

Intel® Xe Super Sampling (XeSS) API Developer Guide v1.3

Intel® Xe Super Sampling (XeSS) delivers innovative, framerate-boosting technology, which is supported by Intel® Arc™ graphics cards and other GPU vendors. It upscales with AI deep learning, so offers higher framerates at no cost to image quality. The XeSS API is for any game developer who wants to optimize image quality and performance.

This developer guide supplements the *XeSS API Reference Guide*.

Table of Contents

Introduction.....	4
X ^e SS SDK 1.3 Update notes.....	4
X ^e SS Components	5
Versioning	5
Compatibility.....	6
TAA and X ^e SS.....	7
X ^e SS Game Setting Recommendations	8
Naming Conventions for Intel X ^e Super Sampling Branding	8
Game Graphics Settings Menu/Game Installer/Launcher Settings.....	8
Graphics Preset Default Recommendations	9
Intel X ^e Super Sampling UI Example.....	9
Deployment	10
Programming Guidance	11
Thread safety	11
Inputs and Outputs	11
Jitter	11
Jitter Sequence	12
Color	12
Motion Vectors.....	14
Depth	15
Responsive Pixel Mask	15
Resource States	15
Resource Formats	16
Mip Bias.....	16
Initialization	17
Execution.....	18
Fixed input resolution.....	18
Dynamic input resolution.....	20
Jitter scale.....	21

Velocity scale.....	21
Exposure multiplier.....	21
Debug and Logging Capabilities	21
Logging Callback.....	21
Recommended Practices	23
Visual Quality	23
Driver Verification	23
Debugging Tips.....	23
Motion Vectors Debugging.....	23
Jitter Offset Debugging	24
Additional Resources	25
Notices	26

Introduction

X^e Super Sampling is implemented as a sequence of Microsoft[®] Direct3D[®] 12 (DX3D) compute shader passes, executed before the rendering engine's post-processing stage (as described in the section entitled 'TAA and X^eSS'). The rendering engine initializes X^eSS by passing a Direct3D[®] 12 (D3D12) device, which is being used for the main rendering, and a pointer to a descriptor heap, where X^eSS creates all its internal resource descriptors. X^eSS allocates GPU resources for one of two categories:

- Persistent allocations, such as network weights, and other constant data.
- Temporary allocations, such as network activations.

The game engine can control the location where X^eSS makes its temporary allocations by passing XESS_INIT_FLAG_EXTERNAL_DESCRIPTOR_HEAP initialization flag to xessD3D12Init call and a pointer to an external resource heap in the xessD3D12Execute call. To ensure optimal game performance with X^eSS when game engine provides external resource heap, this heap should have HIGH memory residency priority. Persistent allocations are always owned by the X^eSS library.

X^eSS SDK 1.3 Update notes

X^eSS SDK 1.3 introduces new Ultra-Performance (3.0x upscaling), Ultra Quality Plus (1.3x), Native Anti-Aliasing (1.0x upscaling) presets, and **increases resolution scaling for existing quality presets**:

Preset	Resolution scaling in previous X ^e SS versions	Resolution scaling in X ^e SS 1.3
Native Anti-Aliasing	N/A	1.0x (Native resolution)
Ultra Quality Plus	N/A	1.3x
Ultra Quality	1.3x	1.5x
Quality	1.5x	1.7x
Balanced	1.7x	2.0x
Performance	2.0x	2.3x
Ultra Performance	N/A	3.0x
Off	Turns Intel X ^e SS off	Turns Intel X ^e SS off

When updating to X^eSS 1.3 from previous X^eSS versions, it is critical to verify that X^eSS integration in the game is satisfying the following:

- Resolution scaling ratios, additional mip bias and jitter sequence length should not be hardcoded per quality preset in the game code. Corresponding function calls and formulas should be used in the runtime
- xessGetOptimalInputResolution function should be used to query input resolution

- Additional texture mip-bias should be calculated using the formula: $\log_2\left(\frac{\text{Input Width}}{\text{Target Width}}\right)$. For example, XeSS 1.3 Performance quality preset should result in additional mip bias of -1.202, and XeSS 1.3 Ultra Performance quality preset should result in additional mip bias of -1.585.
- Jitter sequence must be at least $8 * \left(\frac{\text{Target Width}}{\text{Input Width}}\right)^2$. For example, XeSS 1.3 Ultra Performance quality preset should have jitter sequence length of at least 72.

Please refer to the corresponding sections of this document for more details

XeSS Components

XeSS is accessible through the XeSS SDK, which provides a D3D12-based API for integration into a game engine, and includes the following D3D12 components:

- An HLSL-based cross-vendor implementation that runs on any GPU supporting SM 6.4. Hardware acceleration for DP4a or equivalent is recommended.
- An Intel implementation optimized to run on Intel® Arc™ Graphics, and Intel® Iris® Xe Graphics.
- An implementation dispatcher, which loads either the XeSS runtime shipped with the game, the version provided with the Intel® Graphics driver, or the cross-vendor implementation.

