Individual Lab Report #5

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Team A / Team Avengers

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I. Individual Progress

This week I successfully got the obstacle detection system working with multiple sensors. The obstacle detection system meets the Fall Validation Experiment requirement. I arranged six ultrasonic sensors as per my design of the sensor layout design for obstacle detection system. I got the system of six ultrasonic sensors functioning sequentially to avoid interference among sensors. This dydtem of six ultrasonic sensors can detect any obstacle region of 120 degrees (horizontally) and 90 degrees (vertically) from the sensors. I have divided this week's work in following two sections:

1) CAD model of ultrasonic sensor layout on UAV
2) Obstacle detection system for detecting any obstacle region of 120 degrees (horizontally) and 90 degrees (vertically) from the sensors
    a) Time taken by one ultrasonic sensor to take one reading during sequential pinging of sensors
    b) Putting all pieces together -Visualizing the results of the whole system

1. CAD model of ultrasonic sensor layout on UAV

Figure one, two and three shows the sensor layout on the UAV model. As seen in figure 1 Maxbotix ultrasonic sensors initially have cone shaped detection area (for 60 cm distance) and then they have cylindrical detection area (of 60cm diameter). As seen in figure three we have three sensors in front and two sensors in each side. We have two such systems of seven sensors each – one exactly horizontal and other at 42.5 degree inclination with the horizontal axis. Our system requirements define the minimum width of an obstacle to be fifty centimetre. Hence the sensors are so arranged that there is a gap of fifty centimetres between cones at a distance of 150 centimetres. With this arrangement any obstacle of size 50cm or more will always be detected irrespective of the direction and orientation with which it comes towards the UAV.

