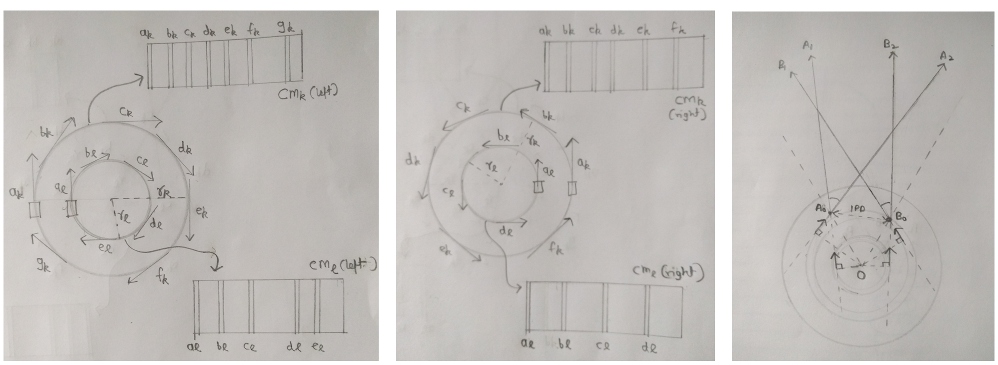
EE 367 Term Project
Rendering stereoscopic panoramas from Concentric Mosaics

Ishan Patil [iapatil@stanford.edu]

Project Motivation

Cylindrical stereoscopic panoramas give a 360° view of the scene around us. They comprise of a pair of images, one for the left eye and other for the right eye, which can be merged and then experienced through a VR viewer, for example the Google Cardboard. One way in which they can be captured is by rotating two slit cameras separated by the Interpupillary distance (IPD) (to stimulate a stereo panorama for human eyes) around an axis which passes through the center of the two cameras. This gives stereoscopic depth cues for all possible viewing directions, but from a fixed viewpoint.
If we were to replace each of the slit cameras by conventional cameras that capture multiple vertical "slits" to from a regular 2D Image, we would be capturing overlapping images of the scene at each angular position. The Concentric Mosaics representation of this data can then be used to theoretically render novel views from any point inside the circle with radius equal to the distance of the camera from the rotation axis. Since one off centered camera, either to the left or the right of the center, would only capture rays in the clockwise or counterclockwise direction respectively, we need a hardware setup that would capture images corresponding to both of these rays for each angular position. This is illustrated for the case of slit cameras in Figure 1 (a) and (b).
In [1], authors captured the CM's by first rotating the camera in clockwise direction and then in the anti-clockwise direction. Hence, with only one camera a representation as captured by the two-camera setup was obtained. The advantage of the two-camera setup is to capture both (clockwise and anti-clockwise) rays in one go. More importantly, this project is motivated by the fact that one can generate stereoscopic views from any two points in the circular region separated by the IPD, once such a representation is captured through the two-camera setup as shown in Figure 1 (c).



(a) (b) (c)

Figure 1: (a) Concentric Mosaics, CM_k and CM_l captured by rotating a slit camera in the clockwise direction for rendering a panorama for the left eye. (b) Concentric Mosaics, CM_k and CM_l captured by rotating a slit camera in the counterclockwise direction for rendering a panorama for the right eye. (c) A novel stereoscopic view rendered from two points A_0 and B_0.

Related Work

The Concentric Mosaics scheme was introduced in [1] as an image based rendering technique that captures a 3D slice of the plenoptic function by constraining camera motion to planar concentric circles around a fixed point. The authors in [1] also mention that an equivalent and much simpler method to capture such a representation is to use a single off-centered camera that rotates along a circle. Efficient rendering strategies to generate novel views from these mosaics without vertical distortion and necessary minimum sampling rates are further elucidated in [2]. Some innovative ways of capturing stereo panoramas are mentioned in [3] and [4]. More particularly, a setup as shown in [4] has been already developed in the Stanford Computational Imaging Lab to capture omni directional stereo panoramas which uses two off-centered cameras, along a line passing through the axis of rotation.

Project Overview

The idea for the project is to use the dataset of left and right images captured using the existing setup to render two sets of Concentric Mosaics. The 3D slice of the plenoptic function captured through these two mosaics will then allow us to render novel views from any two points within the space of the the circular region captured through the left and right off-centered camera. If these two points are separated by the IPD, then the rendered views corresponding to the set of concentric mosaics from the left camera and right camera respectively will theoretically give a stereoscopic panorama from a viewpoint that is at the middle of the two selected points. Although, in reality, the possible viewing directions would be limited by the angle of view of the camera and a reduced set of directions would be obtained, this would nonetheless give a perception of translating the head slightly and getting to see the parallax in a stereoscopic panorama. The reason behind this is explained through Figure 1(c). Rays spanning the field of view from A_0A_1 to A_0A_2 are rendered from rays tangent to previously captured CM's from camera in orientation as in Figure 1(a). Similarly, the field of view from B_0B_1 to B_0B_2 is rendered from rays tangent to previously captured CM's from camera in orientation as in Figure 1(b). Since both these points are separated by the IPD, a stereo novel view is generated. The theoretical concept will also be validated by rendering for a synthetic scene simulated using a ray-tracing software. This project is also being pursued as an independent study project under Prof. Gordon Wetzstein.

Milestones, Timeline & Goals

The project is divided into two major chunks as below-

- Reconstructing a set of concentric mosaics from the dataset
- Rendering novel views for these "actual" mosaics as well as those simulated "synthetically" to validate the idea.

The work on the first part of the project has been accomplished to a great extent and the ongoing task is to realize novel views from these already reconstructed mosaics and possibly apply one of the vertical undistortion techniques as mentioned in [2] if the novel views don't turn out to be as expected ideally. There are a few practical difficulties that also need to be addressed, as the small range of possible novel views due to limited angle of view of camera. There isn't any plan of changing the hardware setup for this project as of now, but could be discussed as a possible extension if the small baseline between the two cameras isn't enough to generate the effect of a subject being able to translate their head and see parallax changes which has been the intended motivation to pursue this project.

References

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- [4] Bourke, Paul. "Capturing omni-directional stereoscopic spherical projections with a single camera." Virtual Systems and Multimedia (VSMM), 2010 16th International Conference on. IEEE, 2010.