Individual Lab Report #2

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Team A / Team Avengers

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I. Individual Progress

For this week I did the following tasks:

1. Developed obstacle avoidance sensor system of two IR and two ultrasonic sensors on UAV model that Sean built so that we can perform various tests indoors as well as outdoors. I then did conduct range test with the sensors.
2. I decided details for our UAV obstacle avoidance system, read related research papers and looked through different sensors and software ways to maximize the range and minimize the number of sensors for uav obstacle avoidance

Experimental Obstacle Avoidance Setup

I developed sensor setup of two Sharp GP2Y0A02 IR sensors and two Maxbotics LV Maxsonar EZ ultrasonic sensors on the UAV model made by Sean. I interfaced the sensors to Arduino Uno and viewed the reading on laptop using serial connection. The system is wired in a way that it can be taken outdoors for testing.

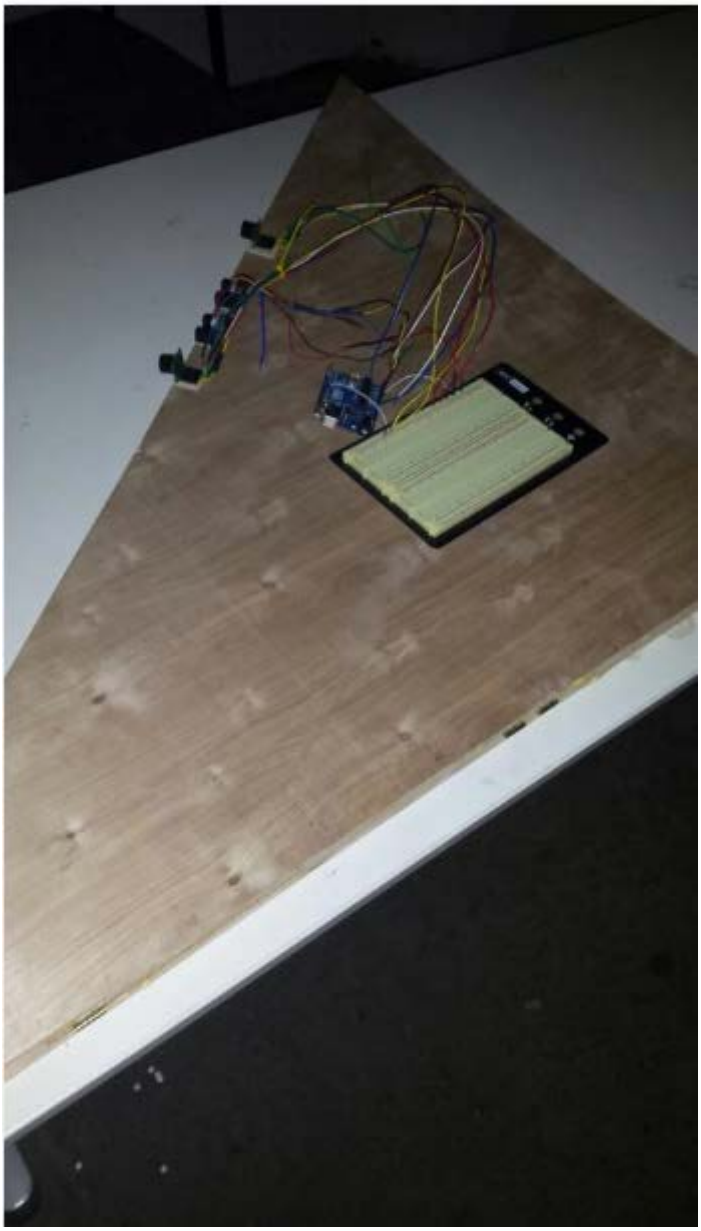

Figure 1 Sensor system on UAV model

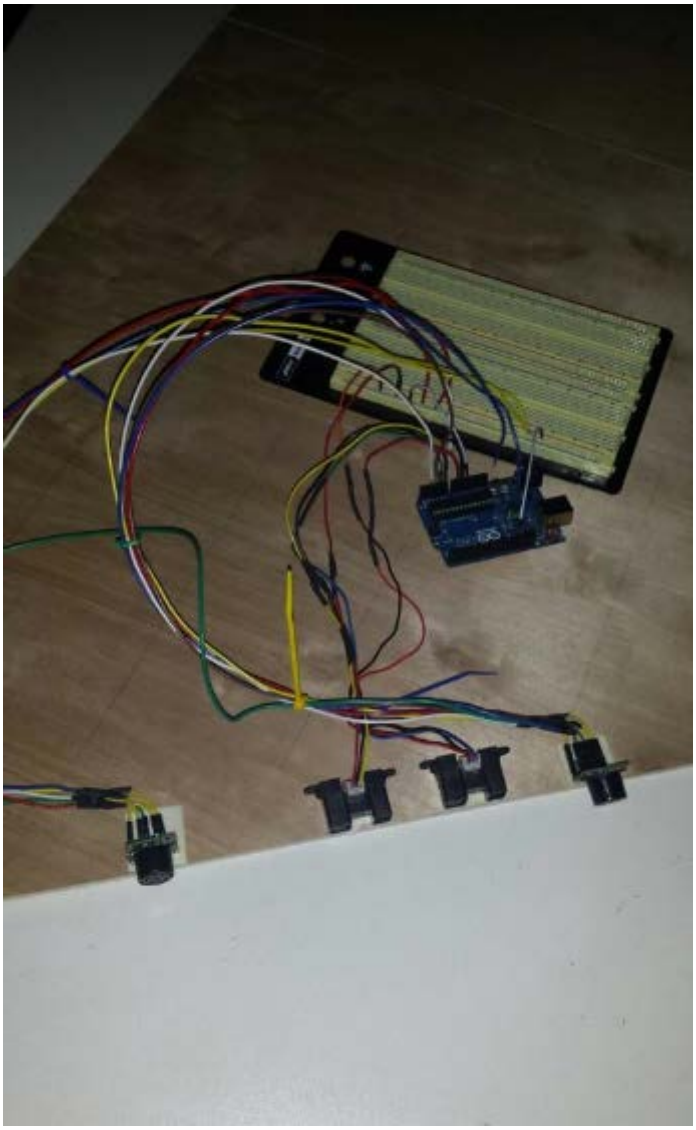

Figure 2 closer view of sensor system

I obtained the following results for the sensor tests that I carried out

