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Embedded Systems Project Report

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Abstract

In this project, there will be the design and development of an embedded robotic system which will entail the use of both the line following and obstacle avoidance capabilities in one robotic system. The robotic system will be designed using a microcontroller-based control system and infrared and ultrasonic sensors for its functionalities to be achieved. The use of this project will demonstrate a wide range of aspects within the topic of embedded systems.

Introduction

Embedded systems are specialized computing systems designed for performing only specific tasks within larger systems. They are widely used in robotics, used for the demonstration of sensor interfacing, motor control, and real-time decision making.

A mobile robot was developed in the project to follow a black line on a white surface using infrared sensors. Obstacle detection is enabled on the front-mounted fixed ultrasonic sensor. Subsequently, the movement of the robot stops or alters whenever an obstacle has been detected. This project integrates mechanical construction, electrical interfacing, and embedded software design.

System Design

Mechanical Design

The robot is constructed using a lightweight base that supports all components securely. Two DC motors with wheels are used for movement, allowing the robot to move forward and turn. A caster wheel is used to maintain balance. The ultrasonic sensor is fixed at the front of the robot for obstacle detection, and a separate servo motor is used only for the flag mechanism.

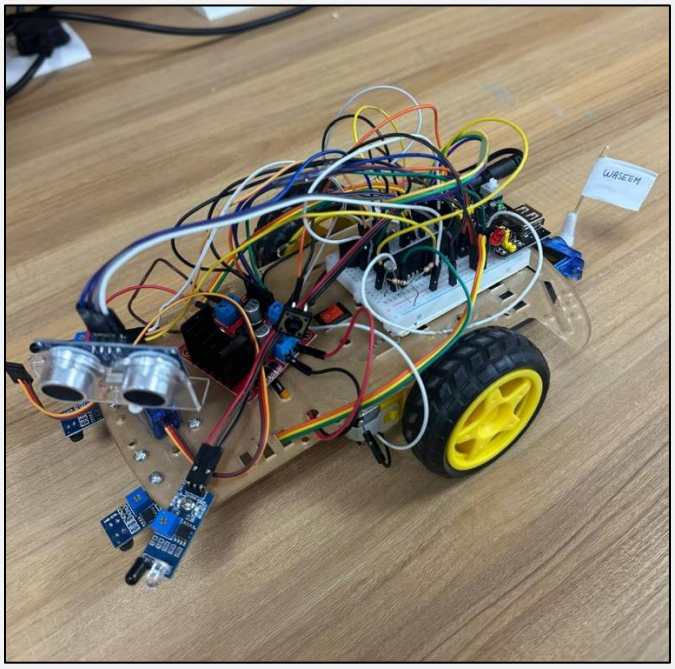

Figure 1: Mechanical Design

Electrical Design

The electrical system is based on a PIC16F877A microcontroller. The main components include:

- Infrared sensors for line detection
- A fixed ultrasonic sensor for obstacle detection
- DC motors connected through an H-bridge motor driver
- A servo motor used for the flag mechanism
- Power supply and voltage regulation components

