Crysis 2

DX11 Ultra Upgrade

1   Introduction

With Crysis 2 being our first multi-platform game, our main focus was to ensure a successful delivery on all supported platforms. Unfortunately, such constraint didn't allow us to concentrate on DirectX 11 with the level of commitment that is to be expected from a Crytek release. This is the reason why it was decided to give the R&D team sufficient time and effort after the release of Crysis 2. The "DX11 Ultra Upgrade" is the result of this work: it is a free visual upgrade add-on introducing DirectX 11 support, as well as a wealth of graphical improvements and performance optimizations for both DX11 and DX9 API's.

Several visual improvements are made available in this free upgrade, such as hardware tessellation, soft shadows with variable penumbra, improved water rendering, particles motion blur and shadows, re-introduced parallax occlusion mapping and full resolution HDR motion blur.

Furthermore, three new technologies have been developed: realtime local reflections, contact shadows and sprite-based Bokeh depth of field. We also provide several performance optimizations, hardware based occlusion culling for DirectX 11 being one of the most significant. All these updates are now part of the new "Ultra spec" settings. In addition, we're releasing a free higher resolution texture pack together with an advanced graphics menu and improved multi-GPU support.

Since the release of Crysis 2, a major effort by the R&D and Art departments was necessary in order to develop this DX11 Ultra Upgrade. The DX9-to-DX11 transition also required a strong QA involvement, ensuring that all functionalities were working as intended. Adding hardware tessellation support and updating the tools to pre-process all assets to support such a feature and to generate first-step height maps for displacement monopolized the majority of the time frame allowed for the development of this upgrade. These displacement maps were later processed by the Art team in order to ensure high quality hardware tessellation.

2   Tessellation and Displacement Mapping

One of the most important updates provided by the DirectX 11 API is the introduction of programmable hardware tessellation, via Hull/Domain shaders. We decided to push harder in this area, since the few DirectX 11 capable games on the market only use this feature for certain simple procedural effects.

Picture 1: Wireframe view of the hardware tessellation for the alien tentacles

CryENGINE 3 now supports tessellation for all mesh types, which means all assets can potentially use tessellation. Many Crysis 2 assets are relatively low poly and this is not necessarily ideal for hardware tessellation to work properly. In certain hardware configurations, the more tessellation you need to process, the worse the performance. As such, all geometries are pre-tessellated. The Art department can then easily decide which assets should use such feature, finding an ideal compromise between quality and performance. In addition to the tessellation, we apply displacement mapping for fine geometry details.

One of the biggest benefits from tessellation is the increased details on geometry silhouettes without visible under-sampling artifacts which is not easily achievable on shader-based techniques like Parallax Occlusion Mapping.

Picture 2: Notice the higher amount of detail on the rubbles

However, we found out that the current hardware is still not fast enough to tessellate an entire world and there are fundamental issues with tessellation and displacement mapping that hardware vendors did not anticipate. These include visual glitches with decals, character foot IK and geometry intersections. Such issues were addressed by the Art department with a balanced usage of deferred decals and parallax occlusion mapping.

Picture 3: Notice the higher amount of details on the brick walls and their better silhouettes

Picture 4: Notice the higher amount of details on the alien tentacles

3   Parallax Occlusion Mapping

For the latest CryENGINE 3 iteration, we have re-introduced Parallax Occlusion Mapping (POM) in order to add macro details that are not efficiently possible with hardware Tessellation.

Picture 5: Notice the amount of details and the self-shadowing on the mud and on the pavement

This technique efficiently approximates surface displacement in tangent space (there is no real geometry displacement, just a noticeable view dependent parallax motion change). Although POM is not as flexible as hardware tessellation, it has a couple of strong advantages such as simulation of macro details and self-shadowing.

Picture 6: Notice the higher amount of detail on the plastic floor

4   Realistic Shadows with Variable Penumbra

The Ultra spec introduces the support for variable penumbra soft shadows. This feature simulates real-world shadows: the bigger the distance between the shadow caster and the shadow receiver, the softer the shadow becomes over distance. This produces more physically accurate shadows approximation, rather than applying a constant blur on the entire shadow.

Picture 7: Notice the smoother shadows over distance: the shadow from the tree is blurrier at far distance and the ones from the ambulance and from the stretcher are sharper at close range

5 Water and Ocean Improvements

Water volumes and ocean now support DirectX 11 hardware tessellation. The mesh geometry is now dynamically tessellated based on the distance to the camera. This allows a high amount of geometry details close to the camera and eliminates geometry aliasing, which was noticeable on camera rotations with the former static mesh approach. The water ocean animation is implemented through a sum of FFTs octaves, which provides a much higher frequency wave composition.

