EE368 Project Proposal
360 Rendering of Stereoscopic 3D Views from Spherical Image Pairs

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1 Introduction

This project aims to render stereoscopic 3D views of an environment based on pairs of 360 degree images captured at different heights. By capturing these images, it is possible to estmate pixel disparities and corresponding pixel depths to create a 3D construction of the environment surrounding the cameras. Stereoscopic views of this depth map are then calculated by projecting the environment to two horizontally displaced viewpoints, and performing hole filling to give realistic parallax effects.

Images will be captured with two Ricoh Theta 360 degree cameras. These cameras use two 185 degree fisheye lenses each to capture and stitch 360 by 180 degree images. This capture method has several advantages over traditional panoramic image capture, primarily that it allows for capture of moving scenes by photographing an entire scene simultaneously. This means that such that such a capture system and 3D rendering could create completely immersive video experiences to be viewed on a device such as an Oculus Rift. We will not be using a DROID phone.

2 Generating Depth Map

The first half of this project will be to generate a depth map that can later be used for steroscopic reconstruction. Two 360 images will be captured at different heights and will be used to generate a disparity map. Normally, with a spherical camera, stereo matching requires a search along a conic curve, however, a vertical displacement simplifies this search to a single vertical line. For depth reconstruction, we first need to generate a disparity map, which provides information on the distance for each pixel between the two images. The distance of a single point from the two cameras is then determined by triangulation.

To generate the disparity field, we will be using PDE-based estimation that minimizes an energy function. However, there are several difficulties with this approach such as segmentation of textured regions, stereo occlusions, and computational complexity. [1] addresses many of these problems and proposes various solutions for each. With their method, we should be able to construct a disparity map that will allow accurate stereoscopic reconstruction.

3 Stereoscopic 3D Reconstruction from Depth Map

After successful generation of depth map, the second half of the project will focus on computationally rendering a stereoscopic view of the 360 image. In theory, creating stereoscopic from a single image can be thought of as generating a 'second view' by shifting each pixel in the original image based on its depth information previously computed. In practice, however, the computed depth map tends to be noisy and hence, a naïve pixel-level algorithm described previously will fail to produce a stereo view of acceptable quality. Smoothing out depth map using filtering [3] and image segmentation to identify foreground objects and background [2] are helpful in tacking this issue.

Another challenge is the phenomenon of *disocclusion*, which refers to regions which are visible only from the new viewpoint but not from the original one, due to the displacement of the viewing position. And hence, information about these areas is missing from both, the original photo and also from the depth map. These regions can be filled in, in the new view, by the process of averaging textures over neighboring pixels [3], also called *hole-filling* or *inpainting*.

References

[1] Hansung Kim and Adrian Hilton. 3d scene reconstruction from multiple spherical stereo pairs. *International Journal of Computer Vision*, 104(1):94–116, 2013.

[2] Hansung Kim, Muhammad Sarim, Takeshi Takai, Jean-Yves Guillemaut, and Adrian Hilton. Dynamic 3d scene reconstruction in outdoor environments. In *International Symposium on 3D Data Processing, Visualization and Transmission 3DPVT*, 2010.

[3] L. Zhang and Wa James Tam. Stereoscopic image generation based on depth images for 3d tv. *Broadcasting, IEEE Transactions on*, 51(2):191–199, June 2005.