Electrical & Computer ENGINEERING

Carnegie Mellon University

Ph.D. Defense

High Resolution 2D Imaging and 3D Scanning with Line Sensors

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Committee

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Abstract:

In the past few decades, imaging technology has made great strides. From high resolution sensors for photography to 3D scanners in autonomous driving, imaging has become one of the key drivers of the modern society. However, there are still many scenarios where the traditional methods of imaging are woefully inadequate. Examples include high-resolution non-visible light imaging, 3D scanning in the presence of strong ambient light, and imaging through scattering media. In these scenarios, the two classical solutions of single-shot imaging using 2D sensors and point scanning using photodiodes provide widely varying operating points in terms of cost, measurement rate and robustness to non-idealities in the imaging process.

The goal of this dissertation is the design of computational imagers that work under traditionally difficult conditions by providing the robustness and economy of point scanning systems along with the speed and resolution of conventional cameras. In order to achieve this goal, we use line sensors or 1D sensors and make three contributions in this dissertation. The first contribution is the design of a line sensor based compressive camera (LiSens) which uses a line sensor and a spatial light modulator for 2D imaging. It can provide a measurement rate that is equal to that of a 2D sensor but with only a fraction of the number of pixels. The second contribution is the design of a dual structured light (DualSL) system which uses a 1D sensor and a 2D projector to achieve 3D scanning with same resolution and performance as traditional structured light system. The third contribution is the design of programmable light curtains for proximity detection by rotating a 1D sensor and a 1D light source in synchrony. This device detects the presence of objects that intersect a programmable virtual shell around itself. The shape of this virtual shell can be changed during operation and the device can perform under strong sunlight as well as in foggy and smoky environments. We believe that the camera architectures proposed in this dissertation can be used in a wide range of applications, such as autonomous driving cars, field robotics, and underwater exploration.