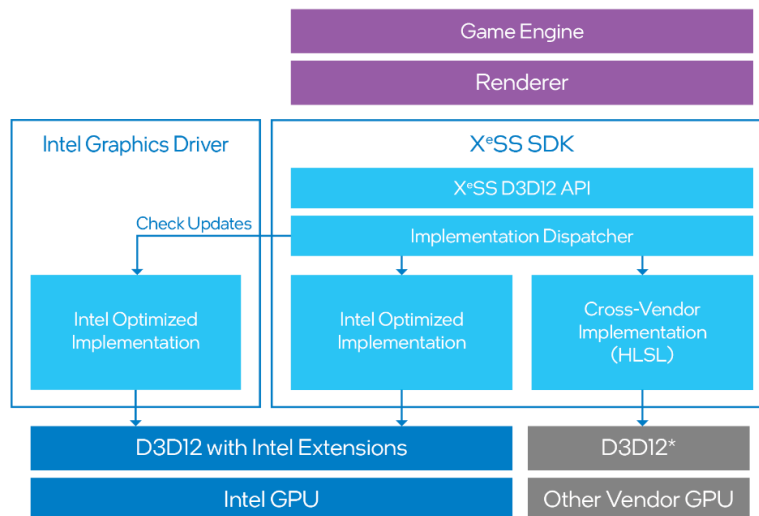


Figure 1. XeSS SDK components for both Intel-specific, and cross-vendor solutions.

Versioning

XeSS uses major.minor.patch version format, and Numeric 90+ scheme, for development stage builds. The XeSS version is specified by the 64-bit function [xess_version_t] structure, in which:

- A major version increment indicates a new API, and potentially a break in functionality.
- A minor version increment indicates incremental changes such as optional inputs or flags. This does not change existing functionality.

- A patch version increment may include performance or quality tweaks, or fixes, for known issues. There is no change in the interfaces. Versions beyond 90 are used for development builds to change the interface for the next release.

The XeSS version is baked into the XeSS SDK release and can be accessed using the function `xessGetVersion`. The version is included in the zip file and in the accompanying README, as well as the header of the code samples.

Compatibility

All future Intel® Graphics driver releases provide compatibility with previous XeSS versions.

During initialization of the XeSS library it will check driver compatibility and choose which version to use – version distributed with an application or version bundled with the driver.

TAA and X^eSS

X^eSS is a temporally amortized super-sampling/up-sampling technique that drops in place of the Temporal Anti-Aliasing (TAA) stage in the game renderer, achieving significantly better image quality than current state-of-the-art techniques in games.

The figure 2 shows a renderer with TAA. The renderer jitters the camera in every frame to sample different coordinates in screen space. The TAA stage accumulates these samples temporally to produce a super-sampled image. The previously accumulated frame (history) is warped using renderer-generated motion vectors to align it with the current frame before accumulation. Unfortunately, the warped sample history can be mismatched, with respect to the current pixel, due to frame-to-frame changes in visibility and shading or errors in the motion vector. This typically results in ghosting artifacts. TAA implementations use heuristics such as neighborhood clamping to detect mismatches and reject the history. However, these heuristics often fail, and produce a noticeable amount of ghosting, over-blurring, or flickering.

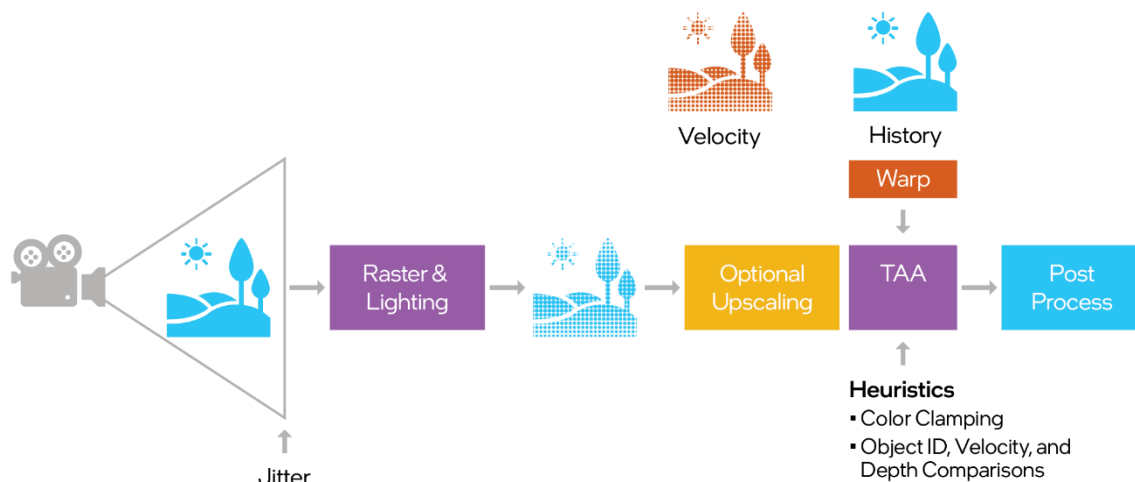


Figure 2. Flow chart of a typical rendering pipeline with TAA.

