Carnegie Mellon University
Electrical & Computer Engineering

Ph.D. Thesis Defense

Wide-Baseline Light Fields — Imaging and Applications

April 9, 2024 | 11:00 a.m. ET | HH 1303

Zoom Meeting

Meeting ID: 957 4064 4987

SPEAKER

Michael De Zeeuw

COMMITTEE

Aswin Sankaranarayanan (*Advisor*)
CMU-ECE

Vijayakumar Bhagavatula
CMU-ECE

Srinivasa Narasimhan
CMU-RI

Wolfgang Heidrich
King Abdullah University of Science and Technology

ABSTRACT

The world around us is filled with complex visual phenomena and geometry that we may wish to understand or recreate. Iridescence, intricate geometry, and complex spatial texture are all examples of such phenomena that can be challenging to both capture and represent. In order to characterize these scenes, we need to consider how light is interacting with different scene points over a broad range of incoming and outgoing directions. Light field cameras provide a framework for capturing this spatial and angular information in a single image exposure; however, traditional hand-held light field cameras only observe a small fraction of the cone of light emitted by a given scene point. As a consequence, the study of interesting angular effects like iridescence are beyond the scope of such cameras.

The aim of this thesis is to present a novel light field imaging device capable of measuring over a wide baseline and to explore the space of applications that would significantly benefit from such light field data. We present motivation for why and how wide-baseline light fields (WBLFs) open up many exciting new capabilities in light field processing, 3D shape reconstruction, and iridescent reflectance reconstruction.

The core contribution of this thesis is the imaging system design for a WBLF camera. We achieve a wide-baseline by imaging the scene with a light field camera indirectly through an ellipsoidal mirror, which provides rich measurements in space and angle. We further analyze the captured light fields to understand the system's capabilities, including considerations of resolution, angular range, coverage, and depth of field. We show this WBLF camera in action through a set of different applications that benefit from our data. First, we develop a suite of geometric processing algorithms to provide a parallel to the techniques employed in traditional light field imaging, including viewpoint synthesis, refocusing, and shape reconstruction. Second, we develop a network similar to state-of-the-art 3D scene representations to train over WBLF data and produce 3D shape and reflectance reconstructions for small objects with varied appearance. Finally, we show that our system is capable of measuring and reconstructing the high dimensionality of the spatially-varying bidirectional reflectance distribution function (SVBRDF) efficiently, particularly for iridescent objects.

In total, these contributions provide a significant advance to light field imaging by establishing the foundation for wide-baseline light field imaging and its applications.

PUBLIC DEFENSE

Event Contact: Michael De Zeeuw (mdezeeu2@andrew.cmu.edu)

Co-Host: Aswin Sankaranarayanan (saswin@andrew.cmu.edu)