Upscaler Offline Manual (PDF)

v1.0.0

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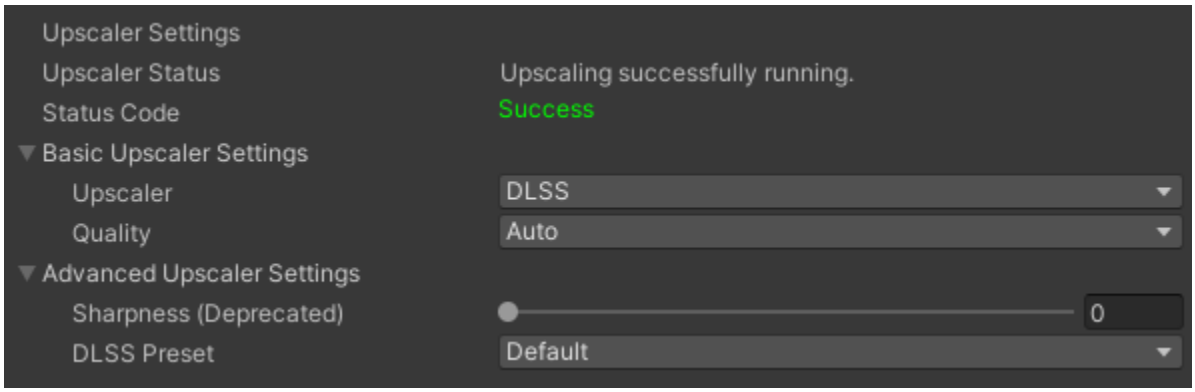
1 Using the .unitypackage File

After importing Upscaler be sure to restart Unity. This must be done so that Upscaler's native plugin can load into memory. If you neglect to restart Unity at this point, expect Unity to crash as soon as you try to use Upscaler. Start by opening the demo scene in the Assets→Conifer→Upscaler→Demo directory. Consult the README.md file in this directory for more information on how to use the demo scene. Play around here and get familiar with Upscaler. When you are ready to integrate Upscaler into your project, open your scene, delete the Demo directory, then go to the Assets→Conifer→Upscaler→Scripts directory and drag and drop the **`Upscaler.cs`** script onto the camera(s) that you want to upscale.

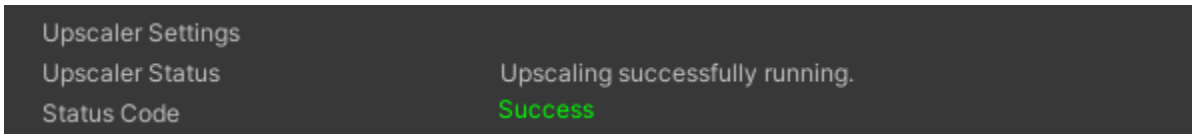
Consult Using the Unity Editor GUI for more information on how to control the upscaling from the Unity Editor. Consult Changing Settings to learn how to control the upscaling from within your scripts. Finally, check out GUI Integration in order to add upscaling controls to your game's GUI.

2 Using the Unity Editor GUI



When correctly attached to the camera, Upscaler's settings should appear as they do above in the camera's inspector. This section provides detailed descriptions on the uses of each of the elements in this GUI.

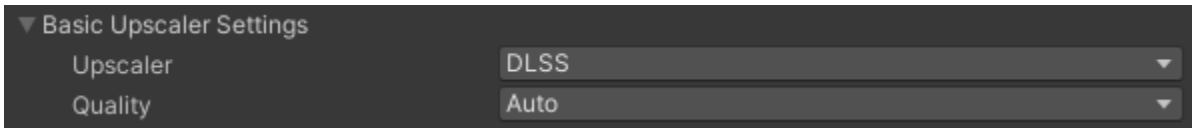
2.1 Upscaler Settings



The “Upscaler Status” field will provide a description of Upscaler’s current state in plain English. When Upscaler is behaving as expected, it will read, “Upscaling successfully running.” If Upscaler has encountered any type of error this field will change to read, “Upscaling encountered an Error. Fell back to the 'None' Upscaler.” When this message appears it means that the DLSS upscaler has encountered an error and was unable to continue. Upscaler has automatically reverted settings to use the “None” or dummy upscaler. For more information on how to properly handle and recover from these errors consult section 3.3 Handling Errors.