X^eSS replaces the TAA stage with a neural-network-based approach, as shown below, with the same set of inputs and outputs as TAA. Please refer to this report for an overview of TAA techniques.

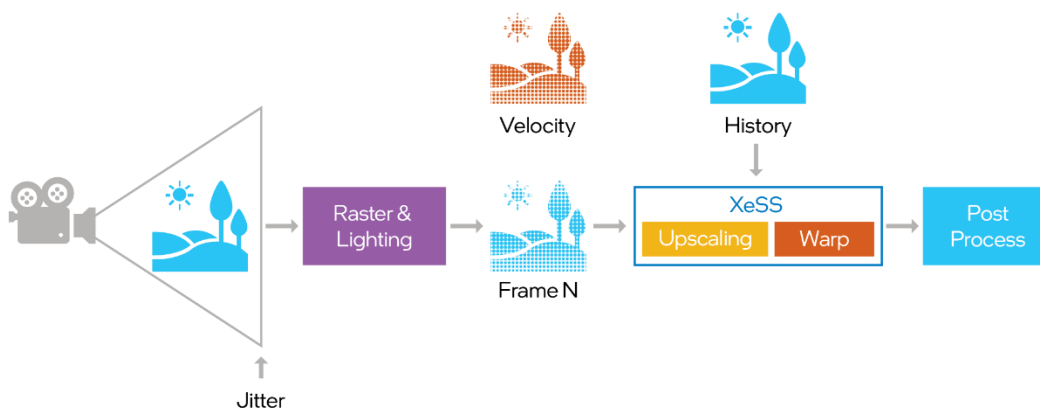


Figure 3. X^eSS inclusion into the rendering pipeline.

X^eSS Game Setting Recommendations

When integrating X^eSS into your game, make sure you follow these guidelines for your titles so that your users have a consistent experience when modifying X^eSS options.

There are also guidelines for the font, official naming, and descriptions of the X^eSS functionality below.

Naming Conventions for Intel X^e Super Sampling Branding

You should use the approved naming conventions for X^eSS in your settings menus and descriptions. The official font for X^eSS-related communication is IntelOneText-Regular. Please use the official superscripted e in X^eSS, unless the font system does not support superscript, in which case X^eSS is acceptable. For the smaller e in X^eSS, you can reduce the font size for just that character to keep the proportions.

Label	Intel X ^e SS
Short Description	Intel® Xe Super Sampling (XeSS) technology uses AI to deliver more performance with exceptional image quality. XeSS is optimized for Intel® Arc™ GPUs with AI acceleration hardware.
Minimum Description	Intel® Xe Super Sampling (XeSS) technology uses AI to deliver more performance with exceptional image quality.

Game Graphics Settings Menu/Game Installer/Launcher Settings

Game-title graphics settings should clearly display the XeSS option name and allow the user to choose the quality/performance level option settings, as follows.

Preset	Description	Recommended Resolution
Native Anti-Aliasing	AI-based Anti-Aliasing for maximum visual quality	1080p and above
Ultra Quality Plus	Highest quality visual upscale	1080p and above
Ultra Quality	Higher quality visual upscale	1080p and above
Quality	High quality visual upscale	1080p and above
Balanced	Best balance between performance and visual quality	1080p and above
Performance	High performance improvement	1440p and above
Ultra Performance	Highest performance improvement	1440p and above
Off	Turns Intel XeSS off	NA

Note: To enable XeSS, your title needs to disable other upscaling technologies, such as DLSS and FSR, and temporal anti-aliasing (TAA) technologies, to reduce the possibility of any incompatibility issues.

Graphics Preset Default Recommendations

The XeSS preset selected by default in the game's menu should be based on the target resolution that the user has set. The entries below are the recommended default settings.

Default XeSS recommendations	Description	Recommended Setting
Resolution specific	Your game adjusts the XeSS default preset based on the output resolution	1080p and lower set to 'Balanced' 1440p and higher set to 'Performance'
General	Your game selects one XeSS preset as default.	Intel XeSS ON set to 'Performance'

Note: All Intel Xe Super Sampling settings should be exposed to a user through a selection menu, if supported, to encourage customization.

Intel Xe Super Sampling UI Example

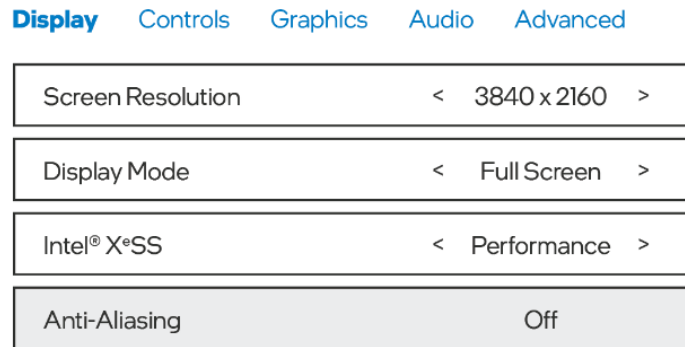


Figure 4. Example of game UI with X°SS settings.

