Interactive Virtual Shadows on Real Objects in Augmented Reality

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Abstract *:*

In realistic Augmented Reality, interaction between real and virtual objects plays a significant role. Interaction between virtual shadows on real environments and vice versa are the topics of research being conducted in this area. In this paper we introduce a new technique to cast virtual shadows on real environments. A Kinect camera is used to generate a depth map of the real scene. Then, based on the depth of each pixel a 3D mesh is constructed which is the required material for generating the reconstructed scene in virtual environments. This model is called Phantom which is constructed in real-time. Converting the phantom into transparent tacit surface and track it in the same place of real environments is the final step of the proposed method. We demonstrate the tracking ability of our algorithm and the results are evaluated using qualitative and quantitative methods and compared with previous phantom generations in AR applications.

Keywords-component; Real-time shadows, augmented reality, 3D reconstruction

I . Introduction

Mixed Reality (MR) is the integration of Virtual Environments (VE) and Real Environments (RE). A virtual object set within a real environment constitutes an Augmented Reality (AR) system. An AR-system incorporates more real objects and a few virtual objects with the real AR taking a dominant role over the virtual. On the other hand, if a real object is set within a virtual environment, the system is called Augmented Virtuality (AV). In this case, most of the system is virtual. Figure 1 illustrates these concepts.

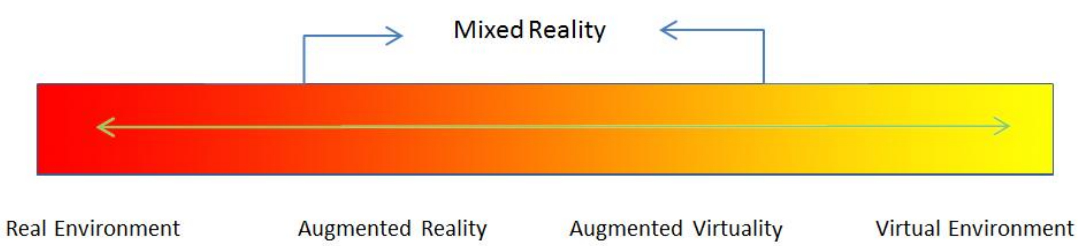

Figure 1. Illustration of Mixed Reality

Nowadays many researchers have focused on augmented reality due to most of computer graphics applications require computer-generated objects to be seamlessly integrated into natural images or videos such as environmental assessments and computer games. Moreover, the appearance of virtual objects should reveal the consistent with effect of the interaction between objects or even sky color in outdoor rendering.

Augmented Reality is the current demand in any different area that AR is involved such as medicine, education, manufacturing, advertising, gaming and tourism [1][2][3][4]. To create realistic AR systems, shadows are very important as they create the perceptual illusion that the virtual content is in the real world. Shadows enable the spectator to detect the distance between different objects, and to reveal the complexity of such objects, resulting in a more realistic environments. Shadows are also helpful to reveal information about lighting and light position. Overall, they make it more believable that the virtual object is in the real world.

II . LITERATURE

There have been many computer graphics techniques [5] [6] that have been developed for reconstructing physical scenes [7][8]. In our work we are interested in real time environment modeling using depth sensors such as the Microsoft Kinect. Izadi et al. [8] introduced KinectFusion to reconstruct a real-time mesh of real environments. They employed the Kinect camera to read the depth data and to track 3D pose of the Kinect depth sensor for creating 3D models of real scenes. The method is GPU based which is used for object segmentation and user interaction.

Newcombe et al. [9] demonstrated real-time mapping of indoor environments using a Kinect camera to reconstruct the scene's geometry. While moving the camera, they fused all the current and previous depth data from the Kinect to reconstruct the current situation of the environments.

Many researchers have studied how the shadows in AR environments can be applied and improved [10] [11] [12]. Other research has focused on enhancement of virtual shadows, making objects more realistic in outdoor AR rendering [13] [14] apart from any interaction between real and virtual objects. An interaction between sky colour and virtual objects during daytime is one of the latest works that makes the AR system more realistic, but suffers from casting shadows on real environments [15].