Picture 8: Notice the higher amount of detail on the water nearby the camera and the wave crest foam

Furthermore, the shading has been updated: we now support sub-surface scattering and wave crest foam approximation, done in the domain shader. The water also offers a more accurate surface normal computation. Plus, the water interaction physics have been polished further.

Picture 9: Notice the high quality water interaction on water surface

6   Full Resolution HDR Motion Blur

The Ultra specs for DirectX 11 re-introduced full resolution temporal anti-aliasing, commonly called motion blur. The new improved and efficient version provides much sharper motion blur results, compared to the DX9 version counterpart. The object motion blur masking was improved as well.

Picture 10: Notice the lower picture definition and the motion blur bleeding on the arms and the weapon

Picture 11: Notice the higher image definition and the absence of motion blur bleeding on first person assets

7 Sprite-based Bokeh Depth of Field

A new depth of field technique was implemented for DX11: instead of using a post process, we use a sprite rendering technique. Such approach is commonly used in the movie industry.

Picture 12: Notice the limited out-of-focus regions range for minimizing the noticeable under-sampling occurring with DirectX 9

For each screen pixel, we render a quad/sprite. This sprite size is scaled based on a factor of how much of the pixel is in focus or out of focus (commonly denominated as Circle of Confusion). Such sprites can also feature a mask approximating the camera aperture shape.

Unfortunately, the graphics hardware is still a few years away from being able to efficiently use such techniques at full screen resolution. Thus, this implementation is done at half resolution and includes a number of additional optimizations. One of the main advantages of this approach is the ability for arbitrary large defocus amount, without under sampling.

Picture 13: Notice the more accurate camera model representation allowing a much higher range for the defocused areas with DirectX 11

Picture 11: Notice the pentagonal Bokeh mask shape used for this example, simulating a different type of camera aperture

8 Contact Shadows

Contact Shadows or Screen Space Directional Occlusion (SSDO) is a novel technique that is used in Crysis 2 for the first time in a shipped title. SSDO is more physically correct than our former SSAO (Screen Space Ambient Occlusion) approach and provides smooth contact shadows that are especially noticeable when using ambient deferred lights which do not cast traditional shadow. We came up with a new implementation which is efficient enough to allow contact shadows to be applied to every light source in the world.

Picture 14: Notice the smooth contact shadows produced on the rubbles and on the sand bags

The SSDO can also help fixing self-shadowing issues and greatly improves the global lighting quality, especially in interiors.

Picture 15: Notice the increased quality of the self-shadowing on the crates thanks to the SSDO

9   Realtime Local Reflections

Reflections are one of the biggest challenges to solve efficiently in real-time rendering, particularly for deferred rendering/lighting based engines. The options for generating reflections are limited: planar reflections as seen on water or cube map reflections. We introduce a novel approach: realtime local reflections (RLR).

Picture 16: Notice the reflections rendered on the glossy plastic protection on the ground

RLR approximates ray-traced HDR reflections local to objects. Although the results are not always perfect this technique allows for any kind of curved surface in the scene to efficiently

reflect the nearby surroundings in real time, including self-reflections which are not possible with cube map or planar reflections.

Picture 17: Notice the reflections of the characters, the neon lamps and the fence on the glossy metal panels

10 Particles: Motion Blur, Shadows and Art Updates

The particles have received support for motion blur, meaning the faster they move the more motion blur they will receive. Particle can also receive shadows, which improves particle lighting consistency. Both those features can be enabled by the VFX artists, who have beautified further the particle effects of Crysis 2 for this DX11 Ultra Upgrade.