Notes:

- Screen resolution: X°SS supports resolutions of 1080p and above.
- Display mode: X°SS supports full screen, borderless windowed mode, and windowed mode.
- Intel® X°SS: Off, Ultra Performance, Performance, Balanced, Quality, Ultra Quality, Ultra Quality Plus, Native Anti-Aliasing.
- Anti-Aliasing: AA mode should be returned to the previous setting when Intel X°SS is disabled.

Deployment

To build with X°SS library user need to complete following steps:

- Add "inc" folder to include path
- Include xess.h and xess_d3d12.h
- Link with lib/libxess.lib

Following file must be placed to executable location or dll search path:

- libxess.dll

Programming Guidance

Thread safety

The X^eSS is not thread safe. The client application must ensure that calls to the X^eSS functions are performed safely. In general, all calls to X^eSS API must be done from within the same thread where X^eSS was initialized.

Inputs and Outputs

X^eSS requires a minimum set of inputs every frame:

- Jitter
- Input color
- Dilated high-res motion vectors

In place of the high-res motion vectors, the renderer can provide the motion vectors at the input resolution—along with the depth values:

- Undilated low-res motion vectors
- Depth

In the latter case, motion vectors will be dilated and upsampled inside X^eSS.

Jitter

As a temporal super-sampling technique, X^eSS requires a sub-pixel jitter offset (J_x, J_y) to be applied to the projection matrix in every frame. This process produces a new subpixel sample location every frame and guarantees temporal convergence even on static scenes. Jitter offset values should be in the range $[-0.5, 0.5]$. This jitter can be applied by adding a shear transform to the camera projection matrix:

```
ProjectionMatrix.M[2][0] += Jx * 2.0f / InputWidth  
ProjectionMatrix.M[2][1] -= Jy * 2.0f / InputHeight
```

The jitter applied to the camera results in a displacement of the sample points in the frame, as shown below, where the target image is scaled 2x in width and height. Note that effective jitter is negated with respect to (J_x, J_y) , because the projection matrix is applied to geometry, and it corresponds to a negative camera jitter.

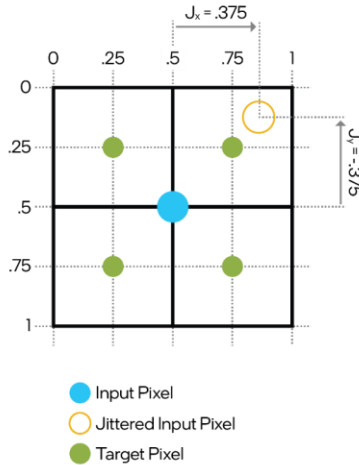


Figure 5. Jitter displacement of sample points.

Jitter Sequence

A quasi-random sampling sequence with a good spatial distribution of characteristics is required to get the best quality of X^eSS algorithm (Halton sequence would be a fair choice). The scaling factor should be considered when using such a sequence to modify the length of a repeated pattern. For example: if the game is using Halton sequence of a length eight in native rendering, it must become $8 * \left(\frac{\text{Target Width}}{\text{Input Width}}\right)^2$ if used with X^eSS upscaling to ensure a good distribution of samples in the area covered by a single low-resolution pixel. Sometimes, increasing the length even more leads to an additional quality improvement, so we encourage experimentation with the sequence length. Avoid sampling techniques that bias the jitter sample distribution regarding the input pixel, however.

Color

X^eSS accepts both LDR and HDR input colors in any linear color format, for example:

- DXGI_FORMAT_R16G16B16A16_FLOAT
- DXGI_FORMAT_R11G11B10_FLOAT
- DXGI_FORMAT_R8G8B8A8_UNORM

The input colors are expected to be in the sRGB color space, which is scene-referred—i.e., the color values represent luminance levels. A value of (1.0,1.0,1.0) encodes D65 white at 80 nits and represents the maximum luminance for SDR displays. The color values can exceed (1.0,1.0,1.0) for HDR content.

It is recommended to provide HDR input color to X^eSS, since X^eSS can internally apply tonemapping tuned for optimizing X^eSS AI Models visual quality. If LDR input color is provided, X^eSS quality may decrease.

If HDR input color values have not been adjusted for the exposure, or if they are scaled differently from the sRGB space, a separate scale value can be provided in the following ways:

- If no exposure value is available, XeSS can calculate it when the XESS_INIT_FLAG_ENABLE_AUTOEXPOSURE flag is used at initialization. Note that the use of this flag will cause a measurable performance impact.
- Input exposure value can be provided by passing value inside xess_d3d12_execute_params_t structure or by providing an exposure scale texture which can be updated by the GPU.

