumeration Documentation

10.85.2.1 anonymous enum

Enumerator

Debug	Insert debug information.
O1	Optimization level 1.
O2	Optimization level 2.
O3	Optimization level 3.
WarnError	Warnings are treated as errors.

The documentation for this struct was generated from the following file:

- ShaderFlags.h

10.86 LLGL::ShaderDescriptor Struct Reference

Shader source and binary code descriptor structure.

```
#include <ShaderFlags.h>
```

Classes

- struct StreamOutput

  Additional descriptor for stream outputs.

Public Member Functions

- ShaderDescriptor ()=default
- ShaderDescriptor (const ShaderDescriptor &)=default
- ShaderDescriptor & operator= (const ShaderDescriptor &)=default
- ShaderDescriptor (const ShaderType type, const char ∗source)

  Constructor to initialize the shader descriptor with a source filename.
- ShaderDescriptor (const ShaderType type, const char ∗source, const char ∗entryPoint, const char ∗profile, long flags=0)

  Constructor to initialize the shader descriptor with a source filename, entry point, profile, and optional flags.

Public Attributes

- ShaderType type = ShaderType::Undefined

    Specifies the type of the shader, i.e. if it is either a vertex or fragment shader or the like. By default ShaderType::↩ Undefined.
- const char ∗ source = nullptr

    Pointer to the shader source. This is either a null terminated string or a raw byte buffer (depending on the 'sourceType' member).
- std::size_t sourceSize = 0

    Specifies the size of the shader source (excluding the null terminator).
- ShaderSourceType sourceType = ShaderSourceType::CodeFile

    Specifies the type of the shader source. By default ShaderSourceType::CodeFile.
- const char ∗ entryPoint = nullptr

    Shader entry point (shader main function). If this is null, the empty string is used. By default null.
- const char ∗ profile = nullptr
- long flags = 0

    Optional compilation flags. By default 0.
- StreamOutput streamOutput

    Optional stream output descriptor for a geometry shader (or a vertex shader when used with OpenGL).

10.86.1 Detailed Description

Shader source and binary code descriptor structure.

See also

RenderSystem::CreateShader

10.86.2 Constructor & Destructor Documentation

10.86.2.1 LLGL::ShaderDescriptor::ShaderDescriptor ( ) `[default]`

10.86.2.2 LLGL::ShaderDescriptor::ShaderDescriptor (const ShaderDescriptor &) `[default]`

10.86.2.3 LLGL::ShaderDescriptor::ShaderDescriptor (const ShaderType *type*, const char ∗ *source*) `[inline]`

Constructor to initialize the shader descriptor with a source filename.

10.86.2.4 LLGL::ShaderDescriptor::ShaderDescriptor (const ShaderType *type*, const char ∗ *source*, const char ∗ *entryPoint*, const char ∗ *profile*, long *flags* = 0) `[inline]`

Constructor to initialize the shader descriptor with a source filename, entry point, profile, and optional flags.

10.86.3 Member Function Documentation

10.86.3.1 ShaderDescriptor& LLGL::ShaderDescriptor::operator= (const ShaderDescriptor &) [default]

10.86.4 Member Data Documentation

10.86.4.1 const char∗ LLGL::ShaderDescriptor::entryPoint = nullptr

Shader entry point (shader main function). If this is null, the empty string is used. By default null.

Note

Only supported with: HLSL, SPIR-V.

10.86.4.2 long LLGL::ShaderDescriptor::flags = 0

Optional compilation flags. By default 0.

Remarks

This can be a bitwise OR combination of the 'ShaderCompileFlags' enumeration entries.

Note

Only supported with: Direct3D 11, Direct3D 12.

See also

ShaderCompileFlags

10.86.4.3 const char∗ LLGL::ShaderDescriptor::profile = nullptr

10.86.4.4 const char∗ LLGL::ShaderDescriptor::source = nullptr

Pointer to the shader source. This is either a null terminated string or a raw byte buffer (depending on the 'source↩ Type' member).

Remarks

This must not be null when passed to the RenderSystem::CreateShader function. If this is raw byte buffer rather than a null terminated string, the 'sourceSize' member must not be zero!

See also

sourceSize
sourceType

10.86.4.5 std::size_t LLGL::ShaderDescriptor::sourceSize = 0

Specifies the size of the shader source (excluding the null terminator).

Remarks

If this is zero, the 'source' member is expected to point to a null terminated string and the size is automatically determined. For the binrary buffer source type (i.e. ShaderSourceType::BinaryBuffer), this must not be zero!

See also

source

10.86.4.6 ShaderSourceType LLGL::ShaderDescriptor::sourceType = ShaderSourceType::CodeFile

Specifies the type of the shader source. By default ShaderSourceType::CodeFile.

Remarks

With the filename source types (i.e. ShaderSourceType::CodeFile and ShaderSourceType::BinaryFile), the shader source or binary code will be loaded from file using the standard C++ file streams (i.e. std::ifstream). Only the binary buffer source type (i.e. ShaderSourceType::BinaryBuffer) does not require a null terminator for the 'source' pointer.

See also

ShaderSourceType
source

10.86.4.7 StreamOutput LLGL::ShaderDescriptor::streamOutput

Optional stream output descriptor for a geometry shader (or a vertex shader when used with OpenGL).

10.86.4.8 ShaderType LLGL::ShaderDescriptor::type = ShaderType::Undefined

Specifies the type of the shader, i.e. if it is either a vertex or fragment shader or the like. By default ShaderType::←
Undefined.

The documentation for this struct was generated from the following file:

- ShaderFlags.h

10.87 LLGL::ShaderDisassembleFlags Struct Reference

Shader disassemble flags enumeration.

```
#include <ShaderFlags.h>
```

Public Types

- enum { InstructionOnly = (1 << 0) }

10.87.1 Detailed Description

Shader disassemble flags enumeration.

10.87.2 Member Enumeration Documentation

10.87.2.1 anonymous enum

Enumerator

InstructionOnly Show only instructions in disassembly output.

The documentation for this struct was generated from the following file:

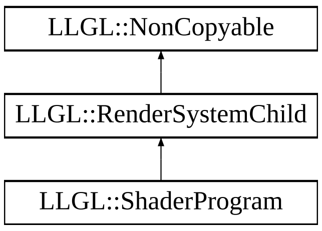
- ShaderFlags.h

10.88 LLGL::ShaderProgram Class Reference

Shader program interface.

```
#include <ShaderProgram.h>
```

Inheritance diagram for LLGL::ShaderProgram:



Public Member Functions

- virtual bool HasErrors () const =0

  Returns true if this shader program has any errors. Otherwise, the linking was successful.
- virtual std::string QueryInfoLog ()=0

  Returns the information log after the shader linkage.
- virtual ShaderReflectionDescriptor QueryReflectionDesc () const =0

  Returns a descriptor of the shader pipeline layout with all required shader resources.
- virtual void BindConstantBuffer (const std::string &name, std::uint32_t bindingIndex)=0

  Binds the specified constant buffer to this shader.
- virtual void BindStorageBuffer (const std::string &name, std::uint32_t bindingIndex)=0

  Binds the specified storage buffer to this shader.
- virtual ShaderUniform ∗ LockShaderUniform ()=0

  Locks the shader uniform handler.
- virtual void UnlockShaderUniform ()=0

  Unlocks the shader uniform handler.

Protected Types

- enum LinkError {
  LinkError::NoError, LinkError::InvalidComposition, LinkError::InvalidByteCode, LinkError::TooMany←
  Attachments,
  LinkError::IncompleteAttachments }

  Linker error codes for internal error checking.

Static Protected Member Functions

- static bool ValidateShaderComposition (Shader ∗const ∗shaders, std::size_t numShaders)

  Validates the composition of the specified shader attachments.
- static void FinalizeShaderReflection (ShaderReflectionDescriptor &reflectionDesc)

  Sorts the resource views of the specified shader reflection descriptor as described in the QueryReflectionDesc function.
- static const char ∗ LinkErrorToString (const LinkError errorCode)

  Returns a string representation for the specified shader linker error, or null if the no error is entered (i.e. LinkError::←NoError).

Additional Inherited Members

10.88.1 Detailed Description

Shader program interface.

Remarks

A shader program combines multiple instances of the Shader class to be used in a complete shader pipeline.

See also

RenderSystem::CreateShaderProgram

10.88.2 Member Enumeration Documentation

10.88.2.1 enum LLGL::ShaderProgram::LinkError [strong], [protected]

Linker error codes for internal error checking.

Enumerator

NoError

InvalidComposition

InvalidByteCode

TooManyAttachments

IncompleteAttachments

10.88.3 Member Function Documentation

10.88.3.1 virtual void LLGL::ShaderProgram::BindConstantBuffer (const std::string & *name*, std::uint32_t *bindingIndex*) [pure virtual]

Binds the specified constant buffer to this shader.

Parameters

in	*name*	Specifies the name of the constant buffer within this shader.
in	*bindingIndex*	Specifies the binding index. This index must match the index which will be used for "RenderContext::BindConstantBuffer".

Remarks

This function is only necessary if the binding index does not match the default binding index of the constant buffer within the shader.

See also

QueryConstantBuffers
RenderContext::BindConstantBuffer

10.88.3.2 virtual void LLGL::ShaderProgram::BindStorageBuffer (const std::string & *name*, std::uint32_t *bindingIndex*) [pure virtual]

Binds the specified storage buffer to this shader.

Parameters

in	*name*	Specifies the name of the storage buffer within this shader.
in	*bindingIndex*	Specifies the binding index. This index must match the index which will be used for "RenderContext::BindStorageBuffer".

Remarks

This function is only necessary if the binding index does not match the default binding index of the storage buffer within the shader.

See also

RenderContext::BindStorageBuffer

10.88.3.3 static void LLGL::ShaderProgram::FinalizeShaderReflection (ShaderReflectionDescriptor & *reflectionDesc*) [static], [protected]

Sorts the resource views of the specified shader reflection descriptor as described in the QueryReflectionDesc function.

See also

QueryReflectionDesc

10.88.3.4 virtual bool LLGL::ShaderProgram::HasErrors ( ) const [pure virtual]

Returns true if this shader program has any errors. Otherwise, the linking was successful.

Remarks

If the linking failed, this shader program can not be used for a graphics or compute pipeline. However, the details about the failure can be queried by the QueryInfoLog function.

See also

QueryInfoLog

10.88.3.5 static const char∗ LLGL::ShaderProgram::LinkErrorToString (const LinkError *errorCode*) [static], [protected]

Returns a string representation for the specified shader linker error, or null if the no error is entered (i.e. LinkError↩ ::NoError).

10.88.3.6 virtual ShaderUniform∗ LLGL::ShaderProgram::LockShaderUniform ( ) [pure virtual]

Locks the shader uniform handler.

Returns

Pointer to the shader uniform handler or null if the render system does not support individual shader uniforms.

Remarks

This must be called to set individual shader uniforms.

```
if (auto myUniformHandler = myShaderProgram->LockShaderUniform()) {
    myUniformHandler->SetUniform1i("mySampler1", 0);
    myUniformHandler->SetUniform1i("mySampler2", 1);
    myUniformHandler->SetUniform4x4fv("projection", &myProjectionMatrix[0]);
    myShaderProgram->UnlockShaderUniform();
}
```

Note

Only supported with: OpenGL.

See also

UnlockShaderUniform

10.88.3.7 virtual std::string LLGL::ShaderProgram::QueryInfoLog ( ) [pure virtual]

Returns the information log after the shader linkage.

10.88.3.8 virtual ShaderReflectionDescriptor LLGL::ShaderProgram::QueryReflectionDesc ( ) const [pure virtual]

Returns a descriptor of the shader pipeline layout with all required shader resources.

Remarks

The list of resource views in the output descriptor (i.e. 'resourceViews' attribute) is always sorted in the following manner: First sorting criterion is the resource type (in ascending order), second sorting criterion is the binding slot (in ascending order). Here is an example of such a sorted list (pseudocode):

```
resourceViews[0] = { type: ResourceType::ConstantBuffer, slot: 0 }
resourceViews[1] = { type: ResourceType::ConstantBuffer, slot: 2 }
resourceViews[2] = { type: ResourceType::Texture, slot: 0 }
resourceViews[3] = { type: ResourceType::Texture, slot: 1 }
resourceViews[4] = { type: ResourceType::Texture, slot: 2 }
resourceViews[5] = { type: ResourceType::Sampler, slot: 2 }
```

See also

ShaderReflectionDescriptor::resourceViews

Exceptions

std::runtime_error	If shader reflection failed.

10.88.3.9 virtual void LLGL::ShaderProgram::UnlockShaderUniform ( ) [pure virtual]

Unlocks the shader uniform handler.

See also

LockShaderUniform

10.88.3.10 static bool LLGL::ShaderProgram::ValidateShaderComposition (Shader ∗const ∗ *shaders,* std::size_t *numShaders*) [static], [protected]

Validates the composition of the specified shader attachments.

Parameters

in	*shaders*	Array of Shader objects that belong to this shader program. Null pointers within the array are ignored.
in	*numShaders*	Specifies the number of entries in the array 'shaders'. This must not be larger than the number of entries in the 'shaders' array.

Returns

True if the shader composition is valid, otherwise false.

Remarks

For example, a composition of a compute shader and a fragment shader is invalid, but a composition of a vertex shader and a fragment shader is valid.

The documentation for this class was generated from the following file:

- ShaderProgram.h

10.89 LLGL::ShaderProgramDescriptor Struct Reference

Descriptor structure for shader programs.

```
#include <ShaderProgramFlags.h>
```

Public Attributes

- std::vector< VertexFormat > vertexFormats

  Vertex format list. This may also be empty, if the vertex shader has no input attributes or only a compute shader is specified.
- Shader ∗ vertexShader = nullptr

  Specifies the vertex shader.
- Shader ∗ tessControlShader = nullptr

  Specifies the tessellation-control shader (also referred to as "Hull Shader").
- Shader ∗ tessEvaluationShader = nullptr

  Specifies the tessellation-evaluation shader (also referred to as "Domain Shader").
- Shader ∗ geometryShader = nullptr

  Specifies an optional geometry shader.
- Shader ∗ fragmentShader = nullptr

  Specifies an optional fragment shader (also referred to as "Pixel Shader").
- Shader ∗ computeShader = nullptr

  Specifies the compute shader.

10.89.1 Detailed Description

Descriptor structure for shader programs.

See also

RenderSystem::CreateShaderProgram
RenderSystem::CreateShader

10.89.2 Member Data Documentation

10.89.2.1 Shader∗ LLGL::ShaderProgramDescriptor::computeShader = nullptr

Specifies the compute shader.

Remarks

This shader cannot be used in conjunction with any other shaders.

10.89.2.2 Shader∗ LLGL::ShaderProgramDescriptor::fragmentShader = nullptr

Specifies an optional fragment shader (also referred to as "Pixel Shader").

Remarks

If no fragment shader is specified, generated fragments are discarded by the output merger and only the stream-output functionality is used by either the vertex or geometry shader.

10.89.2.3 Shader∗ LLGL::ShaderProgramDescriptor::geometryShader = nullptr

Specifies an optional geometry shader.

Remarks

This shader may also have a stream output.

See also

ShaderDescriptor::streamOutput

10.89.2.4 Shader∗ LLGL::ShaderProgramDescriptor::tessControlShader = nullptr

Specifies the tessellation-control shader (also referred to as "Hull Shader").

Remarks

If this is used, the counter part must also be specified (i.e. `tessEvaluationShader`).

See also

tessEvaluationShader

10.89.2.5 Shader∗ LLGL::ShaderProgramDescriptor::tessEvaluationShader = nullptr

Specifies the tessellation-evaluation shader (also referred to as "Domain Shader").

Remarks

If this is used, the counter part must also be specified (i.e. `tessControlShader`).

See also

tessControlShader

10.89.2.6 std::vector< VertexFormat > LLGL::ShaderProgramDescriptor::vertexFormats

Vertex format list. This may also be empty, if the vertex shader has no input attributes or only a compute shader is specified.

See also

VertexFormat

10.89.2.7 Shader∗ LLGL::ShaderProgramDescriptor::vertexShader = nullptr

Specifies the vertex shader.

Remarks

Each graphics shader program must have at least a vertex shader. For a compute shader program, only a compute shader must be specified. With OpenGL, this shader may also have a stream output.

See also

ShaderDescriptor::streamOutput

The documentation for this struct was generated from the following file:

- ShaderProgramFlags.h

10.90 LLGL::ShaderReflectionDescriptor Struct Reference

Shader reflection descriptor structure.

```
#include <ShaderProgramFlags.h>
```

Classes

- struct ResourceView
  Shader reflection resource view structure.

Public Attributes

- std::vector< VertexAttribute > vertexAttributes
  List of all vertex attributes.
- std::vector< StreamOutputAttribute > streamOutputAttributes
  List of all stream-output attributes.
- std::vector< ResourceView > resourceViews
  List of all shader reflection resource views.
- std::vector< UniformDescriptor > uniforms
  List of all uniforms.

10.90.1 Detailed Description

Shader reflection descriptor structure.

Remarks

Contains all information of resources and attributes that can be queried from a shader program.

See also

ShaderProgram::QueryReflectionDesc

10.90.2 Member Data Documentation

10.90.2.1 std::vector< ResourceView > LLGL::ShaderReflectionDescriptor::resourceViews

List of all shader reflection resource views.

10.90.2.2 std::vector< StreamOutputAttribute > LLGL::ShaderReflectionDescriptor::streamOutputAttributes

List of all stream-output attributes.

10.90.2.3 std::vector< UniformDescriptor > LLGL::ShaderReflectionDescriptor::uniforms

List of all uniforms.

Note

Only supported with: OpenGL, Vulkan.

10.90.2.4 std::vector< VertexAttribute > LLGL::ShaderReflectionDescriptor::vertexAttributes

List of all vertex attributes.

The documentation for this struct was generated from the following file:

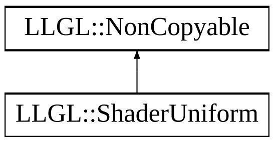
- ShaderProgramFlags.h

10.91 LLGL::ShaderUniform Class Reference

Shader uniform setter interface.

```
#include <ShaderUniform.h>
```

Inheritance diagram for LLGL::ShaderUniform:



Public Member Functions

- virtual void SetUniform1i (const UniformLocation location, int value0)=0

  Sets an integral scalar uniform.
- virtual void SetUniform2i (const UniformLocation location, int value0, int value1)=0
- virtual void SetUniform3i (const UniformLocation location, int value0, int value1, int value2)=0
- virtual void SetUniform4i (const UniformLocation location, int value0, int value1, int value2, int value3)=0
- virtual void SetUniform1f (const UniformLocation location, float value0)=0
- virtual void SetUniform2f (const UniformLocation location, float value0, float value1)=0
- virtual void SetUniform3f (const UniformLocation location, float value0, float value1, float value2)=0
- virtual void SetUniform4f (const UniformLocation location, float value0, float value1, float value2, float value3)=0
- virtual void SetUniform1iv (const UniformLocation location, const int ∗value, std::size_t count=1)=0
- virtual void SetUniform2iv (const UniformLocation location, const int ∗value, std::size_t count=1)=0
- virtual void SetUniform3iv (const UniformLocation location, const int ∗value, std::size_t count=1)=0
- virtual void SetUniform4iv (const UniformLocation location, const int ∗value, std::size_t count=1)=0
- virtual void SetUniform1fv (const UniformLocation location, const float ∗value, std::size_t count=1)=0
- virtual void SetUniform2fv (const UniformLocation location, const float ∗value, std::size_t count=1)=0
- virtual void SetUniform3fv (const UniformLocation location, const float ∗value, std::size_t count=1)=0
- virtual void SetUniform4fv (const UniformLocation location, const float ∗value, std::size_t count=1)=0
- virtual void SetUniform2x2fv (const UniformLocation location, const float ∗value, std::size_t count=1)=0
- virtual void SetUniform3x3fv (const UniformLocation location, const float ∗value, std::size_t count=1)=0
- virtual void SetUniform4x4fv (const UniformLocation location, const float ∗value, std::size_t count=1)=0
- virtual void SetUniform1i (const char ∗name, int value0)=0
- virtual void SetUniform2i (const char ∗name, int value0, int value1)=0
- virtual void SetUniform3i (const char ∗name, int value0, int value1, int value2)=0
- virtual void SetUniform4i (const char ∗name, int value0, int value1, int value2, int value3)=0
- virtual void SetUniform1f (const char ∗name, float value0)=0
- virtual void SetUniform2f (const char ∗name, float value0, float value1)=0
- virtual void SetUniform3f (const char ∗name, float value0, float value1, float value2)=0
- virtual void SetUniform4f (const char ∗name, float value0, float value1, float value2, float value3)=0
- virtual void SetUniform1iv (const char ∗name, const int ∗value, std::size_t count=1)=0
- virtual void SetUniform2iv (const char ∗name, const int ∗value, std::size_t count=1)=0
- virtual void SetUniform3iv (const char ∗name, const int ∗value, std::size_t count=1)=0
- virtual void SetUniform4iv (const char ∗name, const int ∗value, std::size_t count=1)=0
- virtual void SetUniform1fv (const char ∗name, const float ∗value, std::size_t count=1)=0
- virtual void SetUniform2fv (const char ∗name, const float ∗value, std::size_t count=1)=0
- virtual void SetUniform3fv (const char ∗name, const float ∗value, std::size_t count=1)=0
- virtual void SetUniform4fv (const char ∗name, const float ∗value, std::size_t count=1)=0
- virtual void SetUniform2x2fv (const char ∗name, const float ∗value, std::size_t count=1)=0
- virtual void SetUniform3x3fv (const char ∗name, const float ∗value, std::size_t count=1)=0
- virtual void SetUniform4x4fv (const char ∗name, const float ∗value, std::size_t count=1)=0

Additional Inherited Members

10.91.1 Detailed Description

Shader uniform setter interface.

