Laboratory 1: Wall Following Report

ECSE 211: Design Principles and Methods

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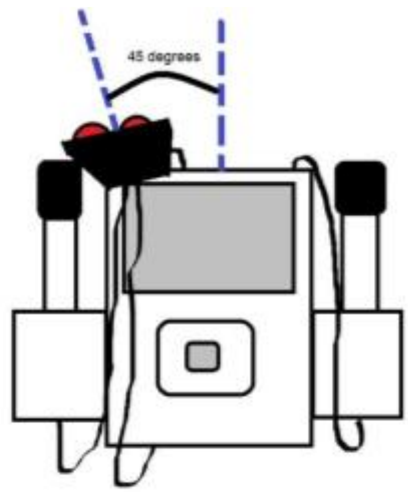
I. Design evaluation

Hardware design: The design relied upon consists of the Mindstorm Brick as the center piece to which were mounted two large EV3 motors, one on each side, in order to allow the rotation of the wheels they have been assembled with. Additionally, an ultrasonic sensor (US) was attached above the left motor at an angle of approximately 45˚ from the front of the machine.



PICTURE OF THE ROBOT

Figure 1 Simplified design scheme of the robot

Software design:

1- Bang-Bang controller: This software allows the robot to adjust its path by reducing or increasing the speed of its motors by a certain constant number no matter what the error is.
2- P Controller: Modifies the speed of rotation of the motors by applying a correction to the given motor speed which relies on multiplying the error calculated by a proportionality constant

see appendix for the flowchart

II. Test Data

Bang-Bang Controller test: After putting the robot at the corner of a wall, it was able to run without hitting the wall after a few trials, as the software was modified and optimized, the success rate increased with the number of trials. Its band center was not the same throughout the run as oscillations were large and the robot ran left and right constantly switching between the two directions.

P-type Controller test: The same lap was done by the robot when using the P-type Controller however the variation in its band center was largely reduced in comparison with the Bang-Bang Controller test. Oscillations were smaller and the run was “smoother” as it automatically achieved a tight or strong turn when it was too close or too far from the wall. The robot stayed at relatively the same distance from the wall.

III. Test Analysis

The Bang-Bang Controller test showed that the constant correction being subtracted or added to the motors' speed is leading the robot to oscillate and considerably changing its distance from the wall as the speed modifications did not depend on the magnitude of the error but only on the fact that the machine is close or far from the wall. This design led to large variations of the actual distance around the specified band center.

However, using the P-Type Controller, the correction was proportional to the error calculated and thus the speed of the motors was adjusted such that the robot reacts in an adequate manner, keeping an almost constant distance from the wall. A quick dampening of the oscillations was observables as the proportionality constant scaled the generated correction.

IV. Observations and Conclusions

What errors does the ultrasonic sensor experience?

The main errors experienced by the ultrasonic sensors consist of acquiring values which are too large when the robot is turning around a corner for example or going near a gap between two wall bricks.

Furthermore, the ultrasonic sensor is rather slow at acquiring values and can sometimes be late to give values around corners. Also, as the battery level reduces, the sensor's performance does so as well. Finally, if not directed at an angle the sensor cannot have a wide enough angle to correctly direct the robot relative to the wheel.

Can these errors be filtered?

These errors can be effectively filtered as the software can avoid considering values which surpass a certain threshold or limit, for example, values which are too large can be ignored and the robot can then be programmed to achieve a tight turn if these large values persist for it can be going away from the its path and as values keep getting larger then this might mean that it is not a gap.

Does the ultrasonic sensor produce false positives, i.e. detection of non-existent objects?

Yes, from time to time, the sensor would detect an object even though the closest object would be at least thirty centimeters away.

Does the ultrasonic sensor produce false negatives, i.e. failure to detect objects?

Yes, when one of the "eyes" of the sensor is covered, it does not detect that object. When the sensor it is very close to the wall, the sensor would sometimes output a very large value even though it was right next to the wall.

V. Further Improvements

What improvements could you make to both the physical and software design to improve the performance? Give 3 examples

The physical design can be improved by adjusting the angle of the ultrasonic sensor such that it detects in the best way possible the upcoming convex or concave corners in the path of the robot. Also, the design can be made more compact in order to avoid having the machine or its wires touch the wall.

Moreover, the software design can be improved by changing the constants by which the speed of the motors is modified in the Bang-Bang Controller to reduce the oscillations intensity. For the P-type Controller, the proportionality constant can possibly be adjusted to better fit the task that the robot must execute and additional filters for the ultrasonic sensors can be implemented as well as a backwards moving method which leads the robot to reverse back when it is too close to the wall.

What other controller types could be used in place of the Bang-Bang or P-controllers?

Other types of controllers include the Integral Controller where the correction is proportional to the integral of the error and the Derivative Controller which allows the correction to be proportional to the derivative of the error calculated.

appendix