Picture 18: Notice the shadows on the smoke particle effect

11 Advanced Tone Mapping

The latest version of our tone mapper introduces S-Shaped curve color control to better mimic the behavior of Film tone reproduction.
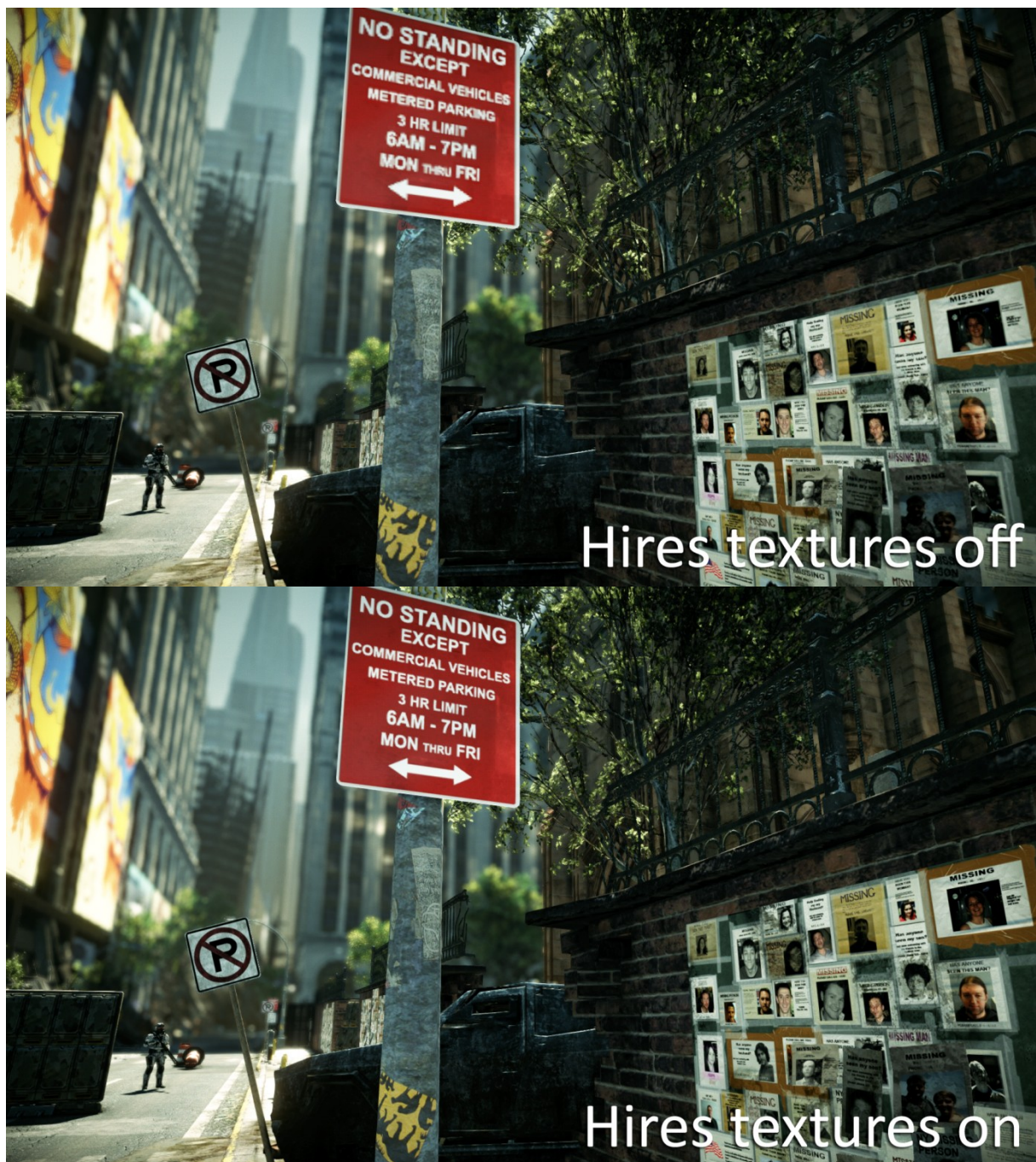

Picture 19: Notice the improved tonal definition and the more vibrant overall picture

Such change allows for a wider tonal range, with perceivable improved definition on the dark tones, which the human eye is particularly sensitive to. It also provides a better control for the lighting artist on the exposure of the scene.

