Princess Sumaya University for Technology

King Abdullah II Faculty of Engineering

EMBEDDED SYSTEMS

TRASH PICKING ROBOT

Authors:

Supervisor
:

Salma Shabib	20210140	NIS Engineering	sal20210140@std.psut.edu.jo
Batool Allan	20210108	IOT engineering	bat20210108@std.psut.edu.jo
Joud Alsouri	20210598	NIS Engineering	jou20210598@std.psut.edu.jo

Dr.Belal Sababha

January 10, 2025

Abstract

The abstract should be written concisely in normal rather than highly abbreviated English. The author should assume that the reader has some knowledge of the subject but has not read the report. Thus, the abstract should be intelligible and complete in itself; particularly it should not cite figures, tables, or sections of the report. In the abstract, indicate the subjects dealt with in the report and state the main objective of the investigation. The body of the abstract should indicate newly observed facts and the main conclusions of the experiment. Its optimum length will vary somewhat with the nature and extent of the conducted experiment, but it should not exceed 100 words.

TABLE OF CONTENTS

INTRODUCTION

Waste management is an important issue that affects our daily lives, especially in crowded urban areas. This project focuses on building a trash-picking robot that can help address this problem by automating the process of detecting, collecting, and moving waste. The robot uses sensors like an IR sensor to detect objects and an ultrasonic sensor to avoid obstacles. It also includes a servo motor to pick up and release objects, while Bluetooth communication allows it to be controlled remotely.

The robot is designed to operate efficiently, with features like motor speed adjustment through a potentiometer and interrupt-based tasks for precise control. The goal of this project is to create a working prototype that demonstrates how simple embedded systems can be used to tackle practical problems like waste collection. This robot not only fulfills the requirements for an embedded systems project but also shows how technology can contribute to keeping our environment cleaner.

OBJECTIVES

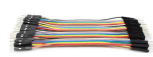
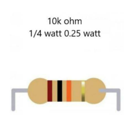
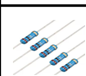
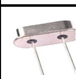
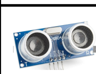
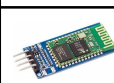
The primary objectives of this project were to:

1. **Develop an autonomous trash-picking robot that** uses embedded systems to tackle waste management tasks effectively.
2. **Implement pulse-width modulation (PWM)** motor control to fine-tune the robot's speed, ensuring optimal performance and power efficiency.
3. **Enhance operational efficiency** by leveraging precise movement control and real-time sensor data for accurate decision-making.

The key goal of this project was to design and implement both the electrical and software architecture necessary for an autonomous robot capable of efficiently collecting trash. Essential hardware components included motor drivers for precise control of movement, ultrasonic sensors for obstacle detection and distance measurement, and the PIC16F877A microcontroller as the central processing unit. The software development focused on programming the microcontroller to process sensor inputs, adjust motor speeds using PWM, and coordinate the robot's cleaning and navigation tasks seamlessly.

COMPONENTS AND ILLUSTRATIONS

The table below provides a comprehensive list of all hardware components used in the Trash-Picking Robot, along with their respective figures for visual reference.

117S 2-pin ON/OFF switch -250V3A 125V6A KCD1-101	
HC-SR04 Crystal Ultrasonic Bracket Holder	
2X (Lithium Battery18650 3.7v 3800mAh Golden Power)	
2X18650 Battery Storage Box Holder 7.4v	
2X(10cm Male TO Female 40Pin Jumper Wires)	
2X (10cm Male TO Male 40Pin Jumper Wires)	
2X (20cm Female to Female 40Pin Jumper Wires 20cm Female to Female 40Pin Jumper Wires)	
feet push 4 button 12*12*5 large push button 4 feet 12*12*5	
Single Union Potentiometer B10K	
10k Ohm Resistor 1/4w (0.25 Watt) 10k Ohm Resistor 1/4w	
Ohm 220 Resistor 1/2w Ohm Resistor 220 1/2w	
crystal oscillator 8M	
Ultrasonic Sensor HC-SR04	
E18-D80NK SV Adjustable Infrared Sensor Switch 3-80cm 45m	
HC-06 Wireless Bluetooth Module TTL (normal Quality)	

