Fused AR Experience

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Figure 1: *Spring Training 2009, Peoria, AZ.*

Abstract

Traditionally Augmented Reality has taken three main forms each with its own drawbacks. Optical see-through gives us a good view of the real world but it is difficult to show virtual objects effectively as occlusion cannot be achieved. Spatial Augmented reality doesn't allow the user to view the virtual content at the correct depth. The closest to approach to ours is Video See through augmented reality however it suffers from mismatch between the location of eye and the camera center. In recent years there has been a lot of work on accurately reconstructing a 3D representation of the environment using RGBD sensors. We propose a system that combines such a realtime reconstruction method with a Head mounted display to create a wide field of view Augmnented Reality system.

Keywords: KinectFusion, RGBD, Augmented Reality

Concepts: •**Computing methodologies** → **Image manipulation;** *Computational photography;*

1 Introduction

Recent advances in reconstruction methods means that we can create a 3D representation of an environment in real time. The ability of these methods lead us to imagine an alternate form of Augmented Reality. By attaching an RGBD sensor to a VR HMD we can reconstruct the environment around the user as he moves around in his environment. As we have a 3D model of the environment we can render the view from each of the user's eyes. This enables us to accurately reproduce the real environment of the user in stereo. Virtual content can then be composited over the model of the real environment. By using the tracking from the reconstruction method we can align the virtual content with the reconstruction.

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Figure 2: *Ferrari LaFerrari. Image courtesy Flickr user "gfreeman23."*

2 Related Work

Our work is most related to the idea presented by [Izadi et al. 2011] that KinectFusion can allow for more realistic "Geometry Aware" Augmented Reality where virtual objects could be overlaid on the reconstruction of the real world. In the past Depth Cameras have been used in spatial augmented reality for overlaying the a mesh of the real world on the environment and modifying it through interaction [Wilson and Benko 2010].
Our generation of virtual content relies on deforming the virtual model. This is achieved through the use of dual quaternion blending [Kavan et al. 2008].

3 System Design

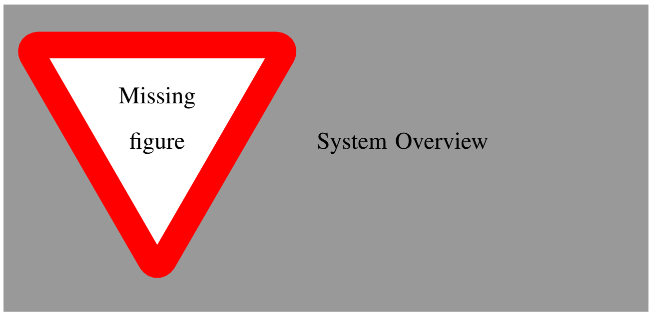
Our setup consists of a Kinect camera rigidly aligned to an Oculus Rift HMD (Figure

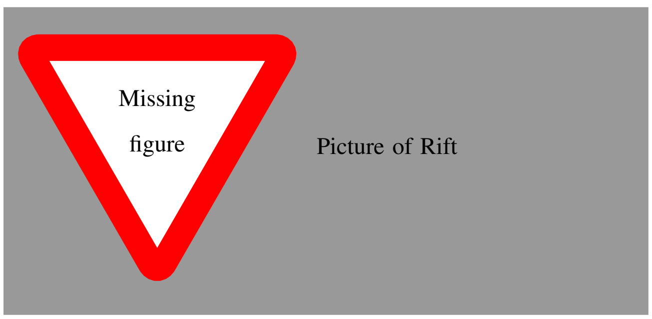
Add picture of rft and kinect

). The kinect acquires RGBD images which as used as input to the KinectFusion algorithm. Using the RGBD images, KinectFusion estimates the camera pose and uses this to integrate the current depthmap into the reconstruction. Virtual content is generated by animating a rigged model of a virtual character. The reconstruction is rendered from the viewpoint of the eyes. The virtual content is then composited onto this. If the virtual content is transformed using the same tracking as the reconstruction then it remains aligned to the environment.The combination of the reconstruction and virtual content is then rendered onto the HMD. Figure

Add system overview figure

shows the System Overview.





