3D Mapping using Photogrammetry

Grant proposal produced for Professor Barrett Hazeltine

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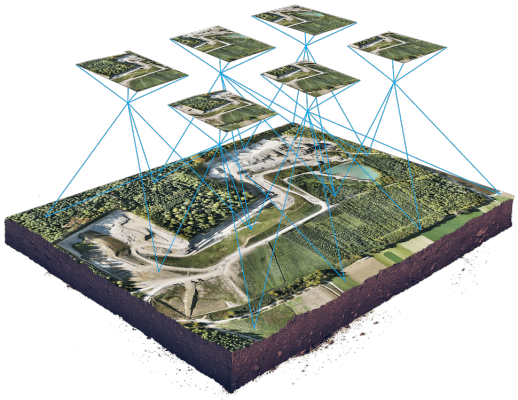

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1 Introduction

The primary motivation behind this project is to design a low-cost, open-source, open-design drone-camera system that will produce a three dimensional map of buildings and terrain in a given area. It will do so by systematically taking photographs of the area at height and then running the image data through a photogrammetry algorithm that will extract and output the 3D data. All of these are explored in much further detail in the following sections of this document.

Firstly, similar land surveying technology is expensive and accessible only by large organizations that can foot the bill. The largest drone-maker in the world, DJI, prices a complete photogrammetry set starting at $20,000, with LiDAR based systems starting at $30,000. Other manufacturers have an even higher range, starting at $20,000 for photogrammetry and $80,000 for LiDAR based systems respectively.

Our system, on the other hand, is projected to cost at least 20 times less. Furthermore, all of our parts are off-the-shelf components and we are set to publish a complete step-by-step guide making the technical details of this project accessible to all those interested. To our knowledge there are no other such fully detailed instructions for assembling and running this system, as such, we would be lowering the barrier to entry into drone photogrammetry, which could have many positive consequences. One important consequence being that institutions and individuals will have increased access to the means and knowledge necessary to 3D map their chosen locations, from historic sites to home-based construction projects, general land surveying etc.

2 The Drone

In order to obtain the images required to put together the 3D map, we are planning to elevate the camera using a specialised drone. This drone will be manufactured in house, requiring only the raw materials and components to build. The drone primarily consists of a carbon fibre frame, the electronics, and 4 brushless motors. We plan to manufacture the frame using the CNC Tormach in the Brown Design Workshop (BDW). It will be designed to accommodate the measurements of the other components and parts. The electronics will consist of a power management system, a lithium polymer battery, a flight control board, 4 electronic speed controllers (one for each motor) and a Raspberry Pi Computer module which will enable us to store images, their respective coordinates and do additional processing.

The primary software for controlling and stabilizing the drone will come from an open source software called 'ArduPilot'. We will develop the software that takes care of navigation, GPS logging, and image processing, which will all happen on board the Raspberry Pi. Finally, in order to stabilize the on board camera, we will likely 3D-print a gimbal in the BDW.

In the bill of materials below we have linked a transmitter and receiver. While the hope is that the drone will be able to fly without human input and return to its original position, it is important that we still have the option of maintaining control of the drone mid-flight in case of a required course correction during the testing phase.

3 Photogrammetry

Photogrammetry is the science of extracting three dimensional data from two-dimensional images. After obtaining the necessary photos, we will run the collection through multiple existing photogrammetry algorithms. Currently, we are aware of two options. There is an open source photogrammetry algorithm called 'AliceVision/Meshroom' that is free to use. The other option is using Autodesk's photogrammetry software which we should have access two under our Brown educational license. Although, once we reach this stage of the project, we will run the photos through as many algorithms we are able to test out in order to produce the best quality 3D map.

It is important to note that running a photogrammetry algorithm will require graphical processing units (GPUs) which are available in the CIT (if this is not an option, we can find a cloud based solution for handling the processing power required instead). Once we find the best software and build the first 3D maps, we will try to build a general photo processing pipeline that will take input images and produce maps without little to no human interaction.

4 Projected Timeline

Given the complexity and scale of the project, we expect it to last about 6 - 8 months. The first stage of the project will be manufacturing and assembling the frame of the drone, while simultaneously, getting the camera and photogrammetry system up and running. The next stage would involve fitting all the components and electronics together and running multiple static tests to ensure all systems function properly. The third phase, which would take the longest, involves achieving full flight functionality through repeated testing and design iteration. Finally, the last phase involves combining the photo and flight functionality of the drone to take high quality images of certain areas around campus, and then stitching them together to form a 3D map.

5 Bill Of Materials

Part	Quantity	Price (in USD)	Purchase Link
Navio Flight Controller	1	$205	Link
Carbon Fibre Chassis	1	$52	Link
Carbon Fibre Sheet	1	$36	Link
Electronic Speed Controllers	4	$100	Link
Power Distribution Board	1	$9	Link
Battery Module	1	$65	Link
Battery Charging Module	1	$12	Link
Tri-blade Propellers	12	$17	Link
Brushless Motors	4	$90	Link
Raspberry Pi V4 Companion Board	1	$95	Link
High Speed Mini SD Card	1	$24	Link
Transmitter & Receiver	1	$58	Link
Pi Camera HQ	1	$50	Link
Pi Camera Telephoto Lens	1	$50	Link

Total Initial Cost: 863 USD

**It is important to note that additional funding for parts may be required (albeit much less than the initial costs detailed above) as components may fail throughout the testing process. The costs above also do not account for shipping or tax.*

6 About Us

We are both freshmen, one concentrating in Mechanical Engineering and the other concentrating in Computer Science and we both have a strong passion for making. We have experience with electronics and CS related projects and are incredibly passionate about building projects that aim to improve access to knowledge related to such endeavours, as well as improve on the costs of current projects to make them more accessible to the masses.