Note

Only supported with: OpenGL.

See also

ShaderProgram::LockShaderUniform

Todo Complete documentation.

10.91.2 Member Function Documentation

10.91.2.1 virtual void LLGL::ShaderUniform::SetUniform1f (const UniformLocation *location*, float *value0*) [pure virtual]

10.91.2.2 virtual void LLGL::ShaderUniform::SetUniform1f (const char ∗ *name*, float *value0*) [pure virtual]

10.91.2.3 virtual void LLGL::ShaderUniform::SetUniform1fv (const UniformLocation *location*, const float ∗ *value*, std::size_t *count* = 1) [pure virtual]

10.91.2.4 virtual void LLGL::ShaderUniform::SetUniform1fv (const char ∗ *name*, const float ∗ *value*, std::size_t *count* = 1) [pure virtual]

10.91.2.5 virtual void LLGL::ShaderUniform::SetUniform1i (const UniformLocation *location*, int *value0*) [pure virtual]

Sets an integral scalar uniform.

Remarks

This can be used to set the binding slot for samplers, like in the following GLSL example:

```
uniform sampler2D myColorSampler;
```

10.91.2.6 virtual void LLGL::ShaderUniform::SetUniform1i (const char ∗ *name*, int *value0*) [pure virtual]

10.91.2.7 virtual void LLGL::ShaderUniform::SetUniform1iv (const UniformLocation *location*, const int ∗ *value*, std::size_t *count* = 1) [pure virtual]

10.91.2.8 virtual void LLGL::ShaderUniform::SetUniform1iv (const char ∗ *name*, const int ∗ *value*, std::size_t *count* = 1) [pure virtual]

10.91.2.9 virtual void LLGL::ShaderUniform::SetUniform2f (const UniformLocation *location*, float *value0*, float *value1*) [pure virtual]

10.91.2.10 virtual void LLGL::ShaderUniform::SetUniform2f (const char ∗ *name*, float *value0*, float *value1*) [pure virtual]

10.91.2.11 virtual void LLGL::ShaderUniform::SetUniform2fv (const UniformLocation *location*, const float ∗ *value*, std::size_t *count* = 1) [pure virtual]

10.91.2.12 virtual void LLGL::ShaderUniform::SetUniform2fv (const char ∗ *name*, const float ∗ *value*, std::size_t *count* = 1) [pure virtual]

10.91.2.13 virtual void LLGL::ShaderUniform::SetUniform2i (const UniformLocation *location*, int *value0*, int *value1*) [pure virtual]

10.91.2.14 virtual void LLGL::ShaderUniform::SetUniform2i (const char ∗ *name*, int *value0*, int *value1*) [pure virtual]

10.91.2.15 virtual void LLGL::ShaderUniform::SetUniform2iv (const UniformLocation *location*, const int ∗ *value*, std::size_t *count* = `1`) `[pure virtual]`

10.91.2.16 virtual void LLGL::ShaderUniform::SetUniform2iv (const char ∗ *name*, const int ∗ *value*, std::size_t *count* = `1`) `[pure virtual]`

10.91.2.17 virtual void LLGL::ShaderUniform::SetUniform2x2fv (const UniformLocation *location*, const float ∗ *value*, std::size_t *count* = `1`) `[pure virtual]`

10.91.2.18 virtual void LLGL::ShaderUniform::SetUniform2x2fv (const char ∗ *name*, const float ∗ *value*, std::size_t *count* = `1`) `[pure virtual]`

10.91.2.19 virtual void LLGL::ShaderUniform::SetUniform3f (const UniformLocation *location*, float *value0*, float *value1*, float *value2*) `[pure virtual]`

10.91.2.20 virtual void LLGL::ShaderUniform::SetUniform3f (const char ∗ *name*, float *value0*, float *value1*, float *value2*) `[pure virtual]`

10.91.2.21 virtual void LLGL::ShaderUniform::SetUniform3fv (const UniformLocation *location*, const float ∗ *value*, std::size_t *count* = `1`) `[pure virtual]`

10.91.2.22 virtual void LLGL::ShaderUniform::SetUniform3fv (const char ∗ *name*, const float ∗ *value*, std::size_t *count* = `1`) `[pure virtual]`

10.91.2.23 virtual void LLGL::ShaderUniform::SetUniform3i (const UniformLocation *location*, int *value0*, int *value1*, int *value2*) `[pure virtual]`

10.91.2.24 virtual void LLGL::ShaderUniform::SetUniform3i (const char ∗ *name*, int *value0*, int *value1*, int *value2*) `[pure virtual]`

10.91.2.25 virtual void LLGL::ShaderUniform::SetUniform3iv (const UniformLocation *location*, const int ∗ *value*, std::size_t *count* = `1`) `[pure virtual]`

10.91.2.26 virtual void LLGL::ShaderUniform::SetUniform3iv (const char ∗ *name*, const int ∗ *value*, std::size_t *count* = `1`) `[pure virtual]`

10.91.2.27 virtual void LLGL::ShaderUniform::SetUniform3x3fv (const UniformLocation *location*, const float ∗ *value*, std::size_t *count* = `1`) `[pure virtual]`

10.91.2.28 virtual void LLGL::ShaderUniform::SetUniform3x3fv (const char ∗ *name*, const float ∗ *value*, std::size_t *count* = `1`) `[pure virtual]`

10.91.2.29 virtual void LLGL::ShaderUniform::SetUniform4f (const UniformLocation *location*, float *value0*, float *value1*, float *value2*, float *value3*) `[pure virtual]`

10.91.2.30 virtual void LLGL::ShaderUniform::SetUniform4f (const char ∗ *name*, float *value0*, float *value1*, float *value2*, float *value3*) `[pure virtual]`

10.91.2.31 virtual void LLGL::ShaderUniform::SetUniform4fv (const UniformLocation *location*, const float ∗ *value*, std::size_t *count* = 1) [pure virtual]

10.91.2.32 virtual void LLGL::ShaderUniform::SetUniform4fv (const char ∗ *name*, const float ∗ *value*, std::size_t *count* = 1) [pure virtual]

10.91.2.33 virtual void LLGL::ShaderUniform::SetUniform4i (const UniformLocation *location*, int *value0*, int *value1*, int *value2*, int *value3*) [pure virtual]

10.91.2.34 virtual void LLGL::ShaderUniform::SetUniform4i (const char ∗ *name*, int *value0*, int *value1*, int *value2*, int *value3*) [pure virtual]

10.91.2.35 virtual void LLGL::ShaderUniform::SetUniform4iv (const UniformLocation *location*, const int ∗ *value*, std::size_t *count* = 1) [pure virtual]

10.91.2.36 virtual void LLGL::ShaderUniform::SetUniform4iv (const char ∗ *name*, const int ∗ *value*, std::size_t *count* = 1) [pure virtual]

10.91.2.37 virtual void LLGL::ShaderUniform::SetUniform4x4fv (const UniformLocation *location*, const float ∗ *value*, std::size_t *count* = 1) [pure virtual]

10.91.2.38 virtual void LLGL::ShaderUniform::SetUniform4x4fv (const char ∗ *name*, const float ∗ *value*, std::size_t *count* = 1) [pure virtual]

The documentation for this class was generated from the following file:

- ShaderUniform.h

10.92 LLGL::SrcImageDescriptor Struct Reference

Descriptor structure for an image that is used as source for reading the image data.

`#include <ImageFlags.h>`

Public Member Functions

- SrcImageDescriptor ()=default
- SrcImageDescriptor (const SrcImageDescriptor &)=default
- SrcImageDescriptor (ImageFormat format, DataType dataType, const void ∗data, std::size_t dataSize)

  Constructor to initialize all attributes.

Public Attributes

- ImageFormat format = ImageFormat::RGBA

  Specifies the image format. By default ImageFormat::RGBA.
- DataType dataType = DataType::UInt8

  Specifies the image data type. This must be DataType::UInt8 for compressed images. By default DataType::UInt8.
- const void ∗ data = nullptr

  Pointer to the read-only image data.
- std::size_t dataSize = 0

  Specifies the size (in bytes) of the image data. This is primarily used for compressed images and serves for robustness.

10.92.1 Detailed Description

Descriptor structure for an image that is used as source for reading the image data.

Remarks

This kind of 'Image' is mainly used to fill a MIP-map within a hardware texture by reading from a source image. The counterpart for reading a MIP-map from a hardware texture by writing to a destination image is the DstImageDescriptor structure.

See also

DstImageDescriptor
ConvertImageBuffer
RenderSystem::CreateTexture
RenderSystem::WriteTexture

10.92.2 Constructor & Destructor Documentation

10.92.2.1 LLGL::SrcImageDescriptor::SrcImageDescriptor ( ) [default]

10.92.2.2 LLGL::SrcImageDescriptor::SrcImageDescriptor (const SrcImageDescriptor &) [default]

10.92.2.3 LLGL::SrcImageDescriptor::SrcImageDescriptor (ImageFormat *format*, DataType *dataType*, const void ∗ *data*, std::size_t *dataSize*) [inline]

Constructor to initialize all attributes.

10.92.3 Member Data Documentation

10.92.3.1 const void∗ LLGL::SrcImageDescriptor::data = nullptr

Pointer to the read-only image data.

10.92.3.2 std::size_t LLGL::SrcImageDescriptor::dataSize = 0

Specifies the size (in bytes) of the image data. This is primarily used for compressed images and serves for robustness.

10.92.3.3 DataType LLGL::SrcImageDescriptor::dataType = DataType::UInt8

Specifies the image data type. This must be DataType::UInt8 for compressed images. By default DataType::UInt8.

10.92.3.4 ImageFormat LLGL::SrcImageDescriptor::format = ImageFormat::RGBA

Specifies the image format. By default ImageFormat::RGBA.

The documentation for this struct was generated from the following file:

- ImageFlags.h

10.93 LLGL::StageFlags Struct Reference

Shader stage flags enumeration.

`#include <ShaderFlags.h>`

Public Types

- enum {
  VertexStage = (1 << 0), TessControlStage = (1 << 1), TessEvaluationStage = (1 << 2), GeometryStage = (1 << 3),
  FragmentStage = (1 << 4), ComputeStage = (1 << 5), StorageUsage = (1 << 6), AllTessStages = (Tess↩
  ControlStage | TessEvaluationStage),
  AllGraphicsStages = (VertexStage | AllTessStages | GeometryStage | FragmentStage), AllStages = (All↩
  GraphicsStages | ComputeStage) }

10.93.1 Detailed Description

Shader stage flags enumeration.

Remarks

Specifies which shader stages are affected by a state change, e.g. to which shader stages a constant buffer is set. For the render systems, which do not support these flags, always all shader stages are affected.

10.93.2 Member Enumeration Documentation

10.93.2.1 anonymous enum

Enumerator

VertexStage Specifies the vertex shader stage.

TessControlStage Specifies the tessellation-control shader stage (also "Hull Shader").

TessEvaluationStage Specifies the tessellation-evaluation shader stage (also "Domain Shader").

GeometryStage Specifies the geometry shader stage.

FragmentStage Specifies the fragment shader stage (also "Pixel Shader").

ComputeStage Specifies the compute shader stage.

StorageUsage Specifies whether a resource is bound to the shader stages as unordered access view (UAV) instead of a read-only shader resource view (SRV).

Remarks

This can be used to bind a storage buffer (i.e. BufferType::Storage) that was created with read/write access (e.g. StorageBufferType::RWBuffer) as UAV instead of SRV.

AllTessStages Specifies all tessellation stages, i.e. tessellation-control-, tessellation-evaluation shader stages.

AllGraphicsStages Specifies all graphics pipeline shader stages, i.e. vertex-, tessellation-, geometry-, and fragment shader stages.

AllStages Specifies all shader stages.

The documentation for this struct was generated from the following file:

- ShaderFlags.h

10.94 LLGL::StencilDescriptor Struct Reference

Stencil state descriptor structure.

```
#include <GraphicsPipelineFlags.h>
```

Public Attributes

- bool testEnabled = false

  Specifies whether the stencil test is enabled or disabled.
- StencilFaceDescriptor front

  Specifies the front face settings for the stencil test.
- StencilFaceDescriptor back

  Specifies the back face settings for the stencil test.

10.94.1 Detailed Description

Stencil state descriptor structure.

See also

GraphicsPipelineDescriptor::stencil

10.94.2 Member Data Documentation

10.94.2.1 StencilFaceDescriptor LLGL::StencilDescriptor::back

Specifies the back face settings for the stencil test.

10.94.2.2 StencilFaceDescriptor LLGL::StencilDescriptor::front

Specifies the front face settings for the stencil test.

Note

For Direct3D 11 and Direct3D 12, the members `readMask`, `writeMask`, and `reference` are only supported for the front face.

See also

StencilFaceDescriptor::readMask
StencilFaceDescriptor::writeMask
StencilFaceDescriptor::reference

10.94.2.3 bool LLGL::StencilDescriptor::testEnabled = false

Specifies whether the stencil test is enabled or disabled.

Remarks

If no pixel shader is used in the graphics pipeline, the stencil test must be disabled.

The documentation for this struct was generated from the following file:

- GraphicsPipelineFlags.h

10.95 LLGL::StencilFaceDescriptor Struct Reference

Stencil face descriptor structure.

```
#include <GraphicsPipelineFlags.h>
```

Public Attributes

- StencilOp stencilFailOp = StencilOp::Keep

    Specifies the operation to take when the stencil test fails.
- StencilOp depthFailOp = StencilOp::Keep

    Specifies the operation to take when the stencil test passes but the depth test fails.
- StencilOp depthPassOp = StencilOp::Keep

    Specifies the operation to take when both the stencil test and the depth test pass.
- CompareOp compareOp = CompareOp::Less

    Specifies the stencil compare operation.
- std::uint32_t readMask = ∼0

    Specifies the portion of the depth-stencil buffer for reading stencil data. By default `0xFFFFFFFF`.
- std::uint32_t writeMask = ∼0

    Specifies the portion of the depth-stencil buffer for writing stencil data. By default `0xFFFFFFFF`.
- std::uint32_t reference = 0

    Specifies the stencil reference value.

10.95.1 Detailed Description

Stencil face descriptor structure.

See also

StencilDescriptor::front
StencilDescriptor::back

10.95.2 Member Data Documentation

10.95.2.1 CompareOp LLGL::StencilFaceDescriptor::compareOp = CompareOp::Less

Specifies the stencil compare operation.

10.95.2.2 StencilOp LLGL::StencilFaceDescriptor::depthFailOp = StencilOp::Keep

Specifies the operation to take when the stencil test passes but the depth test fails.

10.95.2.3 StencilOp LLGL::StencilFaceDescriptor::depthPassOp = StencilOp::Keep

Specifies the operation to take when both the stencil test and the depth test pass.

10.95.2.4 std::uint32_t LLGL::StencilFaceDescriptor::readMask = ∼0

Specifies the portion of the depth-stencil buffer for reading stencil data. By default `0xFFFFFFFF`.

Note

For Direct3D 11 and Direct3D 12, only the first 8 least significant bits (i.e. `readMask & 0xFF`) of the read mask value of the front face will be used.

See also

StencilDescriptor::front

10.95.2.5 std::uint32_t LLGL::StencilFaceDescriptor::reference = 0

Specifies the stencil reference value.

Remarks

This value will be used when the stencil operation is StencilOp::Replace.

Note

For Direct3D 11 and Direct3D 12, only the stencil reference value of the front face will be used.

See also

StencilDescriptor::front

10.95.2.6 StencilOp LLGL::StencilFaceDescriptor::stencilFailOp = StencilOp::Keep

Specifies the operation to take when the stencil test fails.

10.95.2.7 std::uint32_t LLGL::StencilFaceDescriptor::writeMask = ∼0

Specifies the portion of the depth-stencil buffer for writing stencil data. By default `0xFFFFFFFF`.

Note

For Direct3D 11 and Direct3D 12, only the first 8 least significant bits (i.e. `writeMask & 0xFF`) of the write mask value of the front face will be used.

See also

StencilDescriptor::front

The documentation for this struct was generated from the following file:

- GraphicsPipelineFlags.h

10.96 LLGL::BufferDescriptor::StorageBuffer Struct Reference

Storage buffer specific descriptor structure.

```
#include <BufferFlags.h>
```

Public Attributes

- StorageBufferType storageType = StorageBufferType::Undefined

  Specifies the storage buffer type. By defalut StorageBufferType::Undefined.
- Format format = Format::Undefined

  Specifies the vector format of a typed buffer. By default Format::Undefined.
- std::uint32_t stride = 0

  Specifies the stride (in bytes) of each element in a storage buffer.

10.96.1 Detailed Description

Storage buffer specific descriptor structure.

10.96.2 Member Data Documentation

10.96.2.1 Format LLGL::BufferDescriptor::StorageBuffer::format = Format::Undefined

Specifies the vector format of a typed buffer. By default Format::Undefined.

Remarks

This is only used if the storage type is either StorageBufferType::Buffer or StorageBufferType::RWBuffer.

See also

IsStorageBufferTyped

10.96.2.2 StorageBufferType LLGL::BufferDescriptor::StorageBuffer::storageType = StorageBufferType::Undefined

Specifies the storage buffer type. By defalut StorageBufferType::Undefined.

Remarks

In OpenGL there are only generic storage buffers (or rather "Shader Storage Buffer Objects"). However, a valid type should always be specified when a storage buffer is created.

10.96.2.3 std::uint32_t LLGL::BufferDescriptor::StorageBuffer::stride = 0

Specifies the stride (in bytes) of each element in a storage buffer.

Remarks

If this value is zero, the behavior of the buffer creation is undefined.

The documentation for this struct was generated from the following file:

- BufferFlags.h

10.97 LLGL::ShaderDescriptor::StreamOutput Struct Reference

Additional descriptor for stream outputs.

```
#include <ShaderFlags.h>
```

Public Attributes

- StreamOutputFormat format
  Stream-output buffer format.

10.97.1 Detailed Description

Additional descriptor for stream outputs.

10.97.2 Member Data Documentation

10.97.2.1 StreamOutputFormat LLGL::ShaderDescriptor::StreamOutput::format

Stream-output buffer format.

The documentation for this struct was generated from the following file:

- ShaderFlags.h

10.98 LLGL::StreamOutputAttribute Struct Reference

Stream-output attribute structure.

```
#include <StreamOutputAttribute.h>
```

Public Member Functions

- StreamOutputAttribute ()=default
- StreamOutputAttribute (const StreamOutputAttribute &)=default
- StreamOutputAttribute & operator= (const StreamOutputAttribute &)=default

Public Attributes

- std::string name

    Vertex attribute name (for GLSL) or semantic name (for HLSL).
- std::uint32_t stream = 0

    Zero-based stream number. By default 0.
- std::uint8_t startComponent = 0

    Start vector component index, which is to be written. Must be 0, 1, 2, or 3. By default 0.
- std::uint8_t components = 4

    Number of vector components, which are to be written. Must be 1, 2, 3, or 4.
- std::uint32_t semanticIndex = 0

    Semantic index.
- std::uint8_t outputSlot = 0

    Stream-output buffer output slot.

10.98.1 Detailed Description

Stream-output attribute structure.

10.98.2 Constructor & Destructor Documentation

10.98.2.1 LLGL::StreamOutputAttribute::StreamOutputAttribute ( ) [default]

10.98.2.2 LLGL::StreamOutputAttribute::StreamOutputAttribute (const StreamOutputAttribute &) [default]

10.98.3 Member Function Documentation

10.98.3.1 StreamOutputAttribute& LLGL::StreamOutputAttribute::operator= (const StreamOutputAttribute &) [default]

10.98.4 Member Data Documentation

10.98.4.1 std::uint8_t LLGL::StreamOutputAttribute::components = 4

Number of vector components, which are to be written. Must be 1, 2, 3, or 4.

Remarks

The number of components plus the start component index (see 'startComponent') must not be larger than 4.

See also

startComponent

10.98.4.2 std::string LLGL::StreamOutputAttribute::name

Vertex attribute name (for GLSL) or semantic name (for HLSL).

10.98.4.3 std::uint8_t LLGL::StreamOutputAttribute::outputSlot = 0

Stream-output buffer output slot.

Remarks

This is used when multiple stream-output buffers are used simultaneously.

10.98.4.4 std::uint32_t LLGL::StreamOutputAttribute::semanticIndex = 0

Semantic index.

Note

Only supported with: Direct3D 11, Direct3D 12.

10.98.4.5 std::uint8_t LLGL::StreamOutputAttribute::startComponent = 0

Start vector component index, which is to be written. Must be 0, 1, 2, or 3. By default 0.

10.98.4.6 std::uint32_t LLGL::StreamOutputAttribute::stream = 0

Zero-based stream number. By default 0.

The documentation for this struct was generated from the following file:

- StreamOutputAttribute.h

10.99 LLGL::StreamOutputFormat Struct Reference

Stream-output format descriptor structure.

```
#include <StreamOutputFormat.h>
```

Public Member Functions

- void AppendAttribute (const StreamOutputAttribute &attrib)
  Appends the specified stream-output attribute to this stream-output format.
- void AppendAttributes (const StreamOutputFormat &format)
  Append all attributes of the specified stream-output format.

Public Attributes

- std::vector< StreamOutputAttribute > attributes
  Specifies the list of vertex attributes.

10.99.1 Detailed Description

Stream-output format descriptor structure.

