DEVELOPMENT AND PERFORMANCE OF CLEANY BOT ON CORRIDORS AND ROADS OF BUETK

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DEDICATION

Dedicated to our beloved parents and adored siblings whose tremendous support and cooperation led us to this wonderful accomplishment

ABSTRACT

Domestic cleaning has become a time-consuming task, and hiring professionals is often a financial burden. To address this, Cleany-Bot, an autonomous vacuum cleaner robot, has been developed and tested in the corridors of mechanical engineering department at Balochistan university of engineering and technology, Khuzdar. This robot aims to provide an efficient and cost-effective solution for household floor cleaning. The conventional methods of domestic cleaning are labor-intensive, and professional services incur financial costs. Cleany-Bot addresses these challenges by automating the cleaning process, offering an alternative that is both time-efficient and economical. Cleany-Bot's development involves three key phases: mechanical design, electrical design, and software design. The mechanical design focuses on the creation of a durable chassis and an effective cleaning system. The electrical design incorporates carefully selected components, including batteries, motors, drives, sensors, and microcontrollers. The software design includes a simple remote-control device for manual and Bluetooth-enabled remote operation.Cleany-Bot's implementation has resulted in a robust chassis, an efficient cleaning system, and successful integration of electrical and software components. The robot demonstrates effective navigation around obstacles, dust vacuuming capabilities, and provides a practical and swift solution for domestic cleaning.

AKNOWLEDGEMENT

In the name of the Almighty ALLAH, we express our deep gratitude for the opportunity to undertake our Final Year Project on an emerging technology.

Our sincere thanks go to our project Supervisor, **Engr. Salman Masroor (lecturer mechanical department)**, whose unwavering support and guidance were invaluable in shaping the success of our project. His expertise and mentorship elevated our work to new heights.

We also extend our appreciation to the **Dr. Abdullah Mengal** (Chairman Mechanical Engineering Department) for providing an environment conducive to learning and innovation. Their leadership has been instrumental in fostering a culture of excellence within the department.

We acknowledge the collective efforts of all our teachers, staff, and technicians, as well as the indispensable support of our friends. Special thanks to our parents for their enduring sacrifices.

As we conclude this chapter, we carry forward the knowledge gained and look forward to future endeavors.

DEVELOPMENT AND PERFORMANCE OF CLEANY BOT ON CORRIDORS AND ROADS OF BUETK

DEPARTMENT OF MECHANICAL ENGINEERING

CERTIFICATE

This is to certify that the work presented in this project report/thesis "DEVELOPMENT AND PERFORMANCE OF CLEANY BOT ON CORRIDORS AND ROADS OF BUETK" is entirely written by the following students themselves under the supervision of Engr.Salman Masroor.

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This project is submitted in partial fulfillment of the requirement for the award of "Bachelor Degree in Mechanical Engineering"

Project Supervisor **Head of Department**

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Vacuum robots are a popular product. However, new products with upgraded or enhanced features are always coming out on the market. The main purpose of robotic vacuum cleaners in homes is to remove trash from indoor floors. Cleaning has long been one of the most important tasks that individuals complete on a daily basis, and it requires time. It should come as no surprise that smart cleaning robots are becoming more and more common in today's modern world. Robotic lawn mowers and vacuum cleaners that can clean a house on their own are becoming increasingly popular. People, especially women, find it more difficult to manage both the house and the office at the same time as they have become more focused on their careers in recent years due to their erratic work hours. Most of the time, they employ cleaners to keep their homes, offices, etc. clean, but they have little faith in them. The Smart Vacuum Cleaner uses more advanced technology to solve the issue and is built to automate the cleaning process.