If the application provides LDR color to XeSS, it is recommended to set exposure value as “1” and avoid using auto-exposure.

If the input color from the application is pre-exposed, it is recommended to provide pre-exposure in one of following ways:

- Provide exposure value divided by pre-exposure.
- Provide inverse of pre-exposure value as input to xessSetExposureMultiplier.

Exposure multiplier will be applied to all exposure values including one generated by built-in auto-exposure functionality.

Exposure values are applied to input color in following way:

```
if (useAutoexposure)
{
    scale = XeSSCalculatedExposure(...)
}
else if (useExposureScaleTexture)
{
    scale = exposureScaleTexture.Load(int3(0, 0, 0)).x
}
else
{
    scale = inputScale
}

inputColor *= scale * exposure_multiplier
```

If a scale value is applied to the input, as shown above, the inverse of this scale is applied to the output color.

XeSS maintains an internal history state to perform temporal accumulation of incoming samples. That means the history should be dropped if the scene or view suddenly changes. This is achieved by setting the historyReset flag in xess_xxx_execute_params_t.

The output must be in the same color space as the input. It can be any linear color format similar to the input.

Motion Vectors

Motion vectors specify the screen-space motion in pixels from the current frame to the previous frame. X^eSS accepts motion vectors in the format `DXGI_FORMAT_R16G16_FLOAT`, where the R channel encodes the motion in x, and the G in y. The motion vectors do not include motion induced by the camera jitter. Motion vectors can be low-res (default), or high-res (`XESS_INIT_FLAG_HIGH_RES_MV`). Low-res motion vectors are represented by a 2D texture at the input resolution, whereas high-res motion vectors are represented by a 2D texture at the target resolution.

In the case of high-res motion vectors, the velocity component resulting from camera animations is computed at the target resolution in a deferred pass, using the camera transformation and depth values. However, the velocity component related to particles and object animations is typically computed at the input resolution and stored in the G-Buffer. This velocity component is upsampled and combined with the camera velocity to produce the texture for high-res motion vectors. X^eSS also expects the high-res motion vectors to be dilated. For example, the motion vectors represent the motion of the foremost surface in a small neighborhood of input pixels (such as 3×3). High-res motion vectors can be computed in a separate pass by the user.

Low-res motion vectors are not dilated, and directly represent the velocity sampled at each jittered pixel position. X^eSS internally up-samples motion vectors to the target grid and uses the depth texture to dilate them. The figure 6 shows the same motion specified with low-res and high-res motion vectors.

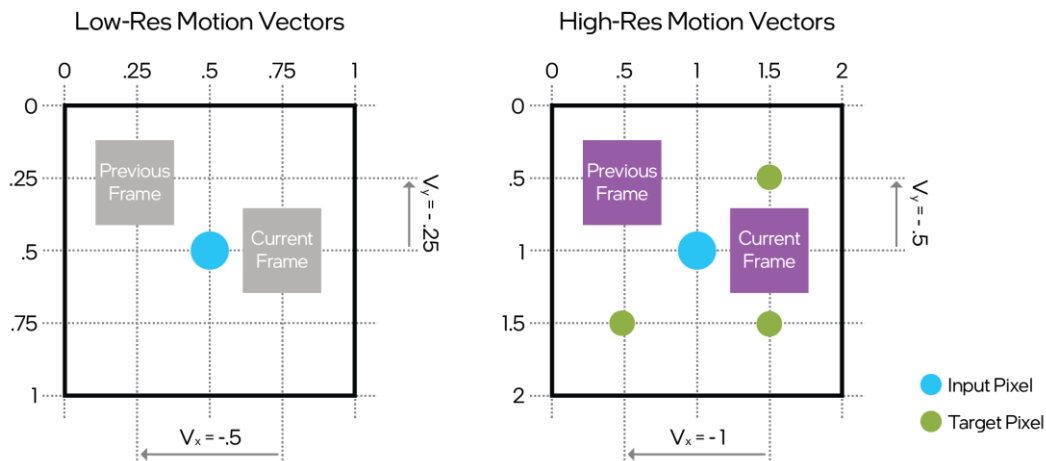


Figure 6. Convention for specifying the low-res and high-res motion vector to X^eSS.

Some game engines only render objects into the gbuffer, and quickly compute the camera velocity in the TAA shader. In such cases, an additional pass is required before X^eSS execution to merge object and camera velocities and generate a flattened velocity buffer. In such scenarios, high-res motion vectors might be a better choice, as the flattening pass can be executed at the target resolution.

Depth

If X^eSS is used with low-res motion vectors, it also requires a depth texture for velocity dilation. Any depth format, such as D32_FLOAT or D24_UNORM, is supported. By default, X^eSS assumes that smaller depth values are closer to the camera. However, several game engines use inverted depth, and this can be enabled by setting XESS_INIT_FLAG_INVERTED_DEPTH.

