Underwater Toolkit: Mixed Reality Object Blending for 360° Videos

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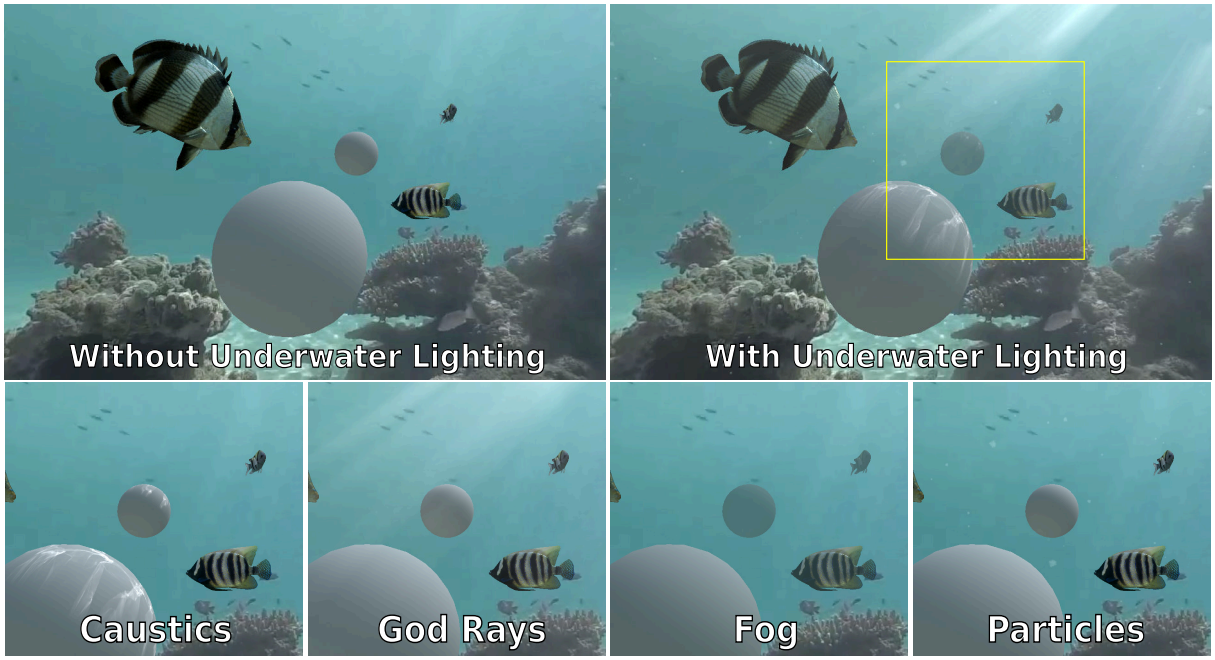

Figure 1: Real-time mixed reality underwater rendering into a 360° video. Top left is without our method, top right is with our method applying underwater lighting. The bottom row shows each of the underwater lighting effects individually.

Abstract

We present the Underwater Toolkit, a mixed reality (MR) toolkit that enables seamless blending of virtual objects into underwater 360° videos (360-video) in real-time. It is fully integrated into commercial game engines such as Unity3D and Unreal Engine 4 (UE4), providing a complete pipeline for underwater 360° videos. The toolkit provides real-time underwater lighting (caustics, god rays, fog, and particulates) to ensure that the virtual objects are lit and blend similarly to each frame of the underwater video semi-automatically and in real-time. Our toolkit's user-friendly interface enables users to fine-tune the underwater lighting parameters so they can match the lighting observed in the 360-video for improved visual quality and seamless blending. In our demonstration, users will be able to immerse themselves into underwater 360-videos using a HMD. Using motion controllers, the users will be able to interact with fish by feeding or catching them. An additional user will be able to interact with our toolkit, changing underwater lighting parameters to seamlessly blend fish into the 360-video in real-time.

Index Terms: Computing methodologies—Graphics systems and interfaces—Mixed / augmented reality

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1 Introduction

360° omnidirectional videos (360-video) shown in head mounted displays (HMDs) provide a wide field of regard and immersive viewing experience, giving the user a high sense of presence in the surrounding scene in a video. Recent mixed reality (MR) research [2] provides real-time high-fidelity composition and seamless blending of virtual objects into the 360-video. This is done with image based lighting and shadowing that utilise the 360-video as the light source to illuminate the virtual objects as well as the background for compositing into. This allows for interactive MR experiences with virtual assets that seamlessly blend into the 360-video.

360° cameras have advanced such that people can film underwater environments. While high-fidelity blending of virtual objects with 360-video has advanced in recent research, compositing into underwater footage needs to address the additional challenges posed by the complex lighting that occurs in water. Current methods do not take into account the underwater lighting effects, resulting in rendered virtual objects that feel superimposed rather than seamlessly blended into the underwater 360-video.