The use of autonomous cleaning robots in locations other than houses is incredibly promising. Examples of these locations include shopping centers, auditoriums, and schools. This thesis aims at creating a proof-of-concept for an autonomous cleaning robot for BUETK's classrooms, hallways, and roads. Cleaning floors and roads are generally the most frequent cleaning activities that need to be completed. The procedure of cleaning floors and roads usually takes two steps to complete. Using a vacuum cleaner, dust is removed during the first step of dry cleaning. Next, wet mopping is used to finish the cleaning process. This thesis focuses on the creation of a vacuum-cleaning dry cleaning system. In this case, the robot has to have freedom of movement inside its workspace. Typically, the floor is covered in a mixture of small stones, gravel, paper pieces, and dust, and the cleaning area is quite large. Therefore, in order to efficiently suction the trash listed above, a sturdy vacuum cleaning system needs to be built with a good dust-pickup capability. In addition, in order to clean the maximum area in a single charging cycle, the system needs longer running cycles. The choice of sensor array and path planning algorithms is critical to ensuring full coverage of the area, which affects the effectiveness and security of autonomous vacuum cleaning.

Vacuum cleaners started as relatively simple mechanical devices that had to be operated by hand. Today they (relatively) think for themselves and keep as away from asthmas and allergens. Most homes before the Industrial Revolution had hardwood (or stone) floors that could be cleaned with brooms. As carpets and rugs became cheaper, more people began to use them in their homes. People used to hang carpets outside and beat them with carpet beaters to clean them, but this approach was inconvenient. A new one had to be created.

1.1.1 History of Carpet Sweeper

Melville R. Bissell of Grand Rapids, Michigan, United States, invented the carpet sweeper in 1876. He and his wife Anna ran a little crockery shop, and because crockery (tableware) is packed in wooden boxes and sawdust, their show was always covered with sawdust, which had to be cleaned at the end of the day. Sawdust had the irritating property of being embedded in the carpet and being difficult to remove with a conventional broom. This irritated Anna, so she informed her husband about the situation. He constructed her a carpet sweeper because he is mechanically inclined. He designed it as a wooden box with an open bottom and wheels that carry the box when pushed with a long handle. These wheels are connected to the roller, which contains brushes and cleans the surface over which it is pushed while revolving. Dust is collected and placed in a receptacle, which must be emptied when full. Melville's sweeper performed admirably, and others quickly learned about it and desired one for themselves. Melville and Anna seized the marketing opportunity and began making them the same year Melville invented it. They began little. Local women produced brushes in their houses, while Melville and Anna constructed full sweepers in a room above the store. They also sold sweepers on their own. They'd fill up their buggy with carpet sweepers and walk from door to door, Melville on one side of the street and Anna on the other.

