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UVS DEVELOPMENT REPORT 3

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Summary:

Enclosed is the report of obstacle avoidance and waypoint navigation system through sonar senor and using the information from encoder and PWM signal. This report gives overview of up to date work that has been till this time .We previously carried out series of experiment to figure out eticks, reference length and amount of DC required to both the left and right wheel to keep the vehicle moving in desired positon. Now adding Mb1240 Sonar range sensor to the system which is used to detect the distance between obstacle and vehicle, using range information from sensor the Phidgets motor helps to change direction and reach the waypoint. Simple program and some changes is made to the GNC and tank file on Simulink to implement sonar sensor and able to perform obstacle avoidance waypoint navigation.

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The University of Texas at Arlington	MAE,EE,IE,CSE	

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NOMENCLATURE

ROS=Robot Operating System
NUC=Next Unit of Computing
NiMH=Nickel Metal Hydride
LiPo=Lithium Polymer
DC=Direct Current
PPM=Pulse Position Modulation
PWM=Pulse Width Modulation
GPS=Global Positioning System
V=Voltage

LIST OF FIGURES

PROJECT OVERVIEW

It is the multidisciplinary project with five group member from different department. We have two week to implement the sonar sensor into system and make it able to obstacle avoidance and capable of performing waypoint navigation at the same time. In this project we are developing autonomous rover with help of Sonar Range Sensor, Phidgets and Intel NUC by using dead reckoning and performing waypoint navigation, obstacle avoidance with the use of ultrasonic sensor. This report includes brief introduction of each component and layout the related concept, experiment on parameter identification and waypoint navigation and approach to use of sonar sensor for obstacle avoidance. The main objective for this report was to present use of sonar sensor for detecting the obstacle and implementing the algorithm in navigation Simulink file.

1 ASSEMBLY OF SONAR, NUC AND PHIDGETS

The two Phidgets motors gets power from 7.2 NiMH battery and the other end is connected to the left and right encoder motors with 5 pin where yellow and white wired pin provide the signal. There are three pin, ground (Pin 7), 5V power (Pin 6) and analog out (Pin 3) pins of MB1240 sensor which is connected to analog port 0 of the Phidgets. The sensor line is calibrated to match the sensor beam patterns and provides a long range detection zone. The Phidgets motor gets the information from the ROS node which subscribes the message from the GNC block created in the Simulink Matlab file via USB cable. Both Phidgets boards is powered from the same battery with a Y-cable and is other connection cable is screwed into the power ports. Encoder pins for left and right motor are connected in opposite manner (yellow and green), since if connected in same manner would result in one turning in positive while other turns in negative direction with respect to their turn direction.
Intel NUC has both the Linux and Matlab installed in it which can be operated in another PC by team viewer for Windows OS and by hotspot connection for Ubuntu 14.04 Thrusty Linux distribution. In these way we are able to run Simulink /Matlab on the platform during our waypoint navigation. It helps us to run the program and debug it when performing the evaluation of the platform easily and faster.Matlab supports communication with the motors and s different sensor connected to the NUC either through direct connection or through ROS .This way the GNC algorithms can be run with actual sensor data while the vehicle performs actual mission by the actuator commands produced by the program/code written.