Remarks

A vertex format is required to describe how the vertex attributes are supported inside a vertex buffer.

10.99.2 Member Function Documentation

10.99.2.1 void LLGL::StreamOutputFormat::AppendAttribute (const StreamOutputAttribute & *attrib*)

Appends the specified stream-output attribute to this stream-output format.

Parameters

in	*attrib*	Specifies the new attribute which is appended to this stream-output format.

10.99.2.2 void LLGL::StreamOutputFormat::AppendAttributes (const StreamOutputFormat & *format*)

Append all attributes of the specified stream-output format.

Remarks

This can be used to build a stream-output format for stream-output buffer arrays.

10.99.3 Member Data Documentation

10.99.3.1 std::vector<StreamOutputAttribute> LLGL::StreamOutputFormat::attributes

Specifies the list of vertex attributes.

Remarks

Use "AppendAttribute" or "AppendAttributes" to append new attributes.

The documentation for this struct was generated from the following file:

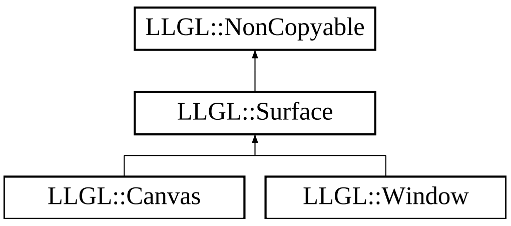
- StreamOutputFormat.h

10.100 LLGL::Surface Class Reference

The Surface interface is the base interface for Window (on Desktop platforms) and Canvas (on movile platforms).

```
#include <Surface.h>
```

Inheritance diagram for LLGL::Surface:



Public Member Functions

- virtual void GetNativeHandle (void ∗nativeHandle) const =0

  Returns the native surface handle.
- virtual Extent2D GetContentSize () const =0

  Returns the size of the surface context (or rather the drawing area).
- virtual bool AdaptForVideoMode (VideoModeDescriptor &videoModeDesc)=0

  Adapts the surface to fits the needs for the specified video mode descriptor.
- virtual void ResetPixelFormat ()=0

  Resets the internal pixel format of the surface.

Additional Inherited Members

10.100.1 Detailed Description

The Surface interface is the base interface for Window (on Desktop platforms) and Canvas (on movile platforms).

Remarks

Surface provides the minimal required interface for a graphics rendering context, such as the access to the native handle, information about the content size (i.e. the client area size), and the ability to adapt for a new video mode or an updated pixel format. (which is required for multi-sampled framebuffers on a WGL context for instance).

See also

Window
Canvas

10.100.2 Member Function Documentation

10.100.2.1 virtual bool LLGL::Surface::AdaptForVideoMode (VideoModeDescriptor & *videoModeDesc*) [pure virtual]

Adapts the surface to fits the needs for the specified video mode descriptor.

Parameters

in,out	*videoModeDesc*	Specifies the input and output video mode descriptor.

Returns

If the video mode descriptor has been accepted with no modifications and this surface has been updated then the return value is true. Otherwise the video mode descriptor has been modified to the value this surface supports and the return value is false.

Implemented in LLGL::Window, and LLGL::Canvas.

10.100.2.2 virtual Extent2D LLGL::Surface::GetContentSize ( ) const [pure virtual]

Returns the size of the surface context (or rather the drawing area).

Remarks

For the Window interface this is equivalent of calling `Window::GetSize(true)` for instance.

See also

Window::GetSize

10.100.2.3 virtual void LLGL::Surface::GetNativeHandle (void ∗ *nativeHandle*) const [pure virtual]

Returns the native surface handle.

Remarks

This must be casted to a platform specific structure:

```
// Example for a custom Win32 window class
#include <LLGL/Platform/NativeHandle.h>
//...
void MyWindowClass::GetNativeHandle(void* nativeHandle) {
    auto handle = reinterpret_cast<LLGL::NativeHandle*>(nativeHandle);
    //handle->window = 'some HWND window handle';
}
```

10.100.2.4 virtual void LLGL::Surface::ResetPixelFormat ( ) [pure virtual]

Resets the internal pixel format of the surface.

Remarks

This function is mainly used by the OpenGL renderer on Win32 when a multi-sampled framebuffer is created.

Note

This may invalidate the native handle previously returned by `GetNativeHandle`.

See also

GetNativeHandle

The documentation for this class was generated from the following file:

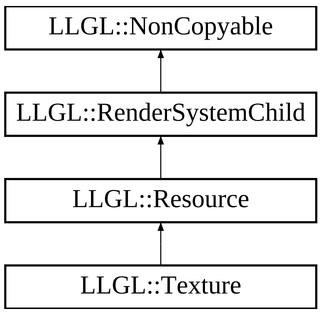
- Surface.h

10.101 LLGL::Texture Class Reference

Texture interface.

`#include <Texture.h>`

Inheritance diagram for LLGL::Texture:



Public Member Functions

- ResourceType QueryResourceType () const override

    Returns ResourceType::Texture.
- TextureType GetType () const

    Returns the type of this texture.
- virtual TextureDescriptor QueryDesc () const =0

    Queries a descriptor of this texture (including type, format, and size).
- virtual Extent3D QueryMipExtent (std::uint32_t mipLevel) const =0

    Returns the texture extent for the specified MIP-level. This also includes the number of array layers.

Protected Member Functions

- Texture (const TextureType type)

10.101.1 Detailed Description

Texture interface.

See also

RenderSystem::CreateTexture

10.101.2 Constructor & Destructor Documentation

10.101.2.1 LLGL::Texture::Texture (const TextureType *type*) `[protected]`

10.101.3 Member Function Documentation

10.101.3.1 TextureType LLGL::Texture::GetType ( ) const `[inline]`

Returns the type of this texture.

10.101.3.2 virtual TextureDescriptor LLGL::Texture::QueryDesc ( ) const [pure virtual]

Queries a descriptor of this texture (including type, format, and size).

Remarks

This function is guaranteed to keep the currently bound textures, i.e. all previously boundd textures (e.g. using the CommandBufferExt::SetTexture function) will remain.

Note

The field TextureDescriptor::flags will always be 0, i.e. the texture flags cannot be retrived after texture creation.

See also

TextureDescriptor

10.101.3.3 virtual Extent3D LLGL::Texture::QueryMipExtent (std::uint32_t *mipLevel*) const [pure virtual]

Returns the texture extent for the specified MIP-level. This also includes the number of array layers.

For a 1D array texture, the number of array layers is stored in the height extent. For a 2D and cube array texture, the number of array layers is stored in the depth extent.

Parameters

in	*mipLevel*	Specifies the MIP-map level to query from. The first and largest MIP-map is level zero. If this level is greater than or equal to the maxmimum number of MIP-maps for this texture, the return value is undefined (i.e. depends on the render system).

Remarks

This function is guaranteed to keep the currently bound textures, i.e. all previously bounds textures (e.g. using the CommandBufferExt::SetTexture function) will remain.

Note

For cube textures and cube array textures (i.e. texture type TextureType::TextureCube and TextureType::←TextureCubeArray), the depth extent will be a multiple of 6. This is in contrast to the other handling of cube array layers, because this function determines the actual buffer extent of the hardware texture.

See also

RenderSystem::GenerateMips
CommandBufferExt::SetTexture

10.101.3.4 ResourceType LLGL::Texture::QueryResourceType ( ) const [override], [virtual]

Returns ResourceType::Texture.

Implements LLGL::Resource.

The documentation for this class was generated from the following file:

- Texture.h

10.102 LLGL::TextureDescriptor Struct Reference

Texture descriptor structure.

`#include <TextureFlags.h>`

Public Attributes

- TextureType type = TextureType::Texture1D

  Hardware texture type. By default TextureType::Texture1D.
- long flags = TextureFlags::Default

  Specifies the texture creation flags (e.g. if MIP-mapping is required). By default TextureFlags::Default.
- Format format = Format::RGBA8UNorm

  Hardware texture format. By default Format::RGBA8UNorm.
- Extent3D extent = { 1, 1, 1 }

  Texture extent. By default (1, 1, 1).
- std::uint32_t arrayLayers = 1

  Number of array layers. By default 1.
- std::uint32_t mipLevels = 0

  Number of MIP-map levels. By default 0.
- std::uint32_t samples = 1

  Number of samples per texel. By default 1.

10.102.1 Detailed Description

Texture descriptor structure.

Remarks

This is used to specifiy the dimensions of a texture which is to be created.

See also

RenderSystem::CreateTexture

10.102.2 Member Data Documentation

10.102.2.1 std::uint32_t LLGL::TextureDescriptor::arrayLayers = 1

Number of array layers. By default 1.

Remarks

This can be greater than 1 for array textures and cube textures (i.e. TextureType::Texture1DArray, Texture↩ Type::Texture2DArray, TextureType::TextureCube, TextureType::TextureCubeArray, TextureType::Texture2D↩ MSArray). For cube textures, this must be a multiple of 6 (one array layer for each cube face). For all other texture types, this must be 1. The index offsets for each cube face are as follows:

- `X+` direction has index offset 0.
- `X-` direction has index offset 1.
- `Y+` direction has index offset 2.
- `Y-` direction has index offset 3.
- `Z+` direction has index offset 4.
- `Z-` direction has index offset 5.

See also

IsArrayTexture
IsCubeTexture
RenderingLimits::maxTextureArrayLayers

10.102.2.2 Extent3D LLGL::TextureDescriptor::extent = { 1, 1, 1 }

Texture extent. By default (1, 1, 1).

Remarks

The height component is only used for 2D, 3D, and Cube textures (i.e. TextureType::Texture2D, Texture↩ Type::Texture2DArray, TextureType::Texture3D, TextureType::TextureCube, TextureType::TextureCubeArray, TextureType::Texture2DMS, TextureType::Texture2DMSArray). The depth component is only used for 3D textures (i.e. TextureType::Texture3D). For cube textures, the width and height component must be equal.

See also

IsArrayTexture
IsCubeTexture

10.102.2.3 long LLGL::TextureDescriptor::flags = TextureFlags::Default

Specifies the texture creation flags (e.g. if MIP-mapping is required). By default TextureFlags::Default.

Remarks

This can be bitwise OR combination of the entries of the TextureFlags enumeration.

See also

TextureFlags

10.102.2.4 Format LLGL::TextureDescriptor::format = Format::RGBA8UNorm

Hardware texture format. By default Format::RGBA8UNorm.

10.102.2.5 std::uint32_t LLGL::TextureDescriptor::mipLevels = 0

Number of MIP-map levels. By default 0.

Remarks

If this is 0, the full MIP-chain will be generated. If this is 1, no MIP-mapping is used for this texture and it has only a MIP level. This field is ignored for multi-sampled textures (i.e. TextureType::Texture2DMS, Texture↩ Type::Texture2DMSArray), since these texture types only have a single MIP-map level.

See also

NumMipLevels
RenderSystem::GenerateMips

10.102.2.6 std::uint32_t LLGL::TextureDescriptor::samples = 1

Number of samples per texel. By default 1.

Remarks

This is only used for multi-sampled textures (i.e. TextureType::Texture2DMS and TextureType::Texture2DM↩ SArray). The equivalent member for graphics pipeline states is MultiSamplingDescriptor::samples.

See also

IsMultiSampleTexture

10.102.2.7 TextureType LLGL::TextureDescriptor::type = TextureType::Texture1D

Hardware texture type. By default TextureType::Texture1D.

The documentation for this struct was generated from the following file:

- TextureFlags.h

10.103 LLGL::TextureFlags Struct Reference

Texture creation flags enumeration.

```
#include <TextureFlags.h>
```

Public Types

- enum {
  ColorAttachmentUsage = (1 << 3), DepthStencilAttachmentUsage = (1 << 4), SampleUsage = (1 << 5),
  StorageUsage = (1 << 6),
  FixedSamples = (1 << 7), Default = (ColorAttachmentUsage | SampleUsage | FixedSamples) }

10.103.1 Detailed Description

Texture creation flags enumeration.

See also

TextureDescriptor::flags

10.103.2 Member Enumeration Documentation

10.103.2.1 anonymous enum

Enumerator

ColorAttachmentUsage Texture can be used as render target color attachment.

Remarks

This is part of the default flags.

Note

This cannot be used together with the TextureFlags::DepthStencilAttachmentUsage flag.

See also

AttachmentDescriptor::texture
AttachmentType::Color

DepthStencilAttachmentUsage Texture can be used as render target depth-stencil attachment.

Note

This cannot be used together with the TextureFlags::ColorAttachmentUsage flag.

See also

AttachmentDescriptor::texture
AttachmentType::DepthStencil

SampleUsage Texture can be used for sampling (e.g. "sampler2D" in GLSL, or "Texture2D" in HLSL).

Remarks

This is part of the default flags.

StorageUsage Texture can be used as storage texture (e.g. "image2D" in GLSL, or "RWTexture2D" in HL↩
SL).

FixedSamples Multi-sampled texture has fixed sample locations.

Remarks

This can only be used with multi-sampled textures (i.e. TextureType::Texture2DMS, TextureType↩
::Texture2DMSArray).

See also

TextureType

Default Default texture flags are `(ColorAttachmentUsage | SampleUsage | Fixed↩ Samples)`.

The documentation for this struct was generated from the following file:

- TextureFlags.h

10.104 LLGL::TextureRegion Struct Reference

Texture region structure.

```
#include <TextureFlags.h>
```

Public Attributes

- std::uint32_t mipLevel = 0

  MIP-map level for the sub-texture, where 0 is the base texture, and N $>$ 0 is the N-th MIP-map level. By default 0.
- Offset3D offset = { 0, 0, 0 }

  Sub-texture offset. By default (0, 0, 0).
- Extent3D extent = { 1, 1, 1 }

  Sub-texture extent. By default (1, 1, 1).

10.104.1 Detailed Description

Texture region structure.

Remarks

This is used to write (or partially write) the image data of a texture MIP-map level.

See also

RenderSystem::WriteTexture

10.104.2 Member Data Documentation

10.104.2.1 Extent3D LLGL::TextureRegion::extent = { 1, 1, 1 }

Sub-texture extent. By default (1, 1, 1).

Remarks

For array textures, the depth component specifies the number of array layers (for 1D-array textures it's the height component). For cube textures, the depthj component specifies the number of array layers and cube faces (where each cube has 6 faces).

10.104.2.2 std::uint32_t LLGL::TextureRegion::mipLevel = 0

MIP-map level for the sub-texture, where 0 is the base texture, and N $>$ 0 is the N-th MIP-map level. By default 0.

10.104.2.3 Offset3D LLGL::TextureRegion::offset = { 0, 0, 0 }

Sub-texture offset. By default (0, 0, 0).

Remarks

For array textures, the Z component specifies the array layer. For cube textures, the Z component specifies the array layer and cube face offset (for 1D-array textures it's the Y component). The layer offset for the respective cube faces is described at the TextureDescriptor::arrayLayers member. Negative values of this member are not allowed and result in undefined behavior.

The documentation for this struct was generated from the following file:

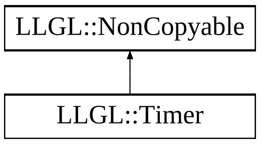
- TextureFlags.h

10.105 LLGL::Timer Class Reference

Interface for a Timer class.

```
#include <Timer.h>
```

Inheritance diagram for LLGL::Timer:



Public Member Functions

- virtual void Start ()=0
  Starts the timer.
- virtual std::uint64_t Stop ()=0
  Stops the timer and returns the elapsed ticks since "Start" was called.
- virtual std::uint64_t GetFrequency () const =0
  Returns the frequency resolution of this timer, or rather 'ticks per second' (e.g. for microseconds this is 1000000).
- virtual bool IsRunning () const =0
  Returns true if the timer is currently running.
- void MeasureTime ()
  Measures the time (elapsed time, and frame count) for each frame.
- double GetDeltaTime () const
  Returns the elapsed time (in seconds) between the current and the previous frame.

Static Public Member Functions

- static std::unique_ptr< Timer > Create ()
  Creates a platform specific timer object.

Additional Inherited Members

10.105.1 Detailed Description

Interface for a Timer class.

Remarks

This basic class is also designed as interface, since the native timer is platform specific.

10.105.2 Member Function Documentation

10.105.2.1 static std::unique_ptr<Timer> LLGL::Timer::Create ( ) [static]

Creates a platform specific timer object.

10.105.2.2 double LLGL::Timer::GetDeltaTime ( ) const [inline]

Returns the elapsed time (in seconds) between the current and the previous frame.

Remarks

This requires that "MeasureTime" is called once every frame.

See also

MeasureTime

10.105.2.3 virtual std::uint64_t LLGL::Timer::GetFrequency ( ) const [pure virtual]

Returns the frequency resolution of this timer, or rather 'ticks per second' (e.g. for microseconds this is 1000000).

10.105.2.4 virtual bool LLGL::Timer::IsRunning ( ) const [pure virtual]

Returns true if the timer is currently running.

Remarks

This is true between a call to "Start" and a call to "Stop".

See also

Start
Stop

10.105.2.5 void LLGL::Timer::MeasureTime ( )

Measures the time (elapsed time, and frame count) for each frame.

See also

GetDeltaTime

10.105.2.6 virtual void LLGL::Timer::Start ( ) `[pure virtual]`

Starts the timer.

10.105.2.7 virtual std::uint64_t LLGL::Timer::Stop ( ) `[pure virtual]`

Stops the timer and returns the elapsed ticks since "Start" was called.

The documentation for this class was generated from the following file:

- Timer.h

10.106 LLGL::UniformDescriptor Struct Reference

Shader uniform descriptor structure.

`#include <ShaderUniformFlags.h>`

Public Attributes

- std::string name

  Name of the uniform inside the shader.
- UniformType type = UniformType::Undefined

  Data type of the uniform. By default UniformType::Undefined.
- UniformLocation location = 0

  Internal location of the uniform within a shader program.
- std::uint32_t size = 0

  Array size of the uniform.

10.106.1 Detailed Description

Shader uniform descriptor structure.

10.106.2 Member Data Documentation

10.106.2.1 UniformLocation LLGL::UniformDescriptor::location = 0

Internal location of the uniform within a shader program.

10.106.2.2 std::string LLGL::UniformDescriptor::name

Name of the uniform inside the shader.

10.106.2.3 std::uint32_t LLGL::UniformDescriptor::size = 0

Array size of the uniform.

10.106.2.4 UniformType LLGL::UniformDescriptor::type = UniformType::Undefined

Data type of the uniform. By default UniformType::Undefined.

The documentation for this struct was generated from the following file:

- ShaderUniformFlags.h

10.107 LLGL::UninitializeTag Struct Reference

Common uninitialize tag.

```
#include <Tags.h>
```

10.107.1 Detailed Description

Common uninitialize tag.

Remarks

This can be used to explicitly construct an uninitialized color or even an entire container of uninitialized colors:

```
// Explicitly uninitialized color.
LLGL::ColorRGBAf color { Gs::UninitializeTag{} };

// Explicitly uninitialized color elements in a container.
std::vector<LLGL::ColorRGBAf> color;
color.resize(1024, LLGL::ColorRGBAf { Gs::UninitializeTag{} });
```

The documentation for this struct was generated from the following file:

- Tags.h

10.108 LLGL::VertexAttribute Struct Reference

Vertex attribute structure.

```
#include <VertexAttribute.h>
```

Public Member Functions

- VertexAttribute ()=default
- VertexAttribute (const VertexAttribute &)=default
- VertexAttribute & operator= (const VertexAttribute &)=default
- VertexAttribute (const std::string &name, const Format format, std::uint32_t instanceDivisor=0)

  Constructs a vertex attribute with a specified name (used for GLSL).
- VertexAttribute (const std::string &semanticName, std::uint32_t semanticIndex, const Format format, std↩ ::uint32_t instanceDivisor=0)

  Constructs a vertex attribute with a specified semantic (used for HLSL).
- std::uint32_t GetSize () const

  Returns the size (in bytes) which is required for this vertex attribute.

Public Attributes

- std::string name

  Vertex attribute name (for GLSL) or semantic name (for HLSL).
- Format format = Format::RGBA32Float

  Vertex attribute format. By default Format::RGBA32Float.
- std::uint32_t instanceDivisor = 0

  Instance data divisor (or instance data step rate).
- std::uint32_t offset = 0

  Byte offset within each vertex and each buffer. By default 0.
- std::uint32_t semanticIndex = 0

  Semantic index (for HLSL) or vector index (for GLSL).

10.108.1 Detailed Description

Vertex attribute structure.

See also

VertexFormat

10.108.2 Constructor & Destructor Documentation

10.108.2.1 LLGL::VertexAttribute::VertexAttribute ( ) `[default]`

10.108.2.2 LLGL::VertexAttribute::VertexAttribute (const VertexAttribute &) `[default]`

10.108.2.3 LLGL::VertexAttribute::VertexAttribute (const std::string & *name*, const Format *format*, std::uint32_t *instanceDivisor* = `0`)

Constructs a vertex attribute with a specified name (used for GLSL).

Parameters

in	*name*	Specifies the attribute name (for GLSL).
in	*format*	Specifies the attribute format (interpreted as vector format rather than color format). For a 3D-vector type, for example, Format::RGB32Float can be used.
in	*instanceDivisor*	Specifies the divisor (or step rate) for instance data. If this is 0, this vertex attribute is considered to be per-vertex. By default 0.

Remarks

This is equivalent to:

```
VertexAttribute(name, 0, dataType, components,
      instanceDivisor);
```

See also

Format

10.108.2.4 LLGL::VertexAttribute::VertexAttribute (const std::string & *semanticName*, std::uint32_t *semanticIndex*, const Format *format*, std::uint32_t *instanceDivisor* = 0)

Constructs a vertex attribute with a specified semantic (used for HLSL).

