RSS Practical - Milestone 2
Group 9

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Updates to structure of the robot

After the previous milestones, we added 4 main improvements to the structure of the robot:

- The wheels were moved a bit further apart. This allowed us to improve slightly the turning precision and to reinforce the gear train to prevent gears from popping out of their sockets.
- The IR sensors were moved closer together and set in a vertical position. This significantly improved the measurements for localization.
- We added a front bumper to improve obstacle detection and take care of the edge cases such as when the robot points directly to the edge of the triangular obstacle.
- Since the IR sensors now point towards the side, we added the sonar to detect obstacles directly in front of the robot.

Localization: Particle Filter

For the localization of the robot we implemented a Particle Filter. The filter uses the sensor models of the IR sensors to evaluate the distance of the robot at angles of 30 degrees from the frontal direction. A model of the arena has been built to ray cast the expected poisitions of the particles.

The Particle Filter allowed us to set a navigation system with waypoints, to trace a route for the robot to follow.

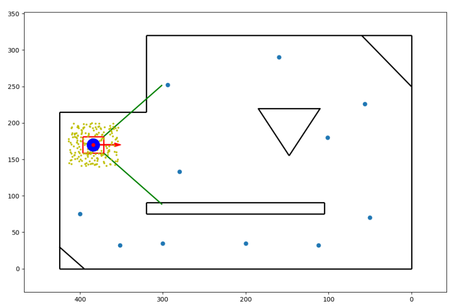

Figure 1: Example of the internal localization of the robot. On the map we can see the maximum range for the sensors, the particles, and the waypoints.

Hall sensor

The hall sensor was attached to the right wheels for measuring both odometry and turning angle of the robot. Since only one hall sensor is allowed, the left and right wheels' velocity of the robot was maintaining the same to keep the measurements reliable. This means that the robot's trajectory was fixed to straight lines so the performance of the robot's movement is highly depends on how straight it goes and how accurate it turns. Therefore a high resolution hall counter counting the rotatory angle of the wheels was integrated on the robot. The performance of the hall counter regarding the displacement and turning angle is tested with real measurements with a ruler and the results are shown in the graph. Fitting a linear regression to these lines, the resolution of the hall sensor is approximately 7.6 degree for angle measurement and 1.5cm for displacement measurement.

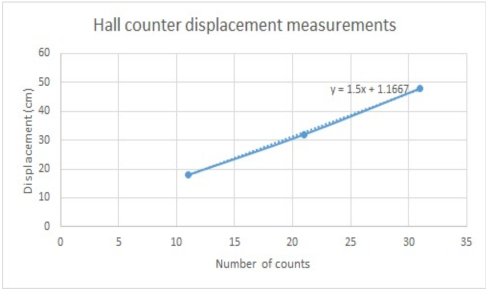

Figure 2: Hall sensor calibration for straight displacement.

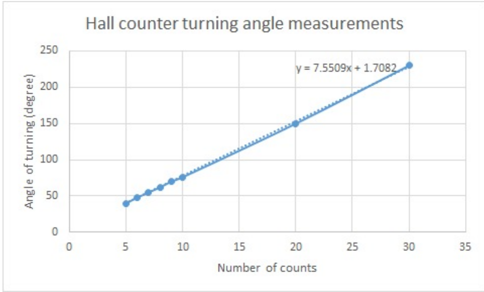

Figure 3: Hall sensor calibration for turning angle

IR sensor calibration

The IR sensor was also integrated to the robot for obstacle avoidance as well as distance measurement for localization. The behaviour of the output from the IR sensor is a logarithm curve so this curve was found out by collecting massive amount of sensor output with respect to the actual distance. The test distance was selected between 10cm to 150cm with a step of 10cm considering the effective range of the IR sensor. 100 samples were collected for each test distance to look at the standard deviation of the measurements. The results are included in the graphs. After fitting the results with a logarithm regression, the function of the distance measurement in terms of the sensor output is obtained and integrate on the localization.

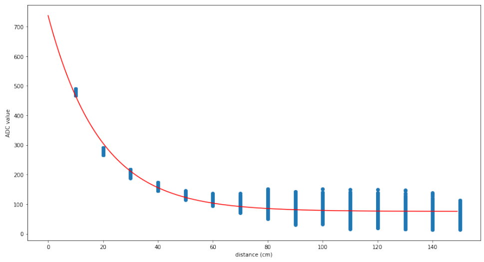

Figure 4: Characteristic of the IR sensors. The graph displays the fitted exponential curve, together with the original points.

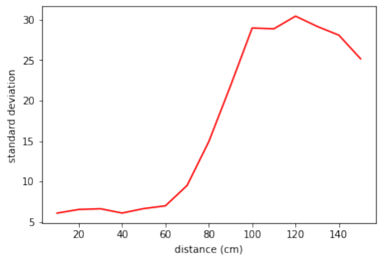

Figure 5: The standard deviation for the sensors, estimated at different distances with the data points.

POI detection

The detection of POI was based on three light sensors (two at the front and one at the back). The decision boundary of detecting a POI was measured with the real POI tapes. To stop exactly on the center of the POIs, a dedicated logic was developed to head towards to the center of POI after one of the light sensor detects the POI.

Antenna alignment

To determine the location of the satellite from the POI, we kept a track of the orientation angle of the robot, along with its position on the arena map, which we chose to divide into 425 x 320 cells. Depending on its relative distance from the antenna and the direction the robot is facing, an angle is computed which would cause the robot to turn at the minimum possible angle, either left or right, in order to correct its orientation to face the antenna. Using this methodology, we tested the error rate for antenna location from three different POI and determined upon the maximum error rate of 8.41 angle. Which mainly was the result of friction generated between the tires of the robot and the uneven surface of the POI plaster.