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MECHANICAL LABORATORY III REPORT– UNIVERSITY OF MAINE

Clean Snowmobile - Chassis

Design and Modification of a Compressed Natural Gas Snowmobile Chassis

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In accordance with the guidelines set forth by the University of Maine for the degree of Bachelors of Science in Mechanical Engineering on May 7th, 2015

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1.0 Project Objectives

As a part of the University of Maine Clean Snowmobile team, the Chassis Team is responsible for improving the handling characteristics of the snowmobile which is modified to run on compressed natural gas (CNG). It has been previously determined that modifications regarding the addition of the CNG tank have sufficiently changed the center of gravity resulting in degradation of the handling characteristics. In efforts to better understand the dynamic response of the snowmobile before and after modification of its center of gravity the snowmobile position and acceleration will be measured as it maneuvers about a closed course.

2.0 Description of Experiment Test Rig and Method

For this experiment an IMU was created which consists of an Arduino UNO, a 6 axis accelerometer, gyroscope and a GPS which logs data to an SD card. The IMU will log the vehicle position and acceleration in the X, Y, and Z planes, the yaw, pitch and roll as the vehicle traverses a pre-determined course.

Table 1: Data aquisition hardware information

Description (Make & Model)	Adafruit Part Number	Purpose
Adafruit Lithium Ion Polymer Battery 3.7V	328	Power Supply
Arduino Uno	N/A	Processing
Adafruit Ultimate GPS Logger Shield	1272	Position
Built in with GPS Shield	1272	Data Acquisition
L3GD20H Triple-Axis Gyro Breakout Board	1032	Acceleration

The instrumentation apparatus will be self-contained in a box, which will be attached on the older arctic cat.

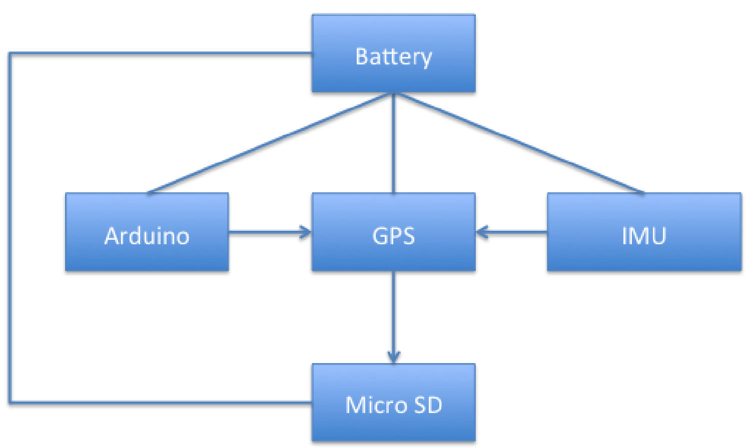

Figure 1: Apparatus for measuring position and acceleration.