3.1 Environment Capture

In order to capture the environment, we rely on the KinectFusion[Newcombe et al. 2011] algorithm as our environment is static and we require the algorithm to be realtime. There are two main implementations of KinectFusion available. The Kinect Development Toolkit for Windows comes with an API to access KinectFusion. They do not provide source code but let the developer access KinectFusion in a limited matter. Also this version has only been demonstrated on small volumes and the tracking is not very stable when using large volumes with small voxel denisty. Given a camera pose and a camera matrix, the API allows the user to render the scene from that camera.
The other popular implementation is KinFu that comes with PCL. This contains extensions on KinectFusion that enable it to work in large areas. It does so by decomposing the environment into chunks that can be uploaded to the GPU. This allows it to reconstruct a large volume while maintaining a high voxel density.This results in more robust tracking.

3.2 Generate Virtual Content

3.3 Composit Real and Virtual Content

We use the textures from KinectFusion as background and composit it with our virtual content.

3.4 Tracking

KinectFusion uses the current depth image and tries to align it with the reconstruction to find out the camera pose. This camera pose is used to track the head-mount with respect to the world. The same transform needs to be applied to the virtual content to keep it fixed with respect to the real world. For our initial experiments however, the rotational tracking from the Oculus was used to align the virtual objects. This can be shifted without too much effort to use the tracking from KinectFusion ensuring that the objects stay aligned to the real world.

3.5 Display on HMD

To render on the HMD, we draw our content on the framebuffer provided by Oculus Rift SDK for each eye. In order to ensure that the content looks correct through the oculus, we provide the desired FOV and texture size expected by the Rift to the KinectFusion API. Some further calibration was performed to ensure that objects in the Oculus appeared the same size as the real world. In our setup, the Kinect is placed above the Rift and thus the perspective from which its looks at the environment is different than the eye. We transform the Kinect to the pose of the centre of the Rift. Eye Position translations are then applied to get the poses for the eyes. The environment is rendered from each of the poses and passed to the Rift. The additional virtual content is rendered on the same buffers. The rift applies lens distortion correction and displays it.

4 System Implementation

As the KinFu implementation is open source and offers the ability to capture larger environments, we tried to use that first. KinFu comes in aversion of PCL that does not come with compiled binaries. Therefore we had to compile PCL from source. With some effort, we were able to get it to compile however there were certain dlls that PCL expected from Windows and those had changed in Windows 10 and so we were unable to run KinFu there. Observing this, we switched to Ubuntu. I was able to compile PCL on both my laptop and a machine obtained from the IT department. However, both machines failed to acknowledge the sensor. Eventually, it was found that our sensor even though the same model was slightly newer and was not supported by the OpenNI 1 library. OpenNI 2 that would've supported our sensor was not supported by KinFu. rather than waste anymore time on modifying KinFu source code to support OpenNI 2, we decided to abandon KinFu and switched to Microsoft's Kinect Fusion API. It gave us limited access to KinectFusion, in particular we could only rely on the API to render the the reconstruction for us. This also meant that we could only render content completely in front of the reconstruction and not partially occluded by it.

5 Results

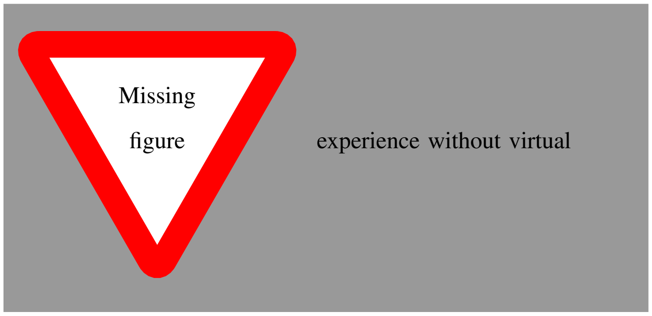
As the user gets into our system, the world around him is reconstructed as he moves his head around. The user can walk around freely in this reconstructed environment as is tracked as he moves around. In addition to the reconstruction of the real world, he sees dynamic virtual characters that are aligned to the real world. Figure

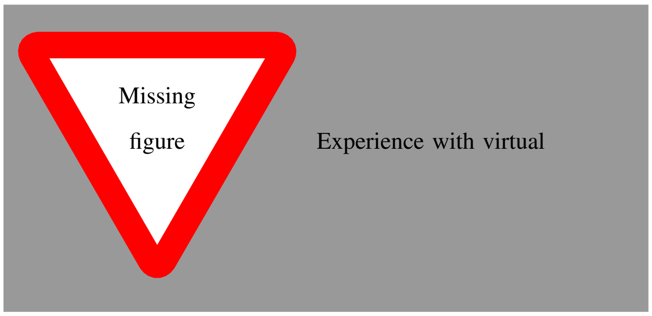
add image without virtual content

shows the experience without the virtual content and figure

add image with virtual content

shows the experience with the virtual content.





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