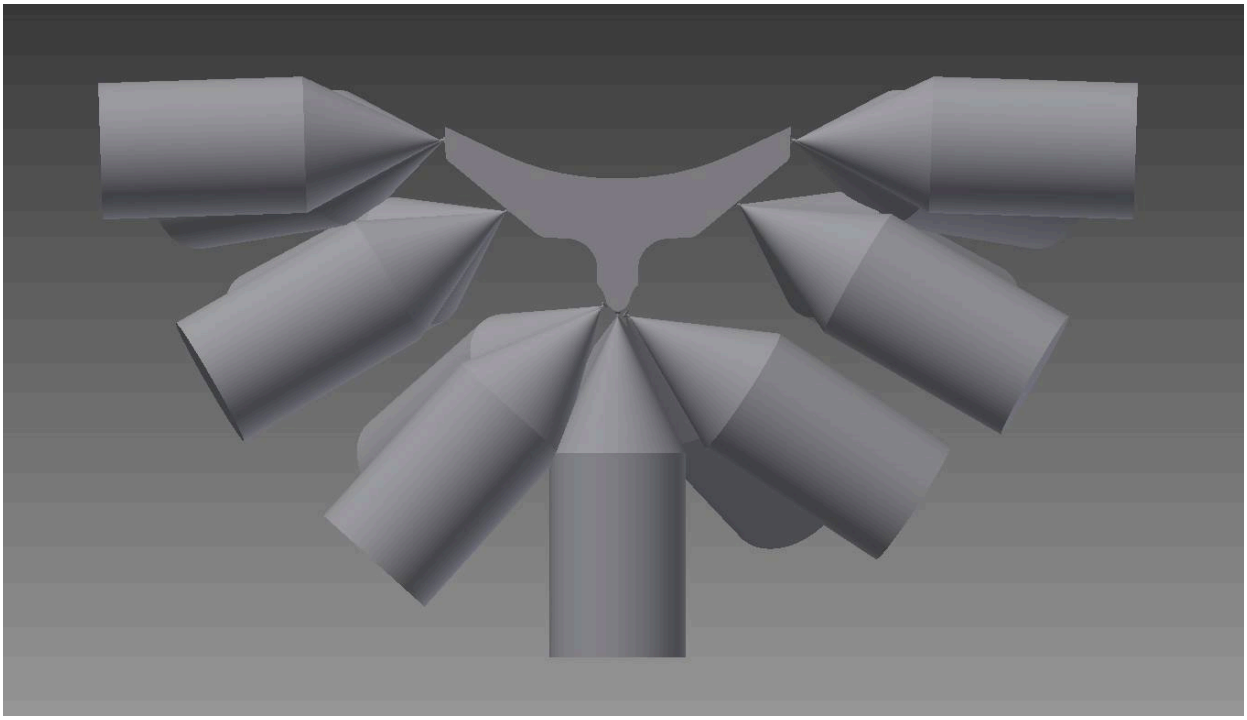

Figure 1 Top View of sensor layout on UAV

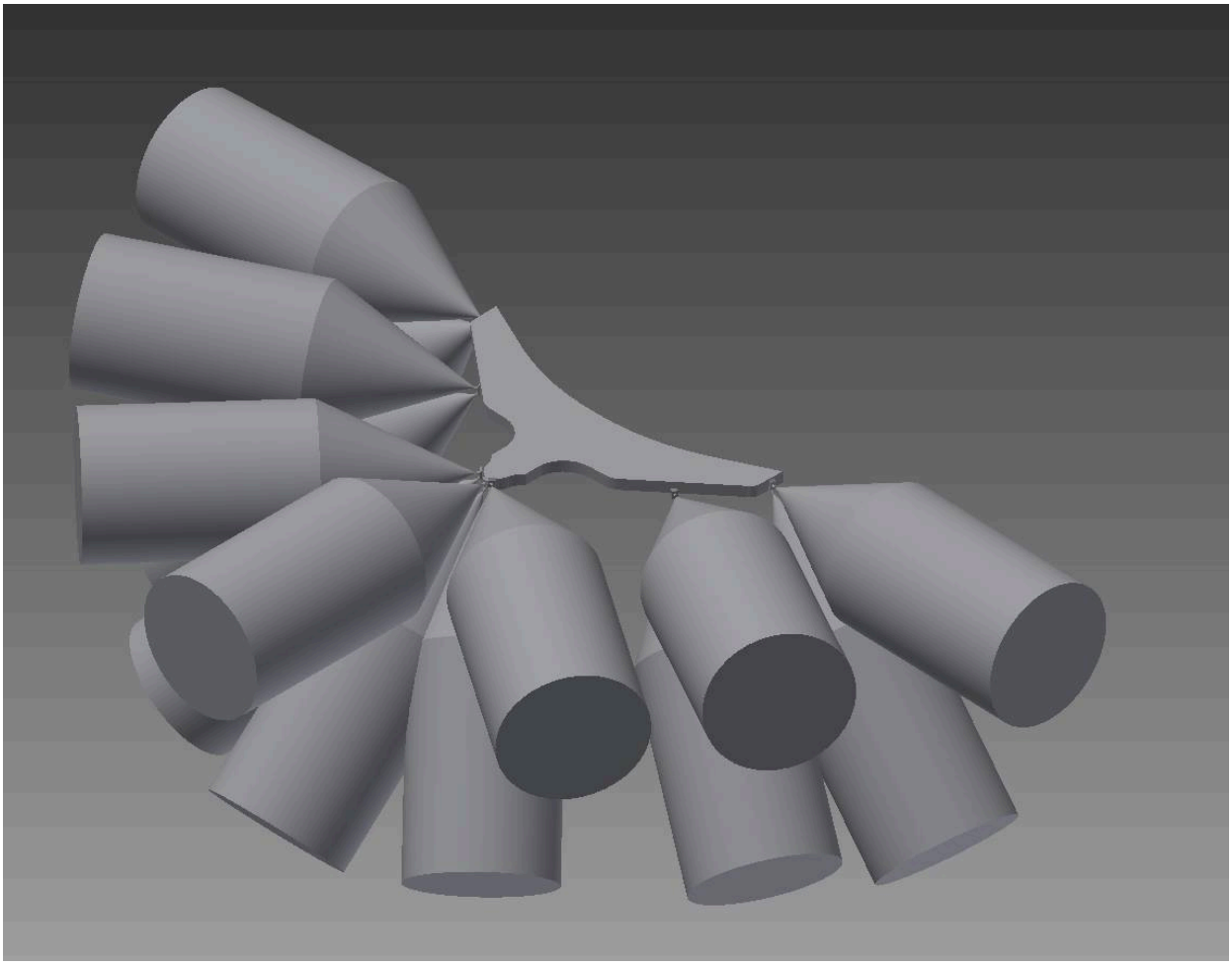

Figure 2 Sensor layout on UAV

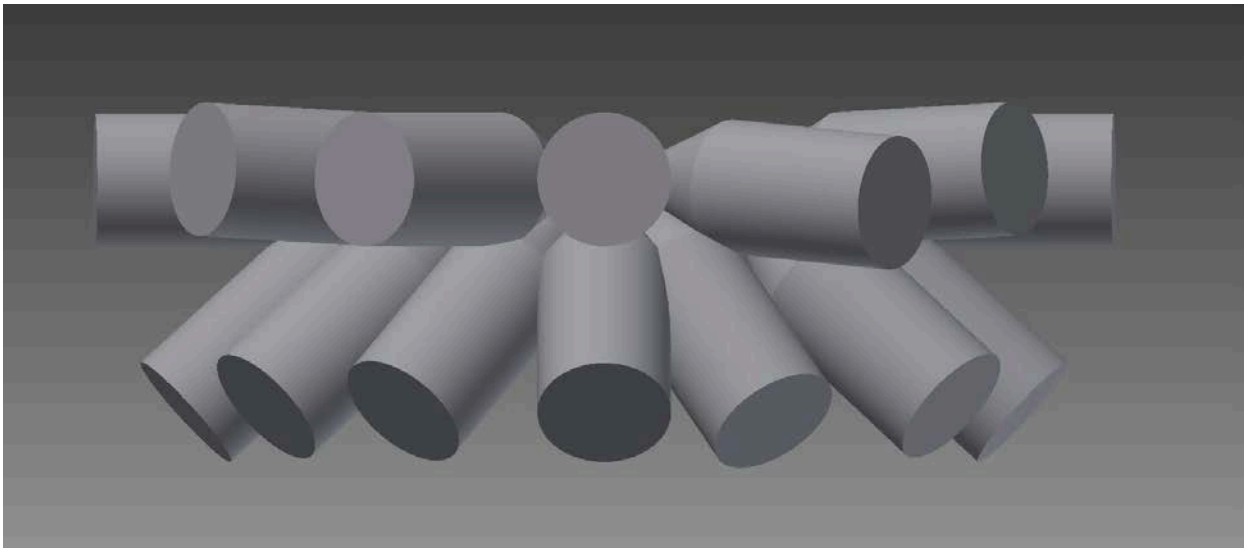

Figure 3 Front view of sensor layout on UAV

2. Obstacle detection system for detecting any obstacle in a region of 120 degrees (horizontally) and 90 degrees (vertically) from the sensors

a) Time taken by one ultrasonic sensor to take one reading during sequential pinging of sensors

To avoid interference among multiple ultrasonic sensors the ultrasonic sensors are connected in series as described in previous ILR. I connected two sensors in series and used a digital oscilloscope to measure the time it takes for one sensor to take reading. I connected probes to a sensor's Rx and Tx pins. As shown in figure four it takes 42ms for one sensor to take reading. However the manufacturing company – Maxbotix recommends giving a delay of 50ms between sensors. It takes (50ms * number of sensors) for all the serially connected sensors to take one reading each in one cycle.