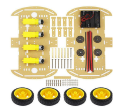
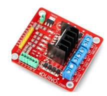
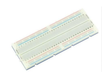
4WD ROBOT SMART CAR 6V DC	
Mini Servo Motor SG90 9g Servo 180 Degree	
Dual H-Bridge DC & Stepper Motor Driver L298	
Breadboard	

Table1: Hardware components

SENSORS OVERVIEW

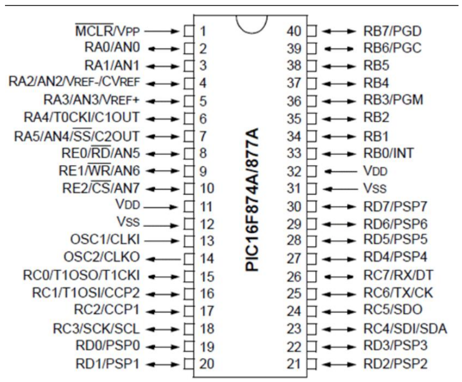
The following descriptions outline the key sensors used in the Trash-Picking Robot, highlighting their functions and contributions to the robot's performance.

1- PIC16F877A Microcontroller

The PIC16F877A microcontroller serves as the central control unit of the trash-picking robot, coordinating all critical operations from navigation and obstacle detection to motor and gripper control. It processes real-time data from multiple sensors, including the ultrasonic and infrared modules, to make informed decisions about movement and object interaction. The microcontroller generates precise PWM (Pulse Width Modulation) signals for the motor driver and servo motor, ensuring smooth motion control and efficient trash collection.

Equipped with 40 pins, including 35 general-purpose input/output (GPIO) pins, the PIC16F877A offers extensive connectivity for sensors, actuators, and communication modules. Its architecture features 8KB of program memory and 368 bytes of RAM, enabling the implementation of complex algorithms such as distance calculations, motor speed adjustments, and multitasking routines. Key onboard features like analog-to-digital conversion (ADC), timers, and hardware PWM generation make it particularly well-suited for robotics projects requiring precise control.

This microcontroller's reliability and versatility ensure it can handle multiple tasks simultaneously, such as reading sensor data, processing Bluetooth commands, and controlling motor outputs without compromising efficiency. Its ease of programming and robust design make it a preferred choice for educational and industrial automation projects, solidifying its role as the core component driving the robot's functionality.



2- HC-SR04 Ultrasonic Sensor

The HC-SR04 ultrasonic sensor plays a vital role in the robot's autonomous navigation system by enabling accurate distance measurement and obstacle detection. It functions by emitting high-frequency sound waves and calculating the time taken for the echo to return after reflecting off a surface. This data is then processed to determine the proximity of obstacles, allowing the robot to make dynamic path adjustments. Its non-contact sensing capability ensures reliable operation, even in cluttered environments, making it ideal for precise movement control and collision avoidance.

3- HC-06 Bluetooth Module

The HC-06 Bluetooth module is crucial for wireless control, allowing seamless communication between the robot and a remote device such as a smartphone or computer. Using UART serial communication, it transmits data bidirectionally, enabling the operator to send real-time movement commands and control the gripper mechanism. This wireless functionality enhances user convenience by eliminating the need for physical connections, making the robot more versatile and adaptable for remote tasks, such as manual testing or supervised operation.

4- E18-D80NK Infrared Sensor

The E18-D80NK infrared sensor is an essential component for close-range object detection and interaction. It operates by emitting infrared light and detecting the intensity of the reflected signal to identify objects within its adjustable sensing range of 3 to 80 cm. This sensor ensures effective identification of trash items and obstacles in the robot's path. Its ability to detect objects without physical contact makes it highly suitable for both object detection and feedback mechanisms during the trash-picking process, enhancing operational precision.