1. Sharp GP2Y0A02 IR sensor has range of twenty to hundred and fifty cm according to datasheet. However I obtained reliable readings for range - twenty to eighty cm. Outside this range the sensor gave noisy and incorrect readings. I used the SharpIR library. For filtering readings I took array of forty sensor reading, allowed readings which were +/- five % apart from the mean value of the sample array and took their average.
2. Next I did test combination of two Sharp IR GP2Y0A02 sensors. The IR sensor has a horizontal detection width of 2.5 inch. Figure shows the detection area of IR sensor. I did not find any interference between the two IR sensors when they were placed side by side touching each other.

Code:

```
#include<SharpIR.h>

#define ir1 A0
#define ir2 A1
#define model 20150
int IR1_min = 20;
int IR1_max = 80;

SharpIR sharp1(ir1,40,95,model);
SharpIR sharp2(ir2,40,95,model);

void setup() {
  // put your setup code here, to run once:
  Serial.begin(9600);
  pinMode(ir1,INPUT);
  pinMode(ir2,INPUT);

}

void loop() {
  // put your main code here, to run repeatedly:

  int IR1_dis=sharp1.distance();
  int IR2_dis=sharp2.distance();

  Serial.print("Sensor 1: ");
    Serial.print(IR1_dis);
    Serial.print("\t");
    Serial.print("Sensor 2: ");
    Serial.println(IR2_dis);
    delay(100);


}
```

3. I did test two Maxbotics LV Maxsonar EZ ultrasonic sensorsr and two sharp GP2Y0A02 together in the arrangement as shown in figure. All the sensors obtained reading simultaneously. I found error of +/- 10 cm in ultrasonic sensors. I will find ranges and details about interference of sensors next week.