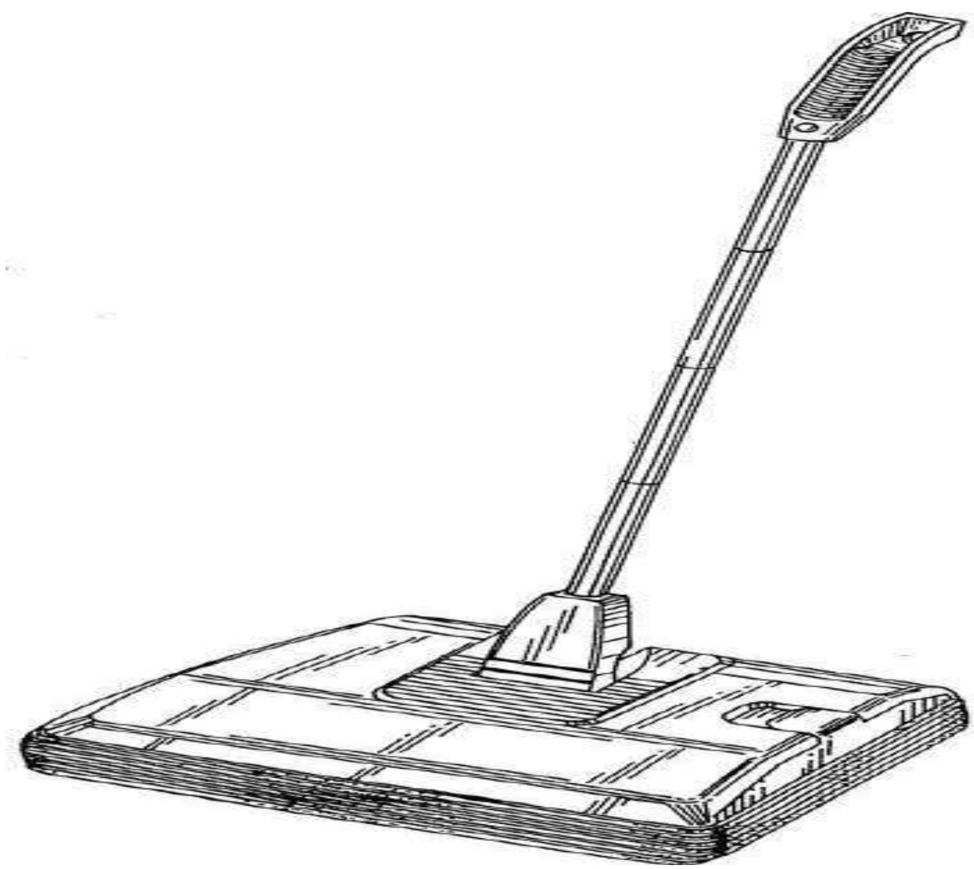

Fig 1.1 first carpet sweeper

1.1.2 History of Robotic Vacuum Cleaner

In 1996, the first robotic vacuum cleaner was introduced. It was given the name "Trilobite" by Electrolux, a Swedish producer of household and commercial appliances. Because of its originality, it was featured on the BBC's science television program Tomorrow's World. It functioned reasonably well, however it had issues clashing with objects and stopping a short distance from walls and other objects, leaving little portions that were not cleaned. Its manufacture has been halted. Dyson, a British technology company, released its DC06 model in 2001, but it was too expensive to mass produce. The Roomba was introduced a year later by iRobot, an American advanced technology company. When it comes across an obstruction, this robovac may shift direction.

Table 1.1 Vacuum Cleaner Timeline

S.NO	Year	Development
1	1860-1870	Manual carpet sweepers
2	1901	Hubert Cecil Booth invents powered vacuum
3	1907	James Murray Spangler invents electric vacuum
4	1908	William Henry Hoover popularizes vacuum cleaner
5	1920s-1930	Canister and upright designs become common
6	1950s	Introduction of self-propelled and disposable bag vacuum cleaners
7	1969s-1970s	Emergency of bagless vacuum cleaner
8	1980s-1990s	Advances in technology, compact designs
9	2000s-2010s	Rise of robotic vacuum cleaner, smart feature
10	2020	Continued advancements in smart and efficient designs

Table 1.2 Automatic Vacuum Cleaner Timeline

S.NO	Year	Development
1	1996	Electrolux introduces the Trilobite, one of the earliest robotic vacuum cleaners
2	2002	iRobot launches the Roomba, a widely popular and successful robotic vacuum
3	2006	Neato Robotics introduces the Neato XV-11, featuring laser-guided navigation
4	2014	Dyson releases the 360 Eye, a robotic vacuum with panoramic camera navigation
5	2016	iRobot introduces the Roomba 980, featuring visual simultaneous localization and mapping (vSLAM)
6	2018	Roborock launches the S5, incorporating both vacuuming and mopping capabilities
7	2020	iRobot releases the Roomba i7+ with a self-emptying dustbin feature
8	2021	Advances continue with more sophisticated mapping, AI, and improved battery life

1.2 Problem Statement

Time management is a big problem in this new technology world. The increasing demands for automation and smart home technologies have led to the development of various autonomous devices, including automatic vacuum cleaners. However, these devices still face significant challenges in terms of navigation efficiency, adaptability to diverse environments, and energy consumption. This thesis aims to address these challenges by designing and implementing an advanced automatic vacuum cleaner system that not only efficiently cleans various types of surfaces but also adapts to changing environments, optimizing its energy consumption for sustainable operation. The goal is to create a more intelligent and efficient household appliance that enhances the quality of life and contributes to the advancement of autonomous systems in smart homes, Especially in life in BALOCHISTAN UNIVERSITY OF ENGINEERING AND TECHNOLOGY KHUZDAR.