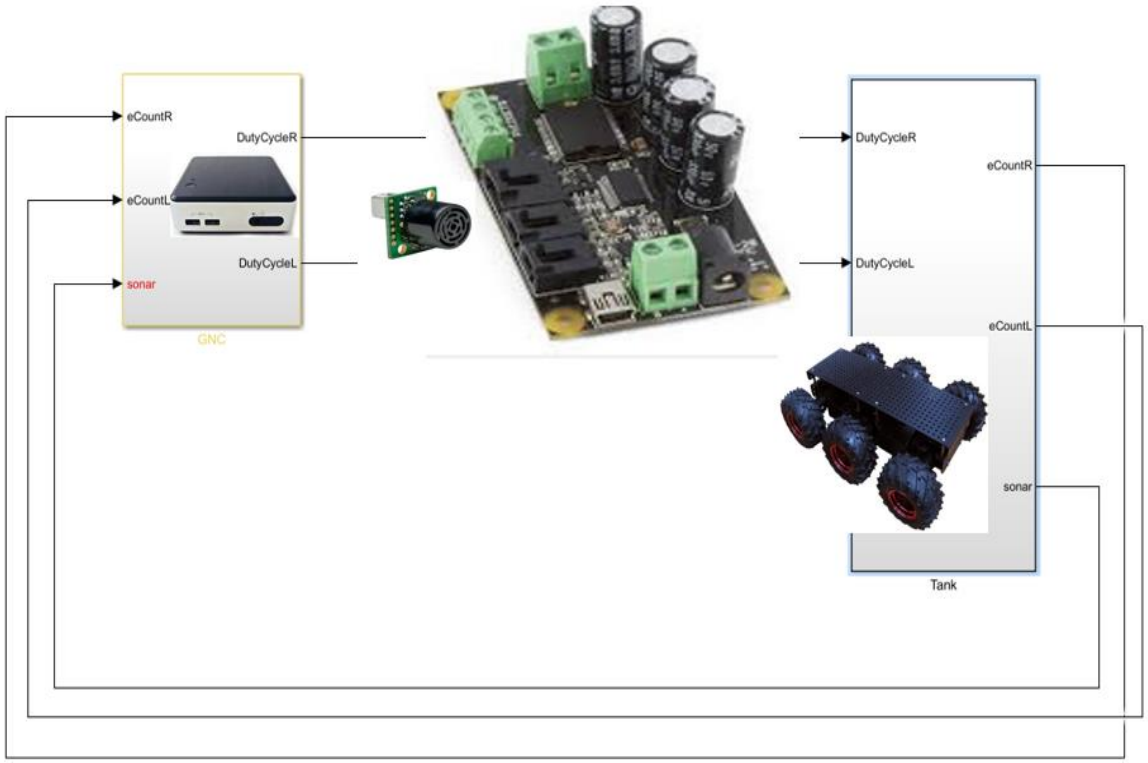

Figure 1: Integration of Sonar, NUC and Phidgets

2 CAD MODEL

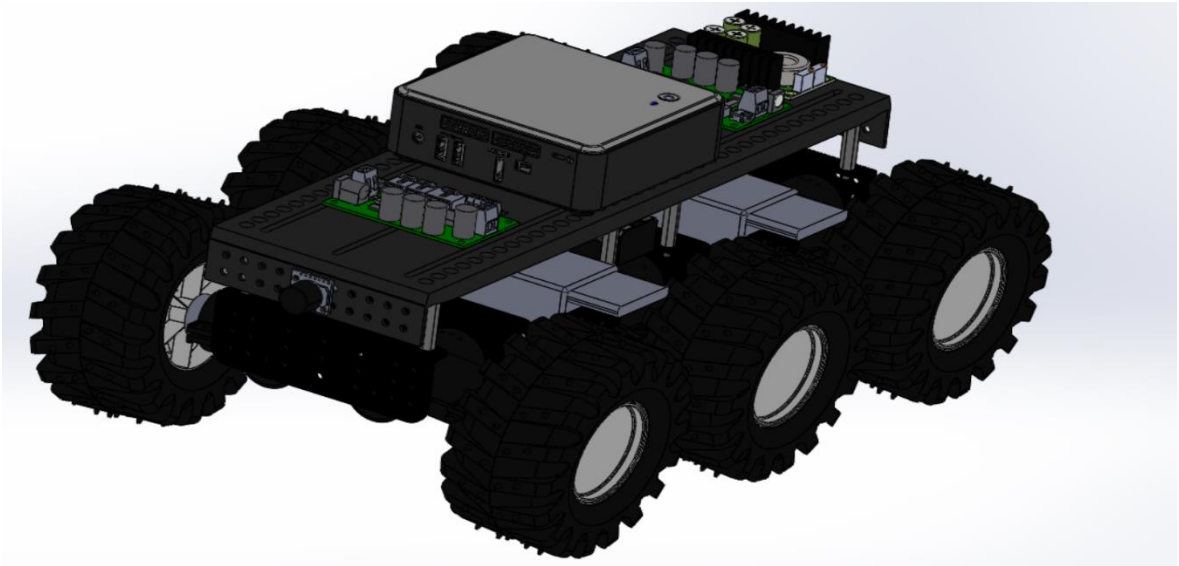

Figure 2: 3D View of Rover Assembly

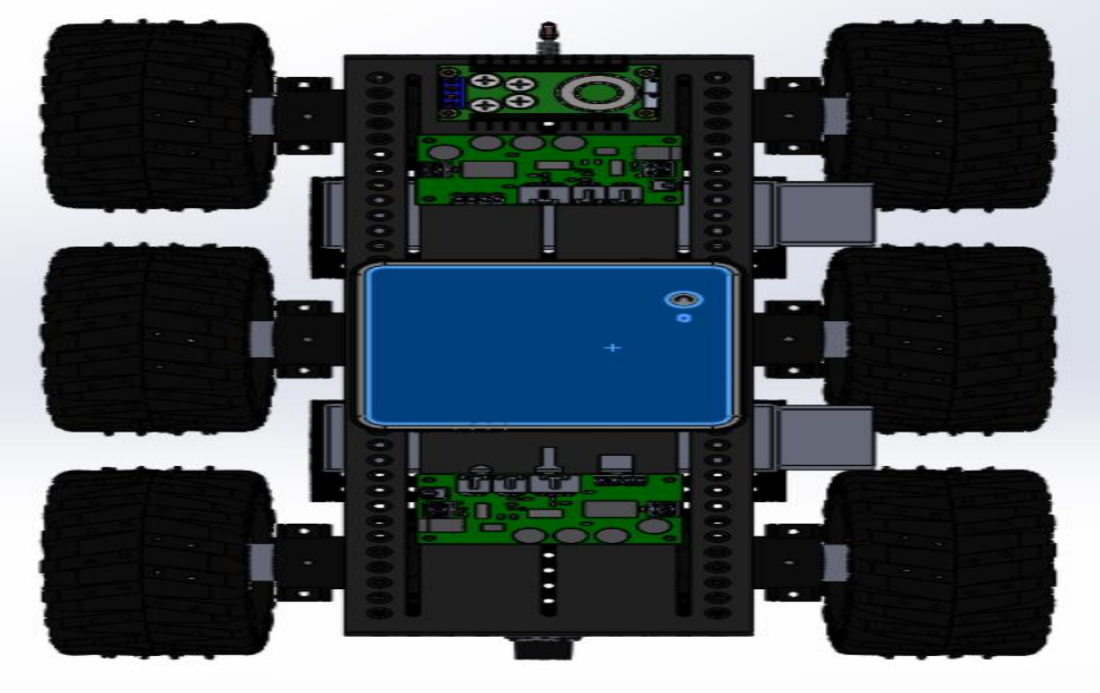

Figure 3: Top view of 3D Rover Assembly (Dead Reckoning)

3 BATTERY

NiMH of 7.2 V is used to power six motors and two Phidgets motor boards. Lithium polymer (LiPo) ion of 14.1 v is used to power NUC via DC to DC converter which get 19V to operate. Lithium batteries are the preferred power sources for most electric modelers today. They are similar to Lithium Ion batteries in that they each have a nominal voltage of 3.6 volts. They offer high discharge rates and a high energy storage/weight ratio. LiPo battery should be handled very carefully while charging.

Figure 4: NiMH/LiPo battery

4 NUC

NUC designed by Intel with Intel® Core™ i5-4250U processor basically,is small computer with central processing unit .It has got 10 GB Samsung SSD with 16 GB DDR3 with the feature of intel WIFI/ Bluetooth card in it .The resistor is used once for connecting into one our personal computer. The NUC is connected to both the motor controller via USB. The Matlab Simulink is inside the NUC is connected to the Phidgets motor via ROS node connection by publishing and subscribing. The NUC gets power supply from 14.8v LiPo battery which converts it to 19 v from DC to DC converter.

Figure 5: NUC

5 DC TO DC CONVERTER

It use to convert the voltage from the LiPo battery which is 14.8v to 19V.The requirement for the NUC power supply is 19v. The power and ground supply is connected to input side of the Converter where as the output is connceted to the power cord.Safey precaution must always followed to insure that NUC is not receiving more than 19v. Every naked wired connection must be insulated, heat sink is the best possible way to insulate them in lab.