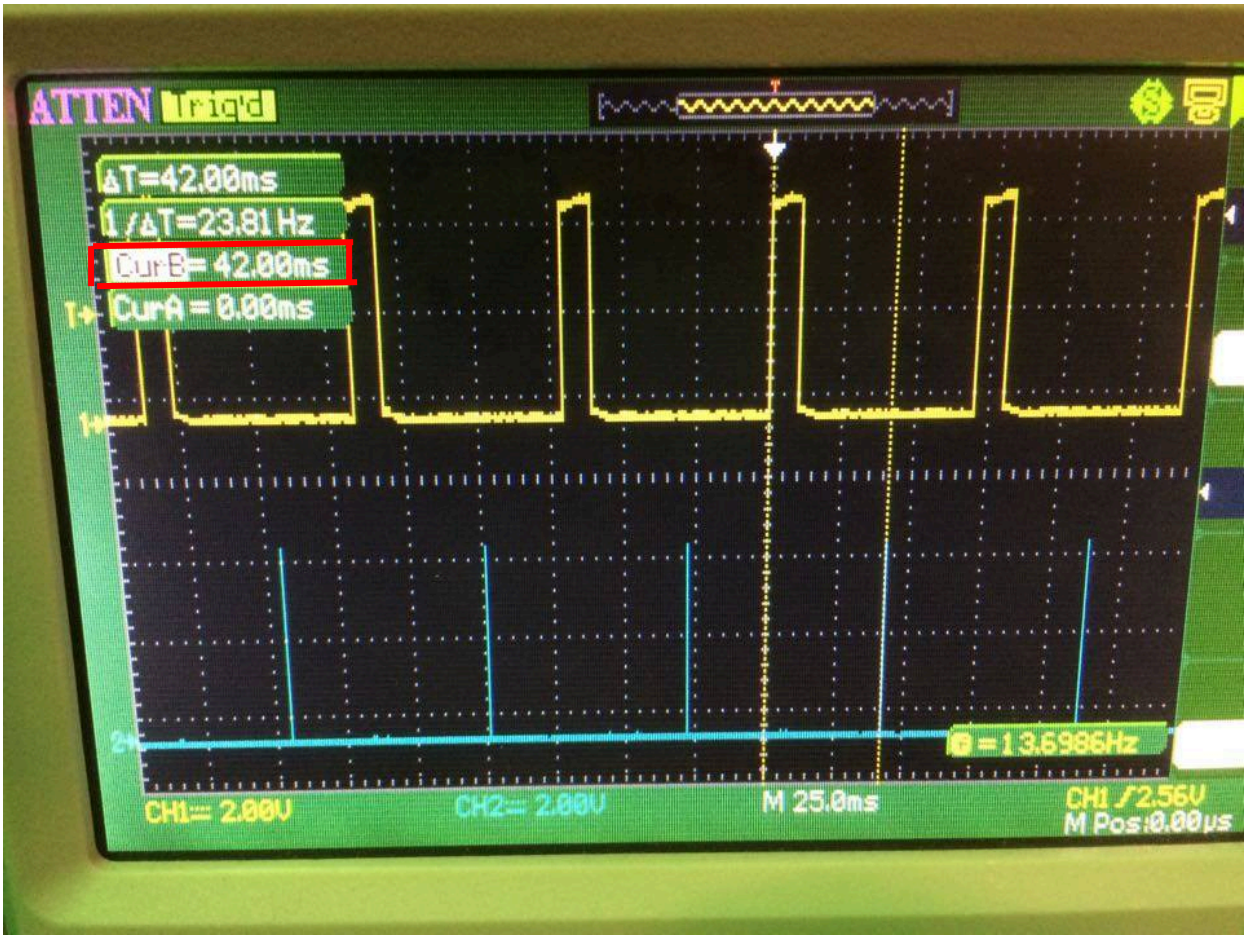

Figure 4 Time taken by one sensor to take reading

Additionally by using a Running Median filter introduces more delay in the system. When there is a sudden change in readings the filter assumes it to noise and filters it out. So for effectively changing the output of a sensor the new reading has to pass through more than half the buffer size so that the median of the buffer outputs the new reading.