Most recent AR systems have tried to create virtual objects in flat surfaces to hide the weakness of realistic shadows on real objects or even other virtual objects [16] [17] [18] [19] [20][35].

Haller et al. [11] used shadow volumes to generate shadows on real objects in AR. In their algorithm a virtual phantom object is created to simulate a real object. The silhouette of both virtual and phantom objects must be detected. Phantoms could receive the virtual shadows. Generating phantoms in 3D software in advance is another issues with this technique. The method is expensive not only due to designing the 3D phantoms in 3D software, but also for employing shadow volumes.

Madsen and Laursen [21] used dynamic range environment maps which could represent the real illumination but in stereo disparity images. The main focus is on shadow detection using a camera equipped with location recognition.

Jensen et al. [3] applied projection shadows, while considering real light, but without taking the shadows from other objects into account. Nowrouzezahrai et al. [22] considered light factorization for augmented frequency shadows in AR environments to enhance the realism. They focused on shadow generation in indoor rendering. The main weakness is casting shadows on flat surfaces.

Aittala [23] applied Convolution Shadow Maps (CoSMs) [24] to produce soft shadow in AR, employing both mip-map filtering and fast summed area tables [25] to enhance blurring with variable radius. Casting virtual shadows on real objects is not taken into account.

Madsen and Lal [26][12] proposed a technique to produce virtual shadows on real objects and vice versa using colour imagery. They estimated the outdoor illumination conditions in AR systems based on detecting the dynamic shadows. They used shadow volumes for generating virtual shadows. The direct sun and sky illuminations from pixel values of dynamic shadows in live video are taken into account. Figueiredo et al. [13] used filtering method such as Percentage Closer Filtering (PCF) [27] and Variance Shadow Maps (VSM) [28] to generate shadows. There is no interaction between real and virtual objects.

Castro et al. [29] proposed a method for producing soft shadows with less aliasing, which uses a fixed distance relative to the marker, but with only one camera. The method also performs sphere mapping [30], but selects a single or a number of light sources, most representative of the scene. This is important because of hardware limitations of mobile devices. The method suffers from self-shadowing as well as soft shadowing. They used filtering methods such as PCF [27] and VSMs [28] to generate semi-soft shadows.

III . METHOD

This section discusses the different components of our AR pipeline and how they create virtual shadows that are cast on the real world to produce realistic AR scenes. The virtual objects were first modeled using 3D Studio Max, and then augmented into the scene using a marker based tracking technique; Metaio game engine. The AR system used the Metaio SDK [31] for tracking and the Unity3D game engine for rendering [32]. A virtual light source was to be placed into the scene to control the situation and direction of shadows. This can move, based on user keyboard input. In our system shadows are generated using widely used techniques to show the its ability to generate virtual shadows on virtual and real objects, simultaneously. Our method is employed to reconstruct the physical scene into a 3D model that is placed in the live video, from a webcam connected to the Kinect camera. Phantoms are rendered using transparency, so the real objects they cover can be seen. Depth data is created using Kinect camera which can be seen in Figure 2.

