**3-D Depth Reconstruction from Multiple Equally-Spaced Images**

**Introduction:** The focus of this research project was to create an imaging system that produces a scaled topographical map of any real-life object, and to quantitatively determine the limits of such a system.

**Method:** Because of the physics behind the thin-lens equation, we know that at a certain distance from a lens (i.e. the focal length), whatever is at that distance is in focus. So, if we’re able to determine when a pixel of an image is in focus, then we already have a distance associated with it: the focal length. Therefore, we can vary a camera's height at a measureable rate, take images at a specified frequency, and record the distances for which a pixel is in focus. In the end, these distances and their corresponding physical location coordinates can be stitched together to produce a scaled topographical map of the object. In order to determine when a pixel is in focus, a twist on the Variance of the Laplacian method was implemented. In order to resolve discrepancies between the changing fields of view (caused by the moving camera), resizing and smart-cropping techniques were applied.

**Results:** Firstly, it was determined that varying the resizing and smart-cropping features had a negligible impact on the output of the program. Secondly, the system was able to recover shape and approximate depth accurately.

**Conclusion:** The first result implies that no apparent physical limit exists to prevent such a technique from working proficiently, but the second result means that more work is needed. Specifically, future research should:

(i) account for the curvature of the lens to more accurately determine location coordinates,

(ii) experiment with other focus detection methods,

(iii) utilize a much higher quality camera (still with fixed focal length), and

(iv) improve computational efficiency / manage dependencies better.

**Scraps**

It is hoped that this study will encourage investment in future research—specifically in terms of the camera technology used and to better account for the lens curvature.

~~by taking a series of images overhead the object and~~

This has a wide variety of applications. In general, it’s extremely difficult to measure irregularly shaped objects without closely examining the object or attaching sensors; this project and future research could change that. ~~A user would be able to calculate gradients of the surface of the object among other interesting computations.~~ Imagine a space shuttle descending onto an unknown planetary body; it could produce a topographical map of the surface in order to land appropriately and prevent catastrophic damage.

The project began as an idea rooted in basic optical principles.

My research attempted to better understand the limits of such a technique. In the end,. My technology

Future Research:

* better camera—less “fish eye”
* account for the curvature of the lens to more accurately determine location coordinates

The problem is far more complex than the classic textbook problem due to irregularities in the surface of the object we're looking at and the fact that images are 2-dimensional structures. Nonetheless, the physics still functions in a similar manner. The idea is simple enough, but the implementation has been enormously complex. For instance, consider the issue of changing the camera's field of view as we raise or lower it.

But these are the types of challenges which I thoroughly enjoy solving. Furthermore, it has been an amazing experience to be able to work on a project from start-to-finish. Software engineers commonly only work on one portion of the software development life cycle. I've been fortunate enough to see this project through from beginning to end. I've also enjoyed learning new technologies like Arduino and Python. Lastly, I've done this project almost entirely independently. No one is supervising me on a day-to-day basis. I simply have to make decisions and execute them, and I'm proud of that. Scraps: The challenge of this project has b I've been attempting to solve this issue for a while. I've built a translational stage, programmed an Arduino to rotate a stepper motor, and wired a breadboard with the stepper motor, a stepper driver, and the Arduino. I've explored many imaging techniques in order to solve the problem of determining when a pixel is in focus. I will continue to look for the 'best' method once this project is complete. For now, I'm using my own twist on a common method called the "variance of the laplacian." Once the system is fully functioning, I will create a virtual environment so my colleagues can easily run the program for whatever future imaging tasks they may have.