UNIVERSITY OF TRENTO – Italy

Master of Science in Mechatronics Engineering

Informatica e programmazione

Mobile Robot

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Submitted to: Prof. Enrico Bertolazzi

Trento, 08/07/2016

I. Abstract

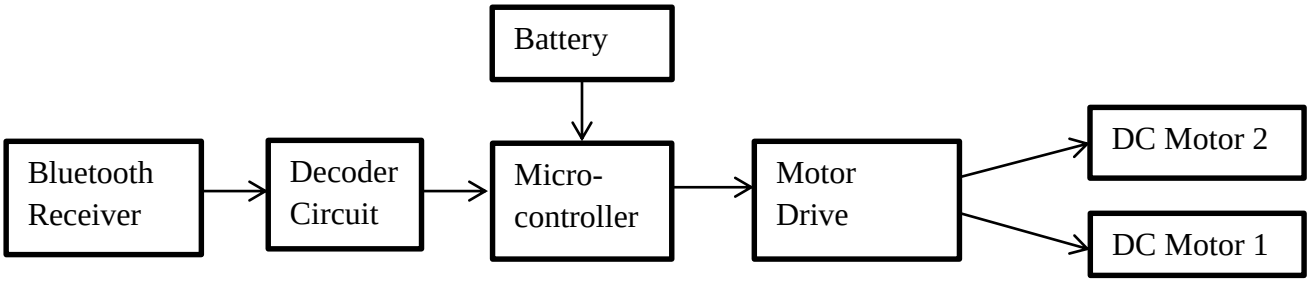
Warehouse distribution and line-side logistics are causing 25% - 35% of the total production cost. Labor costs can be reduced by eliminating the tasks related to material movement through automatically picks up and drops off carts. In this project an autonomous line follower robot has been implemented to work in an environment, where these robots function as a materials carrier to deliver products one point to another where rail, conveyer and gantry solution are not possible. A PID control is used to get smoother line following capability of the robot. Apart from line following capacities, the robot can be controlled by mobile phone through Bluetooth and it is also capable to detect obstacles through ultrasonic sensor.

Keywords: Line Follower, PID Control, Ultrasonic Sensor, Bluetooth.

II. Introduction

The robot is able to:

• **Follow the commands:** (forward, backward, turn left or right, increase or decrease velocity of wheels) from a remote user via Bluetooth using a program to parse inputs coming from a mobile phone, controlling in this manner the two motors. The robot can also avoid obstacles due to ultrasonic sensors put in front of it, disabling the forward driver input.



• **Follow a black line automatically** drawn on the floor as smoothly as possible and continuously correct itself to stay on the track.

• **Recognize crosses**: in the black line and stop till the user manually chooses the turn direction to follow (left, right or forward)

III. Solution

1. Manual control with Bluetooth

We use an Arduino RC application on a smart phone to control the mobile robot to move forward, backward, turn right or left and change speed. The second ability of the mobile robot is obstacle avoidance. When the mobile robot is going to hit an object, the ultrasound sensor will continuously measure distance between the robot and the object. If the distance is too small, command from user that is to move forward will be discarded.