1.3 Objective

- To design & develop cleany-Bot,
- To evaluate the performance of cleany-Bot on main road of BUETK and in corridors of mechanical engineering Department.

1.4 Scope of the Project

The principal aim of this thesis is to create a robot vacuum cleaner capable of carrying out duties that cannot be completed by a standard vacuum cleaner available in the market

1.5 Significance of the Project

- They can clean the floors on their own with little assistance from the worker. They may be set to clean on a routine basis.
- Time-saving: Because robot vacuums complete the cleaning process on their own, they may save you both time and effort. This enables the operator to concentrate on other activities.
- Accessibility: They can fit into small places and behind furniture, which may be difficult for conventional vacuum cleaners to reach.
- Follow a set cleaning pattern, ensuring that no areas are missed, which can be especially useful for large or complex spaces.

1.6 Link with BUETK Vision

The Vision of BUETK is:

> To become a world class higher education Institute leading to socio economic development of the region and beyond.

Both visions share themes of innovation and excellence, but one focuses on education and societal development, while the other pertains to automated cleaning technology.

1.7 Link with Mechanical Department Vision

> To be an advanced recognized Mechanical Engineering Department for the socio-economic development of the society.

An advanced Mechanical Engineering Department contributes to society by innovating and improving technologies like automatic vacuum cleaners, making them more efficient and cost-effective, thus benefiting individuals and the economy.

1.8 Sustainable Development Goals (SDGs)

Automatic vacuum cleaners can be related to several United Nations Sustainable Development Goals (SDGs), including:

1. SDG 12: Responsible Consumption and Production - Automatic vacuum cleaners can help reduce energy consumption and waste by making cleaning more efficient.

2. SDG 7: Affordable and Clean Energy - More efficient vacuum cleaners can contribute to energy savings.

3. SDG 9: Industry, Innovation, and Infrastructure - Innovation in automatic vacuum cleaner technology aligns with this goal.

4. SDG 8: Decent Work and Economic Growth - The development and manufacturing of automatic vacuum cleaners create jobs and stimulate economic growth.

5. SDG 3: Good Health and Well-being - Cleaner homes contribute to improved health and well-being.

6. SDG 11: Sustainable Cities and Communities - Automatic vacuum cleaners can enhance the cleanliness and livability of urban spaces.

Thesis outline/ Structure

This thesis is organized into six chapters.

- **Chapter 01**: This chapter present introduction of the study, problem statement, aim, objective, significance of the research and scope of work, sustainable development goal
- **Chapter 02**: The chapter includes complete review of literature.
- **Chapter 04**: The chapter has detail research methodology.
- **Chapter 05**: This chapter presents the results
- **Chapter 06**: This chapter dials with conclusions.

CHAPTER 2

LITERATURE REVIEWS

2.1 Literature reviews

Hendriks et al (2010) In this paper, we examined user experiences regarding the behavior and the interviews that were done regarding the robotic vacuum cleaner. A future robotic vacuum cleaner was created with this knowledge in mind, and its behavior was tested using a video prototype to see how users interacted with it. Six participants—two women and four men—participated in a semi-structured interview to learn what kind of robot vacuum cleaner personality they would want. They were chosen as it seemed anticipated that they would be among the first to utilize robot vacuum cleaners. Some notable traits are shared by all of the participants. They are all quite active and possess either a technical background or a natural liking for technology. Thirty characteristics from the Big Five were used during the interview. The outcomes show that individuals were able to identify the intended personality in the robot's actions.