5- SG90 Servo Motor

The SG90 servo motor is responsible for operating the robot's trash collection gripper with precision and control. It utilizes PWM (Pulse Width Modulation) signals to adjust its angular position between 0° and 180°, enabling controlled opening and closing of the gripper. This controlled movement ensures a secure grip on objects, preventing accidental drops during collection and transportation. The servo’s lightweight design and accuracy make it ideal for robotic arms or mechanisms requiring fine motion control.

6- B10K Potentiometer

The B10K potentiometer serves as a manual control interface for adjusting critical operational parameters such as motor speed or sensor sensitivity. By varying its resistance, it allows for dynamic voltage adjustments, providing real-time control feedback to the microcontroller. This component is particularly useful during calibration and testing phases, offering a simple yet effective way to fine-tune the robot's responsiveness to ensure optimal performance in varying environments.

7- IR LED and Receiver (IR Detection Module)

The IR LED and receiver module functions as a detection and feedback system during the trash-picking process. It works by emitting infrared light and measuring the reflected signal when an object is nearby. This system helps confirm successful object acquisition and provides feedback for grip verification, preventing failed pickups or accidental drops. Its non-contact detection mechanism ensures reliable performance, even when dealing with reflective or small-sized objects.

8- L298N Dual H-Bridge Motor Driver

The L298N dual H-Bridge motor driver is critical for controlling the robot’s two DC motors, providing full bidirectional control necessary for advanced movement. It enables the motors to operate in both forward and reverse directions using a combination of four MOSFET switches arranged in an H-Bridge configuration. This setup allows precise speed and direction control through PWM signals, ensuring smooth acceleration, deceleration, and turning. The driver’s dual-channel design offers independent control over each motor, making it ideal for complex robotic maneuvers like differential steering. Additionally, its built-in heat sink ensures stable performance during prolonged operations, contributing to the robot’s reliability and efficiency.

FLOWCHART

The flowchart below shows the standard operation method that the robot should work in.

