Autonomous Mobile Robots Challenge

R. Abu Abed, L. Zghayer, and L. Abu Nimeh

Supervisor: Dr. Essam Qaralleh, Dr. Belal Sababha

Embedded Systems Final Design Project, Fall 2025

King Abdullah II School of Engineering

Princess Sumaya University for Technology

Introduction

This project presents the design and implementation of an Autonomous Robot based on the PIC 16F877A microcontroller architecture. Unlike standard line-followers, this robot is engineered to handle a dynamic environment, navigating through complex scenarios that simulate real-world logistical challenges, including tunnels, obstacles, and a parking zones.

Design

The robot is designed to navigate through all the following stages:

1- Line Following: using TCRT5000 (IR) floor sensors

2- T-intersection handling: Ultrasonic sensor (HC-SR04) and TCRT5000 (IR) floor sensors

3- Tunnel navigation: using an LDR (Light-dependent Resistor) and a buzzer

4- Obstacle Avoidance: Ultrasonic sensor (HC-SR04) and side IR sensor module

5- Parking: detecting the parking spot, stop and raise the flag using the servo motor

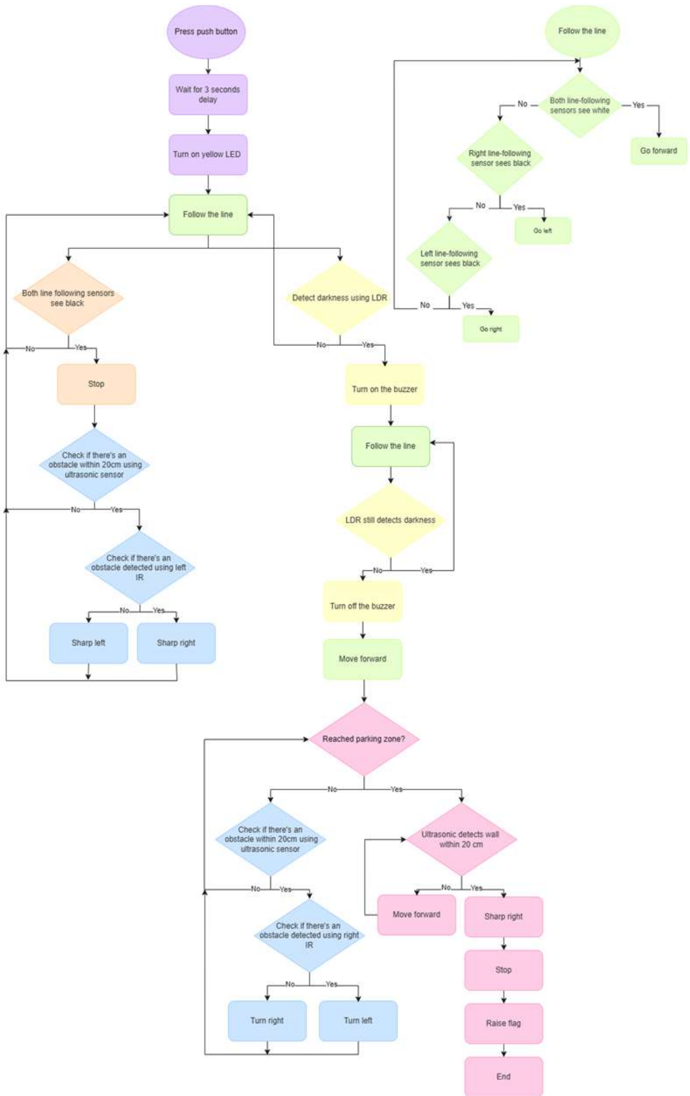

Figure 1: Software design flowchart

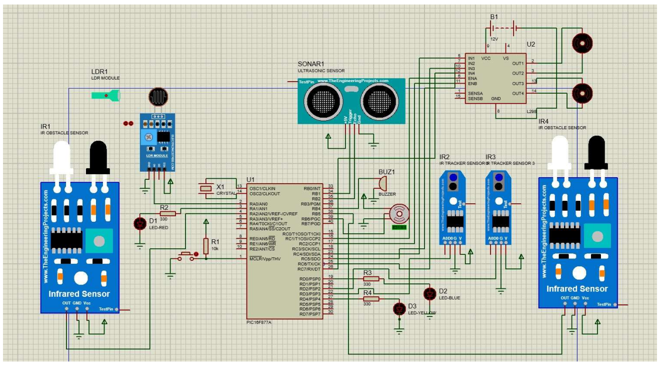

Figure 2: Hardware schematic design

Components
PIC16F877A
H-Bridge
Three LEDs
Two IR Sensor Modules
Ultrasonic sensor (HC-SR04)
Two TCRT5000 IR sensors
Power ON/OFF switch
Two DC motors
Reset push button
Voltage regulator
Buzzer
Servo Motor
LDR sensor module

Results

The robot utilizes a PIC microcontroller and an 8 MHz crystal to coordinate an autonomous navigation system driven by multiple sensor modules. The system employs Timer2-based Pulse Width Modulation (PWM) to regulate motor speeds, allowing it to follow a path using infrared line sensors and perform corrective steering. Environmental awareness is managed through an Analog-to-Digital Converter (ADC) that monitors light levels for tunnel detection. Obstacle detection and avoidance are achieved using an ultrasonic sensor that calculates distance to nearby objects. These sensor inputs are integrated within the program to manage state transitions; switching between line following, tunnel detection, obstacle avoidance and concludes by parking the robot in the parking area and raising a flag.

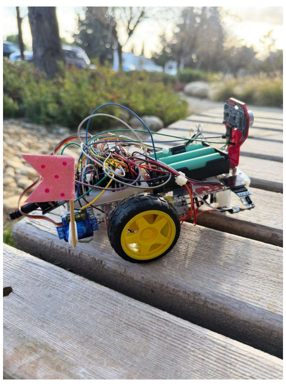

Figure 3 : Robot side view

Figure 4 : Robot front view

Conclusion

This work shows how careful timing, interrupt-driven design, and multi-sensor integration can produce complex behaviour using limited hardware resources. This approach demonstrates practical embedded systems used in robotics and automation, highlighting the relevance of low-cost microcontrollers in real-world autonomous applications.