Parameters

in	*semanticName*	Specifies the semantic name (for HLSL).
in	*semanticIndex*	Specifies the semantic index (for HLSL).
in	*format*	Specifies the attribute format (interpreted as vector format rather than color format). For a 3D-vector type, for example, Format::RGB32Float can be used.
in	*instanceDivisor*	Specifies the divisor (or step rate) for instance data. If this is 0, this vertex attribute is considered to be per-vertex. By default 0.

Remarks

This is equivalent to:

```
VertexAttribute(name, 0, dataType, components,
      instanceDivisor);
```

See also

Format

10.108.3 Member Function Documentation

10.108.3.1 std::uint32_t LLGL::VertexAttribute::GetSize ( ) const

Returns the size (in bytes) which is required for this vertex attribute.

Returns

The format bit size converted to byte size: `FormatBitSize(format) / 8`.

10.108.3.2 VertexAttribute& LLGL::VertexAttribute::operator= (const VertexAttribute &) [default]

10.108.4 Member Data Documentation

10.108.4.1 Format LLGL::VertexAttribute::format = Format::RGBA32Float

Vertex attribute format. By default Format::RGBA32Float.

Remarks

Not all hardware formats are allowed for vertex attributes. In particular, depth-stencil formats and compressed formats are not allowed. To specify a vertex attribute of a matrix type, multiple attributes with ascending semantic indices must be used:

```
myVertexFormat.AppendAttribute({ "myMatrix", 0, LLGL::Format::RGBA32Float });
myVertexFormat.AppendAttribute({ "myMatrix", 1, LLGL::Format::RGBA32Float });
myVertexFormat.AppendAttribute({ "myMatrix", 2, LLGL::Format::RGBA32Float });
myVertexFormat.AppendAttribute({ "myMatrix", 3, LLGL::Format::RGBA32Float });
```

10.108.4.2 std::uint32_t LLGL::VertexAttribute::instanceDivisor = 0

Instance data divisor (or instance data step rate).

Remarks

If this is 0, this attribute is considered to be stored per vertex. If this is greater than 0, this attribute is considered to be stored per every instanceDivisor's instance.

10.108.4.3 std::string LLGL::VertexAttribute::name

Vertex attribute name (for GLSL) or semantic name (for HLSL).

10.108.4.4 std::uint32_t LLGL::VertexAttribute::offset = 0

Byte offset within each vertex and each buffer. By default 0.

10.108.4.5 std::uint32_t LLGL::VertexAttribute::semanticIndex = 0

Semantic index (for HLSL) or vector index (for GLSL).

Remarks

This is used when a matrix is distributed over multiple vector attributes.

The documentation for this struct was generated from the following file:

- VertexAttribute.h

10.109 LLGL::BufferDescriptor::VertexBuffer Struct Reference

Vertex buffer specific descriptor structure.

```
#include <BufferFlags.h>
```

Public Attributes

- VertexFormat format

  Specifies the vertex format layout.

10.109.1 Detailed Description

Vertex buffer specific descriptor structure.

10.109.2 Member Data Documentation

10.109.2.1 VertexFormat LLGL::BufferDescriptor::VertexBuffer::format

Specifies the vertex format layout.

Remarks

This is required to tell the renderer how the vertex attributes are stored inside the vertex buffer and it must be the same vertex format which is used for the respective graphics pipeline shader program.

The documentation for this struct was generated from the following file:

- BufferFlags.h

10.110 LLGL::VertexFormat Struct Reference

Vertex format structure.

```
#include <VertexFormat.h>
```

Public Member Functions

- void AppendAttribute (const VertexAttribute &attrib, std::uint32_t offset=Constants::ignoreOffset)

  Appends the specified vertex attribute to this vertex format.

Public Attributes

- std::vector< VertexAttribute > attributes

  Specifies the list of vertex attributes.
- std::uint32_t stride = 0

  Specifies the vertex data stride (or format size) which describes the byte offset between consecutive vertices.
- std::uint32_t inputSlot = 0

  Vertex buffer input slot. By default 0.

10.110.1 Detailed Description

Vertex format structure.

Remarks

A vertex format is required to describe how the vertex attributes are supported inside a vertex buffer.

See also

BufferDescriptor::VertexBuffer::format
ShaderProgram::BuildInputLayout

10.110.2 Member Function Documentation

10.110.2.1 void LLGL::VertexFormat::AppendAttribute (const **VertexAttribute** & *attrib*, std::uint32_t *offset* = `Constants::ignoreOffset`)

Appends the specified vertex attribute to this vertex format.

Parameters

`in`	*attrib*	Specifies the new attribute which is appended to this vertex format.
`in`	*offset*	Specifies the optional offset (in bytes) for this attribute. If this is `Constants::ignoreOffset`, the offset is determined by the previous vertex attribute offset plus its size. If there is no previous vertex attribute, the determined offset is 0. By default Constants::ignoreOffset.

Remarks

This function will always overwrite the `offset` and `inputSlot` members before the attribute is appended to this vertex format. The `inputSlot` member will be set to the input slot value of the previous vertex attribute and is increased by one, if the new offset of the new vertex attribute is less than the offset plus size of the previous vertex attribute.

Exceptions

std::invalid_argument	If `attrib.components` is neither 1, 2, 3, nor 4.

See also

VertexAttribute::offset
VertexAttribute::inputSlot
Constants::ignoreOffset

10.110.3 Member Data Documentation

10.110.3.1 std::vector< VertexAttribute > LLGL::VertexFormat::attributes

Specifies the list of vertex attributes.

Remarks

Use "AppendAttribute" or "AppendAttributes" to append new attributes.

10.110.3.2 std::uint32_t LLGL::VertexFormat::inputSlot = 0

Vertex buffer input slot. By default 0.

Remarks

This is used when multiple vertex buffers are used simultaneously.

Note

Only supported with: Direct3D 11, Direct3D 12, Vulkan.
For OpenGL, the input slots are automatically generated in ascending order and beginning with zero.

10.110.3.3 std::uint32_t LLGL::VertexFormat::stride = 0

Specifies the vertex data stride (or format size) which describes the byte offset between consecutive vertices.

Remarks

This is updated automatically everytime `AppendAttribute` is called, but it can also be modified manually.
It is commonly the size of all vertex attributes.

See also

AppendAttribute

The documentation for this struct was generated from the following file:

- VertexFormat.h

10.111 LLGL::VideoAdapterDescriptor Struct Reference

Video adapter descriptor structure.

```
#include <VideoAdapter.h>
```

Public Attributes

- std::wstring name

  Hardware adapter name (name of the GPU).
- std::string vendor

  Vendor name (e.g. "NVIDIA Corporation", "Advanced Micro Devices, Inc." etc.).
- std::uint64_t videoMemory = 0

  Video memory size (in bytes).
- std::vector< VideoOutputDescriptor > outputs

  List of all adapter output descriptors.

10.111.1 Detailed Description

Video adapter descriptor structure.

Remarks

A video adapter determines the output capabilities of a GPU.

Todo Currently unused in the interface.

10.111.2 Member Data Documentation

10.111.2.1 std::wstring LLGL::VideoAdapterDescriptor::name

Hardware adapter name (name of the GPU).

10.111.2.2 std::vector< VideoOutputDescriptor > LLGL::VideoAdapterDescriptor::outputs

List of all adapter output descriptors.

10.111.2.3 std::string LLGL::VideoAdapterDescriptor::vendor

Vendor name (e.g. "NVIDIA Corporation", "Advanced Micro Devices, Inc." etc.).

10.111.2.4 std::uint64_t LLGL::VideoAdapterDescriptor::videoMemory = 0

Video memory size (in bytes).

The documentation for this struct was generated from the following file:

- VideoAdapter.h

10.112 LLGL::VideoModeDescriptor Struct Reference

Video mode descriptor structure.

`#include <RenderContextFlags.h>`

Public Attributes

- Extent2D resolution

  Screen resolution (in pixels).
- int colorBits = 32

  Number of bits for each pixel in the color buffer. Should be 24 or 32. By default 32.
- int depthBits = 24

  Number of bits for each pixel in the depth buffer. Should be 24, 32, or zero to disable depth buffer. By default 24.
- int stencilBits = 8

  Number of bits for each pixel in the stencil buffer. Should be 8, or zero to disable stencil buffer. By default 8.
- bool fullscreen = false

  Specifies whether to enable fullscreen mode or windowed mode. By default windowed mode.
- std::uint32_t swapChainSize = 2

  Number of swap-chain buffers. By default 2 (for double-buffering).

10.112.1 Detailed Description

Video mode descriptor structure.

Remarks

This is mainly used to set the video mode of a RenderContext object. The counterpart for a physical display mode is the DisplayModeDescriptor structure.

See also

RenderContext::SetVideoMode
DisplayModeDescriptor

10.112.2 Member Data Documentation

10.112.2.1 int LLGL::VideoModeDescriptor::colorBits = 32

Number of bits for each pixel in the color buffer. Should be 24 or 32. By default 32.

Remarks

This is only a hint to the renderer and there is no guarantee which hardware format is finally used for the color buffer. To determine the actual color format of a render context, use the RenderContext::QueryColorFormat function.

See also

RenderContext::QueryColorFormat

10.112.2.2 int LLGL::VideoModeDescriptor::depthBits = 24

Number of bits for each pixel in the depth buffer. Should be 24, 32, or zero to disable depth buffer. By default 24.

Remarks

This is only a hint to the renderer and there is no guarantee which hardware format is finally used for the depth buffer. To determine the actual depth-stencil format of a render context, use the RenderContext::Query←DepthStencilFormat function.

See also

RenderContext::QueryDepthStencilFormat

10.112.2.3 bool LLGL::VideoModeDescriptor::fullscreen = false

Specifies whether to enable fullscreen mode or windowed mode. By default windowed mode.

10.112.2.4 Extent2D LLGL::VideoModeDescriptor::resolution

Screen resolution (in pixels).

Remarks

If the resolution contains a member with a value of 0, the video mode is invalid.

See also

RenderTarget::GetResolution

10.112.2.5 int LLGL::VideoModeDescriptor::stencilBits = 8

Number of bits for each pixel in the stencil buffer. Should be 8, or zero to disable stencil buffer. By default 8.

Remarks

This is only a hint to the renderer and there is no guarantee which hardware format is finally used for the stencil buffer. To determine the actual depth-stencil format of a render context, use the RenderContext::↩
QueryDepthStencilFormat function.

See also

RenderContext::QueryDepthStencilFormat

10.112.2.6 std::uint32_t LLGL::VideoModeDescriptor::swapChainSize = 2

Number of swap-chain buffers. By default 2 (for double-buffering).

Remarks

This is only a hint to the renderer and there is no guarantee how many buffers are finally used for the swap chain. Especially OpenGL does not support custom swap chain sizes. If this value is 0, the video mode is invalid.

The documentation for this struct was generated from the following file:

- RenderContextFlags.h

10.113 LLGL::VideoOutputDescriptor Struct Reference

Video output structure.

```
#include <VideoAdapter.h>
```

Public Attributes

- std::vector< DisplayModeDescriptor > displayModes

  List of all display mode descriptors for this video output.

10.113.1 Detailed Description

Video output structure.

See also

VideoAdapterDescriptor::outputs

Todo Currently unused in the interface.

10.113.2 Member Data Documentation

10.113.2.1 std::vector<DisplayModeDescriptor> LLGL::VideoOutputDescriptor::displayModes

List of all display mode descriptors for this video output.

The documentation for this struct was generated from the following file:

- VideoAdapter.h

10.114 LLGL::Viewport Struct Reference

Viewport dimensions.

```
#include <GraphicsPipelineFlags.h>
```

Public Member Functions

- Viewport ()=default
- Viewport (const Viewport &)=default
- Viewport (float x, float y, float width, float height)

  Viewport constructor with default depth range of [0, 1].
- Viewport (float x, float y, float width, float height, float minDepth, float maxDepth)

  Viewport constructor with parameters for all attributes.
- Viewport (const Extent2D &extent)

  Viewport constructor with extent and default depth range of [0, 1].
- Viewport (const Extent2D &extent, float minDepth, float maxDepth)

  Viewport constructor with extent and explicit depth range.
- Viewport (const Offset2D &offset, const Extent2D &extent)

  Viewport constructor with offset, extent, and default depth range of [0, 1].
- Viewport (const Offset2D &offset, const Extent2D &extent, float minDepth, float maxDepth)

  Viewport constructor with offset, extent, and explicit depth range.

Public Attributes

- float x = 0.0f

  Y coordinate of the left-top origin. By default 0.0.
- float y = 0.0f
- float width = 0.0f

  Width of the right-bottom size. By default 0.0.
- float height = 0.0f

  Height of the right-bottom size. By default 0.0.
- float minDepth = 0.0f

  Minimum of the depth range. Must be in the range [0, 1]. By default 0.0.
- float maxDepth = 1.0f

  Maximum of the depth range. Must be in the range [0, 1]. By default 1.0.

10.114.1 Detailed Description

Viewport dimensions.

Remarks

A viewport is in screen coordinates where the origin is in the left-top corner.

See also

CommandBuffer::SetViewport
CommandBuffer::SetViewports
GraphicsPipelineDescriptor::viewports

10.114.2 Constructor & Destructor Documentation

10.114.2.1 LLGL::Viewport::Viewport ( ) `[default]`

10.114.2.2 LLGL::Viewport::Viewport (const Viewport &) `[default]`

10.114.2.3 LLGL::Viewport::Viewport (float *x*, float *y*, float *width*, float *height*) `[inline]`

Viewport constructor with default depth range of [0, 1].

10.114.2.4 LLGL::Viewport::Viewport (float *x*, float *y*, float *width*, float *height*, float *minDepth*, float *maxDepth*) `[inline]`

Viewport constructor with parameters for all attributes.

10.114.2.5 LLGL::Viewport::Viewport (const Extent2D & *extent*) `[inline]`

Viewport constructor with extent and default depth range of [0, 1].

10.114.2.6 LLGL::Viewport::Viewport (const Extent2D & *extent*, float *minDepth*, float *maxDepth*) `[inline]`

Viewport constructor with extent and explicit depth range.

10.114.2.7 LLGL::Viewport::Viewport (const Offset2D & *offset*, const Extent2D & *extent*) `[inline]`

Viewport constructor with offset, extent, and default depth range of [0, 1].

10.114.2.8 LLGL::Viewport::Viewport (const Offset2D & *offset*, const Extent2D & *extent*, float *minDepth*, float *maxDepth*) `[inline]`

Viewport constructor with offset, extent, and explicit depth range.

X coordinate of the left-top origin. By default 0.0.

10.114.3 Member Data Documentation

10.114.3.1 float LLGL::Viewport::height = 0.0f

Height of the right-bottom size. By default 0.0.

Remarks

Setting a viewport of negative height results in undefined behavior.

10.114.3.2 float LLGL::Viewport::maxDepth = 1.0f

Maximum of the depth range. Must be in the range [0, 1]. By default 1.0.

Remarks

Reverse mappings such as minDepth=1 and maxDepth=0 are also valid.

10.114.3.3 float LLGL::Viewport::minDepth = 0.0f

Minimum of the depth range. Must be in the range [0, 1]. By default 0.0.

Remarks

Reverse mappings such as minDepth=1 and maxDepth=0 are also valid.

10.114.3.4 float LLGL::Viewport::width = 0.0f

Width of the right-bottom size. By default 0.0.

Remarks

Setting a viewport of negative width results in undefined behavior.

10.114.3.5 float LLGL::Viewport::x = 0.0f

Y coordinate of the left-top origin. By default 0.0.

10.114.3.6 float LLGL::Viewport::y = 0.0f

The documentation for this struct was generated from the following file:

- GraphicsPipelineFlags.h

10.115 LLGL::VsyncDescriptor Struct Reference

Vertical-synchronization (Vsync) descriptor structure.

`#include <RenderContextFlags.h>`

Public Attributes

- bool enabled = false

  Specifies whether vertical-synchronisation (Vsync) is enabled or disabled. By default disabled.
- std::uint32_t refreshRate = 60

  Refresh rate (in Hz). By default 60.
- std::uint32_t interval = 1

  Synchronisation interval. Can be 1, 2, 3, or 4.

10.115.1 Detailed Description

Vertical-synchronization (Vsync) descriptor structure.

Todo Maybe remove this entire structure and only use a "vsyncInterval" parameter.

10.115.2 Member Data Documentation

10.115.2.1 bool LLGL::VsyncDescriptor::enabled = false

Specifies whether vertical-synchronisation (Vsync) is enabled or disabled. By default disabled.

10.115.2.2 std::uint32_t LLGL::VsyncDescriptor::interval = 1

Synchronisation interval. Can be 1, 2, 3, or 4.

Remarks

If Vsync is disabled, this value is implicitly zero.

10.115.2.3 std::uint32_t LLGL::VsyncDescriptor::refreshRate = 60

Refresh rate (in Hz). By default 60.

Note

Only supported with: Direct3D 11, Direct3D 12.

The documentation for this struct was generated from the following file:

- RenderContextFlags.h

10.116 LLGL::VulkanRendererConfiguration Struct Reference

Structure for a Vulkan renderer specific configuration.

```
#include <RenderSystemFlags.h>
```

Public Attributes

- ApplicationDescriptor application

  Application descriptor used when a Vulkan debug or validation layer is enabled.
- std::uint64_t minDeviceMemoryAllocationSize = 1024∗1024

  Minimal allocation size for a device memory chunk. By default 1024∗1024, i.e. 1 MB of VRAM.
- bool reduceDeviceMemoryFragmentation = false

  Specifies whether fragmentation of the device memory blocks shall be kept low. By default false.

10.116.1 Detailed Description

Structure for a Vulkan renderer specific configuration.

Remarks

The nomenclature here is "Renderer" instead of "RenderSystem" since the configuration is renderer specific and does not denote a configuration of the entire system.

10.116.2 Member Data Documentation

10.116.2.1 ApplicationDescriptor LLGL::VulkanRendererConfiguration::application

Application descriptor used when a Vulkan debug or validation layer is enabled.

See also

ApplicationDescriptor

10.116.2.2 std::uint64_t LLGL::VulkanRendererConfiguration::minDeviceMemoryAllocationSize = 1024∗1024

Minimal allocation size for a device memory chunk. By default 1024∗1024, i.e. 1 MB of VRAM.

Remarks

Vulkan only allows a limited set of device memory objects (e.g. 4096 on a GPU with 8 GB of VRAM). This member specifies the minimum size used for hardware memory allocation of such a memory chunk. The Vulkan render system automatically manages sub-region allocation and defragmentation.

10.116.2.3 bool LLGL::VulkanRendererConfiguration::reduceDeviceMemoryFragmentation = false

Specifies whether fragmentation of the device memory blocks shall be kept low. By default false.

Remarks

If this is true, each buffer and image allocation first tries to find a reusable device memory block within a single VkDeviceMemory chunk (which might be potentially slower). Whenever a VkDeviceMemory chunk is full, the memory manager tries to reduce fragmentation anyways.

The documentation for this struct was generated from the following file:

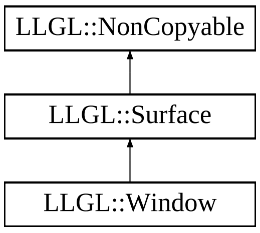
- RenderSystemFlags.h

10.117 LLGL::Window Class Reference

Window interface for desktop platforms.

```
#include <Window.h>
```

Inheritance diagram for LLGL::Window:



Classes

- class EventListener

  Interface for all window event listeners.

Public Member Functions

- virtual void SetPosition (const Offset2D &position)=0

  Sets the window position relative to its parent.
- virtual Offset2D GetPosition () const =0

  Returns the window position relative to its parent.
- virtual void SetSize (const Extent2D &size, bool useClientArea=true)=0

  Sets the either the overall window size or the client area size. By default the client area size is set.
- virtual Extent2D GetSize (bool useClientArea=true) const =0

  Returns either the overall window size or the client area size. By default the client area size is returned.
- virtual void SetTitle (const std::wstring &title)=0

  Sets the window title as UTF16 string. If the OS does not support UTF16 window title, it will be converted to UTF8.
- virtual std::wstring GetTitle () const =0

Returns the window title as UTF16 string.
- virtual void Show (bool show=true)=0

  Shows or hides the window.
- virtual bool IsShown () const =0

  Returns true if this window is visible.
- virtual void SetDesc (const WindowDescriptor &desc)=0

  Sets the window attributes according to the specified window descriptor.
- virtual WindowDescriptor GetDesc () const =0

  Queries a window descriptor, which describes the attributes of this window.
- virtual void SetBehavior (const WindowBehavior &behavior)

  Sets the new window behavior.
- const WindowBehavior & GetBehavior () const

  Returns the window heavior.
- virtual bool HasFocus () const

  Returns true if this window has the keyboard focus.
- bool AdaptForVideoMode (VideoModeDescriptor &videoModeDesc) override

  Adapts the window for the specified video mode.
- bool ProcessEvents ()

  Processes the events for this window (i.e. mouse movement, key presses etc.).
- void AddEventListener (const std::shared_ptr< EventListener > &eventListener)

  Adds the specified event listener to this window.
- void RemoveEventListener (const EventListener ∗eventListener)

  Removes the specified event listener from this window.
- void PostKeyDown (Key keyCode)

  Posts a 'KeyDown' event to all event listeners.
- void PostKeyUp (Key keyCode)
- void PostDoubleClick (Key keyCode)
- void PostChar (wchar_t chr)
- void PostWheelMotion (int motion)
- void PostLocalMotion (const Offset2D &position)
- void PostGlobalMotion (const Offset2D &motion)
- void PostResize (const Extent2D &clientAreaSize)
- void PostGetFocus ()

  Posts a 'GetFocus' event to all event listeners.
- void PostLoseFocus ()

  Posts a 'LoseFocus' event to all event listeners.
- void PostQuit ()

  Posts a 'Quit' event to all event listeners.
- void PostTimer (std::uint32_t timerID)

  Posts a timer event with the specified timer ID number.