Since water is a volumetric medium, light penetrating from the water surface will scatter, absorb or transmit as light rays shine through the body of water. This produces lighting effects such as fog and god-rays. The water surface itself also refracts the light, creating patterns of light below the surface called caustics. There are also particles floating through the volume. Underwater specific lighting is ignored in current solutions to 360° MR rendering, resulting in improper lighting and blending of the virtual objects for underwater 360-video. Furthermore, such underwater lighting in computer graphics is expensive [1, 3], posing the additional chal-

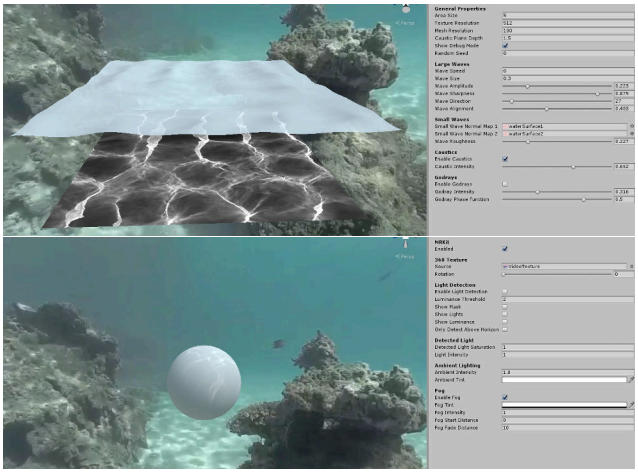

Figure 2: User interface for setting the Underwater Toolkit parameters.

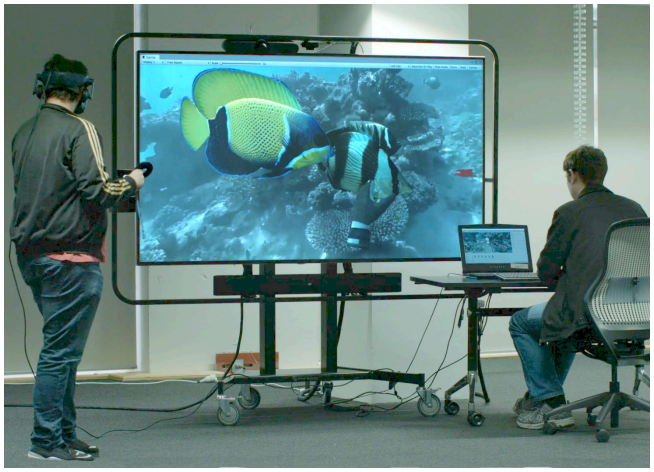

Figure 3: demonstration setup. The first user (left) is interacting with fish in the 360° underwater mixed reality environment. To seamlessly blend the virtual objects into the video, a second user (right) is editing the underwater lighting parameters in our toolkit in real-time.

lenge of producing a high frame rate suitable for modern HMDs (e.g., 90FPS).

We propose the Underwater toolkit, a toolkit that provides semi-automatic blending of objects in underwater 360 videos. Our toolkit includes a novel method to enhance the visual quality of underwater MR using 360-video. We developed four underwater lighting effects to improve the quality for underwater real-time rendering: caustics, god rays, fog, and particles. The flexibility of our toolkit facilitates its integration into commercial game engines (e.g., Unity and Unreal Engine 4 (UE4)), to enable users to semi-automatically blend virtual objects into underwater 360-videos. Once setup, the underwater lighting effects will be automatically updated by the captured light in every frame of the 360-video. Our toolkit is flexible, easy to use, semi-automatic, allows for iterative parameter refinement, and does not require pre-computation.

2 Underwater MR Rendering and Toolkit

The Underwater Toolkit provides a pipeline to semi-automatically blend virtual objects into underwater 360-videos. The underwater lighting is computed in real-time, allowing users to interactively adjust parameters while observing the changes. During video playback, the user can rapidly adjust the underwater lighting to match the background video. Once the parameters are set, the Underwater Toolkit will automatically update the lighting conditions for each frame. The parameters include ambient light intensity, directional light intensity and color, light detection, fog, and water surface.

The water surface and corresponding caustic map can be viewed through the game engine's scene view, providing easier matching with the 360-video. Most parameters are either in a range of 0-1 or set in world space scale. The intensity for the caustics and god rays are kept separate to enable more artist control over the blending. God rays have an additional phase function parameter to define how close to the light source the god rays should scatter. We used the game engine particles system to simulate the particles.

Figure 2 shows the Underwater Toolkit integrated into Unity, where the user can drag and drop a 360-video to set the background and lighting conditions. They can also pull in 3D virtual assets which will seamlessly blend into the 360-video, observable in the editor's preview window. Our toolkit supports real-time rendering covering diffuse, glossy, and mirror-like reflections. We support various input devices for interaction including HTC Vive controllers, Oculus Touch controllers, and Leap Motion hand tracking.

3 Demonstration

In our demonstration, users wear a HMD and immerse themselves into an underwater environment (Figure 3). They are able to observe exotic fish and coral in full 360-degree panoramic view. Using motion controllers, they are able to reach out and interact with fish. They can feed the fish and capture them for closer inspection. A secondary user can interact with the toolkit by editing the underwater lighting parameters, using the Unity3D user interface in edit mode. These updates are done in real-time, allowing them to easily blend the virtual objects into the 360-video. The adjustment of parameters can also be set before the start of the MR experience.

4 Conclusion

We propose a toolkit to seamlessly blend virtual objects into 360-videos in real-time. Our toolkit provides a user interface that is fully integrated into commercial game engines, such as Unity3D and Unreal Engine 4. The toolkit allows users to fine-tune underwater lighting parameters for improved visual quality and blending. Future work include improved simulation of particles on the virtual objects and image-stabilization of the 360-video.

Acknowledgments

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