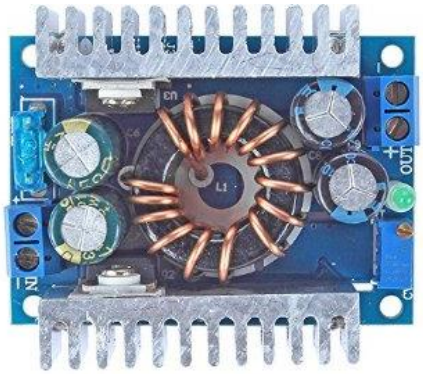

Figure 6: DC to Dc Converter

6 PHIDGETS MOTOR CONTROLLER

Two Phidgets motor is used to control the PWM provided to the middle motor both on left and right wheel respectively. The Phidgets motor has the ability to control the direction, velocity and acceleration of motor. The motor is powered by 7.2 v NiMH and is connected to board by Y cable, current flows through the motor, and it will begin rotating. Depending on the direction of the current,

the motor will rotate clockwise or counterclockwise. Switching the voltage very quick the controller is made smaller, more efficient, and cheaper. It is connected to the NUC through USB and it enables MATLAB to drive motor, and enables it to read an encoder counts up to two analog and two digital sensors.

Figure 7: Phidgets motor Controller

7 SONAR RANGE SENSOR

The MB1240 sonar range sensor is used to detect the obstacle ahead of it and send the range information to the motor controller to change the direction and speed. There are three pin, ground (Pin 7), 5V (Pin 6) and analog out (Pin 3) pins of MB1240 sensor which is connected to analog port 0 of the Phidgets. The sensor line is calibrated to match the sensor beam patterns and provides a long range detection zone. The sensor has the highest noise tolerance and calibrated to provide reliable range information to large targets even in environments with strong acoustic or electrical noise sources.

Figure 8: MB1240 Sonar Range Sensor

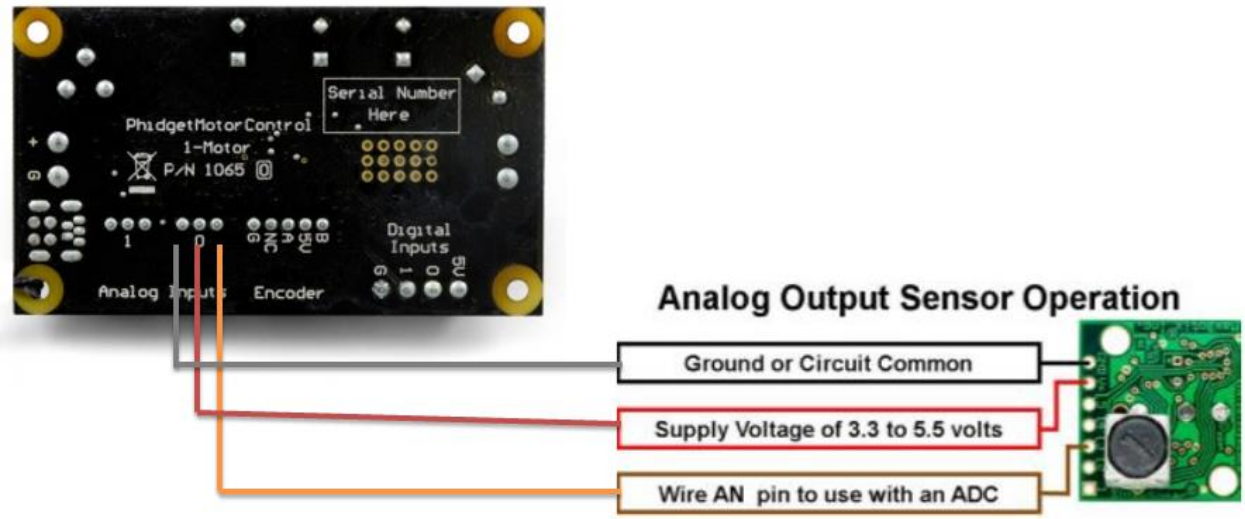

Figure 9: Connection of sensor with the Phidgets

8 OBSTACLE AVOIDANCE WAY POINT NAVIGATION

The main objective to achieve these week was to make our platform obstacle avoidance with waypoint navigation. Each team who want to work on waypoint navigation were allowed to work on platform to waypoint navigation. Since, it's the main foundation for achieving both the objective, we divided our team, some member working on waypoint navigation and other on obstacle avoidance Simulink file. The sonar range sensor we are using MB1240 XL-Max Sonar –EZ/AE4 Beam pattern. It has high power output with real time calibration for disturbance like temperature, voltage and electrical noise. Power required is very low around 3.3v-5.5v and is able to operate for providing short range and long range detection.