Static Public Member Functions

- static std::unique_ptr< Window > Create (const WindowDescriptor &desc)

  Creates a platform specific instance of the Window interface.

Protected Member Functions

- virtual void OnProcessEvents ()=0

  Called inside the "ProcessEvents" function after all event listeners received the same event.

10.117.1 Detailed Description

Window interface for desktop platforms.

Remarks

This is the main interface for the windowing system in LLGL. To implement a custom window (and use GLFW for instance) you have to derive from this class and implement all pure virtual functions. The couterpart is the Canvas interface for mobile platforms.

See also

Canvas

10.117.2 Member Function Documentation

10.117.2.1 bool LLGL::Window::AdaptForVideoMode (**VideoModeDescriptor** & *videoModeDesc*) `[override]`, `[virtual]`

Adapts the window for the specified video mode.

Remarks

This is a default implementation of the base class function and makes use of "GetDesc" and "SetDesc".

See also

GetDesc
SetDesc

Implements LLGL::Surface.

10.117.2.2 void LLGL::Window::AddEventListener (const std::shared_ptr< **EventListener** > & *eventListener*)

Adds the specified event listener to this window.

10.117.2.3 static std::unique_ptr<**Window**> LLGL::Window::Create (const **WindowDescriptor** & *desc*) `[static]`

Creates a platform specific instance of the Window interface.

Returns

Unique pointer to a new instance of the platform specific Window interface or null if the platform does not support windows (such as Android and iOS).

Remarks

For mobile platforms the interface Canvas can be used.

See also

Canvas

10.117.2.4 const WindowBehavior& LLGL::Window::GetBehavior ( ) const [inline]

Returns the window heavior.

10.117.2.5 virtual WindowDescriptor LLGL::Window::GetDesc ( ) const [pure virtual]

Queries a window descriptor, which describes the attributes of this window.

10.117.2.6 virtual Offset2D LLGL::Window::GetPosition ( ) const [pure virtual]

Returns the window position relative to its parent.

10.117.2.7 virtual Extent2D LLGL::Window::GetSize (bool *useClientArea* = true) const [pure virtual]

Returns either the overall window size or the client area size. By default the client area size is returned.

10.117.2.8 virtual std::wstring LLGL::Window::GetTitle ( ) const [pure virtual]

Returns the window title as UTF16 string.

10.117.2.9 virtual bool LLGL::Window::HasFocus ( ) const [virtual]

Returns true if this window has the keyboard focus.

10.117.2.10 virtual bool LLGL::Window::IsShown ( ) const [pure virtual]

Returns true if this window is visible.

10.117.2.11 virtual void LLGL::Window::OnProcessEvents ( ) [protected], [pure virtual]

Called inside the "ProcessEvents" function after all event listeners received the same event.

See also

ProcessEvents
EventListener::OnProcessEvents

10.117.2.12 void LLGL::Window::PostChar (wchar_t *chr*)

See also

PostKeyDown

10.117.2.13 void LLGL::Window::PostDoubleClick (Key *keyCode*)

See also

PostKeyDown

10.117.2.14 void LLGL::Window::PostGetFocus ( )

Posts a 'GetFocus' event to all event listeners.

10.117.2.15 void LLGL::Window::PostGlobalMotion (const Offset2D & *motion*)

See also

PostKeyDown

10.117.2.16 void LLGL::Window::PostKeyDown (Key *keyCode*)

Posts a 'KeyDown' event to all event listeners.

Remarks

This will be called automatically by the "ProcessEvents" function.

See also

EventListener::OnKeyDown
ProcessEvents

10.117.2.17 void LLGL::Window::PostKeyUp (Key *keyCode*)

See also

PostKeyDown

10.117.2.18 void LLGL::Window::PostLocalMotion (const Offset2D & *position*)

See also

PostKeyDown

10.117.2.19 void LLGL::Window::PostLoseFocus ( )

Posts a 'LoseFocus' event to all event listeners.

10.117.2.20 void LLGL::Window::PostQuit ( )

Posts a 'Quit' event to all event listeners.

Remarks

If at least one event listener returns false within the "OnQuit" callback, the window will not quit. If all event listener return true within the "OnQuit" callback, "ProcessEvents" will returns false from now on.

See also

EventListener::OnQuit
ProcessEvents

10.117.2.21 void LLGL::Window::PostResize (const Extent2D & *clientAreaSize*)

See also

PostKeyDown

10.117.2.22 void LLGL::Window::PostTimer (std::uint32_t *timerID*)

Posts a timer event with the specified timer ID number.

Remarks

This can be used to refresh the screen while the underlying window is currently being moved or resized by the user.

Note

Only supported on: MS. Windows.

10.117.2.23 void LLGL::Window::PostWheelMotion (int *motion*)

See also

PostKeyDown

10.117.2.24 bool LLGL::Window::ProcessEvents ( )

Processes the events for this window (i.e. mouse movement, key presses etc.).

Returns

Once the "PostQuit" function was called on this window object, this function returns false. This will happend, when the user clicks on the close button.

10.117.2.25 void LLGL::Window::RemoveEventListener (const EventListener ∗ *eventListener*)

Removes the specified event listener from this window.

10.117.2.26 virtual void LLGL::Window::SetBehavior (const WindowBehavior & *behavior*) [virtual]

Sets the new window behavior.

10.117.2.27 virtual void LLGL::Window::SetDesc (const WindowDescriptor & *desc*) [pure virtual]

Sets the window attributes according to the specified window descriptor.

Remarks

This is used by the RenderContext interface when the video mode is about to change.

See also

RenderContext::SetVideoMode

10.117.2.28 virtual void LLGL::Window::SetPosition (const Offset2D & *position*) [pure virtual]

Sets the window position relative to its parent.

10.117.2.29 virtual void LLGL::Window::SetSize (const Extent2D & *size*, bool *useClientArea* = `true`) [pure virtual]

Sets the either the overall window size or the client area size. By default the client area size is set.

10.117.2.30 virtual void LLGL::Window::SetTitle (const std::wstring & *title*) [pure virtual]

Sets the window title as UTF16 string. If the OS does not support UTF16 window title, it will be converted to UTF8.

10.117.2.31 virtual void LLGL::Window::Show (bool *show* = `true`) [pure virtual]

Shows or hides the window.

The documentation for this class was generated from the following file:

- Window.h

10.118 LLGL::WindowBehavior Struct Reference

Window behavior structure.

```
#include <WindowFlags.h>
```

Public Attributes

- bool disableClearOnResize = false

  Specifies whether to clear the content of the window when it is resized. By default false.
- std::uint32_t moveAndResizeTimerID = invalidWindowTimerID

  Specifies an ID for a timer which will be activated when the window is moved or sized. By default invalidWindow←→ TimerID.

10.118.1 Detailed Description

Window behavior structure.

See also

Window::SetBehavior

10.118.2 Member Data Documentation

10.118.2.1 bool LLGL::WindowBehavior::disableClearOnResize = false

Specifies whether to clear the content of the window when it is resized. By default false.

Remarks

This is used by Win32 to erase (WM_ERASEBKGND message) or keep the background on a window resize. If this is false, some kind of flickering during a window resize can be avoided.

Note

Only supported on: Win32.

10.118.2.2 std::uint32_t LLGL::WindowBehavior::moveAndResizeTimerID = invalidWindowTimerID

Specifies an ID for a timer which will be activated when the window is moved or sized. By default invalidWindow←→ TimerID.

Remarks

This is used by Win32 to set a timer during a window is moved or resized to make continous scene updates. Do not reset it during the 'OnTimer' event, otherwise a timer might be not be released correctly!

Note

Only supported on: Win32.

See also

Window::EventListener::OnTimer
invalidWindowTimerID

The documentation for this struct was generated from the following file:

- WindowFlags.h

10.119 LLGL::WindowDescriptor Struct Reference

Window descriptor structure.

```
#include <WindowFlags.h>
```

Public Attributes

- std::wstring title

  Window title as unicode string.
- Offset2D position

  Window position (relative to the client area).
- Extent2D size

  Window size (this should be the client area size).
- bool visible = false

  Specifies whether the window is visible at creation time. By default false.
- bool borderless = false

  Specifies whether the window is borderless. This is required for a fullscreen render context. By default false.
- bool resizable = false

  Specifies whether the window can be resized. By default false.
- bool acceptDropFiles = false

  Specifies whether the window allows that files can be draged-and-droped onto the window. By default false.
- bool preventForPowerSafe = false

  Specifies whether this window prevents the host system for power-safe mode. By default false.
- bool centered = false

  Specifies whether the window is centered within the desktop screen. By default false.
- const void ∗ windowContext = nullptr

  Window context handle.

10.119.1 Detailed Description

Window descriptor structure.

10.119.2 Member Data Documentation

10.119.2.1 bool LLGL::WindowDescriptor::acceptDropFiles = false

Specifies whether the window allows that files can be draged-and-droped onto the window. By default false.

Note

Only supported on: MS/Windows.

10.119.2.2 bool LLGL::WindowDescriptor::borderless = false

Specifies whether the window is borderless. This is required for a fullscreen render context. By default false.

10.119.2.3 bool LLGL::WindowDescriptor::centered = false

Specifies whether the window is centered within the desktop screen. By default false.

10.119.2.4 Offset2D LLGL::WindowDescriptor::position

Window position (relative to the client area).

10.119.2.5 bool LLGL::WindowDescriptor::preventForPowerSafe = false

Specifies whether this window prevents the host system for power-safe mode. By default false.

Note

Only supported on: MS/Windows.

10.119.2.6 bool LLGL::WindowDescriptor::resizable = false

Specifies whether the window can be resized. By default false.

Remarks

For every window representing the surface for a RenderContext which has been resized, the video mode of that RenderContext must be updated with the resolution of the surface's content size. This can be done by setting the video mode with the new resolution before the respective render context is set as render target, or it can be handled by a window event listener on the 'OnResize' callback:

```
// Alternative 1
class MyEventListener : public LLGL::Window::EventListener {
    void OnResize(Window& sender, const Extent2D& clientAreaSize) override {
        auto myVideoMode = myRenderContext->GetVideoMode();
        myVideoMode.resolution = clientAreaSize;
        myRenderContext->SetVideoMode(myVideoMode);
    }
};
myWindow->AddEventListener(std::make_shared<MyEventListener>());

// Alternative 2
auto myVideoMode = myRenderContext->GetVideoMode();
myVideoMode.resolution = myWindow->GetContentSize();
myRenderContext->SetVideoMode(myVideoMode);
myCmdBuffer->SetRenderTarget(*myRenderContext);
```

Note

Not updating the render context on a resized window is undefined behavior.

See also

RenderContext::SetVideoMode
Surface::GetContentSize
Window::EventListener::OnResize

10.119.2.7 Extent2D LLGL::WindowDescriptor::size

Window size (this should be the client area size).

10.119.2.8 std::wstring LLGL::WindowDescriptor::title

Window title as unicode string.

10.119.2.9 bool LLGL::WindowDescriptor::visible = false

Specifies whether the window is visible at creation time. By default false.

10.119.2.10 const void∗ LLGL::WindowDescriptor::windowContext = nullptr

Window context handle.

Remarks

If used, this must be casted from a platform specific structure:

```
#include <LLGL/Platform/NativeHandle.h>
//...
LLGL::NativeContextHandle handle;
//handle.parentWindow = ...
windowDesc.windowContext = reinterpret_cast<const void*>(&handle);
```

The documentation for this struct was generated from the following file:

- WindowFlags.h

Chapter 11

File Documentation

11.1 Buffer.h File Reference

```
#include "Resource.h"
#include "BufferFlags.h"
```

Classes

- class LLGL::Buffer

  Hardware buffer interface.

Namespaces

- LLGL

11.2 BufferArray.h File Reference

```
#include "RenderSystemChild.h"
#include "BufferFlags.h"
```

Classes

- class LLGL::BufferArray

  Hardware buffer container interface.

Namespaces

- LLGL

11.3 BufferFlags.h File Reference

```
#include "Export.h"
#include "VertexFormat.h"
#include "IndexFormat.h"
#include "RenderSystemFlags.h"
#include <string>
#include <cstdint>
```

Classes

- struct LLGL::BufferFlags

  Buffer creation flags enumeration.
- struct LLGL::BufferDescriptor

  Hardware buffer descriptor structure.
- struct LLGL::BufferDescriptor::VertexBuffer

  Vertex buffer specific descriptor structure.
- struct LLGL::BufferDescriptor::IndexBuffer

  Index buffer specific descriptor structure.
- struct LLGL::BufferDescriptor::StorageBuffer

  Storage buffer specific descriptor structure.

Namespaces

- LLGL

Enumerations

- enum LLGL::BufferType {
  LLGL::BufferType::Vertex, LLGL::BufferType::Index, LLGL::BufferType::Constant, LLGL::BufferType::Storage,
  LLGL::BufferType::StreamOutput }

  Hardware buffer type enumeration.
- enum LLGL::StorageBufferType {
  LLGL::StorageBufferType::Undefined, LLGL::StorageBufferType::Buffer, LLGL::StorageBufferType::↩
  StructuredBuffer, LLGL::StorageBufferType::ByteAddressBuffer,
  LLGL::StorageBufferType::RWBuffer, LLGL::StorageBufferType::RWStructuredBuffer, LLGL::Storage↩
  BufferType::RWByteAddressBuffer, LLGL::StorageBufferType::AppendStructuredBuffer,
  LLGL::StorageBufferType::ConsumeStructuredBuffer }

  Storage buffer type enumeration.

Functions

- LLGL_EXPORT bool LLGL::IsRWBuffer (const StorageBufferType type)

  Returns true if the storage buffer type denotes a read/write (RW) buffer.
- LLGL_EXPORT bool LLGL::IsTypedBuffer (const StorageBufferType type)

  Returns true if the storage buffer type denotes a simply typed buffer.
- LLGL_EXPORT bool LLGL::IsStructuredBuffer (const StorageBufferType type)

  Returns true if the storage buffer type denotes a structured buffer.
- LLGL_EXPORT bool LLGL::IsByteAddressBuffer (const StorageBufferType type)

  Returns true if the storage buffer type denotes a byte addresse buffer.

11.4 Canvas.h File Reference

```
#include "CanvasFlags.h"
#include "Surface.h"
#include "Types.h"
#include "Key.h"
#include <memory>
```

Classes

- class LLGL::Canvas

  Canvas interface for mobile platforms.
- class LLGL::Canvas::EventListener

  Interface for all canvas event listeners.

Namespaces

- LLGL

11.5 CanvasFlags.h File Reference

```
#include <string>
```

Classes

- struct LLGL::CanvasDescriptor

  Canvas descriptor structure.

Namespaces

- LLGL

11.6 Color.h File Reference

```
#include "Tags.h"
#include <algorithm>
#include <type_traits>
#include <cstdint>
#include <stdexcept>
```

Classes

- class LLGL::Color< T, N >

  Base color class with N components.

Namespaces

- LLGL

Functions

- template<typename T >
  T LLGL::MaxColorValue ()

  Returns the maximal color value for the data type T. By default 1.
- template<>
  std::uint8_t LLGL::MaxColorValue< std::uint8_t > ()

  Specialized version. For unsigned 8-bit integers, the return value is 255.
- template<>
  bool LLGL::MaxColorValue< bool > ()

  Specialized version. For booleans, the return value is true.
- template<typename Dst , typename Src >
  Dst LLGL::CastColorValue (const Src &value)

  Casts the specified color value and transforms it from the source data type range to the destination data type range.
- template<>
  bool LLGL::CastColorValue< bool, bool > (const bool &value)

  Specialized template which merely passes the input value as output.
- template<>
  float LLGL::CastColorValue< float, float > (const float &value)

  Specialized template which merely passes the input value as output.
- template<>
  double LLGL::CastColorValue< double, double > (const double &value)

  Specialized template which merely passes the input value as output.
- template<>
  std::uint8_t LLGL::CastColorValue< std::uint8_t, std::uint8_t > (const std::uint8_t &value)

  Specialized template which merely passes the input value as output.
- template<typename T , std::size_t N>
  Color< T, N > LLGL::operator+ (const Color< T, N > &lhs, const Color< T, N > &rhs)
- template<typename T , std::size_t N>
  Color< T, N > LLGL::operator- (const Color< T, N > &lhs, const Color< T, N > &rhs)
- template<typename T , std::size_t N>
  Color< T, N > LLGL::operator* (const Color< T, N > &lhs, const Color< T, N > &rhs)
- template<typename T , std::size_t N>
  Color< T, N > LLGL::operator/ (const Color< T, N > &lhs, const Color< T, N > &rhs)
- template<typename T , std::size_t N>
  Color< T, N > LLGL::operator* (const Color< T, N > &lhs, const T &rhs)
- template<typename T , std::size_t N>
  Color< T, N > LLGL::operator* (const T &lhs, const Color< T, N > &rhs)
- template<typename T , std::size_t N>
  Color< T, N > LLGL::operator/ (const Color< T, N > &lhs, const T &rhs)
- template<typename T , std::size_t N>
  Color< T, N > LLGL::operator/ (const T &lhs, const Color< T, N > &rhs)
- template<typename T , std::size_t N>
  bool LLGL::operator== (const Color< T, N > &lhs, const Color< T, N > &rhs)

  Returns true if all components of both colors 'lhs' and 'rhs' are equal.
- template<typename T , std::size_t N>
  bool LLGL::operator!= (const Color< T, N > &lhs, const Color< T, N > &rhs)

  Returns true if any component of both colors 'lhs' and 'rhs' are unequal.

11.7 ColorRGB.h File Reference

```
#include "Color.h"
```

Classes

- class LLGL::Color< T, 3u >

  RGB color class with components: r, g, and b.

Namespaces

- LLGL

Typedefs

- template<typename T >
  using LLGL::ColorRGBT = Color< T, 3 >
- using LLGL::ColorRGBb = ColorRGBT< bool >
- using LLGL::ColorRGBf = ColorRGBT< float >
- using LLGL::ColorRGBd = ColorRGBT< double >
- using LLGL::ColorRGBub = ColorRGBT< std::uint8_t >

11.8 ColorRGBA.h File Reference

```
#include "Color.h"
```

Classes

- class LLGL::Color< T, 4u >

  RGBA color class with components: r, g, b, and a.

Namespaces

- LLGL

Typedefs

- template<typename T >
  using LLGL::ColorRGBAT = Color< T, 4 >
- using LLGL::ColorRGBAb = ColorRGBAT< bool >
- using LLGL::ColorRGBAf = ColorRGBAT< float >
- using LLGL::ColorRGBAd = ColorRGBAT< double >
- using LLGL::ColorRGBAub = ColorRGBAT< std::uint8_t >

11.9 CommandBuffer.h File Reference

```
#include "RenderSystemChild.h"
#include "CommandBufferFlags.h"
#include "RenderSystemFlags.h"
#include "ColorRGBA.h"
#include "Buffer.h"
#include "BufferArray.h"
#include "ResourceHeap.h"
#include "PipelineLayoutFlags.h"
#include "RenderPass.h"
#include "RenderTarget.h"
#include "ShaderProgram.h"
#include "GraphicsPipeline.h"
#include "ComputePipeline.h"
#include "QueryHeap.h"
#include <cstdint>
```

Classes

- class LLGL::CommandBuffer

  Command buffer interface.

Namespaces

- LLGL

11.10 CommandBufferExt.h File Reference

```
#include "CommandBuffer.h"
#include "ForwardDecls.h"
```

Classes

- class LLGL::CommandBufferExt

  Extended command buffer interface with dynamic state access for shader resources (i.e. Constant Buffers, Storage Buffers, Textures, and Samplers).

Namespaces

- LLGL

11.11 CommandBufferFlags.h File Reference

```
#include "ColorRGBA.h"
```

Classes

- struct LLGL::CommandBufferFlags

  Command buffer creation flags.
- struct LLGL::ClearFlags

  Command buffer clear flags.
- struct LLGL::ClearValue

  Clear value structure for color, depth, and stencil clear operations.
- struct LLGL::AttachmentClear

  Attachment clear command structure.
- struct LLGL::OpenGLDependentStateDescriptor

  Graphics API dependent state descriptor for the OpenGL renderer.
- struct LLGL::CommandBufferDescriptor

  Command buffer descriptor structure.

Namespaces

- LLGL

Enumerations

- enum LLGL::RenderConditionMode {
  LLGL::RenderConditionMode::Wait, LLGL::RenderConditionMode::NoWait, LLGL::RenderConditionMode↩
  ::ByRegionWait, LLGL::RenderConditionMode::ByRegionNoWait,
  LLGL::RenderConditionMode::WaitInverted, LLGL::RenderConditionMode::NoWaitInverted, LLGL::↩
  RenderConditionMode::ByRegionWaitInverted, LLGL::RenderConditionMode::ByRegionNoWaitInverted }

  Render condition mode enumeration.

11.12 CommandQueue.h File Reference

```
#include "RenderSystemChild.h"
#include "ForwardDecls.h"
#include <cstdint>
#include <cstddef>
```

Classes

- class LLGL::CommandQueue

  Command queue interface.