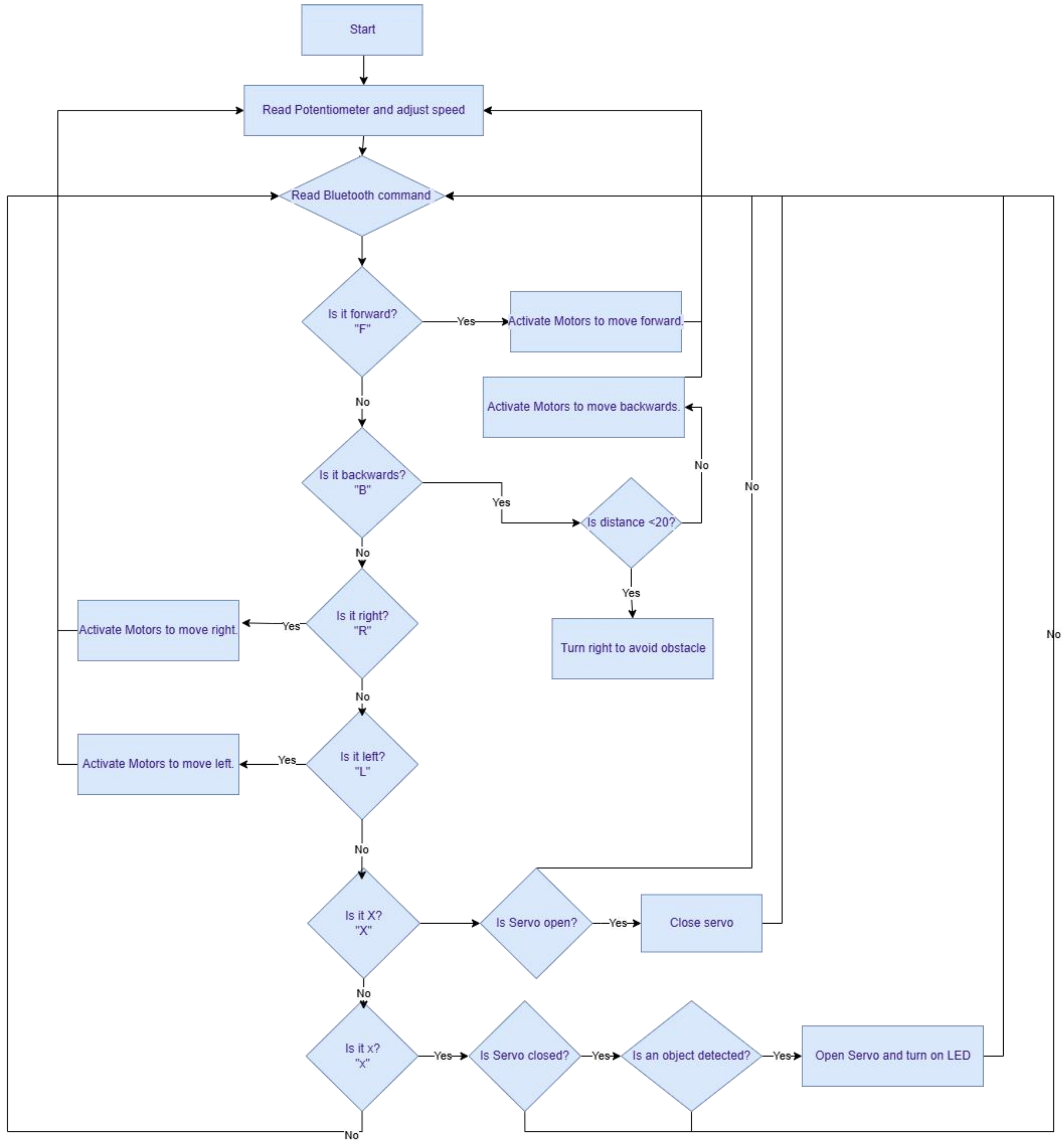
