Panoramic Reconstruction from Multiple Light-Field Images

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Introduction

Panorama imaging has already become an essential part of commercial photography applications. It is considered to be a necessary feature for a camera rather than an extra feature. On the other hand, light-field imaging, where the angular incidence data is also collected in addition to the conventional 2D image data, is a new field with enormous potential in commercial photography. Especially with the emergence of the 3D imaging and display industry, light-field imaging holds great promise. Hence, it can be expected that light-field imaging will become much more common in the near future and everything available to the conventional imaging needs to be available in the light-field domain. Panorama is one of these applications. Therefore, demonstration and implementation of light-field panorama imaging are very interesting projects that we are aiming to accomplish.

Related Work and Project Overview

In this project, we aim to implement the creation of a light-field panoramic image by taking multiple light-field images with a Lytro camera at different camera angles. In converting multiple images to the panoramic one, we aim to capture the correct occlusion boundaries, anisotropic reflections, refractions, and other complicated light effects in order to preserve the reality of the scene as much as possible. This preservation is actually required to have the distinctive effect of light-field images, which is the presence of directional ray information, compared to the more traditional microlens-free imaging technique.

A brief investigation of the literature reveals three leading methods for creating light-field panoramic images. The first method, which is naïve multi-perspective image stitching[1], stitches corresponding perspective images of the input light fields individually using classical panorama imaging. Despite its simplicity in implementation, since this method stitches the light-field images independent of their directional domain, the resulting image might exhibit artifacts during the synthetic refocusing operation.

A more advanced (and computationally expensive) method to implement light-field stitching is to calculate focal stacks in all images and then stitch these images individually[2]. Then, the panoramic focal stacks are merged to get a four-dimensional light-field image. This method eliminates the previously mentioned synthetic refocusing difficulties with the panoramic image. However, the data is essentially a direct concatenation of 3D images and experiences difficulties with showing direction dependent reflection effects.

The state-of-the-art method, which processes ray entries directly[3], eliminates problems associated with occlusion boundaries, anisotropic reflections, etc. since it computes the panoramic light-field directly from the individual light-field images. This method works by taking multiple light-field images at pre-determined angles, calculating the corresponding cylindrical light-field parametrizations, and blending the resulting data. An initial calibration step is required for a specific focus and zoom setting in order to extract the intrinsic parameters of a light-field camera. This calibration step is largely similar to the one discussed in an earlier study[4].

Optional Work

Moreover, if we have time after we obtain our primary result, we would like to extend our project by implementing optional user-interaction features. We think these features would be especially useful for our project demonstration. We have three ideas which we will try to implement if we have time to do so:

1. We want to be able to rotate our panorama light-field image via a mouse. When we drag the mouse, the image in the screen will rotate and change. Since the monitors have lower aspect ratio than our panoramic image, the monitor will show only a part of the image. When we move the mouse cursor, the part of the image shown on the screen will move.

2. We want to implement this rotation feature of our image by tracking the head of a user. In this way, the user interaction will be via a head-tracking system instead of a mouse. We may implement a simple, and moderately accurate head tracking system. For this purpose, we may benefit from an elliptical head tracking method using intensity gradients and color histograms[5].

3. If we still have time, we would like to take multiple panoramic light-field images from regularly separated positions, and show a different image in the screen by tracking the head of a user. Thus, users will be able to look at the scene from a different perspective corresponding to the position of their heads.

Tentative Timeline

- Developing a detailed understanding of light-field panorama literature – 1 week
- Implementation of light-field panorama with the available methods and images – 1-2 weeks
- Taking our own images and obtaining light-field panorama images – 1 week
- Implementation of the optional parts – 1-2 weeks

Conclusions

In summary, our primary goal in this project is to implement one of the major ways of light-field panorama imaging while preserving the natural image cues as much as possible. On top of this demonstration, we came up with multiple optional steps that will potentially enrich the overall experience for us. Even though we believe that demonstration of light-field panorama is satisfying by itself, the optional additions will make the overall experience more valuable. These optional parts will also make the project demo more fun for our audience.

With this project, we will hopefully improve our backgrounds to the state-of-the-art level in the field of light-field panorama imaging. We will be able to familiarize ourselves with the light-field imaging (both Lytro camera and the processing of the images).

In conclusion, this project will be a very high-level implementation of one of the best performing methods of light-field panorama imaging while the optional parts hold the promise of a very fun and tangible demonstration of this concept.

References

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