Namespaces

- LLGL

11.13 ComputePipeline.h File Reference

```
#include "RenderSystemChild.h"
#include "ComputePipelineFlags.h"
```

Classes

- class LLGL::ComputePipeline

  Compute pipeline interface.

Namespaces

- LLGL

11.14 ComputePipelineFlags.h File Reference

Classes

- struct LLGL::ComputePipelineDescriptor

  Compute pipeline descriptor structure.

Namespaces

- LLGL

11.15 Constants.h File Reference

```
#include <cstddef>
#include <cstdint>
```

Namespaces

- LLGL
- LLGL::Constants

  Namespace with all constants used as default arguments.

11.16 Display.h File Reference

```
#include "NonCopyable.h"
#include "DisplayFlags.h"
#include <vector>
#include <memory>
```

Classes

- class LLGL::Display

    Display interface to query the attributes of all connected displays/monitors.

Namespaces

- LLGL

11.17 DisplayFlags.h File Reference

```
#include "Export.h"
#include "Types.h"
```

Classes

- struct LLGL::DisplayModeDescriptor

    Display mode descriptor structure.

Namespaces

- LLGL

Functions

- LLGL_EXPORT bool LLGL::operator== (const DisplayModeDescriptor &lhs, const DisplayModeDescriptor &rhs)

    Compares the two specified display mode descriptors on equality.
- LLGL_EXPORT bool LLGL::operator!= (const DisplayModeDescriptor &lhs, const DisplayModeDescriptor &rhs)

    Compares the two specified display mode descriptors on inequality.
- LLGL_EXPORT bool LLGL::CompareSWO (const DisplayModeDescriptor &lhs, const DisplayMode←Descriptor &rhs)

    Compares the two display modes in a strict-weak-order (SWO) fashion.
- LLGL_EXPORT Extent2D LLGL::GetExtentRatio (const Extent2D &extent)

    Returns the ratio of the specified extent as another extent, i.e. all attributes are divided by their greatest common divisor.

11.18 Export.h File Reference

Macros

- #define LLGL_EXPORT

11.18.1 Macro Definition Documentation

11.18.1.1 #define LLGL_EXPORT

11.19 Fence.h File Reference

```
#include "RenderSystemChild.h"
```

Classes

- class LLGL::Fence

  Fence interface for CPU/GPU synchronization.

Namespaces

- LLGL

11.20 Format.h File Reference

```
#include "Export.h"
#include <cstdint>
```

Namespaces

- LLGL

Enumerations

- enum LLGL::Format {
  LLGL::Format::Undefined, LLGL::Format::R8UNorm, LLGL::Format::R8SNorm, LLGL::Format::R8UInt,
  LLGL::Format::R8SInt, LLGL::Format::R16UNorm, LLGL::Format::R16SNorm, LLGL::Format::R16UInt,
  LLGL::Format::R16SInt, LLGL::Format::R16Float, LLGL::Format::R32UInt, LLGL::Format::R32SInt,
  LLGL::Format::R32Float, LLGL::Format::RG8UNorm, LLGL::Format::RG8SNorm, LLGL::Format::RG8UInt,
  LLGL::Format::RG8SInt, LLGL::Format::RG16UNorm, LLGL::Format::RG16SNorm, LLGL::Format::RG16↩
  UInt,
  LLGL::Format::RG16SInt, LLGL::Format::RG16Float, LLGL::Format::RG32UInt, LLGL::Format::RG32SInt,
  LLGL::Format::RG32Float, LLGL::Format::RGB8UNorm, LLGL::Format::RGB8SNorm, LLGL::Format::RG↩
  B8UInt,
  LLGL::Format::RGB8SInt, LLGL::Format::RGB16UNorm, LLGL::Format::RGB16SNorm, LLGL::Format::R↩
  GB16UInt,
  LLGL::Format::RGB16SInt, LLGL::Format::RGB16Float, LLGL::Format::RGB32UInt, LLGL::Format::RG↩
  B32SInt,
  LLGL::Format::RGB32Float, LLGL::Format::RGBA8UNorm, LLGL::Format::RGBA8SNorm, LLGL::Format↩
  ::RGBA8UInt,
  LLGL::Format::RGBA8SInt, LLGL::Format::RGBA16UNorm, LLGL::Format::RGBA16SNorm, LLGL::↩

Format::RGBA16UInt,
LLGL::Format::RGBA16SInt, LLGL::Format::RGBA16Float, LLGL::Format::RGBA32UInt, LLGL::Format::↩
RGBA32SInt,
LLGL::Format::RGBA32Float, LLGL::Format::R64Float, LLGL::Format::RG64Float, LLGL::Format::RGB64↩
Float,
LLGL::Format::RGBA64Float, LLGL::Format::BGRA8UNorm, LLGL::Format::BGRA8SNorm, LLGL::↩
Format::BGRA8UInt,
LLGL::Format::BGRA8SInt, LLGL::Format::BGRA8sRGB, LLGL::Format::D16UNorm, LLGL::Format::D24↩
UNormS8UInt,
LLGL::Format::D32Float, LLGL::Format::D32FloatS8X24UInt, LLGL::Format::BC1RGB, LLGL::Format::B↩
C1RGBA,
LLGL::Format::BC2RGBA, LLGL::Format::BC3RGBA }

Hardware vector and pixel format enumeration.

- enum LLGL::DataType {
LLGL::DataType::Int8, LLGL::DataType::UInt8, LLGL::DataType::Int16, LLGL::DataType::UInt16,
LLGL::DataType::Int32, LLGL::DataType::UInt32, LLGL::DataType::Float16, LLGL::DataType::Float32,
LLGL::DataType::Float64 }

  Renderer data types enumeration.

Functions

- LLGL_EXPORT std::uint32_t LLGL::FormatBitSize (const Format format)

  Returns the bit size of the specified hardware format.
- LLGL_EXPORT bool LLGL::SplitFormat (const Format format, DataType &dataType, std::uint32_t &components)

  Splits the specified hardware format into a data type and the number of components.
- LLGL_EXPORT bool LLGL::IsCompressedFormat (const Format format)

  Returns true if the specified hardware format is a compressed format, i.e. either Format::BC1RGB, Format::BC1R↩ GBA, Format::BC2RGBA, or Format::BC3RGBA.
- LLGL_EXPORT bool LLGL::IsDepthStencilFormat (const Format format)

  Returns true if the specified hardware format is a depth or depth-stencil format, i.e. Format::D16UNorm, Format::↩ D24UNormS8UInt, Format::D32Float, or Format::D32FloatS8X24UInt.
- LLGL_EXPORT bool LLGL::IsDepthFormat (const Format format)

  Returns true if the specified hardware format is a depth format, i.e. Format::D16UNorm, Format::D24UNormS8UInt, Format::D32Float, or Format::D32FloatS8X24UInt.
- LLGL_EXPORT bool LLGL::IsStencilFormat (const Format format)

  Returns true if the specified hardware format is a stencil format, i.e. Format::D24UNormS8UInt or Format::D32↩ FloatS8X24UInt.
- LLGL_EXPORT bool LLGL::IsNormalizedFormat (const Format format)

  Returns true if the specified hardware format is a normalized format (like Format::RGBA8UNorm, Format::R8SNorm etc.).
- LLGL_EXPORT bool LLGL::IsIntegralFormat (const Format format)

  Returns true if the specified hardware format is an integral format (like Format::RGBA8UInt, Format::R8SInt etc.).
- LLGL_EXPORT bool LLGL::IsFloatFormat (const Format format)

  Returns true if the specified hardware format is a floating-point format (like Format::RGBA32Float, Format::R32Float etc.).
- LLGL_EXPORT std::uint32_t LLGL::DataTypeSize (const DataType dataType)

  Returns the size (in bytes) of the specified data type.
- LLGL_EXPORT bool LLGL::IsIntDataType (const DataType dataType)

  Determines if the argument refers to a signed integer data type.
- LLGL_EXPORT bool LLGL::IsUIntDataType (const DataType dataType)

  Determines if the argument refers to an unsigned integer data type.
- LLGL_EXPORT bool LLGL::IsFloatDataType (const DataType dataType)

  Determines if the argument refers to a floating-pointer data type.

11.21 ForwardDecls.h File Reference

Namespaces

- LLGL

11.22 GraphicsPipeline.h File Reference

```
#include "RenderSystemChild.h"
```

Classes

- class LLGL::GraphicsPipeline

    Graphics pipeline interface.

Namespaces

- LLGL

11.23 GraphicsPipelineFlags.h File Reference

```
#include "Export.h"
#include "ColorRGBA.h"
#include "Types.h"
#include "ForwardDecls.h"
#include <vector>
#include <cstdint>
```

Classes

- struct LLGL::Viewport

    Viewport dimensions.
- struct LLGL::Scissor

    Scissor dimensions.
- struct LLGL::MultiSamplingDescriptor

    Multi-sampling descriptor structure.
- struct LLGL::DepthDescriptor

    Depth state descriptor structure.
- struct LLGL::StencilFaceDescriptor

    Stencil face descriptor structure.
- struct LLGL::StencilDescriptor

    Stencil state descriptor structure.
- struct LLGL::DepthBiasDescriptor

    Depth bias descriptor structure to control fragment depth values.

- struct LLGL::RasterizerDescriptor

  Rasterizer state descriptor structure.
- struct LLGL::BlendTargetDescriptor

  Blend target state descriptor structure.
- struct LLGL::BlendDescriptor

  Blending state descriptor structure.
- struct LLGL::GraphicsPipelineDescriptor

  Graphics pipeline descriptor structure.

Namespaces

- LLGL

Enumerations

- enum LLGL::PrimitiveType { LLGL::PrimitiveType::Points, LLGL::PrimitiveType::Lines, LLGL::PrimitiveType↩ ::Triangles }

  Primitive type enumeration.
- enum LLGL::PrimitiveTopology {
  LLGL::PrimitiveTopology::PointList, LLGL::PrimitiveTopology::LineList, LLGL::PrimitiveTopology::LineStrip, LLGL::PrimitiveTopology::LineLoop,
  LLGL::PrimitiveTopology::LineListAdjacency, LLGL::PrimitiveTopology::LineStripAdjacency, LLGL::↩ PrimitiveTopology::TriangleList, LLGL::PrimitiveTopology::TriangleStrip,
  LLGL::PrimitiveTopology::TriangleFan, LLGL::PrimitiveTopology::TriangleListAdjacency, LLGL::Primitive↩ Topology::TriangleStripAdjacency, LLGL::PrimitiveTopology::Patches1,
  LLGL::PrimitiveTopology::Patches2, LLGL::PrimitiveTopology::Patches3, LLGL::PrimitiveTopology::Patches4, LLGL::PrimitiveTopology::Patches5,
  LLGL::PrimitiveTopology::Patches6, LLGL::PrimitiveTopology::Patches7, LLGL::PrimitiveTopology::Patches8, LLGL::PrimitiveTopology::Patches9,
  LLGL::PrimitiveTopology::Patches10, LLGL::PrimitiveTopology::Patches11, LLGL::PrimitiveTopology::↩ Patches12, LLGL::PrimitiveTopology::Patches13,
  LLGL::PrimitiveTopology::Patches14, LLGL::PrimitiveTopology::Patches15, LLGL::PrimitiveTopology::↩ Patches16, LLGL::PrimitiveTopology::Patches17,
  LLGL::PrimitiveTopology::Patches18, LLGL::PrimitiveTopology::Patches19, LLGL::PrimitiveTopology::↩ Patches20, LLGL::PrimitiveTopology::Patches21,
  LLGL::PrimitiveTopology::Patches22, LLGL::PrimitiveTopology::Patches23, LLGL::PrimitiveTopology::↩ Patches24, LLGL::PrimitiveTopology::Patches25,
  LLGL::PrimitiveTopology::Patches26, LLGL::PrimitiveTopology::Patches27, LLGL::PrimitiveTopology::↩ Patches28, LLGL::PrimitiveTopology::Patches29,
  LLGL::PrimitiveTopology::Patches30, LLGL::PrimitiveTopology::Patches31, LLGL::PrimitiveTopology::↩ Patches32 }

  Primitive topology enumeration.
- enum LLGL::CompareOp {
  LLGL::CompareOp::NeverPass, LLGL::CompareOp::Less, LLGL::CompareOp::Equal, LLGL::CompareOp↩ ::LessEqual,
  LLGL::CompareOp::Greater, LLGL::CompareOp::NotEqual, LLGL::CompareOp::GreaterEqual, LLGL::↩ CompareOp::AlwaysPass }

  Compare operations enumeration.
- enum LLGL::StencilOp {
  LLGL::StencilOp::Keep, LLGL::StencilOp::Zero, LLGL::StencilOp::Replace, LLGL::StencilOp::IncClamp,
  LLGL::StencilOp::DecClamp, LLGL::StencilOp::Invert, LLGL::StencilOp::IncWrap, LLGL::StencilOp::Dec↩ Wrap }

  Stencil operations enumeration.

- enum LLGL::BlendOp {
LLGL::BlendOp::Zero, LLGL::BlendOp::One, LLGL::BlendOp::SrcColor, LLGL::BlendOp::InvSrcColor,
LLGL::BlendOp::SrcAlpha, LLGL::BlendOp::InvSrcAlpha, LLGL::BlendOp::DstColor, LLGL::BlendOp::Inv↵
DstColor,
LLGL::BlendOp::DstAlpha, LLGL::BlendOp::InvDstAlpha, LLGL::BlendOp::SrcAlphaSaturate, LLGL::Blend↵
Op::BlendFactor,
LLGL::BlendOp::InvBlendFactor, LLGL::BlendOp::Src1Color, LLGL::BlendOp::InvSrc1Color, LLGL::Blend↵
Op::Src1Alpha,
LLGL::BlendOp::InvSrc1Alpha }

  Blending operations enumeration.
- enum LLGL::BlendArithmetic {
LLGL::BlendArithmetic::Add, LLGL::BlendArithmetic::Subtract, LLGL::BlendArithmetic::RevSubtract, LLGL↵
::BlendArithmetic::Min,
LLGL::BlendArithmetic::Max }

  Blending arithmetic operations enumeration.
- enum LLGL::PolygonMode { LLGL::PolygonMode::Fill, LLGL::PolygonMode::Wireframe, LLGL::Polygon↵
Mode::Points }

  Polygon filling modes enumeration.
- enum LLGL::CullMode { LLGL::CullMode::Disabled, LLGL::CullMode::Front, LLGL::CullMode::Back }

  Polygon culling modes enumeration.
- enum LLGL::LogicOp {
LLGL::LogicOp::Disabled, LLGL::LogicOp::Clear, LLGL::LogicOp::Set, LLGL::LogicOp::Copy,
LLGL::LogicOp::CopyInverted, LLGL::LogicOp::NoOp, LLGL::LogicOp::Invert, LLGL::LogicOp::AND,
LLGL::LogicOp::ANDReverse, LLGL::LogicOp::ANDInverted, LLGL::LogicOp::NAND, LLGL::LogicOp::OR,
LLGL::LogicOp::ORReverse, LLGL::LogicOp::ORInverted, LLGL::LogicOp::NOR, LLGL::LogicOp::XOR,
LLGL::LogicOp::Equiv }

  Logical pixel operation enumeration.

Functions

- LLGL_EXPORT bool LLGL::IsPrimitiveTopologyPatches (const PrimitiveTopology primitiveTopology)

  Returns true if the specified primitive topology is a patch list.
- LLGL_EXPORT std::uint32_t LLGL::GetPrimitiveTopologyPatchSize (const PrimitiveTopology primitive↵
Topology)

  Returns the number of patch control points of the specified primitive topology (in range [1, 32]), or 0 if the topology is not a patch list.

11.24 Image.h File Reference

```
#include "Export.h"
#include "Types.h"
#include "ImageFlags.h"
#include "SamplerFlags.h"
```

Classes

- class LLGL::Image

  Utility class to manage the storage and attributes of an image.

Namespaces

- LLGL

11.25 ImageFlags.h File Reference

```
#include "Export.h"
#include "Format.h"
#include "RenderSystemFlags.h"
#include "TextureFlags.h"
#include "ColorRGBA.h"
#include <memory>
#include <cstdint>
```

Classes

- struct LLGL::SrcImageDescriptor

  Descriptor structure for an image that is used as source for reading the image data.
- struct LLGL::DstImageDescriptor

  Descriptor structure for an image that is used as destination for writing the image data.

Namespaces

- LLGL

Typedefs

- using LLGL::ByteBuffer = std::unique_ptr< char[ ]>

  Common byte buffer type.

Enumerations

- enum LLGL::ImageFormat {
  LLGL::ImageFormat::R, LLGL::ImageFormat::RG, LLGL::ImageFormat::RGB, LLGL::ImageFormat::BGR,
  LLGL::ImageFormat::RGBA, LLGL::ImageFormat::BGRA, LLGL::ImageFormat::ARGB, LLGL::Image↩
  Format::ABGR,
  LLGL::ImageFormat::Depth, LLGL::ImageFormat::DepthStencil, LLGL::ImageFormat::CompressedRGB,
  LLGL::ImageFormat::CompressedRGBA }

  Image format enumeration that applies to each pixel of an image.

Functions

- LLGL_EXPORT std::uint32_t LLGL::ImageFormatSize (const ImageFormat imageFormat)

  Returns the size (in number of components) of the specified image format.
- LLGL_EXPORT std::uint32_t LLGL::ImageDataSize (const ImageFormat imageFormat, const DataType dataType, std::uint32_t numPixels)

  Returns the required data size (in bytes) of an image with the specified format, data type, and number of pixels.
- LLGL_EXPORT bool LLGL::IsCompressedFormat (const ImageFormat imageFormat)

  Returns true if the specified color format is a compressed format, i.e. either ImageFormat::CompressedRGB, or ImageFormat::CompressedRGBA.
- LLGL_EXPORT bool LLGL::IsDepthStencilFormat (const ImageFormat imageFormat)

  Returns true if the specified color format is a depth-stencil format, i.e. either ImageFormat::Depth or ImageFormat↩ ::DepthStencil.
- LLGL_EXPORT bool LLGL::FindSuitableImageFormat (const Format format, ImageFormat &imageFormat, DataType &dataType)

  Finds a suitable image format for the specified texture hardware format.
- LLGL_EXPORT bool LLGL::ConvertImageBuffer (const SrcImageDescriptor &srcImageDesc, const Dst↩ ImageDescriptor &dstImageDesc, std::size_t threadCount=0)

  Converts the image format and data type of the source image (only uncompressed color formats).
- LLGL_EXPORT ByteBuffer LLGL::ConvertImageBuffer (const SrcImageDescriptor &srcImageDesc, Image↩ Format dstFormat, DataType dstDataType, std::size_t threadCount=0)

  Converst the image format and data type of the source image (only uncompressed color formats) and returns the new generated image buffer.
- LLGL_EXPORT ByteBuffer LLGL::GenerateImageBuffer (ImageFormat format, DataType dataType, std↩ ::size_t imageSize, const ColorRGBAd &fillColor)

  Generates an image buffer with the specified fill data for each pixel.
- LLGL_EXPORT ByteBuffer LLGL::GenerateEmptyByteBuffer (std::size_t bufferSize, bool initialize=true)

  Generates a new byte buffer with zeros in each byte.

11.26 IndexFormat.h File Reference

```
#include "Export.h"
#include "ImageFlags.h"
```

Classes

- class LLGL::IndexFormat

  Index buffer format class.

Namespaces

- LLGL

11.27 Input.h File Reference

```
#include <LLGL/Window.h>
#include <LLGL/Types.h>
#include <array>
#include <string>
```

Classes

- class LLGL::Input

  Default window event listener to receive user input.

Namespaces

- LLGL

11.28 IOSNativeHandle.h File Reference

```
#include <UIKit/UIKit.h>
```

Classes

- struct LLGL::NativeHandle

  iOS native handle structure.
- struct LLGL::NativeContextHandle

  iOS native context handle structure.

