Title: Depth Map Fusion with Alternating Pulse Widths
Author: Hanseul Jun

Motivation

Although depth cameras play a huge role as a affordable device to scan 3D spaces, the precision of the device does not match other conventional cameras with color sensors. Considering their sophisticated nature, it is impossible to not vindicate depth cameras from this blame. However, the demand from the relevant fields is strong, including augmented reality which I am mostly concerned of. Though the usage of depth cameras is usually restricted to indoors, due to its vulnerability to sun light, considering the stage of augmented reality technology, the value of conquering the indoor environments is apparent, even justifying preprocessing stages to achieve practical precision. Therefore, I would like to improve the quality of depth maps from a depth camera in a stable pose in terms of errors and ranges by alternating pulse widths. The goal is to merge the depth maps into a high quality depth map.

Related Work

There has been several approaches to produce a better depth map using the currently available hardwares. Choi *et al.* [2] tried to unfold—extend the range beyond its conventional limit—the range of depth cameras. They used a model based on the Markov random field which made a significant achievement in their results. They reported that their average success rate is 92.4%. Crabb and Manduchi [3, 4] have made efforts to overcome the limit of range the depth cameras only with a single frequency. Stating that the unwrapping problem is not unique to the field of time-of-flight depth imaging, they tend to adopt techniques from other fields and the first [3] is a probabilistic interpretation toward the phase of depth camera signals, where folding happens. After overcoming [2], they made a step further in [4]. In this paper, they refer "the use of multiple frequencies" as a de facto solution. The papers cited for usage of multiple frequency [6, 5, 1] achieve better precision utilizing the redundancy from the range of frequencies. This result does match the motivating conjecture that usage of multiple frequencies will improve the quality of depth maps.

Project Overview

For this project, an amount of depth maps toward a stable scene from the same spot with different pulse widths are necessary. To obtain them, a hardware for this purpose has to exist. Fortunately, there is a TI TOF camera in the Computational Imaging Lab, and I guess I can use it to collect data. With the collection, I will test several methods to solve the 2-D pulse unwrapping problem using several algorithms including the ones from the course. Seemingly, the algorithms introduced for high-dynamic-range images should be applied at first. Acquiring ground truth would also become a challenge in some cases.

Milestone, timeline & goals

Week6. Collect data using a time-of-flight depth camera with alternating pulse widths.
Week7. Try implementing some of the techniques for the 2-D pulse unwrapping problem to extend range and improve precision.
Week8. Implement other algorithms to solve the problem and compare the results.
Week9. Iterate the above step with different algorithms, trying to beat the existing ones.

References

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