Rubio et al (2019) In this paper, We examined how one of the scientific fields with the greatest rate of expansion is mobile robots. Mobile robots have the ability to replace people in a variety of industries. In order to adapt to a changing environment, mobile robots need to be able to take actions (such as moving themselves) and have a source of input data. Mobile robots now days are capable of walking, running, jumping, and other movements much like humans do. Many robotics areas have grown up, including wheeled mobile robots, legged robots, flying robots, robot vision, artificial intelligence, and so on. These areas involve several technological subjects, including computer science, electronics, and mechanics. This article examines the field of mobile robots, considering recent developments. Artificial intelligence, self-driving cars, network communication, teamwork, nanorobotics, safe and nice human-robot interfaces, and the expression and perception of emotions are at the forefront of these emerging developments.

T.B. Asafa et al (2018) In this paper, we studied that vacuum cleaners have made cleaning the house easier, they are usually noisy and large for regular use **Error! Reference source not found.**. Therefore, reducing these drawbacks requires advancements in vacuum cleaning technologies. Here, we describe the creation of a small, effective vacuum cleaner robot that may be used at home or in an office. The newly created robot has a disk shape, an Arduino mega microcontroller for control, and vacuum and cleaning capabilities. It draws dirt in through two sweepers, each powered by a 3 V DC motor, and a flexible garbage can with a cooling fan installed on top. The robot uses a front roller wheel that controls turning as well as two motor shield powered rear wheels to travel. Placed at a 90-degree angle, the four ultrasonic sensors identify obstructions and subsequently assist the robot in navigating. Three batteries (28.8 V DC) that can be recharged using a built-in AC-DC adaptor power the robot.

Min-Chie Chiu et al (2014) In this paper, we study the developing a robotic vacuum cleaner that is both intelligent and interactive. Through the use of a computer interface and wireless transport protocol (802.11b), the user can remotely control the robot's movements and track its location. Two types of features have been produced by research: a remote manipulating mode and an auto-vacuum cleaning mode. The robot weighs 10.5 kg and has dimensions of 400 mm in diameter by 200 mm in height. The base plate is round throughout. A vacuum hole and 120-degree collector combine to form a system designed to gather the dust. The research's initial objectives include manipulating and controlling from a PC server, vacuuming function, and mapping and monitoring a path.

K. Sarath Kumar et al 2023) In this paper, we Studied an effective way to clean the desired region. Dangerous areas can be cleaned using this vacuum cleaner, lowering the risks to people. By putting in place an autonomous system, this is done. This project's primary goal is to design and build a vacuum robot prototype. To this end, an Arduino Uno, a motor shield, an ultrasonic sensor, and a wheeled motor will be used. Robot and obstacle distance is measured using the ultrasonic sensor. A 12 volt battery powers the entire circuit. A vacuum robot will be equipped with a number of user-friendly features. This vacuum cleaner is powered by a 3.6 watt lithium battery designed specifically for this project. A pressure gauge gauges the pressure within the vacuum cleaner, while an anemometer measures the air velocity going through it. The efficiency of the vacuum cleaner is 29.79%.

Pawan kumar Ramkisoon et.al (2020) This Paper presents an advanced, self-cleaning and mopping robot's design. A 12 V rechargeable lithium polymer battery powers the system. Because it has more GPIO (General Purpose Input/Output) pins than other Arduino-based microcontrollers and greater flash memory storage (256 kB), the Arduino Mega board is utilized in this project. The wireless control has a ten-meter range. It is noted that the system operates in both application-controlled and autonomous modes, successfully finishing the requested task.

Rhutuja Patil et al (2023) This paper presents an overview of the development and application of a regulated vacuum cleaning mechanism. Many forms of technology have been developed to make daily tasks for humans easier. The time and labor costs are decreased with this suggested floor cleaning machine. This device makes the process of cleaning floors simpler and more effective. The device can detect obstacles and stay clear of collisions. This device will collect the particles and clean the areas that are typically left unclean. It supplies a novel way to the daily important activity and a means of contemporary living. Its broad audience is made up of individuals from a variety of age groups and backgrounds.