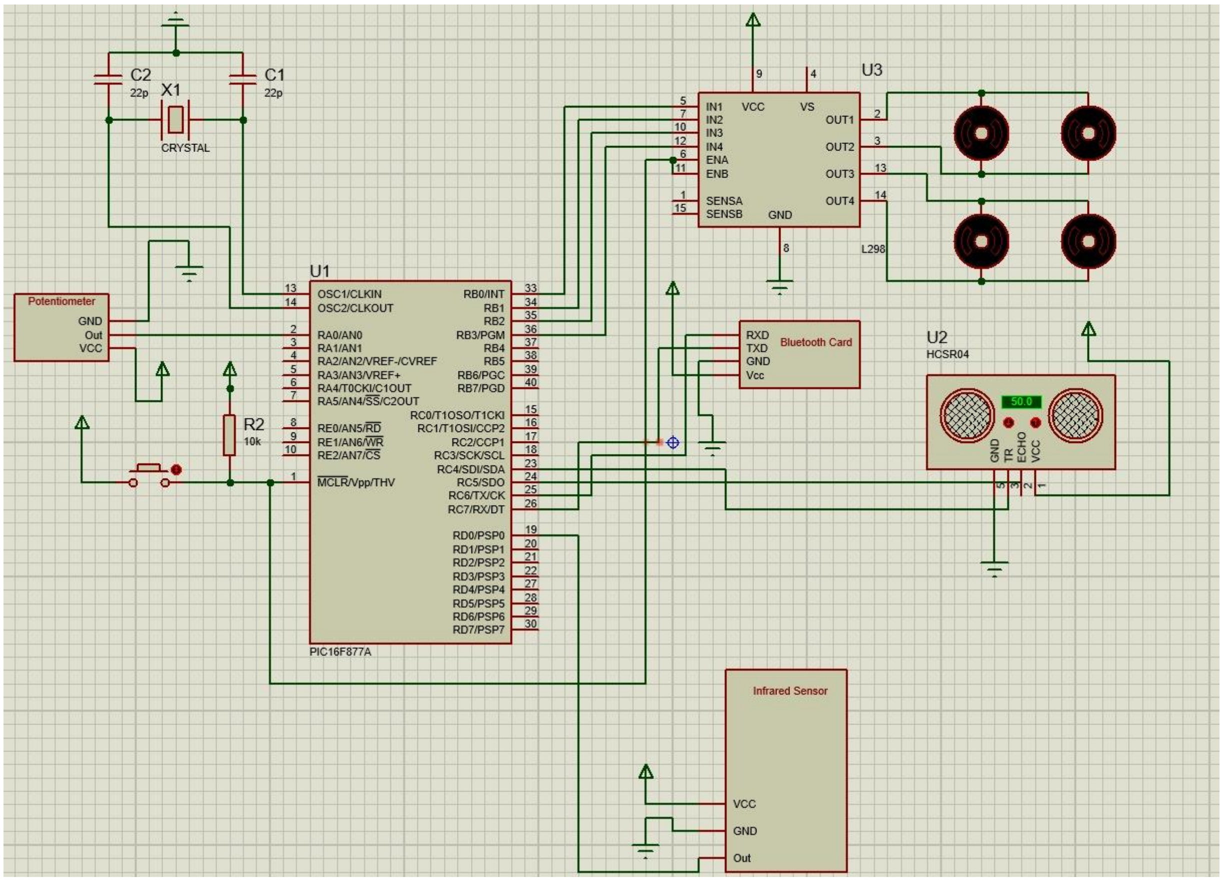