Responsive Pixel Mask

You could provide a responsive pixel mask with a mask value of 1 to force X^eSS to ignore information from previous frames. Although X^eSS is a generalized technique that should handle a wide range of rendering scenarios, there may be rare cases where objects without valid motion vectors may produce ghosting artifacts, for example particles. In such cases, a responsive pixel mask can be set for these objects. Any texture format can be used for the mask if the mask value is in the R channel.

Resource States

X^eSS expects all input textures to be in the following states:

- D3D12_RESOURCE_STATE_NON_PIXEL_SHADER_RESOURCE for input textures.
- D3D12_RESOURCE_STATE_UNORDERED_ACCESS for output texture.

Resource Formats

X^eSS expects all input textures to be typed.

X^eSS can accept some typeless formats for input textures. In case of typeless formats they will be interpreted internally according to following table:

Input typeless format	Internal typed interpretation
DXGI_FORMAT_R32G32B32A32_TYPELESS	DXGI_FORMAT_R32G32B32A32_FLOAT
DXGI_FORMAT_R32G32B32_TYPELESS	DXGI_FORMAT_R32G32B32_FLOAT
DXGI_FORMAT_R16G16B16A16_TYPELESS	DXGI_FORMAT_R16G16B16A16_FLOAT
DXGI_FORMAT_R32G32_TYPELESS	DXGI_FORMAT_R32G32_FLOAT
DXGI_FORMAT_R32G8X24_TYPELESS	DXGI_FORMAT_R32_FLOAT_X8X24_TYPELESS
DXGI_FORMAT_R10G10B10A2_TYPELESS	DXGI_FORMAT_R10G10B10A2_UNORM
DXGI_FORMAT_R8G8B8A8_TYPELESS	DXGI_FORMAT_R8G8B8A8_UNORM
DXGI_FORMAT_R16G16_TYPELESS	DXGI_FORMAT_R16G16_FLOAT
DXGI_FORMAT_R32_TYPELESS	DXGI_FORMAT_R32_FLOAT
DXGI_FORMAT_R24G8_TYPELESS	DXGI_FORMAT_R24_UNORM_X8_TYPELESS
DXGI_FORMAT_R8G8_TYPELESS	DXGI_FORMAT_R8G8_UNORM
DXGI_FORMAT_R16_TYPELESS	DXGI_FORMAT_R16_FLOAT
DXGI_FORMAT_R8_TYPELESS	DXGI_FORMAT_R8_UNORM
DXGI_FORMAT_B8G8R8A8_TYPELESS	DXGI_FORMAT_B8G8R8A8_UNORM
DXGI_FORMAT_B8G8R8X8_TYPELESS	DXGI_FORMAT_B8G8R8X8_UNORM
DXGI_FORMAT_D16_UNORM	DXGI_FORMAT_R16_UNORM
DXGI_FORMAT_D32_FLOAT	DXGI_FORMAT_R32_FLOAT
DXGI_FORMAT_D24_UNORM_S8_UINT	DXGI_FORMAT_R24_UNORM_X8_TYPELESS
DXGI_FORMAT_D32_FLOAT_S8X24_UINT	DXGI_FORMAT_R32_FLOAT_X8X24_TYPELESS

Mip Bias

To preserve texture details at the target resolution, X^eSS requires an additional mip bias. It is recommended to use following formula:

$$\log_2\left(\frac{\text{Input Width}}{\text{Target Width}}\right)$$

For example, a mip bias of -1 should be applied for 2.0x resolution scaling that corresponds to Balanced quality preset. In certain cases, increasing mip bias even more leads to an additional visual quality improvement; this comes with a potential performance overhead, however, due to increased memory bandwidth requirements, and potentially lower temporal stability resulting in flickering and moire. It is recommended to experiment with different texture LOD biases to find optimal values, however mip bias should be close to recommended value and always calculated based on input and output resolutions.

In dynamic resolution scenario, mip bias is recommended to be updated every time XeSS input resolution changes. If changing mip bias every time input resolution is changed is not possible, consider keeping a set of estimated mip biases.

Initialization

First create an XeSS context, as shown below. On Intel GPUs, this step loads the latest Intel-optimized implementation of XeSS. The returned context handle can then be used for initialization and execution.

```
xess_context_handle_t context;  
xessD3D12CreateContext(pD3D12Device, &context)
```

Before initializing XeSS, the user can request a pipeline pre-build process to avoid costly kernel compilation and pipeline creation during initialization.

```
xessD3D12BuildPipelines(context, NULL, false, initFlags);
```

The xessD3D12Init function is then called to initialize XeSS. During initialization, XeSS can create staging buffers and copy queues to upload weights. These will be destroyed at the end of initialization. The XeSS storage and layer specializations are determined by the target resolution. Therefore, the target width and height must be set during initialization.

```
xess_d3d12_init_params_t initParams;  
initParams.outputWidth = 3840;  
initParams.outputHeight = 2160;  
initParams.initFlags = XESS_INIT_FLAG_HIGH_RES_MV;  
initParams.pTempStorageHeap = NULL;  
  
xessD3D12Init(&context, &initParams);
```

XeSS includes three types of storage:

- **Persistent Output-Independent Storage:** persistent storage such as weights are internally allocated and uploaded by XeSS during initialization.
- **Persistent Output-Dependent Storage:** persistent storage such as internal history texture.
- **Temporary Storage:** temporary storage only has valid data during the execution of XeSS.