Ahmet Burhan Soran et al (2021) The Research Demonstrate the development and application of an intelligent vacuum cleaner. It's made to act like the way a smart vacuum cleaner would move around the space. Furthermore, the apparatus stays any obstructions that may arise while in motion. Households nowadays are robotic, which makes things easier and reduces the amount of time spent cleaning. Although they have made cleaning the house easier, vacuum cleaners are heavy and noisy when used continuously. These instruments were utilized. STMicroelectronics manufactures the L298N Motor driver module. ARDUINO MEGA 2560: A brain that can understand data from sensors, apply certain algorithms to process the data. "HC-SR04" Ultrasonic distance sensor: the device must identify and map the space it is in. The Honeywell QMC/HMC5883 axis compass sensor is a three-axis compass sensor.

Anıl Eren et al (2022) In This Paper, We Study the design and manufacturing of a smartphone-controlled, high-performing, low-cost vacuum cleaner robot. The mechanical, electrical, and software design phases make up the three stages of vacuum cleaner robot design. The robot frame and cleaning system have been created and put into effect in the mechanical design. Batteries, motors, drives, sensors, and microcontrollers are examples of electrical components that have been chosen for the electrical design. The power system has also been created with the electrical requirements in mind. In terms of software design, autonomous algorithms like the random walk and snake algorithms have been developed, along with an easy Android application for remote control. The user can choose the navigation algorithm and operate the brush and vacuum motors with an easy-to-use Android application.

Nikhil Sharma et al (2020) In this paper, we study the design and build of a floor-cleaning robot with some automation. The machine and obstacles are controlled by an Arduino-based mobile controller, which also allows it to switch from moving in the right direction to the left. Using the L293D Arduino Shield, it is used. Four DC motors with an L293D Motor Driver Board are utilized in this system to drive the robot, while a fifth motor is used to control the cleaner's speed. Bluetooth is used to provide a wireless connection between the robot and remote control. The external power supply is powered by a rechargeable 12V battery. The core of the system is an Arduino UNO board with an ATmega328P microcontroller. Experiments and a simulation test are conducted for its reliable domestic reaction.

Zakaria et al (2022) In this paper, we study the results of creating an intelligent autonomous robot vacuum cleaner based on a few new concepts in this area. The first step in the development of the robot is building an easy and functional chassis, which houses the motor drivers, microcontroller, wheels, and other electronic bits that make up the robot's body. The assembling of the parts, which involves calibrating and testing the prototype, comes next. Its goal is to lower the cost of the robot and make it practical for the middle class. The built robot will be useful in industries and residential settings.

2.2 Summary of literature review

The collection of papers falls into the growing landscape of robotic vacuum cleaners, focusing on user experiences, advances in technology, and a wide range of applications. The studies investigate consumer preferences, using interviews to incorporate the Big Five personality characteristics, in order to inform the design of future robotic vacuum cleaners.

The rapid expansion of mobile robots is a significant theme, demonstrating their potential to replace human labor in a variety of industries. This field's multidisciplinary nature covers computer science, electronics, and mechanics, allowing robots to move like humans.

Several publications go into detail into specific concepts, such as a small but powerful vacuum cleaner controlled by Arduino and an intelligent, interactive version with remote capabilities. The incorporation of sophisticated technology, such as artificial intelligence and network connection, is emphasized as essential for the development of these robotic systems.

Overall, the study adds to the ongoing evolution of robotic vacuum cleaners by addressing issues such as noise reduction and efficient cleaning processes. The combination of cutting-edge technologies and user-centric design techniques holds the possibility of generating more complex and adaptable robotic vacuum cleaners for a variety of applications as the field advances.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter's goal is to explain how to construct vacuum cleaner models and structures out of various parts, as well as the outcomes of such efforts. The design of this project is divided into three parts MECHANICAL, ELECTRICAL AND SOFTWARE design.

3.2 Mechanical design

The robotic vacuum cleaner's mechanical design may be categorized into several modules. These topics include an explanation of how a robot's shape affects its navigation and cleaning capabilities, a suitable driving mechanism for the robot, the primary materials that can be used for the robot's chassis, and the design of the cleaning system.

