Integration of a fluxgate magnetometer and GPS system into an Unmanned Aircraft System

Proposal for the Undergraduate Research Program

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BACKGROUND

The magnetic method is an important geophysical method used to determine the vector quantity of the Earth's magnetic field at any given point (Burger et al., 2006). The intensity of the Earth's magnetic field can be measured using a magnetometer. These measurements can be used to determine a magnetic anomaly caused by any object with its own magnetic field, including archaeological sites, Unexplored Ordinances (UXOs), and mineral deposits (Burger et al., 2006). Most magnetic surveys are conducted with aircrafts (Burger et al., 2006). Using an unmanned aircraft system UAS (drone) for a magnetic survey could provide an easier alternative to current survey methods. A drone can reach inaccessible locations such as swamps and areas with dense forests (*Advantages of drone surveys*). Drones also can fly at lower altitudes while also covering the same areas a plane could. Additionally, drones are cheaper and easier to use than planes. Integration of a magnetometer with a UAS can create a faster survey procedure and open new possibilities of geophysical exploration.

A magnetic anomaly is the difference between a measured magnetic field and the expected value of the magnetic field at a certain latitude, longitude, and elevation (Burger et al., 2006). A fluxgate magnetometer measures three components of the Earth's magnetic field: x, y, and z. These components can be used to calculate the total magnetic field. The expected magnetic field value can be calculated using latitude, longitude, and elevation with the International Geomagnetic Reference Field or World Magnetic Model models (Chulliat et al., 2014). These models and associated computer programs are available online. The difference between the total magnetic field calculated with field data and the expected magnetic field value is the magnetic anomaly. With the advance of sensor technology, a fluxgate magnetometer can be made small and light enough that can be put onto a UAS for airborne magnetic measurement. Fig.1 shows a triaxial fluxgate magnetometer (dimensions: 2.54 x 10.62 x 2.54 cm^3) and weight of 90g, two global positioning system antennas (each weighs about 35g, 3.7x4.5x1.2 cm^3), and along with a Phantom 2 plus UAS. All were purchased by Geophysical Department and are available for this project.

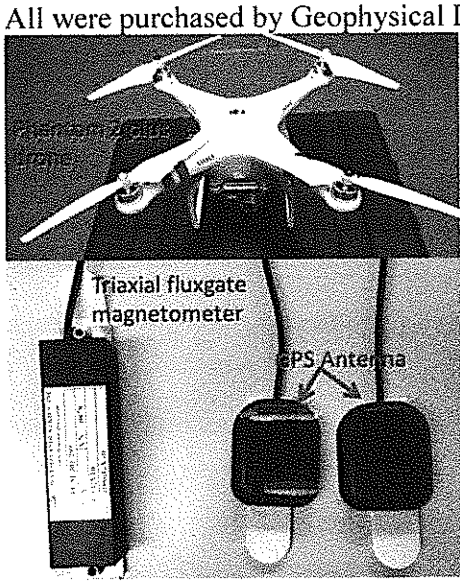

Fig.1 A photo of a drone along with two GPS antennas and a triaxial fluxgate magnetometer available for this project.

The positions where magnetic measurement is made will be logged in using two small Global Positioning System (GPS) antennas. A data logger is needed to collect the data from the magnetometer and GPS simultaneously for each scan. The drone magnetometer system must have a magnetometer, GPS, and data logger to collect and store magnetic field and GPS data. Such a system needs to integrate all discrete components. The geophysical engineering department has most of these components but does not have an integrated system for either research or field class. Once such a system is available, it would provide Montana Tech with a faster and easier way to collect magnetic data for geophysical exploration.

OBJECTIVES

- Integrated all discrete sensor components electronically into a drone for build an integrated drone based magnetometer system,
- Process data collected from the magnetometer and GPS to calculate the magnetic anomaly caused by a buried object as a test for the performance of the system.
- Determine the accuracy of using a drone magnetometer system through comparing with ground measurement using proton-precession magnetometers (G-816 and G856) available in Geophysical Engineering department.

APPROACH

For this project, I plan to integrate a fluxgate magnetometer, two GPS attennas using a multichannel small-sized data logger. If funded, I will buy a multi-channel (≥6 channels) datalogger as the hub for the sensors-drone integration. We will build a separate box with all sensors and datalogger in, electronically separate from the autopilot electronics of the drone. This is the first step for the sensors-drone integration before we fully understand the autopilot electronics and integrate the external sensors with the drone. This is simpler but more secure option avoiding direct interference with the autopilot system. The geophysical engineering department on campus already has a DJI Phantom 2 Plus drone, a fluxgate magnetometer, and two GPS antennas for position measurement. The maximum payload for the DJI Phantom 2 Plus drone is about 1350g. The triaxial magnetometer weighs 70g, the two antennas weigh also about 70g. We will keep the weight of datalogger and the battery for the datalogger under 100g so that drone magnetometer system will be under 250g in weight. During construction of the drone magnetometer system, the current magnetometer, GPS, and data logger will be tested to ensure they are compatible to each other and accurate enough for the project.