Summing all the delays, the total time it takes for a new reading to show up is

= (Size of running median median filter)/2 * (50ms * number of sensors)

Using this equation connecting fourteen sensors in series with a running median filter of size five will take 3 * 50 * 14 = 2.1 seconds for 1 cycle of readings! To reduce the cycle time I decided to subdivide the fourteen sensors in three group which could function independently as they face no interference issues among them. Theis division of subsystem is shown in figure 5

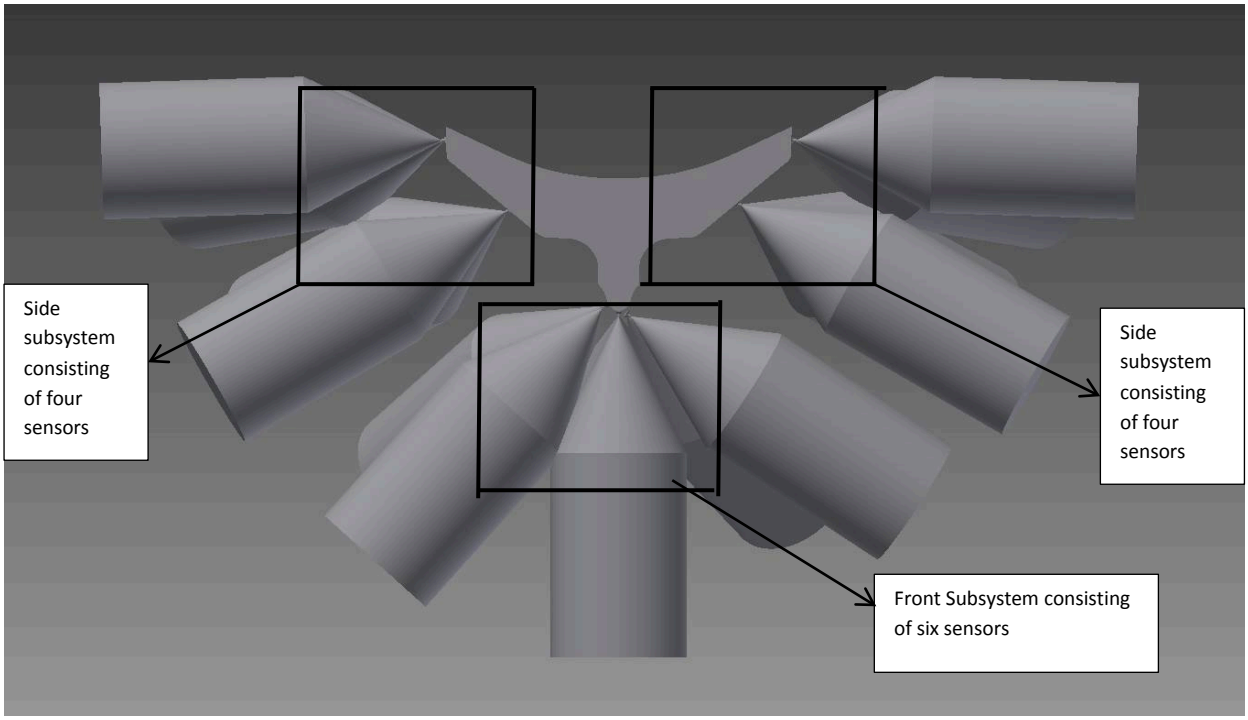

Figure 5 Dividing fourteen sensors in three groups

For six sensor subsystem in the front of the UAV it will take (3)*(50*3) = 900ms = 0.9 second for one reading cycle.

b) Putting all pieces together -Visualizing the results of the whole system

Tushar made the crimp connecters for the six sensors. Once we received our shipment of sensors I physically connected the six sensors as per the CAD layout and visualized the output of the system on the Rviz platform developed by Tushar.

