Autonomous Aerial Mapping

Team Name: Game of Drones

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Introduction:

This project is about creating new solutions with industry leading drone technology. The issue we are aiming to solve is the difficulty of gathering 3D map data in areas with limited topographic information immediately available. 3D map data available currently is limited and sometimes inaccurate, especially in small, remote areas when you want more detail. Our project aims to eliminate these issues by developing a drone that maps the nearby terrain using various data from sensors to produce an interactive 3D model of the area on the user's phone. This can then be done autonomously with our algorithm finding the optimal coverage route.

The fundamental problem this project solves is using a drone to map a 3D model of a landscape and displaying it to a user. This problem can be broken down into four main components. The first is interfacing with the drone itself. We will be using a DJI Matrice 100 quadcopter to develop and deploy our aerial mapping system. The second big component is the data collection, which will be done by a lidar sensor and the cameras provided by the DJI Guidance System which will be equiped to our drone. Lidar sensors can output LAS files which contain the coordinates for a point cloud. This point cloud is then rendered into a 3D model which will look like the landscape we scan. The lidar sensor we will use will be the Sweep V1 360°. The Sweep V1 outputs a distance to the nearest point and a timestamp associated with this point. The Sweep V1 rotates 360° at a frequency of 2-10 Hertz. The third component and brain of the system is the Raspberry Pi. The Pi is connected to the DJI matrice as well as the Lidar sensor. The input will be the point distance as well as the telemetry and velocity of the drone. Then our algorithm will take all this data and create the corresponding LAS file. The raspberry pi will then send this file over WiFi to our mobile device application which is our fourth component. Our mobile application will then render the file and display the corresponding terrain model allowing the user to interact with it accordingly.

The second problem we will address in this project is designing the drone to be autonomous. The beginning of this process begins with the mobile application. The user will select the autonomous flight option and enter the square meters they want scanned and where they want the drone to scan. This command will be sent from the phone to the raspberry pi which will relay the information to the drone. Attached to the drone will be the DJI guidance system. The guidance system has four sensor bars, one on each side of the drone along with cameras. These sensor bars will alert the drone if an object comes within 20 meters of the drone. The drone will then tell the raspberry pi there is an incoming object and the pi will send back the correct evasive movements. This process will repeat itself until the surrounding area has been scanned.

Along with the two main problems, there are going to be many features associated with the mobile application. The mobile application will display information about the drone such as battery life, velocity, and geographical position. Automatic landing will also be available. On the screen of the application the user will be able to zoom in and pan around the 3D model to view the landscape from every angle. The user can also choose to get a bird's-eye view through the drone while the drone flies on their phone screen.

Our main objective is to get the drone to be able to fly over an area - manually first - and produce a 3D rendered model of the area that the user can interact with. Then depending on time constraints we can develop the autonomous aspect of the drone. Our objective mainly relies on our goal of being able to successfully take lidar and drone data and transform it to create an accurate point cloud which can then be rendered by some software to create a 3D model. As a team we want to be able to successfully create a new architecture interfacing hardware and software together bringing technical advancements to drone-mapping with low-cost sensors.

The main development technique that will be implemented is test driven development. Tests for the point cloud function will be created prior to the actual implementation of the algorithm. Tests will be developed for every module of the formula and to test the connections between all the hardware components. These tests will all use Google Test, which is a testing library for C++. The mobile application will also undergo unit testing as well. These cases will be implemented using JUnit testing and will test the basic functions of the application.