Figure 1: Flowchart of operation

CIRCUIT DESIGN



ROBOT LAYOUT

The layout of our Trash-Picking Robot is thoughtfully designed to maximize both operational efficiency and ease of maintenance. The following images illustrate the strategic placement of key components, such as the motors, ultrasonic sensors, microcontroller, gripper mechanism, and power supply, within the chassis. Each element is carefully arranged to ensure optimal performance in navigation and object collection.

This design not only ensures effective trash-picking but also maintains the robot's lightweight and durable structure, enabling it to handle various environments while simplifying maintenance and repairs. The thoughtful component placement contributes to both the robot's efficiency in completing tasks and its overall reliability, making it well-suited for practical use in real-world scenarios.

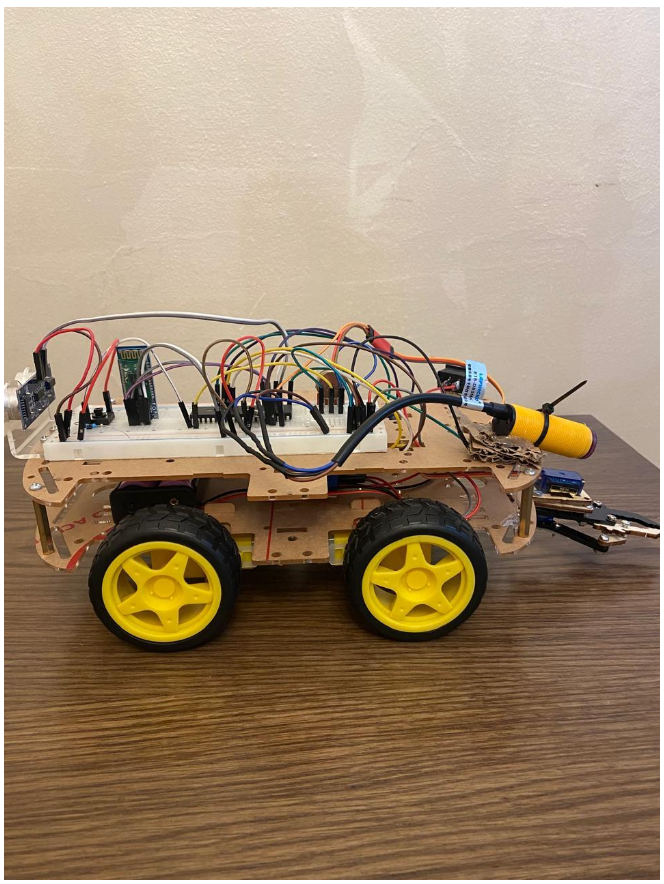


Figure2:Left Side View Of The Picking Trash Robot.

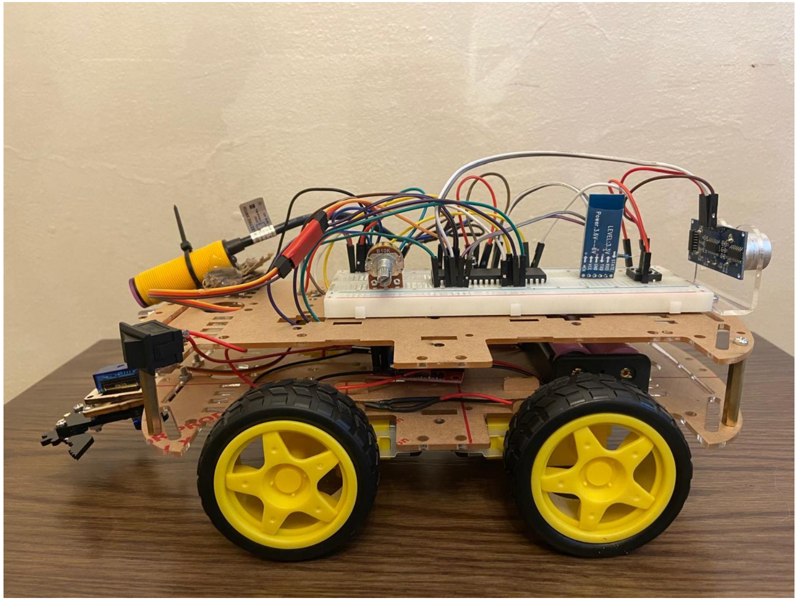


Figure3:Right Side View Of The Picking Trash Robot.

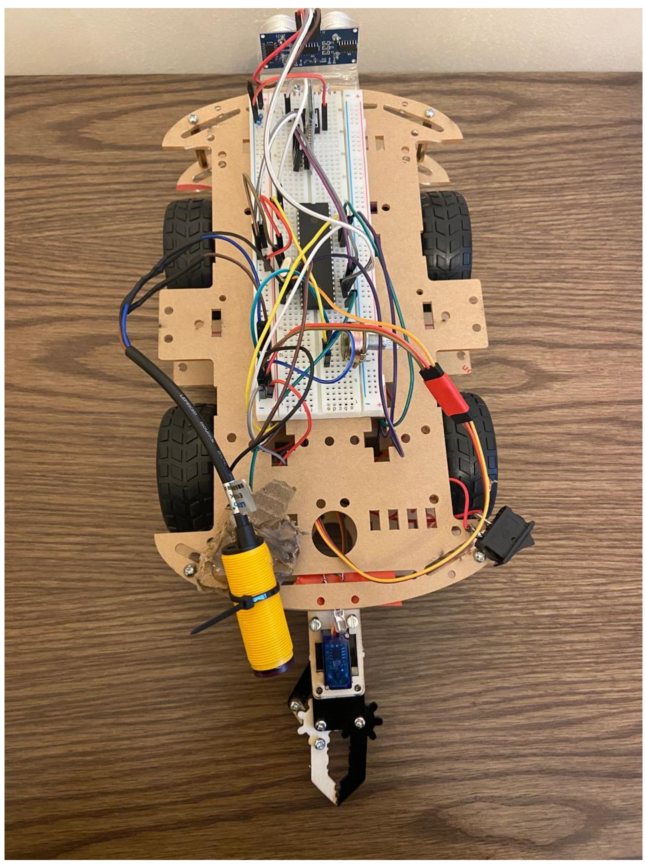


Figure4::Right Top View Of The Picking Trash Robot.

