Scanning With Army of Robotic Minions (SWARM)

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1. Abstract

As rising seniors, we are eager to put the knowledge we have gained to work. This project aims to design, build, and program a small group of drones to autonomously 3D scan large structures in a fast and efficient manner.

This project will utilize many different aspects in the field of computer science to ultimately achieve the goal setout below. We plan on mixing LIDAR and photogrammetry to create highly accurate, detailed models of large structures. Using this method, we will need to learn and understand computer vision concepts, 3D mapping, wireless communication protocols, and potentially AI.

As many industries begin to embrace drone technology, specialized drones' demand capable of performing individual tasks has increased. One such mission is rendering a 3D model from images scanned by a fleet of networked (or a single) drones.

The expendability of drones makes them ideal for completing tasks otherwise too dangerous or tedious for humans. For example, following a significant storm, a drone could be used to verify the structural integrity by collecting images of the many columns that make up the support systems and then rendering a 3D model for engineers to inspect for potential issues.

This project seeks to show the viability of this concept by completing a series of goals paced out over our last two semesters before culminating in our capstone presentation required for graduation. By embarking on this project, we will apply everything we have learned and build upon it further.

2. Project Overview

As a hobby, drones and other forms of autonomous flight, have risen in popularity, developing a large, thriving community, using this community will benefit us immensely as it will allow us to fill in some of the gaps in knowledge we will face due to our inexperience as this project develops. Utilized a collection of off-the-shelf parts and some of the many readily available open-source software libraries, much of the drones' construction and ultimate control will be supplemented by these resources.

The construction phase of the project is pivotal. While many drones are available for purchase, we feel that constructing our own with our specialized needs in mind would ultimately serve the project the best.

We are planning to use 3D printing to tailor the hardware to our specific needs. We understand this is a unique approach to obtaining the drones required for this project, but we are convinced that 3D printing of the frame, chassis, and custom mounts for sensors and cameras will be paramount to our success. For other parts such as motors, props, and flight controllers, outside vendors will be used to acquire them.

One of the significant design hurdles of this project is the size of the drones. A larger drone would allow using a powerful microcomputer like a Raspberry Pi 4, a device fully capable of the planned workload. A larger drone would also allow for larger payload capacity, thereby removing some of the limitations of the cameras used.

On the other hand, a smaller, compact drone could be easier to build, with less turnaround time on revisions and modifications this project is sure to need. However, we will be limited to the type of cameras and microcomputers we can fly. An Arduino is well suited for this regarding the flight controller but might struggle with the required workload from the cameras and image processing.

3. Methods

3.1 Flight Controller

Our planned flight controller will be either a Raspberry Pi or an Arduino. We have narrowed it down to these two because they have a familiar interface that will allow us greater control of the drones with minimal direct modification to the controller.

3.2 Flight Software

We plan on using either ROS or Ardupilot for the flight software. This software is open source and will allow us to communicate with any additional sensors we want to add freely. Having the freedom to hijack the code and modify it is a crucial aspect of this project and would be very difficult/impossible to change the source code for a premade flight controller.

3.3 Camera System

To achieve the highest degree of accuracy, we plan to implement LIDAR technology in unison with Photogrammy to create high definition macro models of structures. LIDAR will help autonomously maneuver the drone and create a 3D point map for the photogrammetry software to reference.

Current drone scanning devices can quickly and efficiently capture large areas, but lose all detail if the user tries to zoom into any part. Our goal is to achieve a large scale scan while maintaining a high degree of accuracy and detail.

3.4 Design Notes

This entire process will take many iterations and designs, from the drone's design to the structure of our software. We will need to experiment with many different types of software and hardware to achieve our goal.

Our plan is not to reinvent the wheel. There are many resources and libraries available that can help us to achieve this goal. We plan to implement OpenCV to help with object tracking and avoidance software. OpenCV is "a library of programming functions mainly aimed at real-time computer vision.". By pairing this software(or similar software) with LIDAR, we will have an efficient and quick 3D scanning tool.

While this project's scope is quite broad, we plan to make small manageable steps to achieve this end. Outlined below are minor details of this project, and the timeline we have given ourselves.

4. Project Timeline

Project timeline is split between Fall 2020 and Spring 2021

4.1. Fall 2020 Semester:

August - September

- Draw up the plans for building the drone/s used throughout this project.
- Buy parts and supplies.
- Setup workspace.

September - October

- *Hardware:* Build v1 of Drone
- *Software:* Successfully scan an object without drone.
- *Software:* Develop the Flight controller software package

October - November

- *Software:* Calculate and implement optimum flight paths around objects.
- *Hardware:* Successful flight with the camera mounted on the drone and scanning of an object.

November - December

- *Software:* Develop software suite for capturing the images required for rendering the model

- *Hardware:* First small scale 3D model rendered with images captured by the drone.

4.2 Spring 2020 Semester:

January - February

- Build a second drone.
    - Based on the successful model used in the Fall

February - March

- Network both together drones and have them complete a series of tasks.
    - Verify their ability to perform real time object avoidance and tracking of each other.
    - Scan objects
        - Small objects(car)
        - Large objects(Statue, house)

March - April

- Successfully integrate third and fourth drones into the swarm.
    - This will facilitate the scanning and rendering of large objects(Office building)

5. Team Management and Structure

5.1 Narrative

As alumni of Durham Technical Community College, Seth and James have had the opportunity of working together on projects before. While the complexity of these projects has varied, ranging from junior engineering class projects to NASA sponsored projects, during this, the two of them were able to develop a close friendship and deep respect for one another.

With 20 years of construction experience, James is no stranger to the unique problem solving a project of this caliber will require. When he decided to leave the construction field, he managed to get a junior engineer job. Despite being vastly underqualified for the position, he worked in the field for two years — this is what led him to pursue a degree in Computer Science. He transferred to UNCC in the spring of 2019, intending to earn his BS in Computer Science with a concentration in Data Science.

Being part of the NASA project, Seth was able to design and implement custom circuit designs, robotic arm pieces, and schematics for the payload's internal components. With the experience gained from this and other projects, he worked as a contracted CAD technician for an automotive parts company and transferred to UNCC to the Computer Engineering program. Not being satisfied with this line of work and the course material in the Computer Engineering program, Seth changed his major to a BS in Computer Science with a concentration in AI, Robotics, and Gaming.

5.2 Contact Information

Name	**Team Role/Title**	**Email**	**Phone Number**
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