Allocate temporary storage either internally in a library-managed heap (default), or in a heap provided by the user in the pTempStorageHeap field of the xess_d3d12_init_params_t structure. If you allocate the temporary storage, it can be reused outside of XeSS execution.

```
ComPtr<ID3D12Heap> pHeap;  
CD3DX12_HEAP_DESC  
    heapDesc(xessProp.tempHeapSize, D3D12_HEAP_TYPE_DEFAULT);
```

```

d3dDevice->CreateHeap(&heapDesc, IID_PPV_ARGS(&pHeap));

initParams.tempStorageOffset = 0;
initParams.pTempStorageHeap = pHeap.Get();

xessD3D12Init(&context, &initParams);

```

You can specify the XESS_INIT_FLAG_EXTERNAL_DESCRIPTOR_HEAP initialization flag to use the external descriptor heap later at the execution stage.

You can also re-initialize X^eSS if there is a change in the target resolution, or any other initialization parameter. However, pending X^eSS command lists must be completed before re-initialization. When temporary X^eSS storage is allocated, it is your responsibility to de-allocate, or reallocate, the heap. Quality preset changes are cheap, but any other parameters change may lead to longer xessD3D12Init execution times.

Execution

The X^eSS execution function does not involve any GPU workloads, rather it records X^eSS commands into the specified command list. The command list is then enqueued by the user. That means it is your responsibility to make sure all input/output resources are alive at the time of the actual GPU execution.

By default, X^eSS creates an internal descriptor heap, but if you have specified XESS_INIT_FLAG_EXTERNAL_DESCRIPTOR_HEAP at the initialization stage, you can pass the pointer to the external descriptor heap and its offset in execution parameters.

If the EXTERNAL_DESCRIPTOR_HEAP flag has been specified in xessD3D12Init parameters, you must create descriptors for the input and output buffers in contiguous locations in the same descriptor heap as the internal descriptors. The external descriptor heap is passed via the pDescriptorHeap field of the xess_d3d12_execute_params_t structure. DescriptorHeapOffset should point to the X^eSS descriptor table.

Fixed input resolution

Default scenario for using X^eSS is using fixed input resolution that depends on the desired quality setting and target resolution. Call xessGetOptimalInputResolution and use pInputResolutionOptimal value to determine input resolution based on quality setting and target resolution. You must provide actual input resolution values as a part of the xess_d3d12_execute_params_t structure in each call to xessD3D12Execute.

Please note, that `xessGetInputResolution` function is deprecated starting XeSS SDK 1.2 and kept for compatibility reasons.

Please note that starting with XeSS 1.3, Quality Preset mapping to resolution scaling has changed. Please refer to the table below for XeSS 1.3:

Preset	Resolution scaling
Native Anti-Aliasing	1.0x (Native resolution)
Ultra Quality Plus	1.3x
Ultra Quality	1.5x
Quality	1.7x
Balanced	2.0x
Performance	2.3x
Ultra Performance	3.0x
Off	Turns Intel XeSS off

XeSS 1.3 provides a way to restore legacy Quality Preset mapping to resolution scaling. It can be done by using `xessForceLegacyScaleFactors` function. Calling this function will result in the following scale factors used in the next call to `xessGetOptimalInputResolution` and `xessD3D12Init`:

Preset	Resolution scaling (Legacy)
Native Anti-Aliasing	1.0x (Native resolution)
Ultra Quality Plus	1.3x
Ultra Quality	1.3x
Quality	1.5x
Balanced	1.7x
Performance	2.0x
Ultra Performance	3.0x
Off	Turns Intel XeSS off

In order to use legacy scale factors, the application should initialize XeSS in the order demonstrated by the following code sample:

```
// 1. Create context
xessD3D12CreateContext(device, &context);

// 2. Request legacy scale factors
xessForceLegacyScaleFactors(context, true);

// 3. Get optimal input resolution and initialize context
xessGetOptimalInputResolution(context, ...);
xessD3D12Init(context, ...);
```