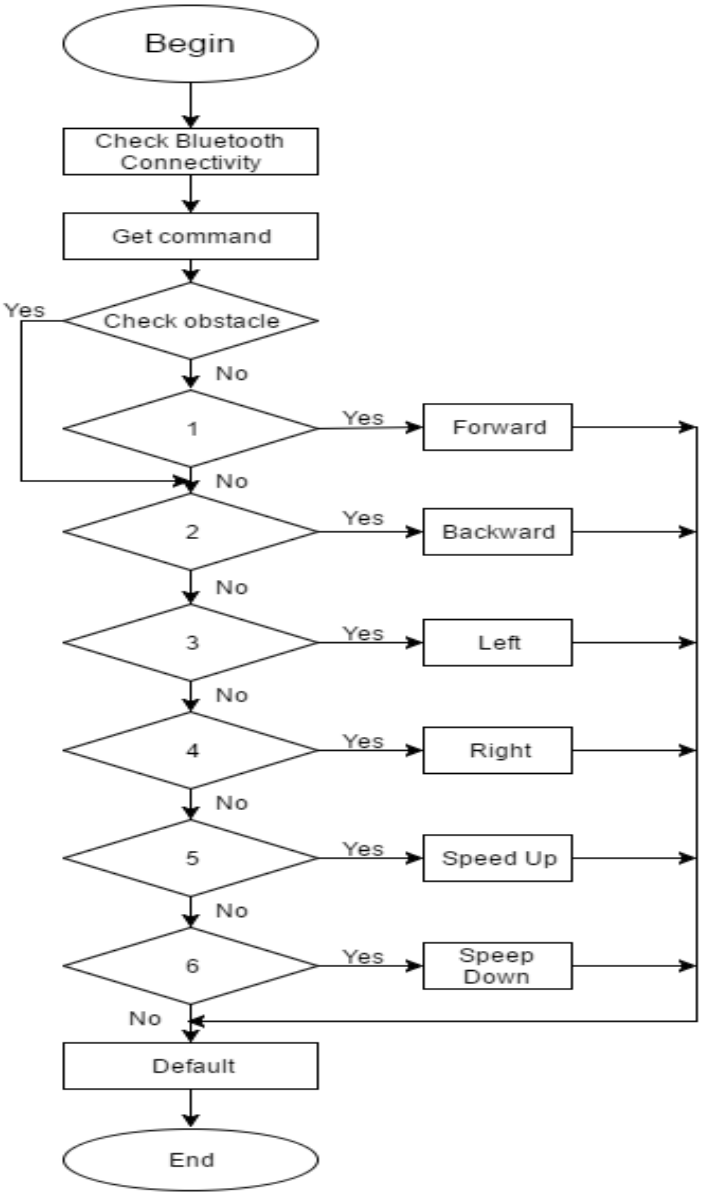


Figure 1: Manual control with obstacle avoidance

2. Automatically follow a black line using PID algorithm

Two tasks (1 and 2) are completed by following these steps:

Step 1: Start

Step 2: Read sensor's data to know robot's position.

Step 3: Check cross-line's appearance.

Step 4: Valid: stop and ask user's commands. Then go to step 5.

Step 5: PID controller, modify and set motor's speeds.

The details of the algorithm could be summarized in this flowchart:

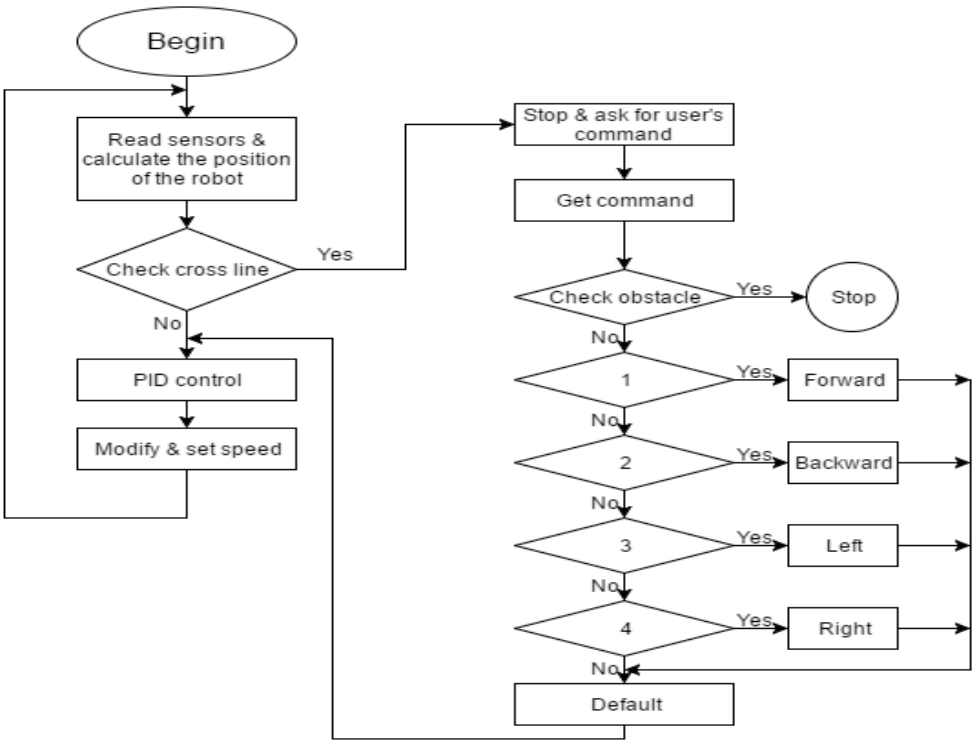


Figure 2: Following line with PID algorithm

Due to the limited availability of hardware components, some problems arose during implementing the robot:

- Digital infrared sensors providing low returned values' resolution.
- Unequal distance between each sensor.
- Noise due to illumination.
- Non-Synchronization of two motor's speed due to lack of encoders.

In this application, the feedback signal is extremely important because the PID controller uses it to calculate and set the motor's speed. For this critical reason, we mounted four digital infrared sensors to increase the resolution.

3. Combination

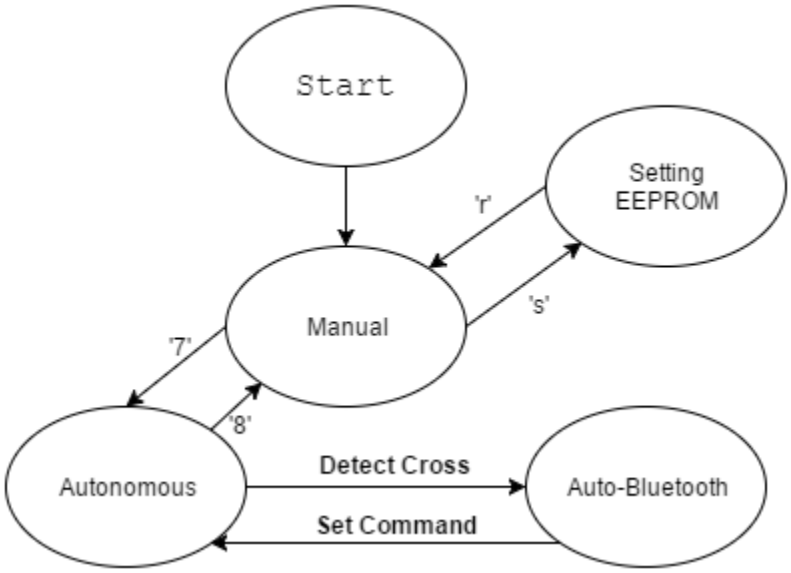


Figure 3: Finite State Machine of mobile robot

Finally, we combine all of above functionalities of the mobile robot to a single program. It will be explained more detail in the finite state machine of system. When the program starts, it will automatically go to "Manual" mode in which we can control the robot via Bluetooth. If we press the button "7", the program will turn into "Autonomous" mode in which the robot will follow a black line by PID algorithm and switch to "Auto-Bluetooth" when it detects a cross. Moreover, we are able to save all setting such as PID parameters and speed base into EEPROM for the next usage.

IV. Conclusion

Building a mobile robot needs a cooperation between different fields like electronics, programming and mechanical concepts. We focus mainly on the programming part, which is the purpose of this project. We managed to fulfill the required tasks and the robot's performance is quite good especially at low velocities. In order to improve the precision of our robot we can add some more IR sensors close to each other or encoders to better estimate the velocity of the wheels. Another good idea could be to integrate a camera to increase accuracy of position of the robot. We used a black line on the floor, but it can also be white, what matters is that the contrast between floor and line's color is strong enough to allow IR sensors distinguish them.

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