These sensor is capable of detecting object that is at 20 cm to 765 cm. The sonar range sensor data is calibrated by measuring the obstacle distance and the output voltage given by sonar at that particular distance. It's not able to detect any object that is below 20cm and is able to see it beam pattern up to 765cm. The Beam pattern represent 2D detection area of the sensor but in reality its 3D cone shaped Having the same detection pattern both vertically and horizontally. For larger target longer range and wider angle is seen whereas for smaller target narrower beam and smaller angle is seen. There are the four patterns A, B, C, and D which represent the detection zone for a given target size which is shown below in figure 20:MB1240 Beam Pattern.

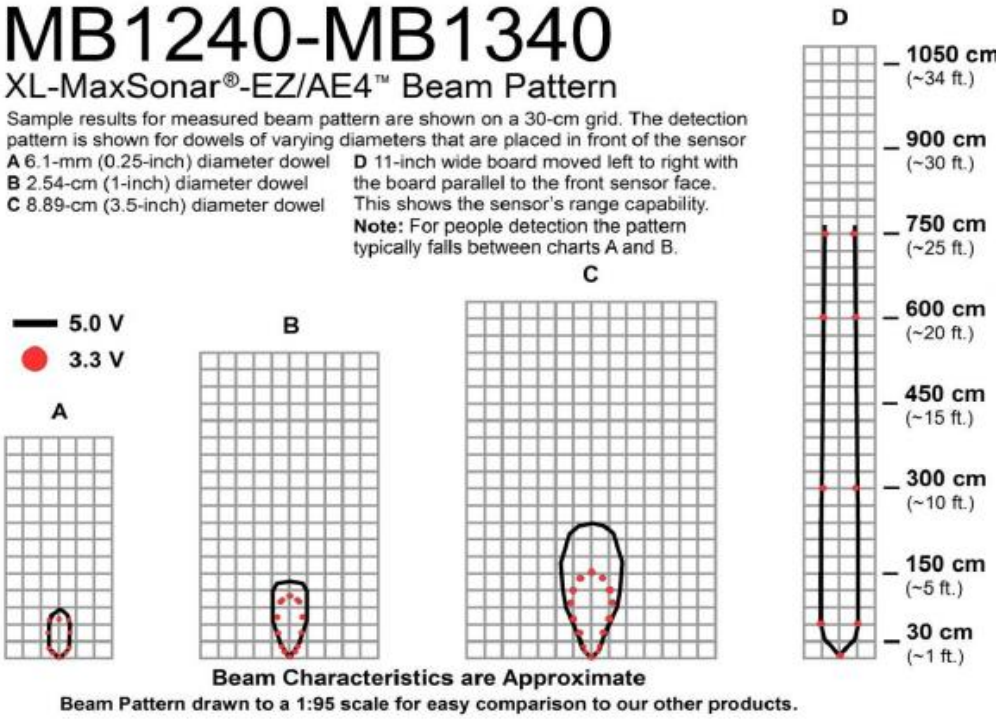

Figure 10 :MB1240 Beam Pattern

So we started to implement sonar sensor block in GNC Simulink file where the range information obtain is utilized to detect obstacle and code in the Simulink to avoid obstacle. After successfully able to implement in Simulink file we started to work on the real platform. Sonar sensor is kept in front attached to the top plate just above the wheel. It has three wire pin where power, ground, signal is connected to the in 0 analogue port of the right Phidgets motor board. We carried out some experiment by putting different kind of obstacle with different radius and height ahead of the waypoint .We were successfully able to accomplish the obstacle avoidance way point using the sonar range sensor. The step by step changes made in the Simulink is presented below.

8.1 STEP 1

Sensor Model is added to the GNC file that was used for waypoint navigation. A simple sonar sensor model is incorporated in Simulink .We have assumed that sensor coverage are rectangular and parameterized and obstacle to be circular with certain radius. So from these sensor model we obtained the range data when the obstacle is within the sensor coverage i.e. between 20cm to 765cm.

8.2 STEP 2

Inside the tank block, a Matlab function1 was created to incorporate sonar sensor where the output is range information which is given in cm, from the information about the position and radius of the obstacle. The positon in XY frame and radius for the multiple obstacle and positon and orientation of

the platform vehicle in XY frame is provided as input to the Matlab function to obtain the range information of the nearest obstacle. The range information is given and stored to outport 3.