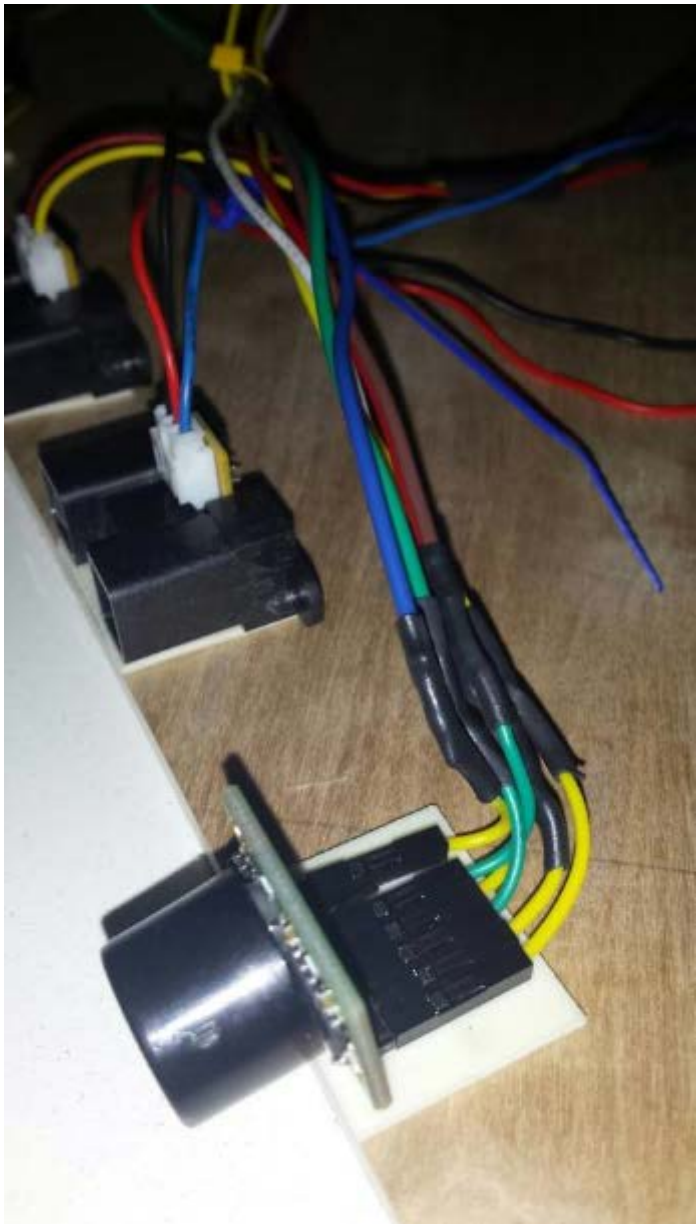

Figure 3 sensor array

Code:

```
#include<SharpIR.h>

#define ir1 A0
#define ir2 A1
#define model 20150
int IR1_min = 20;
int IR1_max = 80;

SharpIR sharp1(ir1,40,95,model);
SharpIR sharp2(ir2,40,95,model);

#define us1Pin A2
#define us2Pin A3

int arraysize = 9;
int rangevalue1[] = { 0, 0, 0, 0, 0, 0, 0, 0, 0};
int modE1;
```

```
int rangevalue2[] = { 0, 0, 0, 0, 0, 0, 0, 0, 0};
int modE2;

int trigger = 2;

long us1Volt, us2Volt, cm1,cm2;

void setup() {
  pinMode(us1Pin,INPUT);
  pinMode(us2Pin,INPUT);
  pinMode(ir1,INPUT);
  pinMode(ir2,INPUT);
  Serial.begin(9600);
  // put your setup code here, to run once:
}

void loop() {
  // put your main code here, to run repeatedly:
   for(int i = 0; i < arraysize; i++)
  {
    us1Volt = analogRead(us1Pin)/2;
    us2Volt = analogRead(us2Pin)/2;
    rangevalue1[i] = us1Volt;
    rangevalue2[i] = us2Volt;
    delay(10);
  }
    isort(rangevalue1,arraysize);
   modE1 = mode(rangevalue1,arraysize);

   isort(rangevalue2,arraysize);
   modE2 = mode(rangevalue2,arraysize);

  cm1 = modE1 * 2.54;
  cm2 = modE2 * 2.54;

  int IR1_dis=sharp1.distance();
  int IR2_dis=sharp2.distance();

  Serial.print("US1 (in cm): ");
  Serial.print(cm1);
  Serial.print("\t");
  Serial.print("US2 (in cm): ");
  Serial.print(cm2);

  Serial.print("\t");
  Serial.print("IRSensor 1: ");
   Serial.print(IR1_dis);
   Serial.print("\t");
   Serial.print("IRSensor 2: ");
   Serial.println(IR2_dis);
   delay(10);


  Serial.println();
  delay(10);
}


void isort(int *a, int n){
// *a is an array pointer function
  for (int i = 1; i < n; ++i)
```

```
  {
    int j = a[i];
    int k;
    for (k = i - 1; (k >= 0) && (j < a[k]); k--)
    {
      a[k + 1] = a[k];
    }
    a[k + 1] = j;
  }
}

int mode(int *x,int n){

  int i = 0;
  int count = 0;
  int maxCount = 0;
  int mode = 0;
  int bimodal;
  int prevCount = 0;
  while(i<(n-1)){
    prevCount=count;
    count=0;
    while(x[i]==x[i+1]){
      count++;
      i++;
    }
    if(count>prevCount&count>maxCount){
      mode=x[i];
      maxCount=count;
      bimodal=0;
    }
    if(count==0){
      i++;
    }
    if(count==maxCount){//If the dataset has 2 or more modes.
      bimodal=1;
    }
    if(mode==0||bimodal==1){//Return the median if there is no mode.
      mode=x[(n/2)];
    }
    return mode;
  }
}
```