3.2.1 Drive Mechanism Drive

A mobile robot's driving system controls its movement from one location to another. Mobile robots can come with a variety of driving systems.

1. ***Motor used for driving***

The Copal HG37-150-AB-00 is used in this project. The HG37-150-AB-00 is a premium motor that has a reputation for reliability and durability. It uses less energy and is rather quiet.

The following are some of the Copal HG37-150-AB-00's specifications:

- Voltage: 24V DC
- Gear ratio: 150:1
- Speed: 33rpm
- Torque: 490 m N-m
- Dimensions: 37mm x 37mm x 53mm
- Weight: 250g

It is used in many fields, including as robotics, automation, and medical devices, and has a torque of 490 mN-m

Fig 3.1. Copal HG37-150-AB-00

2. Tires used for driving

A 65mm rubber tire with a brass hexagonal hub model cars, robots, and other small vehicles frequently use this style of wheel, which has a 65mm rubber tire with a brass hexagonal hub. The metal hub gives the wheel strength and durability, while the rubber tire provides grip and stress absorption.

Using a 65mm rubber tire with a metal hexagonal hub has the following advantages:

- The wheel is resistant to wear and tear because of the brass hub's exceptional strength and durability.
- The wheel has good ground contact because to the rubber tire's strong grip.
- When the car hits obstacles or rough ground, the rubber tire absorbs the shock and reduces the effect on the car.
- Model automobiles, robots, and other tiny vehicles are just a few of the vehicles that may use this wheel.

Fig 3.2. Tires for dive mechanism of robot

3. ***Motor used for brush and dryer***

Mop and brushes use a 12V 200 RPM MOTOR. Normally, brushes push material such as dust toward the vacuum, and mop cleans tiles and other surfaces.

SOME OF THE SPECIFICATION OF THE MOTORS ARE:

- Voltage: 12V
- Speed: 200 RPM
- Torque: 5-10 kg-cm
- Shaft size: 3mm or 6mm

Fig 3.3. Motor

4. ***Water pump***

The mop is used to clean the ground by rolling over it after water is sprayed on it using a water pump.

3.2.2 Cleaning system design

Robotic vacuum cleaners use a cleaning system that consists of a brush, dust bin, and vacuum motor. The floor where the robot moves is cleaned of particles by the vacuum motor. The robot's dust container receives dirt collected from the floor. When the dust container is filled, it is simple to remove. In order to make vacuuming the dirt easier, the brush pushes the dirt into the area that the vacuum motor affects while sweeping the floor.

D.C Blower

As a vacuum motor, a DC blower can be used.

Fig 3.4. Blower

In Figure 12, the DC blower's rectangular side blasts outward, while its round side draws in air.

In order to improve the air pressure that affects cleaning performance, the dust bin is made to entirely enclose the blower's circular side. It is positioned in the body's middle.

Some specification are as follows

Table 3.1 specification of blower

1.	Current	6 A
2.	Speed	8300 RPM
3.	Air volume	300CFM
4.	Wind	20.813 InchH_2O
5.	Noise	84d-BA
6	Standard voltage	12 V

3.3 Electronic hardware design

The vacuum cleaner robot's electronic components make up the electronic hardware design. It falls into several categories, including power and charging systems, Bluetooth, motor drivers, sensors, and microcontrollers, remote controls.

3.3.1 Power and charging system

Power and charging system is one of the main issue in the project that's why the selection of power is important. For Power we used

1. *Lithium 18650 cell*

One kind of rechargeable lithium-ion battery that is frequently used in electrical devices is the 18650 cell. The battery is 18 millimeters (0.71 inches) in diameter and 65 millimeters (2.56 inches) in length, which is responsible for its the name, 18650. The extra lifespan, high energy density, and comparatively low self-discharge rate of 18650 cells are well-known.