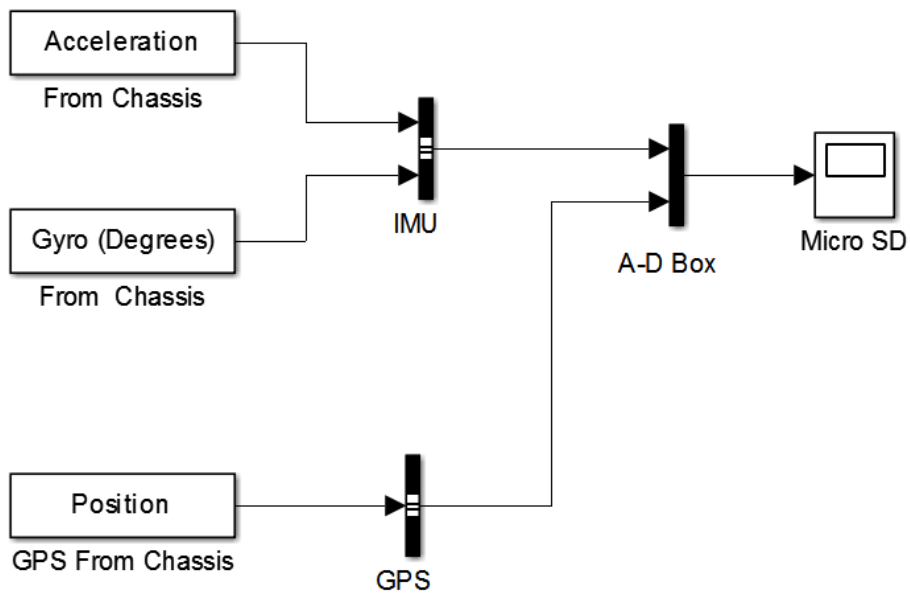

Figure 2: Diagram of data acquisition system

3.0 Uncertainty

Gyro

Resolution: 16 bit
Range: 500 Degrees at 5 V
DPS Uncertainty = $(500/2^{16})*.5 = \pm .0038$ Degrees per Second

Accelerometer

Resolution: 16 bit
Range: ± 2g
Acceleration Uncertainty = ± 4 mg

GPS

Accuracy: 3 meters
Sensitivity: 165 dBm
Updates at a rate of 10 Hz
1 PPS timing support (10 ns jitter)
Position Uncertainty = ± 1.5 meters in the horizontal plane

4.0 Test Plan

An IMU and GPS to measure position, velocity and acceleration of a snowmobile with a modified center of gravity as it travels along a closed course is to be equipped onto the older but functioning Arctic Cat snowmobile. The older snowmobile will be equipped with weight holders such that shifting the additional weight will create a change in the center of gravity. The IMU paired with GPS will be a self-contained unit that will be attached to the snowmobile. The closed course will test the snowmobile's handling after each weight modification. Upon completion of data acquisition and testing, the position, velocity and acceleration data collected from each iterative run will be compiled and a comparison made. Through this comparison a better understanding of how changing weight distribution of the snowmobile effects affects the vehicles dynamics is achieved.

5.0 Results

For this experiment the team was unable to test as planned. This was due to several factors which will be will be outlined in the discussion and conclusions section of this report.

Since testing the snowmobile was no longer a possibility the objective of this laboratory then shifted to confirming that the Arduino IMU (testing apparatus) functioned as planned so that the next chassis team could pick up where this year left off. To accomplish this the IMU was attached to a vehicle and then driven around to simulate forces that the IMU would encounter if it had been attached to a snowmobile

The data was then formatted into the following graphs which appear below. The first graph shows the vehicle position as it traverses a set course – the points were plotted from the GPS coordinates logged by the IMU. The second graph shows the accelerations experienced by the vehicle as it traverses the set course – the readings were similarly logged by the IMU.