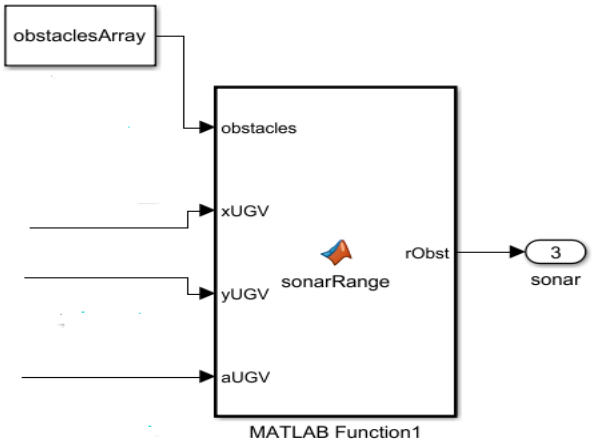

Figure 11: Integration of sonar in Matlab function

8.3 STEP 3

The output from the tank range (output from sonar) and eticks count from both the left and right middle wheel is feedback to the GNC block as an input.

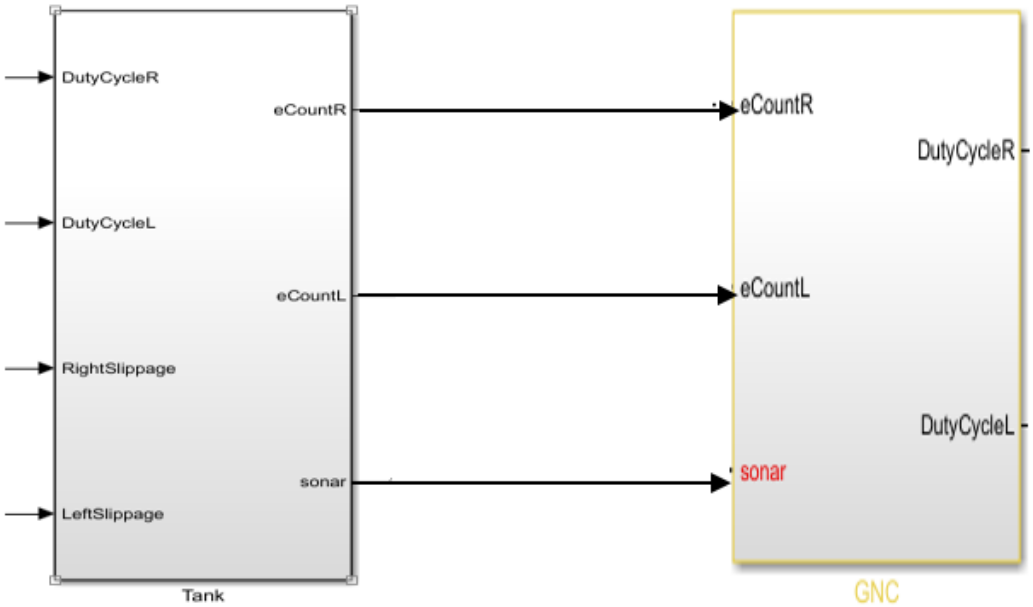

Figure 12: New Tank Model with GNC

8.4 STEP 4

Inside the GNC block, we incorporate certain change in the guidance block the input from port number 3(Sonar Range Output), x and y estimation works as input to the guidance block. The main objective was to use the information from range (port3) we must able to make change the direction when it detects the obstacle. So the sonar port was connected to guidance2 block which is used inside.

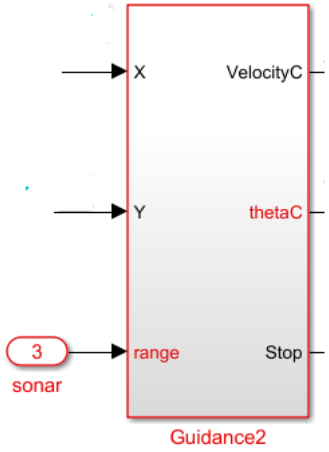

Figure 13: Range O/P connected to Gudiance2

8.5 STEP 5

We created Matlab function where commanded angle is obtain using the difference in heading angle and angle it deviates when it sees the object. The input for Matlab function will be the range obtain from port number 3 and output will be the angle it need to deviates once the sensor beam pattern touches any part of obstacle within in the range. After incorporating Matlab function we have added small logic inside Matlab function that when the obstacle is detected less or equal to than 50 cm make a 2 radian change in angle else zero when obstacle is not detected.