The “Status Code” field provides a more accurate description of the error. It also will take on the name of the value of the **`enum Upscaler.Status`** that is represented by **`Upscaler.status`**. Internally, two of the possible states for this field represent success states, states in which Upscaler is still behaving as desired. They are **`Success`** and **`NoUpscalerSet`**. Those will both appear in the color green. Anything that appears in red is an error.

2.2 Basic Upscaler Settings



The “Upscaler” dropdown menu allows you to select one of the available upscalers. *Currently*, there are just two: “None” and “DLSS”. Selecting “None” will enable the dummy upscaler. This upscaler forces the game to render at the output resolution. It entirely removes Upscaler from Unity’s render pipeline. It hides all of the other settings; ultimately, it behaves as an off switch for Upscaler. Selecting “DLSS” will enable the DLSS on this camera. DLSS passes motion vectors, the depth buffer, and the color buffer through a neural network to quickly perform high quality upscaling. This setting will respect your selection in the “Quality” field.

The “Quality” dropdown menu allows you to select a quality mode at which to run DLSS. This setting is ignored if the “Upscaler” option is set to “None”. DLSS has five quality modes, four of which scale by a constant amount, and “Auto”, which chooses another quality mode as given by the output resolution. Consult the charts below for more information.

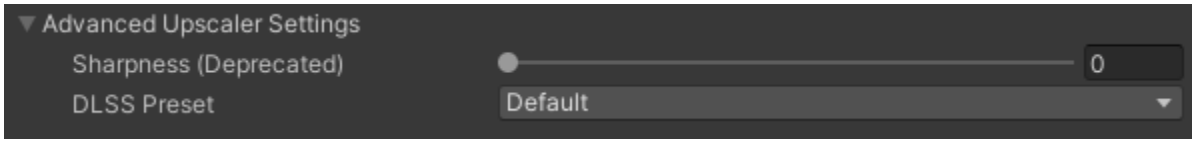
DLSS Quality Mode Effects on Render Resolution

Quality Mode	% less rendered pixels per-axis	% of total pixels rendered
DLAA	0%	100%
Quality	33.3̄%	44.4̄%
Balanced	42%	31%
Performance	50%	25%
Ultra Performance	66.6̄7%	11.1̄%

DLSS “Auto” Quality Mode Choice

Output Resolution	Chosen Quality Mode
Less than or equal to 2560x1440	Quality
Less than or equal to 3840x2160	Performance
Greater than 3840x2160	Ultra Performance

2.3 Advanced Upscaler Settings



The “Sharpness” slider controls the amount of sharpening that DLSS will perform. Please note that this setting has been deprecated by NVIDIA. Even when DLSS is active and this slider is set to a non-zero value, it may be true that no sharpening effect is visible. NVIDIA has provided no replacement and has instead recommended rolling a custom

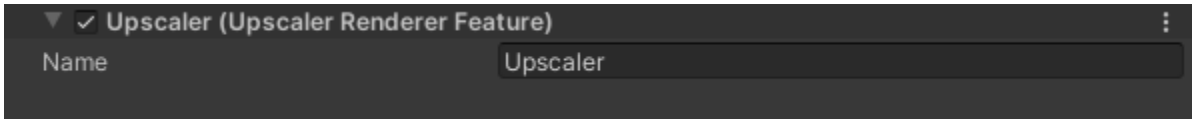
sharpness solution. Conifer also recommends rolling a custom sharpness solution, as even when DLSS' sharpening does work, it often produces very poor results.

The "DLSS Preset" dropdown menu gives you several options to help DLSS work better with your game. Most games will not need to deviate from the default preset, but some games may benefit from them.

- Use "Stable" if the contents of your camera's view changes slowly. This option favors older information for better antialiasing at the expense of ghosting.
- Use "Fast Paced" if the contents of your camera's view changes quickly. This option favors new information for better clarity at the expense of antialiasing quality.
- Use "Anti Ghosting" if some of the contents of your camera's view lacks motion vectors. This can be useful when working with third party plugins that do not correctly handle motion vectors.