PROBLEMS AND SOLUTIONS

1. We bought an arm that uses 4 servo motors, but the pic only has 2 pins for PWM and the solution was to use a decoder which is too complicated, so we removed this arm and only installed a clip that picks up the trash. A picture of the arm is shown below.
2. The batteries of the motors were fried because we accidentally short-circuited the wires, so we were forced to get new batteries.
3. The original design had built-in trash but it didn't work. This is due to the fact that a fully rotational arm is needed to place the trash in the bin. The arm did not work therefore the built-in trash. The proposed solution was installing a trash can under the robot, but the new clip was far too low, so an external bin that the robot would go is the ideal solution.

Figure 2: Original Arm

FUTURE IMPLEMENTATIONS

This project has huge potential and with some additions its functionality and usability would be improved.

1. **Improved Object Detection and Sorting:** Adding additional sensors to enable sorting of objects based on color, size, or material is a huge improvement. Also, integrating color sensors and a camera module with image recognition to identify specific types of trash to help with recycling would revolutionize this project.
2. **Advanced Pathfinding and Navigation:** Implement line-following algorithms using line-tracking sensors to enable the robot to autonomously navigate predefined paths instead of controlling it with a joystick.
3. **Enhanced Bluetooth Communication:** Replacing Bluetooth with a more advanced communication protocol, such as Wi-Fi or Zigbee, is better for control over longer distances or through a network providing an option to remotely control the robot.

4. **Expanded Automation**: Implementing object weight detection using load sensors to determine whether to pick up heavier objects or not.

CONCLUSIONS

This project which is controlled by PIC16F877A microcontroller is going to produce a trash picking robot that is controlled manually by bluetooth that the user controls. This project achieves key objectives successfully such as not only does it meet all requirements and budget constraints, it also successfully leverages embedded systems to address waste management challenges efficiently. he robot is capable of detecting objects using an IR sensor, measuring distances with an ultrasonic sensor, and adjusting motor speed via a potentiometer. It can pick up and release objects with a servo motor controlled by Bluetooth commands and navigate its environment while avoiding obstacles. By integrating interrupt-based tasks and PWM control, the project achieves precise timing and efficient operation. The implementation meets the key design expectations and provides a practical application in waste management. This robot has the potential to be further developed into an autonomous system with advanced features for real-world scenarios, making it a step toward automated solutions for cleaner and more sustainable environments.

References

[1]	"IEEE Editorial Style Manual," 2017. [Online]. Available: https://www.ieee.org/documents/style_manual.pdf.
[2]	G. Masters, Renewable and Efficient Electric Power Systems, Wiley-IEEE Press, 2013.
[3]	"www.digikey.com," [Online]. Available: https://www.digikey.com/schemeit/project/. [Accessed 23 November 2017].
[4]	اكبر متجر للقطع الالكترونية في الاردن - وصلة - Waslleh
[5]	PIC16F87XA Datasheet PIC16F87XA Data Sheet
[6]	Ultrasonic Datasheet HC-SR04
[7]	HC-06 Bluetooth ModuleDatasheetMicrosoft Word - HC-06 datasheet 201104201104 revised.doc
[8]	E18-D80NK Infrared SensorET-MINI KEY 4x4
[9]	SG90 MINI SERVO MOTOR SERVO MOTOR SG90 DATA SHEET
[10]	B10K Potentiometer 10K Potentiometer Pinout, Working & Datasheet Explained
[11]	L298N Dual H-Bridge Motor Driver L298N Motor Driver.pdf