II. Other details for Obstacle Avoidance System

1. Our UAV will most likely be fixed wing Fifefly 6, Vertical Take Off and Landing (VTOL) UAV. It takes off and lands in hover mode and then switches to forward flight mode. Obstacle avoidance system for hover mode and forward flight will be different
2. During take-off and landing in hover mode we need to detect obstacles like house, walls, trees, cars etc. We can use ultrasonic and IR sensor combination which can provide range of 4-5 m. For forward flight the speed of uav will be around 10-15 m/s. Hence our IR and ultrasonic sensor combination won't be useful because it will be difficult to react to an obstacle which is at 4-5 meter distance, when uav is moving with speed of 10-15 m/s. Forward flight would require generation of local occupancy grid map using system of stereo

cameras and LIDAR. For now we will design obstacle avoidance system for hover mode of our UAV.

3. I did go through research papers on topic of obstacle avoidance for uavs. I particularly found [1] & [2] useful. In [1] the author discusses obstacle avoidance and collision avoidance for AQopterI8 uav with twelve ultrasonic and sixteen IR sensors. Author discusses complementary functionality of the ultrasonic and IR sensors. IR fail in poor lighting condition which is no problem to ultrasonic sensors whereas ultrasonic sensors cannot detect sound absorbing surfaces which is no issue for the IR sensors. They developed a weighted filter for data fusion or data selection to obtain best possible result from multiple sensors. They proved its better over Kalman filter as Weighted Filter could adapt rapidly to measurement jumps such as discontinuity of sudden upcoming obstacles while KF minimises the noise or variance. They tested in three cases. A stationary fight in a corner, a stationary fight between two walls and a flight in a room with a person moving towards the quadrotor and obtained successful results for obstacle avoidance.
4. [2] discusses omnidirectional obstacle perception and reactive avoidance by sensor setup consisting of a 3D laser scanner, two stereo camera pair and ultrasonic distance pair. They detected obstacle and aggregated data in egocentric local multiresolution grid maps. They could also detect power cables, windows etc by fusing data of different sensors.
5. Maxbotics has sensor series XL-MaxSonar-WR and XL-MaxSonar-WRA specially built for outdoor or rugged environment. The sensors have range of 765 cm and automatic compensation for noisy and changing environment conditions.
6. Maxbotics provides hardware ways to switch between sensors and fire sensors one by one to interface interference between sensors.

III. Challenges

I faced issue getting multiple ultrasonic sensors work together. They gave noisy readings. I figured out that having delay in reading the sensor reading loop induced error. On reducing the delay to 10ms I obtained reliable readings.

IV. Teamwork

I developed the sensor testing model on the UAV model developed by Sean. Other than that all team members worked indivually. Tushar installed OpenCV on Beagleboard and Adam worked on interfacing Hokuyo Lidar with rapberry pi. He found the raspberry pie to be slow and finally got the Hokuyo Lidar working on Beagleborad

V. Future Work

I will work with Sean to test sensor setup build by me on the UAV model. We will test the sensors in sunlight, ultrasonic sensors near motors, the minimum distance between sensors before they interfere with each other, and the true minimum and maximum ranges of the sensors.

VI. References

[1] Gageik, N.; Benz, P.; Montenegro, S., "Obstacle Detection and Collision Avoidance for a UAV With Complementary Low-Cost Sensors," in *Access, IEEE* , vol.3, no., pp.599-609, 2015 doi: 10.1109/ACCESS.2015.2432455

[2] Nieuwenhuisen, M.; Droeschel, D.; Beul, M.; Behnke, S., "Obstacle detection and navigation planning for autonomous micro aerial vehicles," in *Unmanned Aircraft Systems (ICUAS), 2014 International Conference on* , vol., no., pp.1040-1047, 27-30 May 2014