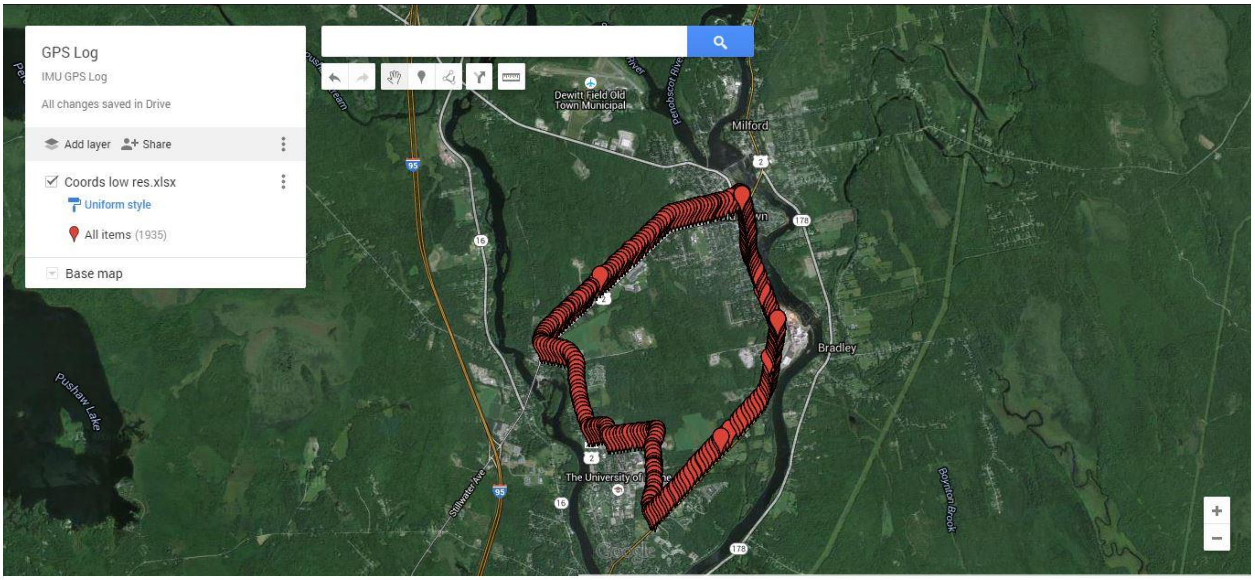

Figure 3: IMU GPS coordinates plotted on Google Earth

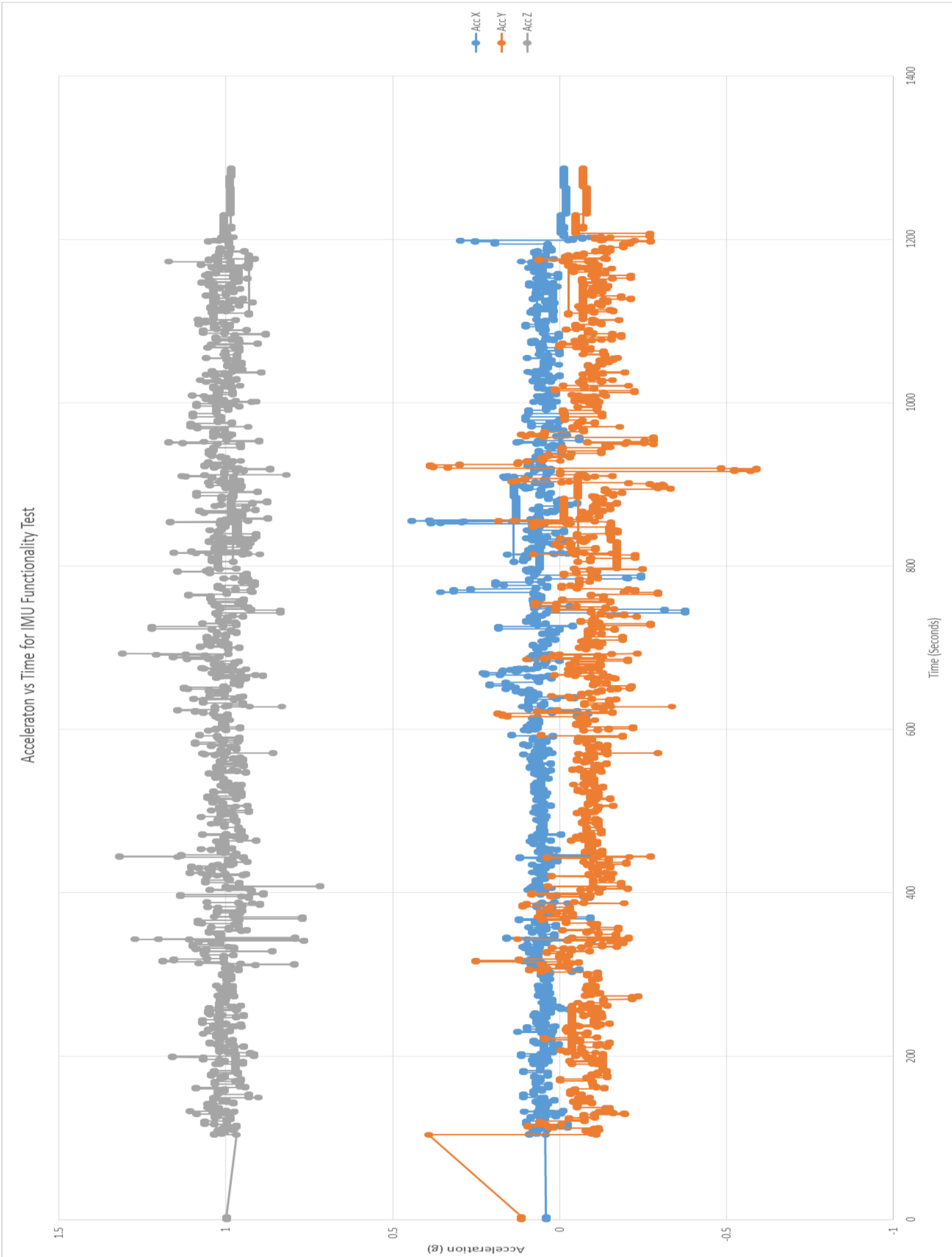

Figure 4: Acceleration vs time for IMU functionality test

6.0 Discussion and conclusions

First it must be addressed that the initial plan to test the Arduino IMU on the snowmobile was unable to be executed. This was due to there being no snow on which to drive the snowmobile for testing. The reason that testing was delayed continuously and then eventually cancelled was the IMU was not yet complete.

The initial plan was to have an Adafruit Ultimate GPS shield on top of an Arduino UNO and use the prototyping area on the shield to solder in the six degree of freedom accelerometer so that it would be able to log to the built in micro SD shield. However while this configuration worked physically, the physical memory taken up by the code required to have the accelerometer log data to the micro SD card while the GPS also parsed and logged data was too great. Of the 2KB of SRAM that the Arduino UNO (ATmega328) had the code occupied 99%. The remaining 1% (20B) of the SRAM was remaining for use as dynamic memory. This amount of memory was insufficient and this lack of memory on the Arduino UNO hardware caused the program to crash.

Note: Dynamic memory is what deals with calling functions, executing functions, parsing data and writing data.

To remedy this lack of memory the code, Ultimate GPS shield, and accelerometer were installed on an Arduino Mega (ATmega2560) which could accommodate the code needed to run the accelerometer and the GPS while parsing and logging the GPS data while simultaneously logging the data from the accelerometer. Again for some reason even though the hardware was configured correctly the code was crashing. After much troubleshooting it was discovered that the pins 10, 11, and 13 which correspond to the micro SD card on the GPS shield did not correspond to the pins 10, 11, and 13 on the Arduino Mega (ATmega2560). After an extensive trial and error approach coupled assistance from the Arduino help forum it was discovered that on the Arduino Mega (ATmega2560) pins 50, 51, and 53 corresponded to pins 10, 11, and 13 on the GPS shield. It was also discovered that this was only in the case of writing to the micro SD shield.

