High Dynamic Range Light Field Imaging

EE367 Computational Imaging & Display
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1 Introduction

The objective of this project is two-fold. Firstly, using the motivating idea behind a recent approach to create single-shot HDR images by adding a simple optical mask to a light field camera, we will attempt to synthesize a data set of simulated HDR images using pre-existing light field data. Secondly, we aim to combine digital refocusing with a lighting adjustment to display an image that goes beyond a more traditional tone-mapped HDR image to more accurately mimic visual perception by taking into consideration the viewer's gaze.

Not only is there in increasing interest in capturing HDR content, but there are also limited solutions to effectively display it. For both images and video, there is room for iteration in the acquisition and display of HDR content. To begin with stills, HDR images are typically captured using multiple exposures. This only produces good results for static scenes and can lead to artifacts like ghosting. The resultant image is heavily stylized in a form. While this format has overtime developed its own appeal, it is unrealistic. While there are formats that are increasingly popular for HDR content, standard dynamic range displays are far more common. Ultimately, capturing HDR content on a single sensor with the ability to refocus and adjust lighting either in response or to direct the viewer's gaze could open up new avenues for creating an interactive and immersive media experience.

2 Related Work

Two approaches to single-shot HDR that bear mention are the KaleidoCamera and Magic Lantern software-add on for Canon. The KaleidoCamera uses a physical add-on to create multiple copies of a sensor image and use optical filters to obtain and reconstruct information for many imaging purposes including light fields. Magic Lantern allows for substantive improvement in dynamic range. Both approaches could be used in tandem or the KaleidoCamera could be used independently to the same effect as what we propose here.

There are also two popular formats for HDR content. HDR10 uses a 10-bit range and produces around 1000 nits. Dolby Vision uses 12-bit depth and supports up to 4000 nits. In contrast, standard dynamic range displays support between 300 to 500 nits. A thorough analysis would look at the overhead of both popular formats and examine how HDR light field capture could compare.

There have been two notable approaches to postulate how to capture high dynamic range light fields. The first involved interleaving different apertures across the microlens array [2]. The second involves using an checkerboard optical mask with the end result being that each sub-aperture image has a different, uniform exposure [3].

Lastly, we hope to leverage recent work in view dependent tone mapping of HDR video to determine how to best simulate a gaze-aware display of HDR light fields on SDR displays [1].

3 Approach

The first stage involves creating high dynamic range light fields. The first approach will be to simulate the checkerboard mask by manipulating the exposures of the sub-aperture images from pre-existing light field data sets. If this is unsuccessful, high dynamic range light fields will be acquired manually by using an optical mask and Lytro camera.

For the second stage, we will experiment with creating view dependent display images of the high dynamic range light fields that involve view dependent tone-mapping and digital refocusing. Because this is a proof of concept implementation, the system does not need to run in real time.

If time permits, there will be an evaluation of the relative costs and trade-offs of using high dynamic range light fields for both static and dynamic content. Also we will investigate and implement a systematic means of evaluating the view dependent output.

4 Milestones & Timeline

Week 1: This first week will primarily constitute experimentation with synthesizing high dynamic range light fields. We will also work on getting access to a Lytro camera in case we need to manually acquire images and creating the optical mask needed to so. We will also begin preliminary work on the poster and report and complete the introduction sections. Finally, we will begin to investigate in more depth possibilities for view dependent high dynamic range display.

Week 2: Next, we will synthesize or acquire the final set of high dynamic range light fields. There are two ways to accomplish this requisite step; however, manual acquisition will be more time intensive. This week is largely reserved for this part of the process and finalizing how to proceed in creating view dependent output. At this point, the related work and approach sections should be largely complete.

Week 3: The bulk of the third week will be spent in generating and experimenting with view dependent output that involves refocusing and gaze-dependent tone-mapping. A variety of methods will be tested and, for now, qualitatively compared. Hopefully, this will yield a largely completed results and discussion section of the report and poster.

Week 4: The final week of the project is reserved as a buffer and for investigating and implementing evaluation metrics.

References

[1] Najaf-Zadeh, H., Budagavi, M., and Faramarzi, E. VR+HDR: A system for view-dependent rendering of hdr video in virtual reality. In *2017 IEEE International Conference on Image Processing (ICIP)* (Sep. 2017), pp. 1032–1036.

[2] Todor Georgiev, A. L., and Goma, S. High dynamic range image capture with plenoptic 2.0 camera. *Frontiers in Optics* (2009).

[3] Wahab, A., Alam, M. Z., and Gunturk, B. K. High dynamic range imaging using a plenoptic camera. In *2017 25th Signal Processing and Communications Applications Conference (SIU)* (May 2017), pp. 1–4.