Namespaces

- LLGL

11.29 Key.h File Reference

Namespaces

- LLGL

Enumerations

- enum LLGL::Key {
  LLGL::Key::LButton, LLGL::Key::RButton, LLGL::Key::Cancel, LLGL::Key::MButton,
  LLGL::Key::XButton1, LLGL::Key::XButton2, LLGL::Key::Back, LLGL::Key::Tab,
  LLGL::Key::Clear, LLGL::Key::Return, LLGL::Key::Shift, LLGL::Key::Control,
  LLGL::Key::Menu, LLGL::Key::Pause, LLGL::Key::Capital, LLGL::Key::Escape,
  LLGL::Key::Space, LLGL::Key::PageUp, LLGL::Key::PageDown, LLGL::Key::End,
  LLGL::Key::Home, LLGL::Key::Left, LLGL::Key::Up, LLGL::Key::Right,
  LLGL::Key::Down, LLGL::Key::Select, LLGL::Key::Print, LLGL::Key::Exe,
  LLGL::Key::Snapshot, LLGL::Key::Insert, LLGL::Key::Delete, LLGL::Key::Help,
  LLGL::Key::D0, LLGL::Key::D1, LLGL::Key::D2, LLGL::Key::D3,
  LLGL::Key::D4, LLGL::Key::D5, LLGL::Key::D6, LLGL::Key::D7,
  LLGL::Key::D8, LLGL::Key::D9, LLGL::Key::A, LLGL::Key::B,
  LLGL::Key::C, LLGL::Key::D, LLGL::Key::E, LLGL::Key::F,
  LLGL::Key::G, LLGL::Key::H, LLGL::Key::I, LLGL::Key::J,
  LLGL::Key::K, LLGL::Key::L, LLGL::Key::M, LLGL::Key::N,
  LLGL::Key::O, LLGL::Key::P, LLGL::Key::Q, LLGL::Key::R,
  LLGL::Key::S, LLGL::Key::T, LLGL::Key::U, LLGL::Key::V,
  LLGL::Key::W, LLGL::Key::X, LLGL::Key::Y, LLGL::Key::Z,
  LLGL::Key::LWin, LLGL::Key::RWin, LLGL::Key::Apps, LLGL::Key::Sleep,
  LLGL::Key::Keypad0, LLGL::Key::Keypad1, LLGL::Key::Keypad2, LLGL::Key::Keypad3,
  LLGL::Key::Keypad4, LLGL::Key::Keypad5, LLGL::Key::Keypad6, LLGL::Key::Keypad7,
  LLGL::Key::Keypad8, LLGL::Key::Keypad9, LLGL::Key::KeypadMultiply, LLGL::Key::KeypadPlus,
  LLGL::Key::KeypadSeparator, LLGL::Key::KeypadMinus, LLGL::Key::KeypadDecimal, LLGL::Key::Keypad↵
  Divide,
  LLGL::Key::F1, LLGL::Key::F2, LLGL::Key::F3, LLGL::Key::F4,
  LLGL::Key::F5, LLGL::Key::F6, LLGL::Key::F7, LLGL::Key::F8,
  LLGL::Key::F9, LLGL::Key::F10, LLGL::Key::F11, LLGL::Key::F12,
  LLGL::Key::F13, LLGL::Key::F14, LLGL::Key::F15, LLGL::Key::F16,
  LLGL::Key::F17, LLGL::Key::F18, LLGL::Key::F19, LLGL::Key::F20,
  LLGL::Key::F21, LLGL::Key::F22, LLGL::Key::F23, LLGL::Key::F24,
  LLGL::Key::NumLock, LLGL::Key::ScrollLock, LLGL::Key::LShift, LLGL::Key::RShift,
  LLGL::Key::LControl, LLGL::Key::RControl, LLGL::Key::LMenu, LLGL::Key::RMenu,
  LLGL::Key::BrowserBack, LLGL::Key::BrowserForward, LLGL::Key::BrowserRefresh, LLGL::Key::Browser↵
  Stop,
  LLGL::Key::BrowserSearch, LLGL::Key::BrowserFavorits, LLGL::Key::BrowserHome, LLGL::Key::Volume↵
  Mute,
  LLGL::Key::VolumeDown, LLGL::Key::VolumeUp, LLGL::Key::MediaNextTrack, LLGL::Key::MediaPrevTrack,
  LLGL::Key::MediaStop, LLGL::Key::MediaPlayPause, LLGL::Key::LaunchMail, LLGL::Key::LaunchMedia↵
  Select,
  LLGL::Key::LaunchApp1, LLGL::Key::LaunchApp2, LLGL::Key::Plus, LLGL::Key::Comma,
  LLGL::Key::Minus, LLGL::Key::Period, LLGL::Key::Exponent, LLGL::Key::Attn,
  LLGL::Key::CrSel, LLGL::Key::ExSel, LLGL::Key::ErEOF, LLGL::Key::Play,
  LLGL::Key::Zoom, LLGL::Key::NoName, LLGL::Key::PA1, LLGL::Key::OEMClear,
  LLGL::Key::Any }

  Input key codes.

11.30 LinuxNativeHandle.h File Reference

```
#include <X11/Xlib.h>
#include <X11/Xutil.h>
```

Classes

- struct LLGL::NativeHandle

    iOS native handle structure.
- struct LLGL::NativeContextHandle

    iOS native context handle structure.

Namespaces

- LLGL

11.31 LLGL.h File Reference

```
#include "Version.h"
#include "Window.h"
#include "Canvas.h"
#include "Display.h"
#include "Input.h"
#include "Timer.h"
#include "ColorRGB.h"
#include "ColorRGBA.h"
#include "RenderSystem.h"
#include "Log.h"
```

11.32 Log.h File Reference

```
#include "Export.h"
#include <functional>
#include <string>
#include <iostream>
```

Namespaces

- LLGL
- LLGL::Log

Typedefs

- using LLGL::Log::ReportCallback = std::function< void(ReportType type, const std::string &message, const std::string &contextInfo, void *userData)>

    Report callback function signature.

Enumerations

- enum LLGL::Log::ReportType { LLGL::Log::ReportType::Error, LLGL::Log::ReportType::Warning, LLGL::↵ Log::ReportType::Information, LLGL::Log::ReportType::Performance }

    Report type enumeration.

Functions

- LLGL_EXPORT void LLGL::Log::PostReport (ReportType type, const std::string &message, const std::string &contextInfo="")
- LLGL_EXPORT void LLGL::Log::SetReportCallback (const ReportCallback &callback, void ∗user←Data=nullptr)

  Sets the new report callback. No report callback is specified by default, in which case the reports are ignored.
- LLGL_EXPORT void LLGL::Log::SetReportCallbackStd (std::ostream &stream=std::cerr)

  Sets the new report callback to the standard output streams.

11.33 MacOSNativeHandle.h File Reference

```
#include <Cocoa/Cocoa.h>
```

Classes

- struct LLGL::NativeHandle

  iOS native handle structure.
- struct LLGL::NativeContextHandle

  iOS native context handle structure.

Namespaces

- LLGL

11.34 NativeHandle.h File Reference

```
#include "Platform.h"
```

11.35 NonCopyable.h File Reference

```
#include "Export.h"
```

Classes

- class LLGL::NonCopyable

  Base class for all interfaces in LLGL.

Namespaces

- LLGL

11.36 PipelineLayout.h File Reference

```
#include "RenderSystemChild.h"
```

Classes

- class LLGL::PipelineLayout

  Pipeline layout interface.

Namespaces

- LLGL

11.37 PipelineLayoutFlags.h File Reference

```
#include "Export.h"
#include "ResourceFlags.h"
#include "BufferFlags.h"
#include "ShaderFlags.h"
#include <vector>
```

Classes

- struct LLGL::BindingDescriptor

  Layout structure for a single binding point of the pipeline layout descriptor.
- struct LLGL::PipelineLayoutDescriptor

  Pipeline layout descritpor structure.

Namespaces

- LLGL

11.38 Platform.h File Reference

11.39 QueryHeap.h File Reference

```
#include "RenderSystemChild.h"
#include "QueryHeapFlags.h"
```

Classes

- class LLGL::QueryHeap

  Query heap interface that holds a certain number of queries that are all of the same type.

Namespaces

- LLGL

11.40 QueryHeapFlags.h File Reference

```
#include "Constants.h"
#include <cstdint>
```

Classes

- struct LLGL::QueryPipelineStatistics

  Query data structure for pipeline statistics.
- struct LLGL::QueryHeapDescriptor

  Query heap descriptor structure.

Namespaces

- LLGL

Enumerations

- enum LLGL::QueryType {
  LLGL::QueryType::SamplesPassed, LLGL::QueryType::AnySamplesPassed, LLGL::QueryType::Any↩
  SamplesPassedConservative, LLGL::QueryType::TimeElapsed,
  LLGL::QueryType::StreamOutPrimitivesWritten, LLGL::QueryType::StreamOutOverflow, LLGL::QueryType↩
  ::PipelineStatistics }

  Query type enumeration.

11.41 RenderContext.h File Reference

```
#include "RenderTarget.h"
#include "RenderContextFlags.h"
#include "RenderSystemFlags.h"
#include "Surface.h"
#include "Buffer.h"
#include "BufferArray.h"
#include "ShaderProgram.h"
#include "Texture.h"
#include "GraphicsPipeline.h"
#include "ComputePipeline.h"
#include "Sampler.h"
#include "QueryHeap.h"
#include <string>
#include <map>
```

Classes

- class LLGL::RenderContext

    Render context interface.

Namespaces

- LLGL

11.42 RenderContextFlags.h File Reference

```
#include "Export.h"
#include "Types.h"
#include "GraphicsPipelineFlags.h"
#include <functional>
#include <cstdint>
```

Classes

- struct LLGL::VsyncDescriptor

    Vertical-synchronization (Vsync) descriptor structure.
- struct LLGL::VideoModeDescriptor

    Video mode descriptor structure.
- struct LLGL::ProfileOpenGLDescriptor

    OpenGL profile descriptor structure.
- struct LLGL::RenderContextDescriptor

    Render context descriptor structure.

Namespaces

- LLGL

Typedefs

- using LLGL::DebugCallback = std::function< void(const std::string &type, const std::string &message)>

    Debug callback function interface.

Enumerations

- enum LLGL::OpenGLContextProfile { LLGL::OpenGLContextProfile::CompatibilityProfile, LLGL::OpenGL↩ ContextProfile::CoreProfile, LLGL::OpenGLContextProfile::ESProfile }

    OpenGL context profile enumeration.

Functions

- LLGL_EXPORT bool LLGL::operator== (const VsyncDescriptor &lhs, const VsyncDescriptor &rhs)

  Compares the two specified V-sync descriptors on equality.
- LLGL_EXPORT bool LLGL::operator!= (const VsyncDescriptor &lhs, const VsyncDescriptor &rhs)

  Compares the two specified V-sync descriptors on inequality.
- LLGL_EXPORT bool LLGL::operator== (const VideoModeDescriptor &lhs, const VideoModeDescriptor &rhs)

  Compares the two specified video mode descriptors on equality.
- LLGL_EXPORT bool LLGL::operator!= (const VideoModeDescriptor &lhs, const VideoModeDescriptor &rhs)

  Compares the two specified video mode descriptors on inequality.

11.43 RenderingDebugger.h File Reference

```
#include "Export.h"
#include <map>
#include <string>
```

Classes

- class LLGL::RenderingDebugger

  Rendering debugger interface.
- class LLGL::RenderingDebugger::Message

  Rendering debugger message class.

Namespaces

- LLGL

Enumerations

- enum LLGL::ErrorType { LLGL::ErrorType::InvalidArgument, LLGL::ErrorType::InvalidState, LLGL::Error↩ Type::UnsupportedFeature, LLGL::ErrorType::UndefinedBehavior }

  Rendering debugger error types enumeration.
- enum LLGL::WarningType { LLGL::WarningType::ImproperArgument, LLGL::WarningType::ImproperState, LLGL::WarningType::PointlessOperation }

  Rendering debugger warning types enumeration.

11.44 RenderingProfiler.h File Reference

```
#include "Export.h"
#include "RenderContextFlags.h"
#include "GraphicsPipelineFlags.h"
#include <cstdint>
#include <algorithm>
```

Classes

- struct LLGL::FrameProfile

    Profile of a rendered frame.
- class LLGL::RenderingProfiler

    Rendering profiler model class.

Namespaces

- LLGL

11.45 RenderPass.h File Reference

```
#include "RenderSystemChild.h"
```

Classes

- class LLGL::RenderPass

    Render pass interface.

Namespaces

- LLGL

11.46 RenderPassFlags.h File Reference

```
#include "Format.h"
#include <vector>
```

Classes

- struct LLGL::AttachmentFormatDescriptor

    Render target attachment descriptor structure.
- struct LLGL::RenderPassDescriptor

    Render pass descriptor structure.

Namespaces

- LLGL

Enumerations

- enum LLGL::AttachmentLoadOp { LLGL::AttachmentLoadOp::Undefined, LLGL::AttachmentLoadOp::Load, LLGL::AttachmentLoadOp::Clear }

  Enumeration for render pass attachment load operations.
- enum LLGL::AttachmentStoreOp { LLGL::AttachmentStoreOp::Undefined, LLGL::AttachmentStoreOp::Store }

  Enumeration for render pass attachment store operations.

11.47 RenderSystem.h File Reference

```
#include "NonCopyable.h"
#include "RenderContext.h"
#include "CommandQueue.h"
#include "CommandBufferExt.h"
#include "RenderSystemFlags.h"
#include "RenderingProfiler.h"
#include "RenderingDebugger.h"
#include "Buffer.h"
#include "BufferArray.h"
#include "Texture.h"
#include "Sampler.h"
#include "ResourceHeap.h"
#include "RenderPass.h"
#include "RenderPassFlags.h"
#include "RenderTarget.h"
#include "Shader.h"
#include "ShaderProgram.h"
#include "PipelineLayout.h"
#include "GraphicsPipeline.h"
#include "ComputePipeline.h"
#include "QueryHeap.h"
#include "Fence.h"
#include <string>
#include <memory>
#include <vector>
#include <cstdint>
```

Classes

- class LLGL::RenderSystem

  Render system interface.

Namespaces

- LLGL

11.48 RenderSystemChild.h File Reference

```
#include "NonCopyable.h"
```

Classes

- class LLGL::RenderSystemChild

  Base class for all interfaces whoes instances are owned by the RenderSystem.

Namespaces

- LLGL

11.49 RenderSystemFlags.h File Reference

```
#include "Export.h"
#include "CommandBufferFlags.h"
#include "TextureFlags.h"
#include "Constants.h"
#include <cstddef>
#include <cstdint>
#include <string>
#include <vector>
#include <functional>
```

Classes

- struct LLGL::ImageInitialization

  Structure of image initialization for textures without initial image data.
- struct LLGL::RenderSystemConfiguration

  Render system configuration structure.
- struct LLGL::RendererID

  Renderer identification number enumeration.
- struct LLGL::RendererInfo

  Renderer basic information structure.
- struct LLGL::ApplicationDescriptor

  Application descriptor structure.
- struct LLGL::VulkanRendererConfiguration

  Structure for a Vulkan renderer specific configuration.
- struct LLGL::RenderSystemDescriptor

  Render system descriptor structure.
- struct LLGL::RenderingFeatures

  Contains the attributes for all supported rendering features.
- struct LLGL::RenderingLimits

  Contains all rendering limitations such as maximum buffer size, maximum texture resolution etc.
- struct LLGL::RenderingCapabilities

  Structure with all attributes describing the rendering capabilities of the render system.

Namespaces

- LLGL

Typedefs

- using LLGL::ValidateRenderingCapsFunc = std::function< bool(const std::string &info, const std::string &attrib)>

  Callback interface for the ValidateRenderingCaps function.

Enumerations

- enum LLGL::ShadingLanguage {
  LLGL::ShadingLanguage::GLSL = (0x10000), LLGL::ShadingLanguage::GLSL_110 = (0x10000 | 110), L←
  LGL::ShadingLanguage::GLSL_120 = (0x10000 | 120), LLGL::ShadingLanguage::GLSL_130 = (0x10000 | 130),
  LLGL::ShadingLanguage::GLSL_140 = (0x10000 | 140), LLGL::ShadingLanguage::GLSL_150 = (0x10000 | 150), LLGL::ShadingLanguage::GLSL_330 = (0x10000 | 330), LLGL::ShadingLanguage::GLSL_400 = (0x10000 | 400),
  LLGL::ShadingLanguage::GLSL_410 = (0x10000 | 410), LLGL::ShadingLanguage::GLSL_420 = (0x10000 | 420), LLGL::ShadingLanguage::GLSL_430 = (0x10000 | 430), LLGL::ShadingLanguage::GLSL_440 = (0x10000 | 440),
  LLGL::ShadingLanguage::GLSL_450 = (0x10000 | 450), LLGL::ShadingLanguage::GLSL_460 = (0x10000 | 460), LLGL::ShadingLanguage::ESSL = (0x20000), LLGL::ShadingLanguage::ESSL_100 = (0x20000 | 100),
  LLGL::ShadingLanguage::ESSL_300 = (0x20000 | 300), LLGL::ShadingLanguage::ESSL_310 = (0x20000 | 310), LLGL::ShadingLanguage::ESSL_320 = (0x20000 | 320), LLGL::ShadingLanguage::HLSL = (0x30000),
  LLGL::ShadingLanguage::HLSL_2_0 = (0x30000 | 200), LLGL::ShadingLanguage::HLSL_2_0a = (0x30000 | 201), LLGL::ShadingLanguage::HLSL_2_0b = (0x30000 | 202), LLGL::ShadingLanguage::HLSL_3_0 = (0x30000 | 300),
  LLGL::ShadingLanguage::HLSL_4_0 = (0x30000 | 400), LLGL::ShadingLanguage::HLSL_4_1 = (0x30000 | 410), LLGL::ShadingLanguage::HLSL_5_0 = (0x30000 | 500), LLGL::ShadingLanguage::HLSL_5_1 = (0x30000 | 510),
  LLGL::ShadingLanguage::Metal = (0x40000), LLGL::ShadingLanguage::Metal_1_0 = (0x40000 | 100), L←
  LGL::ShadingLanguage::Metal_1_1 = (0x40000 | 110), LLGL::ShadingLanguage::Metal_1_2 = (0x40000 | 120),
  LLGL::ShadingLanguage::SPIRV = (0x50000), LLGL::ShadingLanguage::SPIRV_100 = (0x50000 | 100), L←
  LGL::ShadingLanguage::VersionBitmask = 0x0000ffff }

  Shading language version enumation.
- enum LLGL::ScreenOrigin { LLGL::ScreenOrigin::LowerLeft, LLGL::ScreenOrigin::UpperLeft }

  Screen coordinate system origin enumeration.
- enum LLGL::ClippingRange { LLGL::ClippingRange::MinusOneToOne, LLGL::ClippingRange::ZeroToOne }

  Clipping depth range enumeration.
- enum LLGL::CPUAccess { LLGL::CPUAccess::ReadOnly, LLGL::CPUAccess::WriteOnly, LLGL::CPU←
  Access::WriteDiscard, LLGL::CPUAccess::ReadWrite }

  Classifications of CPU access to mapped resources.

Functions

- LLGL_EXPORT bool LLGL::ValidateRenderingCaps (const RenderingCapabilities &presentCaps, const RenderingCapabilities &requiredCaps, const ValidateRenderingCapsFunc &callback={})

  Validates the presence of the specified required rendering capabilities.

11.50 RenderTarget.h File Reference

```
#include "RenderSystemChild.h"
#include "RenderTargetFlags.h"
#include "Types.h"
```

Classes

- class LLGL::RenderTarget

  Render target interface.

Namespaces

- LLGL

11.51 RenderTargetFlags.h File Reference

```
#include "TextureFlags.h"
#include "ForwardDecls.h"
#include "GraphicsPipelineFlags.h"
#include <vector>
#include <cstdint>
```

Classes

- struct LLGL::AttachmentDescriptor

  Render target attachment descriptor structure.
- struct LLGL::RenderTargetDescriptor

  Render target descriptor structure.

Namespaces

- LLGL

Enumerations

- enum LLGL::AttachmentType { LLGL::AttachmentType::Color, LLGL::AttachmentType::Depth, LLGL::↩ AttachmentType::DepthStencil, LLGL::AttachmentType::Stencil }

  Render target attachment type enumeration.

11.52 Resource.h File Reference

```
#include "RenderSystemChild.h"
#include "ResourceFlags.h"
```

Classes

- class LLGL::Resource

  Base class for all hardware resource interfaces.

Namespaces

- LLGL

11.53 ResourceFlags.h File Reference

Namespaces

- LLGL

Enumerations

- enum LLGL::ResourceType {
  LLGL::ResourceType::Undefined, LLGL::ResourceType::VertexBuffer, LLGL::ResourceType::IndexBuffer, LLGL::ResourceType::ConstantBuffer,
  LLGL::ResourceType::StorageBuffer, LLGL::ResourceType::StreamOutputBuffer, LLGL::ResourceType::↩
  Texture, LLGL::ResourceType::Sampler }

  Hardware resource type enumeration.

11.54 ResourceHeap.h File Reference

```
#include "RenderSystemChild.h"
#include "ResourceHeapFlags.h"
```

Classes

- class LLGL::ResourceHeap

  Resource heap interface.

Namespaces

- LLGL

11.55 ResourceHeapFlags.h File Reference

```
#include "Export.h"
#include <vector>
```

Classes

- struct LLGL::ResourceViewDescriptor

  Resource view descriptor structure.
- struct LLGL::ResourceHeapDescriptor

  Resource heap descriptor structure.

Namespaces

- LLGL

11.56 Sampler.h File Reference

```
#include "Resource.h"
#include "SamplerFlags.h"
```

Classes

- class LLGL::Sampler

  Sampler interface.

Namespaces

- LLGL

11.57 SamplerFlags.h File Reference

```
#include "Export.h"
#include "GraphicsPipelineFlags.h"
#include "ColorRGBA.h"
#include <cstddef>
#include <cstdint>
```

Classes

- struct LLGL::SamplerDescriptor

  Texture sampler descriptor structure.

Namespaces

- LLGL

Enumerations

- enum LLGL::SamplerAddressMode {
  LLGL::SamplerAddressMode::Repeat, LLGL::SamplerAddressMode::Mirror, LLGL::SamplerAddressMode↩
  ::Clamp, LLGL::SamplerAddressMode::Border,
  LLGL::SamplerAddressMode::MirrorOnce }

  Technique for resolving texture coordinates that are outside of the range [0, 1].
- enum LLGL::SamplerFilter { LLGL::SamplerFilter::Nearest, LLGL::SamplerFilter::Linear }

  Sampling filter enumeration.

11.58 Shader.h File Reference

```
#include "RenderSystemChild.h"
#include "ShaderFlags.h"
```

Classes

- class LLGL::Shader

  Shader interface.

Namespaces

- LLGL

11.59 ShaderFlags.h File Reference

```
#include "Export.h"
#include "StreamOutputFormat.h"
#include <cstddef>
```

Classes

- struct LLGL::ShaderCompileFlags

  Shader compilation flags enumeration.
- struct LLGL::ShaderDisassembleFlags

  Shader disassemble flags enumeration.
- struct LLGL::StageFlags

  Shader stage flags enumeration.
- struct LLGL::ShaderDescriptor

  Shader source and binary code descriptor structure.
- struct LLGL::ShaderDescriptor::StreamOutput

  Additional descriptor for stream outputs.