The data output by the data logger must be in the correct units to properly analyze the data. If it is necessary, the electronics between the magnetometer, GPS, and data logger may need to be manipulated so all pieces of equipment work together and output the desired information. Additional analysis on the connection between these devices will take place during the literature study with information available on campus. The data logger will have six channels, three for magnetic field components (x, y, z), and three for the GPS data (latitude, longitude, and elevation).

After integrating the sensors into a single system, I will then learn how to fly the drone. The research advisor Dr. Zhou knows how to fly the drone and he will train me to fly the drone. I will test the drone magnetometer system. I plan on borrowing a UXO from Dr Curtis Link and flying the drone magnetometer system over the object. The drone magnetometer system can be tested in any open area. The drone magnetometer system will collect data as I fly it over the object in the same way an aircraft would conduct a magnetic survey. Using a drone will allow the survey to be conducted at a larger range of heights. After data collection, the data will be interpreted to determine the magnetic anomaly and accuracy of the system.

SYSTEM DESIGN

The drone magnetometer system will be composed of:

- A magnetometer,
- Two GPS units for differential GPS position data collection,
- A data logger with at least 6 channels
- A lightweight frame, and
- A drone.

The magnetometer, GPS, data logger, and any additional electronic components that would accompany these devices would be mounted to the lightweight frame. The magnetometer, GPS, and data logger are all very small and will all fit on a small frame. The frame would then be mounted to the bottom of the drone.

TIMELINE

The project will begin at the start of the Fall 2017 semester in August and will end in the Spring 2018 semester by the end of April. Each section of the project is summarized in the Gantt chart in Figure 2. The method of processing magnetic data will be researched during the literature study, and I will be using the materials acquired during my geophysics courses. After determining the best frame material for the box housing all components, the drone magnetometer system will be constructed during from September to October. Data will be collected in November and analyzed through January. The final report will be written by the end of March. The presentation for the URP will be done in March and April.

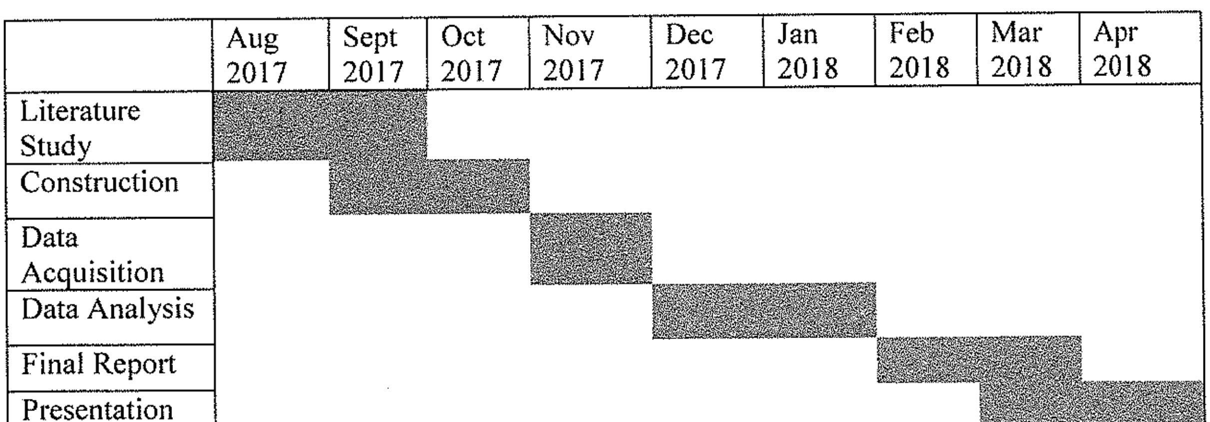

Figure 2: Gantt Chart

BUDGET

The geophysical engineering department already has a DJI Phantom 2 Plus drone. They also have a fluxgate magnetometer, two GPS attennas. A datalogger (<$250) along with materials for the construction of the box are necessary, and additional electronic components that would be required if the others fail or are too heavy. I am requesting $300 from the Undergraduate Research Program to purchase a datalogger and relevant materials.

REFERENCES

1. *Advantages of drone surveys.* T&A Survey. http://www.ta-survey.nl/page.php?id=313 [April 17, 2017].
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3. Chulliat, A., S. Macmillan, P. Alken, C. Beggan, M. Nair, B. Hamilton, A. Woods, V. Ridley, S. Maus and A. Thomson, 2014. The US/UK World Magnetic Model for 2015-2020, NoAA National Geophysical Data Center, Boulder, Co, doi:10.u289/V5TH8JNW [April 17, 2017].