After reconfiguring the hardware onto the Arduino Mega (ATmega2560) and uploading the code which was again modified to reflect the pin changes discussed above, the code inexplicably crashed. To determine which line the code was crashing on a print statement was written in between each line of code so that when the program crashed, the output would show what line the program crashed on. The source of the problem was linked to a function within the library which was downloaded from the manufacturer.

At this point it was decided that to log acceleration data an additional SD shield would be used in conjunction with a separate Arduino UNO (ATmega328), and the GPS Ultimate shield would be placed on another identical Arduino UNO (ATmega328) and would parse gps data and log it to the built in micro SD. This effectively cut the memory occupied by the code on each Arduino UNO (ATmega328) by half and provided enough dynamic memory to handle the processes within the code.

After reconfiguring the hardware and code as described above, the IMU functioned properly. Unfortunately by this point in time the snow had melted and testing the now functional IMU on a snowmobile was not a possibility. To show that the IMU could collect data from a vehicle since there was now snow to run a snowmobile on, the decision was made to attach it to a motor vehicle and drive it around to simulate the forces a snowmobile may exert on the IMU.

It can be concluded that the IMU is able to record position data via GPS and acceleration data via the six degree of freedom accelerometer. While we were not able to test the IMU on a snowmobile, hopefully the 2016-2017 senior design team for the clean snowmobile chassis will be able to pick up where we left off, complete the test as initially intended and find useful data for which to improve their iteration of the chassis design.