EE 367 Project Proposal
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Motivation

Depth sensing and computer vision is critical for robotics, augmented reality, autonomous vehicles, and other applications of growing importance. LIDAR imaging is one of the most promising technologies for quickly acquiring high resolution depth maps, but the high cost of laser/APD pairs and their alignment (which results in low resolutions) and the use of spinning components to mechanically scan the scene reduce their effectiveness in many applications. Compressive sensing approaches using micro-mirror arrays allows a single sensing element to capture information from the entire scene at high resolution without using any (macroscale) moving parts. In this project, we intend to build a single-pixel LIDAR system that uses compressive sensing to capture depth information about a scene.

Related Work

Substantial recent work has been conducted in the realm of compressive sensing for capturing visual or hyperspectral images. However, much less work has been done on the use of compressive sensing to gather range information from the scene. Most of the work in compressive sensing for LIDAR has come from Matthew Ware and John Howell at Illinois State and University of Rochester. Howell's group demonstrated a "proof of principle" of compressive LIDAR in 2011, and furthered that work in papers in 2012 and 2013. In this work, a single pulsed laser illuminated a scene, and reflections off the scene were imaged onto a micro-mirror array. From there, the light was reflected off the patterned mirror array and coupled into a fiber which led to a very sensitive time correlated single photon counting module. To reconstruct the depth map from the sequence of image captures with different pseudo-random patterns, algorithms similar to those in conventional compressive imaging were used, but modifications were required to account for the fact that the measurements included both depth and intensity information. It seems that the algorithmic modifications to account for this were some of the most challenging parts of the research.

Project Overview

Our project will encompass the assembly of the experimental setup as well as the capture and processing of the data to recover range information from the scene. We'll need to get the different hardware parts which will primarily involve a pulsed laser diode, a digital micromirror device (DMD) array, and a time-resolved single-pixel sensor. We plan to construct the experimental setup in parallel with the construction of a fake data set that allows us to start practicing how to process single picture camera images. At the end of the project, we hope to be able to construct a system that generates a 3D point cloud of the scene with a single laser/detector and no moving parts other than the micro-mirror array.

Milestones, Timeline & Goals

Week 1: Research hardware, order materials, study single pixel camera and continue reading relevant academic research

Week 2: Construction of fake data set to use to start building image processing pipeline. Construction and calibration of optical setup using TI lighcrafter and TBD laser/photodiode.

Week 3: First data collection, preliminary 3D reconstruction, validation against fake data sets

Week 4: FInalize data collection for presentation, assemble poster, write paper.

References

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