Carnegie Mellon University
Electrical & Computer Engineering

Ph.D. Thesis Defense

Full-Surround 3D Reconstruction using Kaleidoscopes

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Zoom Meeting

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ABSTRACT

3D scanning of a single view of an object seldom suffices. Be it for 3D printing, augmented reality, or virtual reality, scanning of the shape of the entire object in all its complexity—what we refer to as full-surround 3D—is critical to have a faithful digital twin.

A key factor in achieving a full-surround 3D scan is the number of viewpoints from which an object is imaged. Covering the entire object that we seek to scan typically requires a large number of diverse viewpoints. Furthermore, this number increases with the complexity of the object. This requirement has led to the construction of light stages with multiple cameras, and potentially projectors, that capture digital content at high fidelity. Unfortunately, the cost and complexity of these systems place them beyond the reach of the average consumer of 3D technology.

A simple way to achieve a very large number of viewpoints is to surround the object we want to scan with mirrors, which conveniently provide additional viewpoints without the need to move a camera or construct a multiple-camera system. In particular, a kaleidoscope, which consists of multiple planar mirrors, allows light to bounce around repeatedly until it hits the camera, thereby providing a combinatorial increase in the number of viewpoints. Thus, with a kaleidoscope and a single camera, we can construct a virtual multi-view imaging system that is easy to build, calibrate and deploy, with components that are easily available.

This thesis aims to solve the full-surround 3D reconstruction problem using a kaleidoscope. We establish the theoretical and practical foundations of kaleidoscopic techniques for full-surround 3D reconstruction. We are particularly interested in the reconstruction of highly complex objects with intricate geometry including self-occlusions. The ultimate goal is to address each step of the kaleidoscopic 3D reconstruction pipeline, including kaleidoscope calibration, kaleidoscopic structured light, and kaleidoscopic neural rendering.

PUBLIC DEFENSE

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