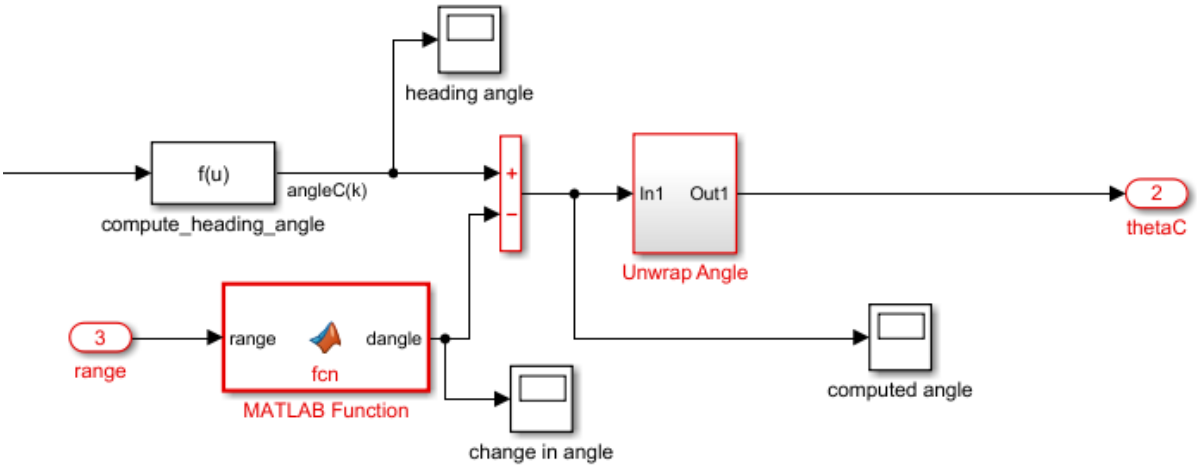

Figure 14: Matlab function in Guidance Block

8.6 STEP 6

We use these changed Simulink file in the platform and carried out some experiment in the lab. We are able to carry out the obstacle avoidance waypoint navigation successfully. The Matlab code for Function in step 5 to avoid obstacle is given below.

```
function dangle = fcn(range)
if range <=50 % range in cm
 dangle=2; % dangle in radian
else
    dangle = 0;
end
```

9 SAFETY

Every time we work on real platform it and good exercise to have safety while integrating the hardware and performing experiment using platform.

- It's always a good practice to use power cord while working on the bench and only power the NUC through battery while driving the vehicle.
- Special care must be taken to be sure the polarity are right while connecting to the batteries and other power distribution to motors.
- Testing Y-cable with a multimeter before applying power to prevent short between power and ground
- While connecting the encoder to the battery we should be very careful about the polarity of the 5V and Ground pins.
- We must always insulate all the control boards Phidgets, DC-2-DC Converter before mounting onto the platform by placing a form padding or 2-sided tape under them in order to avoid short circuit.
- We must always be sure to output voltage from the DC-2-DC converter is no more than 19 V to the NUC.
- Always Charge the battery in correct manner and never let the battery drain completely.
- If incase of confusion while carrying out integration of hardware .always consult to the professor or TA, never take decision solely.

10 CONCLUSION

We carried out series of experiment for obstacle avoidance with our new algorithm and it was manage to successfully avoid all the obstacles from a distance of 50 cm. and move around it with the help of PIDs.

Although this project seemed simple in theory, the actual implementation of it was more difficult than expected. We encountered many missing components, damaged motor and motor controller which halted our progress as scheduled, during testing of rover. One of our biggest problems was time. Because of the limited component and damaged motor we were not able to work on fixing the rover in time. Initially we found that our middle motor with encoder were damaged, we carried out the objective of performing the manual and auto control of the rover with four motors only. We later on found that load carried by the remaining four motors caused stress on these motor which leads to breakage of the gear on two of the motors.

11 ACKNOWLEDGMENT

First of all, we are very thankful to Professor Dr. Wan for providing us lab and instrument during our project. Similarly, we are very thankful to TA Mr. Songwei for guiding and providing the missing components and new motors for making our project successful.

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