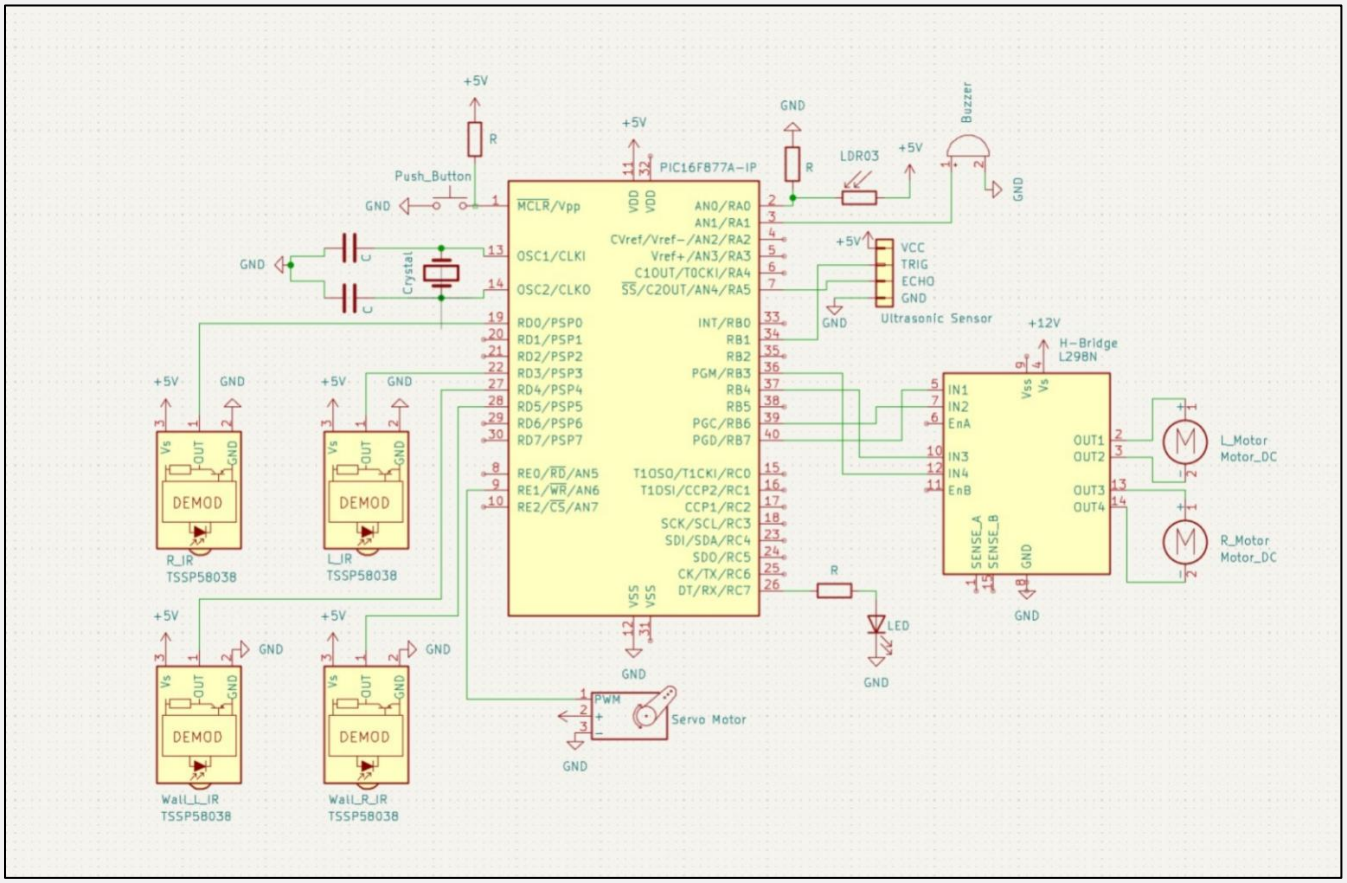

Figure 2: Electrical Design

Software Design

The software is developed in embedded C using the mikroC environment. The program reads input from the IR sensors, LDR sensor, and ultrasonic sensor, then controls the motors accordingly. The robot follows a line during normal operation and responds to obstacles detected by the ultrasonic sensor. The servo motor is controlled separately for the flag mechanism.