3 URP Integration

While integrating with the URP, it is not only important to add the `Upscaler` script to the camera; the `UpscalerRendererFeature` must also be added to the URP Renderer which that camera is using. Failing to do either will result in an error.



The `UpscalerRendererFeature` subscribes its `PreUpscale` static method to the `RenderPipelineManager.beginCameraRendering` event. This performs the necessary checks to ensure that the camera being rendered has an `Upscaler` script on it, then calls the `OnPreCull` method exposed by that script.

It also uses a single `ScriptableRenderPass` to perform the actual upscaling. This goes as follows:

1. Get the depth texture from the `_CameraDepthTexture` global shader texture.
2. Select the output texture from either the `Camera.targetTexture` if that is not `null`, or the integrated color output target.
3. Get the motion vector texture from the `_MotionVectorTexture` global shader texture.
    a. This `ScriptableRenderPass` configures motion vectors as one of its inputs

4. Blit the source depth texture onto the integrated depth target.
    a. This step is necessary to ensure that the size of the depth image is correct when using DLSS with dynamic resolution.
5. Upscale.
6. Either blit the integrated output target onto the `null` camera target, or blit the integrated depth target onto the camera's non-`null` target..

This render pipeline integration injects its `Camera.rect` reset during the `AddRenderPasses` call. This `ScriptableRenderPass` is bound to `RenderPassEvent.BeforeRenderingPostProcessing + 25` which puts it squarely in the middle of post processing. Be sure that effects that should be upscaled go before this event and effects that should not be upscaled go after this event. If you must move this render pass ensure that it stays within the range of `RenderPassEvent.BeforeRenderingPostProcessing + 1` to `RenderPassEvent.BeforeRenderingPostProcessing + 49`. It will break in various ways outside of this range.

4 BRP Integration

BRP integration is very simple. The upscaling happens in the `OnRenderImage` method of the `Upscaler` class. This method will simply blit the source into the destination if the upscaler is set to 'None', but when DLSS is enabled, it will automatically perform all of the following steps.

1. Select the output texture from either the destination if that is not `null`, or the integrated color output target.
2. Blit the depth component of the source onto the integrated depth target.
    a. This step is necessary to ensure that the size of the depth image is correct when using DLSS with dynamic resolution.
3. Get the motion vector texture from the `_CameraMotionVectorsTexture` global shader texture.
    a. The `Camera.depthTextureMode` is set to include the `DepthTextureMode.MotionVectors` and `DepthTextureMode.Depth` flags.

4. Upscale.
5. Either blit the integrated output target onto the `null` camera target, or blit the integrated depth target onto the camera's non-`null` target.

This render pipeline integration injects its `Camera.rect` reset at the beginning of the `OnRenderImage` method.

5 Jitter

Jitter happens during the `OnPreCull` method of the `Upscaler` class. Jitter values are queried from the C++ backend then added to the camera's projection matrix to offset the camera by that many pixels. When integrating Upscaler into your rendering system, be aware that `Camera.ResetProjectionMatrix` is called at this time. This happens so that the last jitter values are cleared from the projection matrix before we add new ones.

6 Viewport Sizing

Viewport sizing happens during the `OnPreCull` method of the `Upscaler` class. Viewport sizing is handled using the `Camera.rect` property. See Dynamic Resolution for how viewport sizing is computed when dynamic resolution is enabled. When dynamic resolution is disabled the camera is sized to `Upscaler.RenderingResolution / Upscaler.OutputResolution` on both axes.

7 Dynamic Resolution

Dynamic resolution is supported by Upscaler. When it is enabled, Upscaler will force `ScalableBufferManager`'s width and height scale factors to stay within the bounds imposed by DLSS. When using dynamic resolution, the camera's rect property does not change. Due to some issues with floating point precision, these bounds are rounded up to the next 0.05 interval. This will usually result in a range from 100% to 55%.

While Upscaler does support dynamic resolution, not all of DLSS' quality modes support it, namely Ultra Performance mode and DLAA mode. Attempting to enable dynamic resolution with one of these modes active will automatically disable dynamic resolution then log a message to the console explaining what happened.

8 Changing Settings

Upscaler allows you to change the settings through C# scripts using its API. Below is an example script that shows how one can get the Upscaler object, then use the API it provides to change upscaling settings on-the-fly.