Dynamic input resolution

X^eSS supports a scenario with dynamic input resolution and fixed target resolution. In this case, it is recommended to ignore `pInputResolutionOptimal` value and freely change input resolution within the supported range `[pInputResolutionMin; pInputResolutionMax]`, letting the application to reach optimal visual quality level while keeping fixed FPS. You must provide actual input resolution values as a part of the `xess_d3d12_execute_params_t` structure in each call to `xessD3D12Execute`. When varying input resolution, it is recommended for the application to keep rendering resolution aspect ratio as close as possible to target resolution aspect ratio, to ensure optimal and stable visual quality of X^eSS.

```
xess_d3d12_execute_params_t params;
params.jitterOffsetX      = 0.4375f;
params.jitterOffsetY      = 0.3579f;

params.inputWidth = 1920;
params.inputHeight = 1080;

// xess records commands into the command list
xessD3D12Execute(&context, pd3dCommandList, &params);

// Application may record more commands as needed
pd3d12GraphicsCommandList->Close();

// Application submits the command list for GPU execution
pCommandQueue->ExecuteCommandLists(1, &pCommandLists);
```

Please note that starting with XeSS 1.3, Quality Preset mapping to resolution scaling has changed. Please refer to the table below for XeSS 1.3:

Preset	Dynamic resolution scaling range
Native Anti-Aliasing	N/A
Ultra Quality	1.0x - 1.5x
Quality	1.0x - 1.7x
Balanced	1.0x - 2.0x
Performance	1.0x - 2.3x
Ultra Performance	1.0x - 3.0x
Off	Turns Intel XeSS off

Jitter scale

The function `xessSetJitterScale` applies a scaling factor to the jitter offset. This might be useful if the application stores jitter in units other than pixels. For example: NDC jitter can be converted to a pixel jitter by setting an appropriate scale.

Velocity scale

The function `xessSetVelocityScale` applies a scaling factor to the velocity. This might be useful if the application stores velocity in units other than pixels. For example, a normalized viewport velocity can be converted to pixel velocity by setting an appropriate scale.

Exposure multiplier

The function `xessSetExposureMultiplier` applies a multiplier for exposure value. This multipliers works in all exposure modes:

- Autoexposure.
- Exposure passed as value inside `xess_d3d12_execute_params_t` structure.
- Exposure texture.

Debug and Logging Capabilities

Logging Callback

The XeSS SDK provides an API to set logging callback. Use function `xessSetLoggingCallback` to define a function to be called in the following circumstances:

- Callback can be called from different threads.
- Callback can be called simultaneously from several threads.

- Message pointer only valid inside function and may be invalid right after return call.
- Message is a null-terminated utf-8 string.

Recommended Practices

Visual Quality

We recommend you run X^eSS in the beginning of the post-processing chain before the tone-mapping. Execution after tone-mapping is possible in certain scenarios; however, this mode is experimental, and good quality is not guaranteed.

The following considerations should be considered to maximize image quality:

- Use high-, or ultra-high-, quality setting for screen-space ambient occlusion (SSAO) and shadows.
- Turn off any techniques for shading-rate reduction and rendering resolution scaling, such as variable rate shading (VRS), adaptive shading, checkerboard rendering, dither, etc.
- Avoid using quarter-resolution effects before X^eSS upscaling.
- Do not rely on X^eSS for any kind of denoising; noisy signal significantly hurts reconstruction quality.
- Use fp16 precision for the color buffer in scene linear HDR space.
- Use fp16 precision for the velocity buffer.
- Adjust mip bias to maximize image quality and keep overhead under control.
- Provide an appropriate scene exposure value. Correct exposure is essential to minimize ghosting of moving objects, blurriness, and precise brightness reconstruction.

Driver Verification

For the best performance and quality, install the latest driver. To facilitate this, after initialization with `xessD3D12CreateContext`, call function `xessIsOptimalDriver` to verify the driver installed will provide the best possible experience. If `XESS_RESULT_WARNING_OLD_DRIVER` is returned from this function, an advisory message or notice should be displayed to the user recommending they install a newer driver. `XESS_RESULT_WARNING_OLD_DRIVER` is not a fatal error, and the user should be allowed to continue.

Debugging Tips

Motion Vectors Debugging

If X^eSS is producing an aliased or shaky image, it is worth concentrating on static scene debugging:

- Emulate zero time-delta between frames in the engine to maintain a fully static scene.
- Set 0 motion vector scale to exclude potential issues with motion vectors.
- Significantly increases the length of a repeated jitter pattern.

X^eSS should produce high-quality, super sampled images. If this does not happen, there might be problems with jitter sequence or the input textures' contents; otherwise, the problem is in the decoding of motion vectors. Make sure that motion vectors buffer contents correspond to currently set units (NDC or pixels), and that axis directions are correct. Try playing with plus or minus 1 motion vector scale factors to align the coordinate axis appropriately.

Jitter Offset Debugging

If the static scene does not look good, try playing with plus or minus 1 jitter offset scaling to appropriately align the coordinate axis. Make sure jitter does not fall off outside of $[-0.5, 0.5]$ bounds.

Additional Resources

[Survey](#) of temporal anti-aliasing techniques

Intel® Arc™ landing [page](#)

Intel® Xe Super Sampling Plugin for Unreal* Engine on [GitHub](#)

DirectX download [page](#)

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