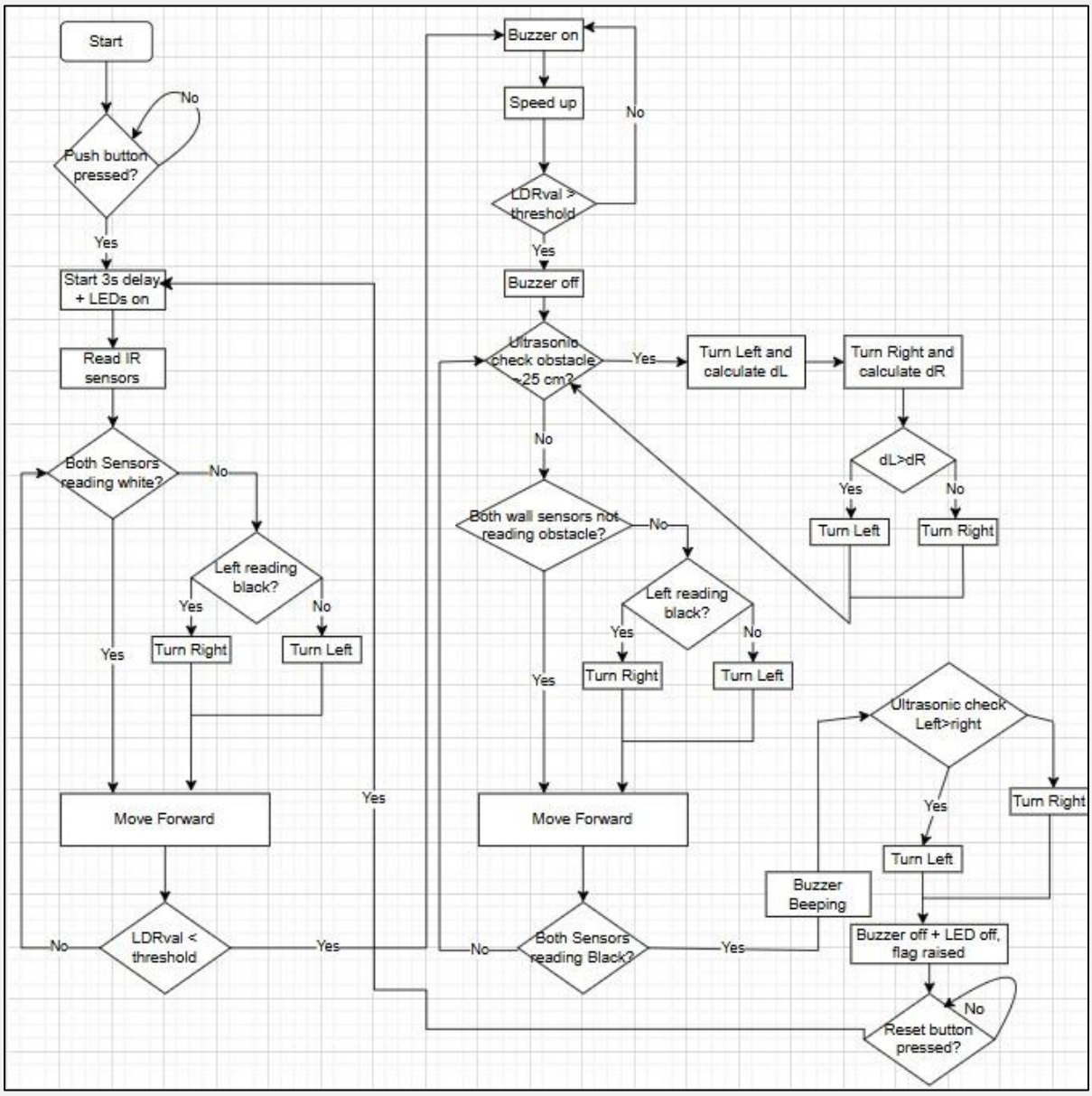

Figure 3: Software Design

Problems and Recommendations

Problems

During the implementation of the project, several difficulties were faced. The first problem was related to the analog LDR sensor. At the beginning, we did not know that the LDR outputs an analog signal, which made it difficult to handle since our design was initially based on digital readings. Converting the sensor behavior from a digital concept to an analog understanding was challenging.

The second problem was using the servo motor under the ultrasonic sensor. Although the hardware connection was completed correctly, we faced difficulties in writing the appropriate code to control the servo movement and synchronize it with the ultrasonic distance measurements.

Another issue was related to the H-bridge motor driver. We were not aware of the function of the enable pins at first, which caused the motors to not respond as expected. Understanding how the enable pins control motor activation and speed required additional learning and testing.

Finally, controlling the servo motor used for the flag mechanism was also difficult. Writing the servo control code was challenging, and we needed assistance from friends to complete this part successfully.

Recommendations

To avoid these issues in future projects, it is recommended to study sensor types in advance, especially the difference between analog and digital sensors. Understanding basic servo motor control and timing concepts before implementation would also be beneficial. Additionally, learning the internal working of motor drivers such as H-bridges, including enable pins, can save time during development. Finally, practicing servo motor programming through small test projects can help improve confidence and coding skills.

Conclusions

This project clearly and effectively translates the design and workings of an embedded robotic system. It shows how it is possible for a robotic system to track a line and avoid obstacles on its own, which are crucial concepts of embedded systems and include real-time processing, interactions with hardware devices, and control logic. This particular project lays a very important foundation for other, more advanced, robotic applications and shows the relevance of incorporating different aspects of design within the context of embedded systems.