Namespaces

- LLGL

Enumerations

- enum LLGL::ShaderType {
  LLGL::ShaderType::Undefined, LLGL::ShaderType::Vertex, LLGL::ShaderType::TessControl, LLGL::↩
  ShaderType::TessEvaluation,
  LLGL::ShaderType::Geometry, LLGL::ShaderType::Fragment, LLGL::ShaderType::Compute }

  Shader type enumeration.
- enum LLGL::ShaderSourceType { LLGL::ShaderSourceType::CodeString, LLGL::ShaderSourceType::↩
  CodeFile, LLGL::ShaderSourceType::BinaryBuffer, LLGL::ShaderSourceType::BinaryFile }

  Shader source type enumeration.

Functions

- LLGL_EXPORT bool LLGL::IsShaderSourceCode (const ShaderSourceType type)

    Returns true if the specified shader source type is either ShaderSourceType::CodeString or ShaderSourceType::↩ CodeFile.
- LLGL_EXPORT bool LLGL::IsShaderSourceBinary (const ShaderSourceType type)

    Returns true if the specified shader source type is either ShaderSourceType::BinaryBuffer or ShaderSourceType::↩ BinaryFile.

11.60 ShaderProgram.h File Reference

```
#include "RenderSystemChild.h"
#include "ShaderProgramFlags.h"
#include "ShaderUniform.h"
```

Classes

- class LLGL::ShaderProgram

    Shader program interface.

Namespaces

- LLGL

11.61 ShaderProgramFlags.h File Reference

```
#include "ForwardDecls.h"
#include "VertexFormat.h"
#include "StreamOutputFormat.h"
#include "ShaderUniformFlags.h"
#include "ResourceFlags.h"
#include "BufferFlags.h"
#include <vector>
#include <string>
```

Classes

- struct LLGL::ShaderProgramDescriptor

    Descriptor structure for shader programs.
- struct LLGL::ShaderReflectionDescriptor

    Shader reflection descriptor structure.
- struct LLGL::ShaderReflectionDescriptor::ResourceView

    Shader reflection resource view structure.

Namespaces

- LLGL

11.62 ShaderUniform.h File Reference

```
#include "NonCopyable.h"
#include "ShaderUniformFlags.h"
```

Classes

- class LLGL::ShaderUniform

    Shader uniform setter interface.

Namespaces

- LLGL

11.63 ShaderUniformFlags.h File Reference

```
#include <string>
#include <cstdint>
```

Classes

- struct LLGL::UniformDescriptor

    Shader uniform descriptor structure.

Namespaces

- LLGL

Typedefs

- using LLGL::UniformLocation = std::int32_t

    Shader uniform location type, as zero-based index in 32-bit signed integer format.

Enumerations

- enum LLGL::UniformType {
  LLGL::UniformType::Undefined, LLGL::UniformType::Float1, LLGL::UniformType::Float2, LLGL::Uniform↩Type::Float3,
  LLGL::UniformType::Float4, LLGL::UniformType::Double1, LLGL::UniformType::Double2, LLGL::Uniform↩Type::Double3,
  LLGL::UniformType::Double4, LLGL::UniformType::Int1, LLGL::UniformType::Int2, LLGL::UniformType::Int3,
  LLGL::UniformType::Int4, LLGL::UniformType::UInt1, LLGL::UniformType::UInt2, LLGL::UniformType::UInt3,
  LLGL::UniformType::UInt4, LLGL::UniformType::Bool1, LLGL::UniformType::Bool2, LLGL::UniformType::↩Bool3,
  LLGL::UniformType::Bool4, LLGL::UniformType::Float2x2, LLGL::UniformType::Float3x3, LLGL::Uniform↩Type::Float4x4,
  LLGL::UniformType::Float2x3, LLGL::UniformType::Float2x4, LLGL::UniformType::Float3x2, LLGL::↩UniformType::Float3x4,
  LLGL::UniformType::Float4x2, LLGL::UniformType::Float4x3, LLGL::UniformType::Double2x2, LLGL::↩UniformType::Double3x3,
  LLGL::UniformType::Double4x4, LLGL::UniformType::Double2x3, LLGL::UniformType::Double2x4, LLGL::↩UniformType::Double3x2,
  LLGL::UniformType::Double3x4, LLGL::UniformType::Double4x2, LLGL::UniformType::Double4x3, LLGL::↩UniformType::Sampler,
  LLGL::UniformType::Image, LLGL::UniformType::AtomicCounter }

  Shader uniform type enumeration.

11.64 StreamOutputAttribute.h File Reference

```
#include "Export.h"
#include "Format.h"
#include <string>
#include <cstdint>
```

Classes

- struct LLGL::StreamOutputAttribute

  Stream-output attribute structure.

Namespaces

- LLGL

Functions

- LLGL_EXPORT bool LLGL::operator== (const StreamOutputAttribute &lhs, const StreamOutputAttribute &rhs)
- LLGL_EXPORT bool LLGL::operator!= (const StreamOutputAttribute &lhs, const StreamOutputAttribute &rhs)

11.65 StreamOutputFormat.h File Reference

```
#include "Export.h"
#include "StreamOutputAttribute.h"
#include <vector>
#include <cstdint>
```

Classes

- struct LLGL::StreamOutputFormat

  Stream-output format descriptor structure.

Namespaces

- LLGL

11.66 Strings.h File Reference

```
#include "Export.h"
#include "ShaderFlags.h"
#include "TextureFlags.h"
#include "RenderingDebugger.h"
#include "RenderSystemFlags.h"
```

Namespaces

- LLGL

Functions

- LLGL_EXPORT const char ∗ LLGL::ToString (const ShaderType t)

  Returns a string representation for the spcified ShaderType value, or null if the input type is invalid.
- LLGL_EXPORT const char ∗ LLGL::ToString (const ErrorType t)

  Returns a string representation for the specified ErrorType value, or null if the input type is invalid.
- LLGL_EXPORT const char ∗ LLGL::ToString (const WarningType t)

  Returns a string representation for the specified WarningType value, or null if the input type is invalid.
- LLGL_EXPORT const char ∗ LLGL::ToString (const ShadingLanguage t)

  Returns a string representation for the specified ShadingLanguage value, or null if the input type is invalid.
- LLGL_EXPORT const char ∗ LLGL::ToString (const Format t)

  Returns a string representation for the specified Format value, or null if the input type is invalid.

11.67 Surface.h File Reference

```
#include "NonCopyable.h"
#include "Types.h"
#include "RenderContextFlags.h"
```

Classes

- class LLGL::Surface

  The Surface interface is the base interface for Window (on Desktop platforms) and Canvas (on movile platforms).

Namespaces

- LLGL

11.68 Tags.h File Reference

Classes

- struct LLGL::UninitializeTag

  Common uninitialize tag.

Namespaces

- LLGL

11.69 Texture.h File Reference

```
#include "Resource.h"
#include "Types.h"
#include "TextureFlags.h"
#include <cstdint>
```

Classes

- class LLGL::Texture

  Texture interface.

Namespaces

- LLGL

11.70 TextureFlags.h File Reference

```
#include "Export.h"
#include "Types.h"
#include "Format.h"
#include <cstddef>
#include <cstdint>
```

Classes

- struct LLGL::TextureFlags

  Texture creation flags enumeration.
- struct LLGL::TextureDescriptor

  Texture descriptor structure.
- struct LLGL::TextureRegion

  Texture region structure.

Namespaces

- LLGL

Enumerations

- enum LLGL::TextureType {
LLGL::TextureType::Texture1D, LLGL::TextureType::Texture2D, LLGL::TextureType::Texture3D, LLGL::↩
TextureType::TextureCube,
LLGL::TextureType::Texture1DArray, LLGL::TextureType::Texture2DArray, LLGL::TextureType::Texture↩
CubeArray, LLGL::TextureType::Texture2DMS,
LLGL::TextureType::Texture2DMSArray }

  Texture type enumeration.

Functions

- LLGL_EXPORT std::uint32_t LLGL::NumMipLevels (std::uint32_t width, std::uint32_t height=1, std::uint32_t depth=1)

  Returns the number of MIP-map levels for a texture with the specified size.
- LLGL_EXPORT std::uint32_t LLGL::NumMipLevels (const TextureDescriptor &textureDesc)

  Returns the number of MIP-map levels for the specified texture descriptor.
- LLGL_EXPORT std::uint32_t LLGL::TextureBufferSize (const Format format, std::uint32_t numTexels)

  Returns the required buffer size (in bytes) of a texture with the specified hardware format and number of texels.
- LLGL_EXPORT std::uint32_t LLGL::TextureSize (const TextureDescriptor &textureDesc)

  Returns the texture size (in texels) of the specified texture descriptor, or zero if the texture type is invalid.
- LLGL_EXPORT bool LLGL::IsMipMappedTexture (const TextureDescriptor &textureDesc)

  Returns true if the specified texture descriptor describes a texture with MIP-mapping enabled.
- LLGL_EXPORT bool LLGL::IsArrayTexture (const TextureType type)

  Returns true if the specified texture type is an array texture.
- LLGL_EXPORT bool LLGL::IsMultiSampleTexture (const TextureType type)

  Returns true if the specified texture type is a multi-sample texture.
- LLGL_EXPORT bool LLGL::IsCubeTexture (const TextureType type)

  Returns true if the specified texture type is a cube texture.

11.71 Timer.h File Reference

```
#include "NonCopyable.h"
#include <memory>
#include <cstdint>
```

Classes

- class LLGL::Timer

  Interface for a Timer class.

Namespaces

- LLGL

11.72 Types.h File Reference

```
#include "Export.h"
#include <cstdint>
```

Classes

- struct LLGL::Extent2D

  2-Dimensional extent structure.
- struct LLGL::Extent3D

  3-Dimensional extent structure.
- struct LLGL::Offset2D

  2-Dimensional offset structure.
- struct LLGL::Offset3D

  3-Dimensional offset structure.

Namespaces

- LLGL

Functions

- LLGL_EXPORT Extent2D LLGL::operator+ (const Extent2D &lhs, const Extent2D &rhs)

  Returns the sum of left hand side extent 'lhs' and the right hand side extent 'rhs'.
- LLGL_EXPORT Extent2D LLGL::operator- (const Extent2D &lhs, const Extent2D &rhs)

  Returns the subtractionn of left hand side extent 'lhs' and the right hand side extent 'rhs'.
- LLGL_EXPORT Extent3D LLGL::operator+ (const Extent3D &lhs, const Extent3D &rhs)

  Returns the sum of left hand side extent 'lhs' and the right hand side extent 'rhs'.
- LLGL_EXPORT Extent3D LLGL::operator- (const Extent3D &lhs, const Extent3D &rhs)

  Returns the subtractionn of left hand side extent 'lhs' and the right hand side extent 'rhs'.
- LLGL_EXPORT Offset2D LLGL::operator+ (const Offset2D &lhs, const Offset2D &rhs)

  Returns the sum of left hand side offset 'lhs' and the right hand side offset 'rhs'.
- LLGL_EXPORT Offset2D LLGL::operator- (const Offset2D &lhs, const Offset2D &rhs)

  Returns the subtractionn of left hand side offset 'lhs' and the right hand side offset 'rhs'.
- LLGL_EXPORT Offset3D LLGL::operator+ (const Offset3D &lhs, const Offset3D &rhs)

  Returns the sum of left hand side offset 'lhs' and the right hand side offset 'rhs'.
- LLGL_EXPORT Offset3D LLGL::operator- (const Offset3D &lhs, const Offset3D &rhs)

  Returns the subtractionn of left hand side offset 'lhs' and the right hand side offset 'rhs'.
- bool LLGL::operator== (const Offset2D &lhs, const Offset2D &rhs)

  Returns true if the left hand side offset 'lhs' is equal to the right hand side offset 'rhs'.
- bool LLGL::operator!= (const Offset2D &lhs, const Offset2D &rhs)

  Returns true if the left hand side offset 'lhs' is unequal to the right hand side offset 'rhs'.
- bool LLGL::operator== (const Offset3D &lhs, const Offset3D &rhs)

  Returns true if the left hand side offset 'lhs' is equal to the right hand side offset 'rhs'.
- bool LLGL::operator!= (const Offset3D &lhs, const Offset3D &rhs)

  Returns true if the left hand side offset 'lhs' is unequal to the right hand side offset 'rhs'.
- bool LLGL::operator== (const Extent2D &lhs, const Extent2D &rhs)

  Returns true if the left hand side extent 'lhs' is equal to the right hand side extent 'rhs'.
- bool LLGL::operator!= (const Extent2D &lhs, const Extent2D &rhs)

  Returns true if the left hand side extent 'lhs' is unequal to the right hand side extent 'rhs'.
- bool LLGL::operator== (const Extent3D &lhs, const Extent3D &rhs)

  Returns true if the left hand side extent 'lhs' is equal to the right hand side extent 'rhs'.
- bool LLGL::operator!= (const Extent3D &lhs, const Extent3D &rhs)

  Returns true if the left hand side extent 'lhs' is unequal to the right hand side extent 'rhs'.

11.73 Utility.h File Reference

```
#include "Export.h"
#include "TextureFlags.h"
#include "BufferFlags.h"
#include "RenderTargetFlags.h"
#include "RenderPassFlags.h"
#include "ResourceHeapFlags.h"
#include "ShaderFlags.h"
#include "ShaderProgramFlags.h"
#include "PipelineLayoutFlags.h"
#include <initializer_list>
```

Namespaces

- LLGL

Functions

- LLGL_EXPORT TextureDescriptor LLGL::Texture1DDesc (Format format, std::uint32_t width, long flags=TextureFlags::Default)

  Returns a TextureDescriptor structure with the TextureType::Texture1D type.
- LLGL_EXPORT TextureDescriptor LLGL::Texture2DDesc (Format format, std::uint32_t width, std::uint32_t height, long flags=TextureFlags::Default)

  Returns a TextureDescriptor structure with the TextureType::Texture2D type.
- LLGL_EXPORT TextureDescriptor LLGL::Texture3DDesc (Format format, std::uint32_t width, std::uint32_t height, std::uint32_t depth, long flags=TextureFlags::Default)

  Returns a TextureDescriptor structure with the TextureType::Texture3D type.
- LLGL_EXPORT TextureDescriptor LLGL::TextureCubeDesc (Format format, std::uint32_t width, std::uint32↩
_t height, long flags=TextureFlags::Default)

  Returns a TextureDescriptor structure with the TextureType::TextureCube type.
- LLGL_EXPORT TextureDescriptor LLGL::Texture1DArrayDesc (Format format, std::uint32_t width, std↩
::uint32_t arrayLayers, long flags=TextureFlags::Default)

  Returns a TextureDescriptor structure with the TextureType::Texture1DArray type.
- LLGL_EXPORT TextureDescriptor LLGL::Texture2DArrayDesc (Format format, std::uint32_t width, std↩
::uint32_t height, std::uint32_t arrayLayers, long flags=TextureFlags::Default)

  Returns a TextureDescriptor structure with the TextureType::Texture2DArray type.
- LLGL_EXPORT TextureDescriptor LLGL::TextureCubeArrayDesc (Format format, std::uint32_t width, std↩
::uint32_t height, std::uint32_t arrayLayers, long flags=TextureFlags::Default)

  Returns a TextureDescriptor structure with the TextureType::TextureCubeArray type.
- LLGL_EXPORT TextureDescriptor LLGL::Texture2DMSDesc (Format format, std::uint32_t width, std↩
::uint32_t height, std::uint32_t samples, long flags=TextureFlags::Default)

  Returns a TextureDescriptor structure with the TextureType::Texture2DMS type.
- LLGL_EXPORT TextureDescriptor LLGL::Texture2DMSArrayDesc (Format format, std::uint32_t width, std↩
::uint32_t height, std::uint32_t arrayLayers, std::uint32_t samples, long flags=TextureFlags::Default)

  Returns a TextureDescriptor structure with the TextureType::Texture2DMSArray type.
- LLGL_EXPORT BufferDescriptor LLGL::VertexBufferDesc (uint64_t size, const VertexFormat &vertexFormat, long flags=0)

  Returns a BufferDescriptor structure for a vertex buffer.
- LLGL_EXPORT BufferDescriptor LLGL::IndexBufferDesc (uint64_t size, const IndexFormat &indexFormat, long flags=0)

  Returns a BufferDescriptor structure for an index buffer.
- LLGL_EXPORT BufferDescriptor LLGL::ConstantBufferDesc (uint64_t size, long flags=BufferFlags::↩
DynamicUsage)

  Returns a BufferDescriptor structure for a constant buffer.
- LLGL_EXPORT BufferDescriptor LLGL::StorageBufferDesc (uint64_t size, const StorageBufferType storageType, std::uint32_t stride, long flags=BufferFlags::MapReadAccess|BufferFlags::MapWriteAccess)

  Returns a BufferDescriptor structure for a storage buffer.
- LLGL_EXPORT ShaderDescriptor LLGL::ShaderDescFromFile (const ShaderType type, const char ∗filename, const char ∗entryPoint=nullptr, const char ∗profile=nullptr, long flags=0)

  Returns a ShaderDescriptor structure.
- LLGL_EXPORT ShaderProgramDescriptor LLGL::ShaderProgramDesc (const std::initializer_list< Shader ∗ > &shaders, const std::initializer_list< VertexFormat > &vertexFormats={})

  Returns a ShaderProgramDescriptor structure and assigns the input shaders into the respective structure members.

- LLGL_EXPORT ShaderProgramDescriptor LLGL::ShaderProgramDesc (const std::vector< Shader ∗ > &shaders, const std::vector< VertexFormat > &vertexFormats={})

    Returns a ShaderProgramDescriptor structure and assigns the input shaders into the respective structure members.
- LLGL_EXPORT PipelineLayoutDescriptor LLGL::PipelineLayoutDesc (const ShaderReflectionDescriptor &reflectionDesc)

    Converts the specified shader reflection descriptor into a pipeline layout descriptor.
- LLGL_EXPORT PipelineLayoutDescriptor LLGL::PipelineLayoutDesc (const char ∗layoutSignature)

    Generates a pipeline layout descriptor by parsing the specified string.
- LLGL_EXPORT RenderPassDescriptor LLGL::RenderPassDesc (const RenderTargetDescriptor &render←TargetDesc)

    Converts the specified render target descriptor into a render pass descriptor with default settings.

11.74 Version.h File Reference

```
#include "Export.h"
#include <string>
#include <cstdint>
```

Namespaces

- LLGL
- LLGL::Version

    Namespace with functions to determine LLGL version.

Functions

- LLGL_EXPORT std::uint32_t LLGL::Version::GetMajor ()

    Returns the major LLGL version (e.g. 1 stands for "1.00").
- LLGL_EXPORT std::uint32_t LLGL::Version::GetMinor ()

    Returns the minor LLGL version (e.g. 1 stands for "0.01"). Must be less than 100.
- LLGL_EXPORT std::uint32_t LLGL::Version::GetRevision ()

    Returns the revision version number. Must be less than 100.
- LLGL_EXPORT std::string LLGL::Version::GetStatus ()

    Returns the LLGL version status (either "Alpha", "Beta", or empty).
- LLGL_EXPORT std::uint32_t LLGL::Version::GetID ()

    Returns the full LLGL version as an ID number (e.g. 200317 stands for "2.03 (Rev. 17)").
- LLGL_EXPORT std::string LLGL::Version::GetString ()

    Returns the full LLGL version as a string (e.g. "0.01 Beta (Rev. 1)").

11.75 VertexAttribute.h File Reference

```
#include "Export.h"
#include "Format.h"
#include <string>
#include <cstdint>
```

Classes

- struct LLGL::VertexAttribute

    Vertex attribute structure.

Namespaces

- LLGL

Functions

- LLGL_EXPORT bool LLGL::operator== (const VertexAttribute &lhs, const VertexAttribute &rhs)

    Compares the two VertexAttribute types for equality (including their names and all other members).
- LLGL_EXPORT bool LLGL::operator!= (const VertexAttribute &lhs, const VertexAttribute &rhs)

    Compares the two VertexAttribute types for inequality (including their names and all other members).

11.76 VertexFormat.h File Reference

```
#include "Export.h"
#include "Constants.h"
#include "VertexAttribute.h"
#include <vector>
#include <cstdint>
```

Classes

- struct LLGL::VertexFormat

    Vertex format structure.

Namespaces

- LLGL

11.77 VideoAdapter.h File Reference

```
#include "Export.h"
#include "DisplayFlags.h"
#include <vector>
#include <string>
#include <cstdint>
```

Classes

- struct LLGL::VideoOutputDescriptor

    Video output structure.
- struct LLGL::VideoAdapterDescriptor

    Video adapter descriptor structure.

Namespaces

- LLGL

11.78 Win32NativeHandle.h File Reference

```
#include <Windows.h>
```

Classes

- struct LLGL::NativeHandle

    iOS native handle structure.
- struct LLGL::NativeContextHandle

    iOS native context handle structure.

Namespaces

- LLGL

11.79 Window.h File Reference

```
#include "Surface.h"
#include "WindowFlags.h"
#include "Key.h"
#include <memory>
#include <vector>
```

Classes

- class LLGL::Window

    Window interface for desktop platforms.
- class LLGL::Window::EventListener

    Interface for all window event listeners.

Namespaces

- LLGL

11.80 WindowFlags.h File Reference

```
#include "Types.h"
#include <string>
#include <cstdint>
```

Classes

- struct LLGL::WindowDescriptor

  Window descriptor structure.
- struct LLGL::WindowBehavior

  Window behavior structure.

Namespaces

- LLGL

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