Obtain an instance of the Upscaler class from the main camera. It is highly recommended that you ensure that the camera actually exists. The example below works, but is not error protected at all. Use it with caution.

```
Upscaler.Upscaler upscaler = Camera.main!.GetComponent<Upscaler.Upscaler>();
```

Use `Upscaler.QuerySettings` to get a copy of the settings currently in use by the upscaler object.

```
var settings = upscaler.QuerySettings();
```

Make your desired changes.

```
settings.upscaler = settings.upscaler == Settings.Upscaler.None ?
Settings.Upscaler.DLSS : Settings.Upscaler.None;
```

Use `Upscaler.ApplySettings` to push your changes to the active upscaler.

```
upscaler.ApplySettings(settings);
```

When calling this function, be aware that it can throw `Upscaler.Status` errors if something goes wrong. It is advisable to handle errors that this function returns in-place.

9 Handling Errors

Errors can occur when requesting a settings change. By default, when this happens the default error handler will reset the current upscaler to “None”. This will remove the `Upscaler` plugin from the pipeline ensuring that `Upscaler` does not cause any rendering errors. If this is not the behavior that you want, you can choose to override the error handler. You may want to instead revert back to the last settings that worked, print the error to the console, or anything else.

$$1 \leq upscalingFactor = \frac{outputResolution}{inputResolution}$$

$$Length = upscalingFactor.x \cdot upscalingFactor.y \cdot 8$$

First, to override the error handler replace the empty lambda with the function that you wish to respond to errors in the code below.

```
Upscaler.Upscaler upscaler = Camera.main!.GetComponent<Upscaler.Upscaler>();
upscaler.ErrorCallback = (status, message) => { };
```

Next, if you wish to perform any settings changes within your error handler, refer to section Changing Settings. If you do not perform any settings changes then the active upscaler will be set to “None” to prevent fatal errors.

The error handler is always called from the `Update` method of the `Upscaler` class in the frame after the error to which it is responding occurs.

10 Things to be Aware of

The following is a list of advice both from Conifer and from NVIDIA as given in their DLSS developer guide.

1. Disable all forms of anti-aliasing including but not limited to MSAA, TAA, FXAA, and SMAA.
2. Textures should use a default mip bias calculated using the formula below when being dynamically added to the scene. When using dynamic resolution, use the lowest possible resolution for the `renderingResolution`. When settings that require a new DLSS feature to be created are changed, the default mip bias handler will set all textures in the scene to have the correct mip bias. You are responsible for any dynamically added textures.

$$mipLevelBias = nativeBias + log_2\left(\frac{renderResolution.x}{outputResolution.x}\right) - 1.0$$

3. Use DLSS for rendering directly to the screen **OR** rendering to an image that will be post processed before being presented directly to the screen. Do **NOT** use DLSS to upscale things such as:
    1. The view through portals.
    2. The view of a security camera onto a monitor.
    3. Static textures.
    4. Shadow maps.
    5. A depth pass.

    Or any number of possible non direct-to-screen views.

4. The Upscaler plugin is incompatible with RenderDoc. While this is unavoidable due to RenderDoc being incompatible with DLSS itself (as of RenderDoc v1.31 and likely long into the future), an alternative is available. Use NVIDIA's Nsight Graphics for graphics debugging. You can connect to Unity's Editor by launching it from Nsight Graphics. Upscaler will be able to load successfully, and will not interfere with any captures. Nsight Graphics is available for both Windows and Linux and was used to help create this plugin.

5. Read the DLSS developer guide for more information.

11 GUI Integration

Consult the DLSS UI Developer Guidelines PDF for more information about integration with in-game GUIs.

Do note that in contrast to what is suggested in the above guidelines PDF, the 'Auto' setting does not disable DLSS under any circumstances. Conifer chose to do this because we believe that the settings that the user selects should be honored. If the user wants DLSS off, they turn off DLSS. If you choose to follow the guidelines PDF more closely you will need to perform the required resolution check yourself.

12 Contact

This document will be kept up-to-date with the latest releases of Upscaler. The document version number will be the same as the Upscaler version number. If any errors in this documentation are found or you have any further questions, please report them to briankirk@conifercomputing.com.