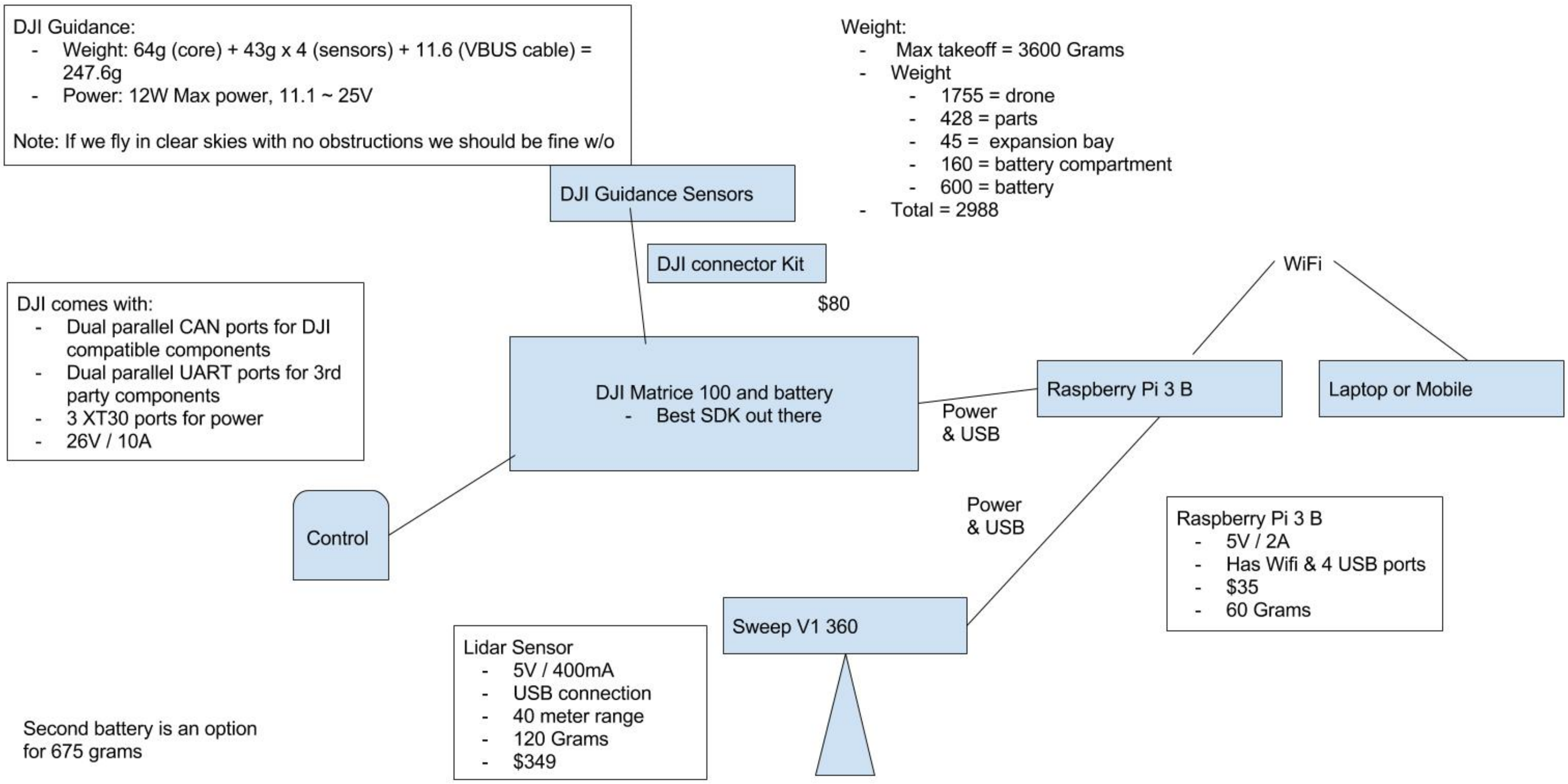
The core technical advancement in this project is designing a cheap system. The typical lidar sensor that would be used for a project like this would cost thousands of dollars. The Sweep V1 sensor cost a few hundred dollars. This sensor does not provide the typical point cloud output like other sensors but the data collection algorithm can replace these large expensive sensors and still give the same output. This advancement has far reaching applications such as autonomous flying and driving on a mass scale due to the cost efficiency of these less advanced sensors.

Some assumptions can be made about this system when it's in use by the user. These can include:

- Can't accurately map an environment/object that's moving/changing
- Making sure the drone will be flying within the Controller and Wi-Fi ranges
- Making sure the drone is flying in appropriate weather conditions (ie. not raining, no heavy wind, no storms, etc.)
- Mapping generally flat areas/Avoiding terrain that varies greatly

System Architecture:

High Level Diagram:



<u>Requirements</u>:

This project requires many different use cases from the system's perspective. Many of these cases can be broken down further, but some of these include:

1) As a system, I need to be able to send information (in this case an LAS file) from a Raspberry Pi to an Android Mobile Device.
2) As a system, I need to send the data from my sensors to the Raspberry Pi.
3) As a system, I need to provide mathematical computations on the Raspberry Pi such that the data provided from the sensors can be transformed accordingly so they are highly accurate.
4) As a system, I need to be able to send information directly from the drone to an Android Mobile Device.
5) As a system, I need the Raspberry Pi to take the transformed data and convert it into an LAS file.
6) As a system, I need the Android Mobile Device to have a viewer to view the LAS file.
7) As a user, I can interact with the 3D model on my Android Phone - zooming in/out, rotating, etc.
8) As a user, I can autonomously map an area by only giving the drone a certain area size in a map.
9) As a user, I want the drone to safely return back mid-flight if it senses that it's running out of battery or if the weather conditions suddenly get unpleasant when flying autonomously.
10) As a system, I need to make sure that all of the components are wired and connected properly as to not fry any connections or cause any issues.

Technologies Employed:

This project requires the use of many different technologies coming together. These include:

- DJI Matrice 100 - Drone

- DJI Guidance System - Has built in sensors and cameras used for obstacle avoidance, but data can be independently read off of them as well
- Sweep V1 360 Degrees Laser Scanner - Lidar sensor used to collect data to help create our point clouds
- Raspberry Pi - Used for computing as well as sending data to the user.