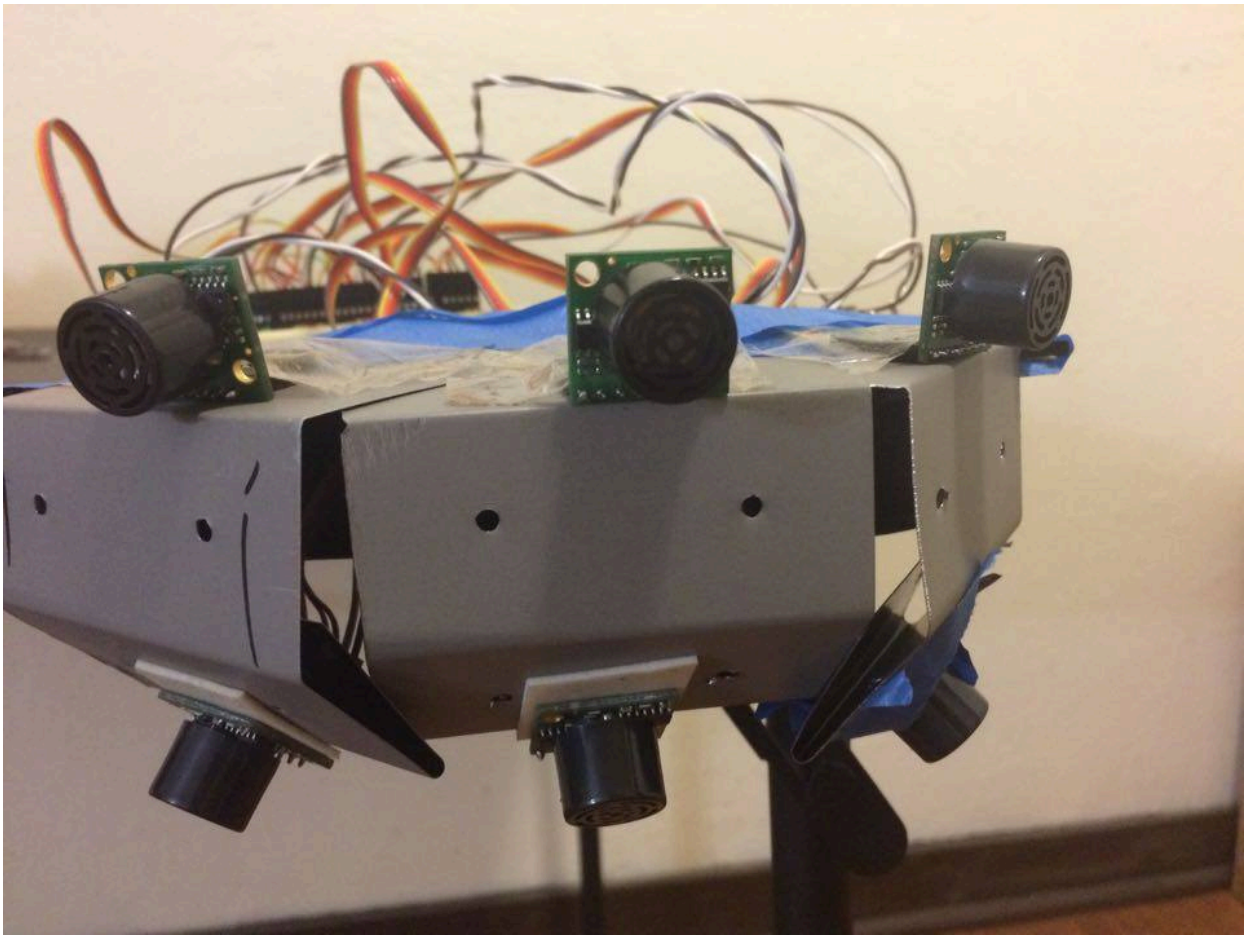

Figure 6 Six sensors obstacle detection system

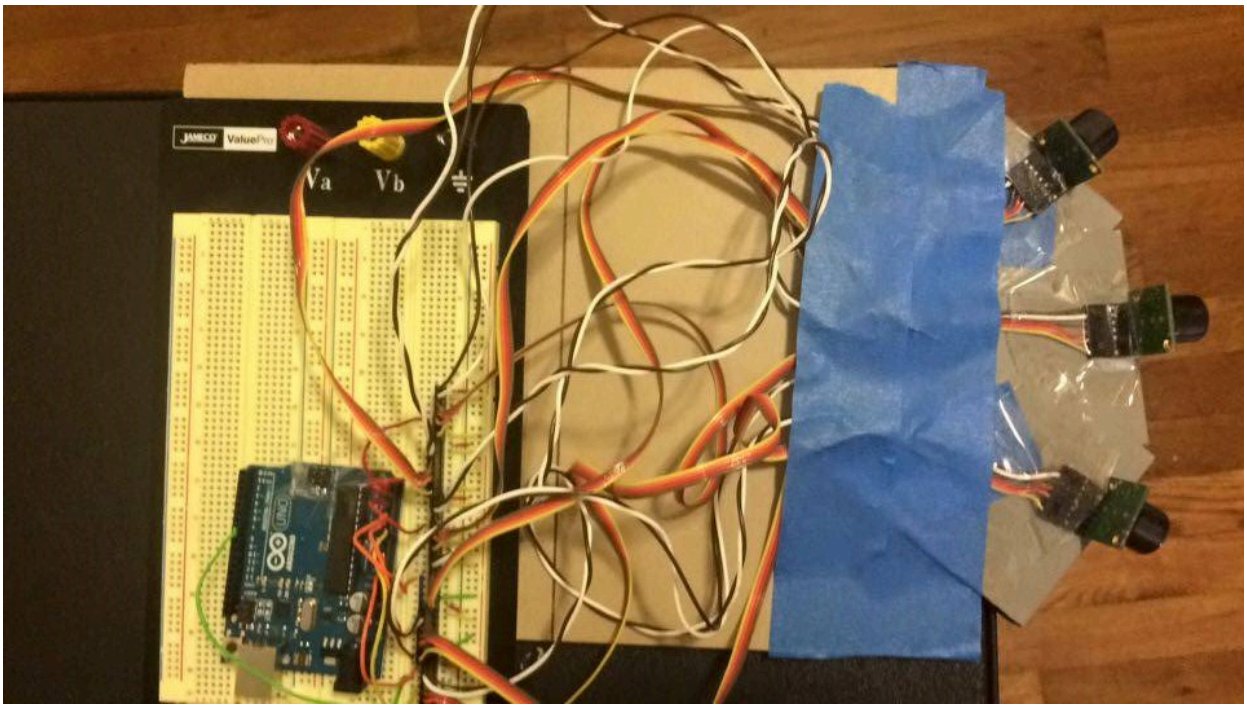

Figure 7 Top view of sensor system

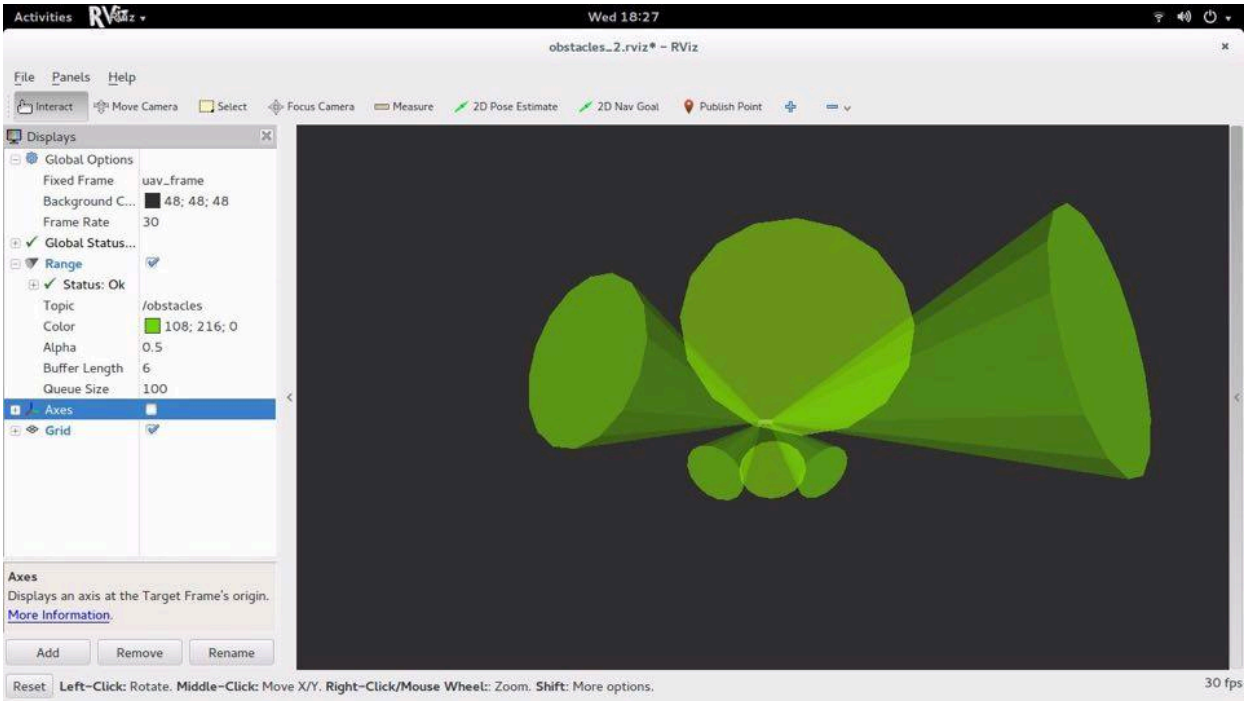

Figure 8 RViz visualization of sensor readings. Here each green cone represents one sensor.

II. Challenges

1. Initially I didn't know we had to give a 50ms delay for each of the sensors. Hence I kept getting arbitrary incorrect readings. Then I realized this problem and used an oscilloscope to find the time it takes for sensors to give one reading. I also checked the manufacturer's site and found method in which they recommend to ping the sensors sequentially! Using the manufacturer's method I obtained reliable readings from the sensors.
2. For the initial part of the week I had not received all the sensors that we ordered. We got couple of extra sensors from lab inventory. However one of the two sensors was not soldered properly and hence it gave arbitrary incorrect readings. I tried to resolder it but it didn't function correctly. Hence I did tests with the sensors that I had and focused on the CAD design till the sensors arrived.
3. The sensors have a detection cone of forty two degrees. Hence the angular sensors always detect ground when placed at a nominal height of 1.5/2 meter. This makes it difficult to detect their actual functioning. To overcome this problem I tested the system by placing it on the tallest object in the surrounding! For FVE we will have to design some system for placing the sensors high enough to visualize their functioning.

III. Teamwork

Tushar helped me in the obstacle avoidance system by figuring out and making the right crimp connectors. He also made the ROS Rviz based obstacle detection visualization. Sean made the CAD model of UAV and a sensor bracket model using which I designed the multiple ultrasonic sensor layout in CAD. Adam got the motors and servos working off the Pixhawk. He also updated the Firmware and got the RC controller configured.

IV. Future Work

I will test different pinging pattern and finalize the most optimal pinging pattern for sensors to reduce the cycle time for all the sensors to take one reading.