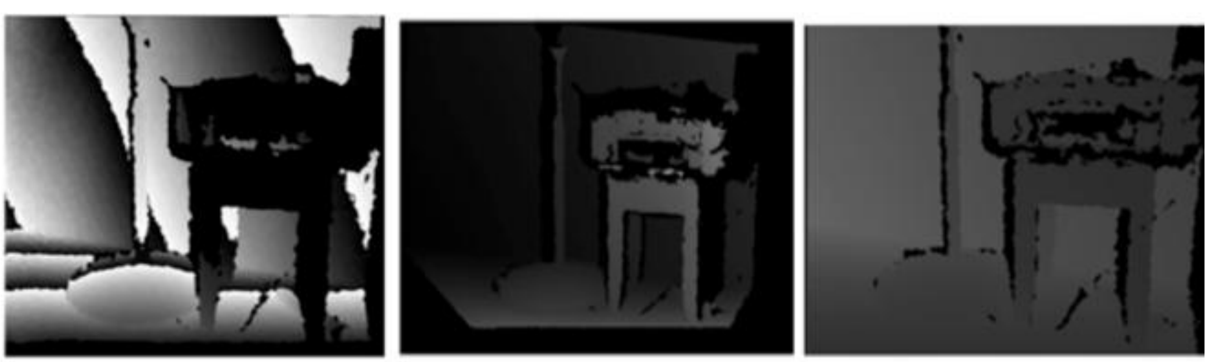

Figure 2. Depth Map generation using Kinect camera

Our method allows users to use a standard Kinect device equipped with a simple webcam to reconstruct the 3D environment to be used as a phantom in AR systems. A simple and small movement of Kinect, generates a different viewpoint and makes the reconstruction more accurate. Capturing the environment from many different viewpoints results in more accurate phantoms but larger models. To avoid this issue the Kinect camera can be fixed or moved quickly, or the real objects has to be moved. A separate webcam lets the users to see the augmented objects from different viewpoints, if the Kinect camera had previously captured them.

IV . RESULTS

In the case of real-time rendering our method is accurate enough. The wire and fingers for each parts of the printer can be observed easily. However the wire on the fan's leg is very thin, observed from the cast shadows. Shadows on these parts can be cast like the real object, and that is illustrated in Figures 3.

To generate shadow on real objects, an object similar to the real one is constructed but in transparency mode. The transparent object is called phantom which, there is no need to be more accurate. The virtual shadow can be cast on phantoms, which are placed on the same location of the real one.

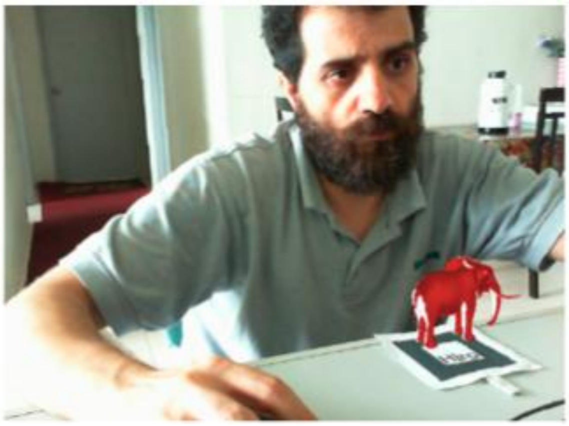

Figure 3. *Left: Augmented reality system includes some real and a virtual object, Right: Interact between virtual object and real one,*

Here we show how the system is robust in the case of interaction between real and virtual environments. Any animated and non-animated object could be used in this system. To make the mixed system more realistic, virtual and real objects need to avoid any conflict. Moving virtual objects through the real objects without taking the real objects as an obstacle makes the mixed scenario non-realistic. Our method prevents this conflict due to the collider of the generated mesh for all real objects.

Physical effects, such as rigid body could be applied on the reconstructed mesh as a mesh collider. Using this ability on the invisible mesh in AR systems makes the environments more interactive.

V. CONCLUSION

Shadows are one the principle parameters to make Augmented Reality systems more realistic. Casting virtual shadows on other virtual and real objects in real-time was the ultimate target of this study to enhance the realism of AR systems.

Our method is introduced to create phantoms in realtime. In this case there is no need to create phantoms in advance. A Kinect camera captures the environments, by connecting the neighboring pixels in the created point cloud, faces and consequently meshes of the real environment are reconstructed to be used as the phantoms in the AR system. The phantoms are loaded in the AR system in transparency mode. Therefore, the main gap of the previous works for casting shadows on real environments which was the weakness in moving, adding, and removing real objects in real-time has been addressed. The virtual shadows could be cast on the phantoms and could be seen on the real environments with no more tolerance in real-time.

VI . ACKNOWLEDGMENT

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