Lab 1: Wall following report.

Data Analysis

a) Did the bang-bang controller keep the robot at a distance bandCentre from the wall? Why is it expected that the robot will oscillate from one side of the band to the other with the bang-bang and p-type controllers?

For the design of both the bang-bang and the p-type controllers our robot followed the following logic regarding its position relevant to the wall:

- The bandCentre was set to 30 cm, with a bandwidth of 3 cm. This means that the robot would not alter its course unless it was at a distance of less than 27 cm from the wall or greater than 33 cm.

Using this logic the bang-bang controller constantly altered the course of the robot to keep it within the bandwidth area (27 to 33 cm from the wall), which resulted in a zig-zag motion because the robot would always traverse through the bandwidth area in diagonal trajectory.

This last point is exactly the reason why we expected the robot to repeatedly oscillate from one side of the band to the other: the trajectory corrections would only be executed to keep the robot at a certain distance, not to correct its path while it was within the bandwidth area.

Observations and Conclusion

Throughout our experimentation we noticed that the ultrasonic sensor would regularly detect false negatives; it would suddenly register the current distance as a very large number even if it had an object no more than 30 cm in front of it. This would cause our correction algorithm to suddenly increase the speed of the right wheel significantly in an attempt to bring the robot closer to the false wall.

This was a significant problem, specially for the p-type controller. The correction algorithm for the p-type controller was set to increase the speed of the right wheel proportional to the size of the error (the measured distance from the wall). The false distance recorded would result in an enormous acceleration of the right wheel, which made it difficult for the robot to correct its trajectory again. In order to fix the issue of false negatives we implemented the following changes:

- Implemented a filter algorithm for both controllers that was set to ignore distances equal to 255 cm unless they occurred more than 20 times successively. In order to do this we keep a counter that tabulates the amount of times a distance of 255 is recorded by the US. This is particularly useful for eliminating false negatives, but also to avoid gaps in the course and take

left turns - the sensor would simply ignore the gap unless it was of a length that allowed it to record 255 as the distance 20 times.

- In the case of the p-type controller, we put a limit on the maximum speed that the right wheel could accept to prevent the robot from accelerating out of control.

Further improvements

- Mount the ultrasonic sensor on a motor to control its position relative to the movement of the robot.

The current implementation of our robot fixed the sensor such that it looks at an angle of 45 degrees from the direction of the wheels. This allows the robot to anticipate corners so that it can successfully execute right turns. If we were to mount the sensor on a motor, we would be able to control its position relative to the wall by having another thread adjust the angle of rotation based on the speed of the wheels. This adjustments would enable us to eliminate the zig-zag pattern that the robot follows by adjusting its trajectory to a straight line once its within the bandwidth area.

- Use a second ultrasonic sensor to anticipate obstacles directly ahead of the robot.

A second ultrasonic sensor would allow us to perform better right turns when there are obstacles directly ahead of the robot. In the current implementation the robot basically depends on the 45 degree angle of the US to detect concave corners; the turns are successful, but the robot tends to get very close to the wall before detecting that it has to start rotating. In order to counter this the right wheel slows down considerably so that the left wheel can complete the turn.

A second sensor would allow us to considerably improve this motion by knowing exactly when the robot is approaching a wall.

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