12 Higher Resolution Textures

Crysis 1 had a limited amount of textures, as scenes were composed mostly with vegetation, rocks and terrain. Crysis 2 features so many more textures than Crysis 1 that it would have required several DVDs to store them.
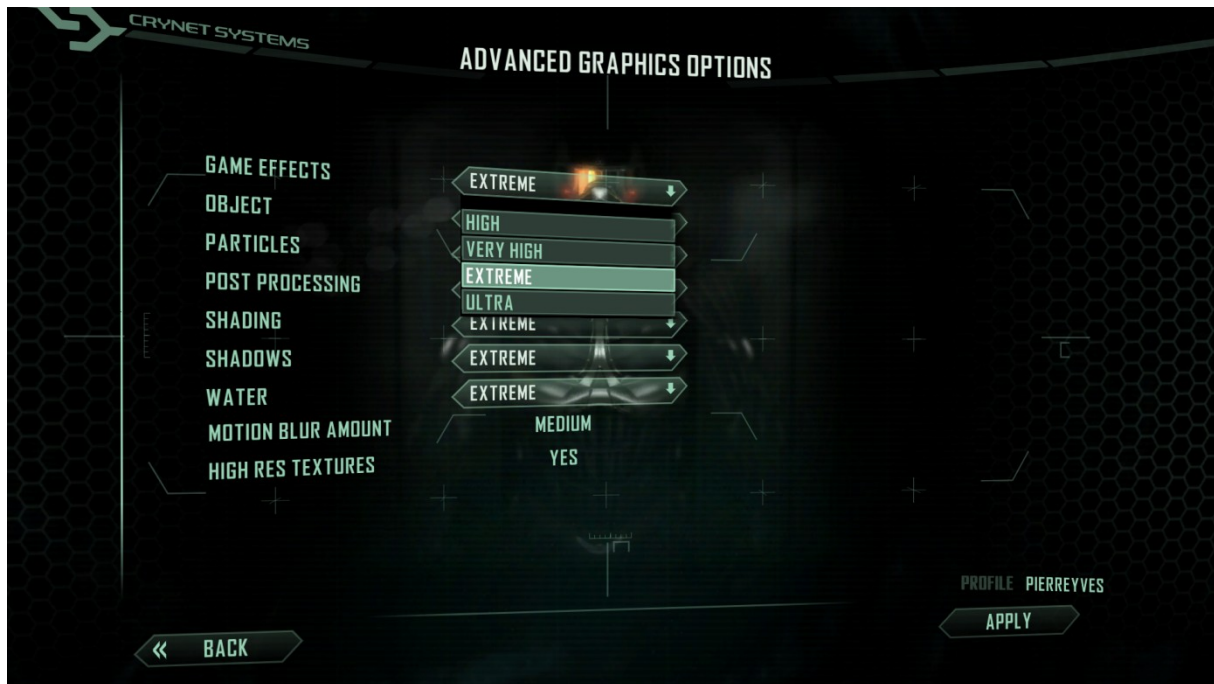
Thus, we now release a higher resolution textures upgrade as a free DLC, which features 2x increased resolution and this actually means 4x extra memory requirement. Thus a minimum of 1 GB memory for the graphics card and a 64-bit operating system is required. This pack of Hi-Res textures is available for both DX9 and DX11.

Picture 20: Notice the higher resolution of many textures, especially assets containing texts

13 Advanced Graphics Options Menu

The DirectX 11 support, the Ultra spec and the extra graphical features introduced with the DX11 Ultra Upgrade come at a performance price: they added an additional overhead of ~30%. It now makes sense to expose more graphical options for the players to be able to fine tune the performance of Crysis 2 on their machine, especially for the owner of DX11 cards that do not appear in the current list of recommended graphics cards.

Picture 21: Advanced graphics options with High/Very High/Extreme/Ultra settings

The new Ultra spec enables:

1. Object: Tessellation, Parallax Occlusion Mapping
2. Particles: Shadows, Particle Motion Blur
3. Post Processing: High Quality Motion Blur and DOF
4. Shading: Contact shadows, Realtime Local Reflections
5. Shadows: Realistic Shadows with Variable Penumbra
6. Water: DX11 version of ocean and water volumes

The owners of high end recommended graphics cards, such as the NVIDIA 480 GTX or equivalent, should be able to run the game with Ultra settings at a resolution of 1080p with an average frame rate of 35 fps.

14 Conclusion

We believe that we only started to scratch the surface of what is possible with the DirectX 11 API. In the near future, we will see a much higher usage of hardware tessellation for visual effects and compute shader functionality for new approaches.

Besides the aforementioned features, there are also additional updates, which are not directly part of Crysis 2, such as light shafts for any light source, HDR support for light coronas and shadow casting particles. They will be made available in a future release of the CryENGINE 3.

The quality upgrades showcased in this article are the results of long hours and hard work against the clock, not only including development and QA, but also simultaneous researches and optimizations. I would like to conclude this article by expressing, once again, that we hope that everyone, on any PC spec, will appreciate the end results of our efforts as much as we enjoyed working on this DX11 Ultra Upgrade.

A big thanks to the entire Crytek team, especially our great Art and R&D team and to those who directly contributed to this latest update: Andrey Khonich, Carsten Wenzel, Chris Auty, Frank Meinl, Kenzo Ter Elst, Michael Kopietz, Michael Glueck, Minghao Pan, Nicolas Schulz, Nick Kasyan, Li Deng, Simon Fuchs, Sergey Sokov, Sean Ellis, Vaclav Kyba and Vladimir Kajalin; last but not least, a big thanks to our Lighting Artist, Pierre-Yves Donzallaz, for his helpful article reviews and for showing our technology under the best possible light with remarkable screenshots.

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15 Comparison Before and After DX11 Ultra Upgrade

Picture 22: Comparison for the Battery Park level

Picture 23: Comparison for the Downtown level

Picture 24: Comparison for the Terminal level