Here are some of the specifications of an 18650 cell:

Table 3.2 Specification of 18650 cell

1.	Voltage	3.7 V
2.	Capacity	2000-3500mAh
3.	Energy density	150-250 Wh-kg
4.	Cycle life	500-1000 cycles

Here are some of the advantages of using an 18650 cell:

- High energy density: 18650 cells have a high energy density, which means that they can store a lot of energy for their size. This makes them a good choice for applications where space is limited.
- Long lifespan: 18650 cells have a long lifespan, which means that they can be recharged many times before they need to be replaced.

Fig 3.5. Batteries

1. **Charging system**
   - The batteries are charged with the universal battery charger.
   - Universal Dual Li-ion Battery Charger can charge any two same or different types of 18650, 26650, 18350,16340 batteries simultaneously. Lithium-ion rechargeable 2 cell charger intelligently distributes the battery charge flow between the two batteries appropriately. This lithium-ion battery pack charger is high quality with IC Protection (HT3582) and CE certification, safe for charging. Li-ion cell charger is designed to charge your batteries quickly and safely.

Fig 3.6. Charger

Some specifications are as follows

Table 3.3 charging system

1.	INPUT	AC100-240v
2.	OUTPUT	3.7v/ 1000mA
3.	FREQUENCY	47-63hz
4.	SLOT	47-63hz

3.3.2 Motors relays

An electronic circuit known as an H-bridge is used to regulate the direction and speed of a DC motor. It consists of four switches grouped in a pattern like a bridge. The motor will rotate in a single direction when the two switches on one side of the bridge are closed. The motor will rotate in the opposite direction when the two switches on the other side of the bridge are closed. The motor will cut off when all four switches are turned on.

H-bridge is constructed using different types of relays and relays are electrically operated switch that uses a small amount of current to control a larger current. It consists of a coil of wire that, when energized, creates a magnetic field. We have constructed H-bridge using relays.

Fig 3.7. Relays

3.3.3 Bluetooth module

Wireless communication between Bluetooth-enabled devices is made possible via Bluetooth modules, which are tiny electrical devices. A microprocessor, a Bluetooth transmitter, and other supporting parts are usually included. Bluetooth modules are frequently utilized in many various situations. In order to enable wireless communication in a variety of applications, including consumer electronics, industrial automation, and medical equipment, Bluetooth modules are required. They are a helpful and flexible technology for wireless communication due to their low power consumption, short-range coverage, simplicity of deployment, and international compatibility.

HC-05 Bluetooth module

A popular wireless connection module for Arduino and other microcontroller applications is the HC-05 Bluetooth module. It is an inexpensive, user-friendly module that allows for short-range wireless communication between two devices. There are two ways to utilize the HC-05 module: slave mode and master mode. The module may establish a connection with another Bluetooth device while it is in master mode. The module's only function when in slave mode is to wait for a connection from another Bluetooth device.

Fig 3.8. Bluetooth module

3.3.4 Sensors

Sensors are the most important and essential electrical components of vacuum cleaner robots because they use them to gather information about their surroundings. For accurate navigation, they are necessary. For detecting walls, barriers, or cliffs that are near a robot, infrared and ultrasonic sensors are the most often utilized types of sensors. The transmitter and receiver components are included in both the infrared and ultrasonic sensors. When a signal is sent by the transmitter and an item gets in the way of it, the object reflects back the signal.

Ultrasonic sensor HC-SR04

The HC-SR04 is an ultrasonic sensor with a ranging accuracy of up to 3 millimeters that can measure distances between 2 and 4 meters. This inexpensive, user-friendly sensor is frequently utilized in Arduino and other microcontroller projects.
The HC-SR04 sensor is a multipurpose, user-friendly sensor with a broad range of applications. Here are some example:

- Robots and other autonomous vehicles can avoid obstacles with the help of the HC-SR04 sensor.
- You can use the HC-SR04 sensor to find the distance between people, furniture, and walls.
- By calculating the separation between objects, the HC-SR04 sensor can assist drivers when parking their vehicles.

Fig 3.9. Sensor

3.3.5 Microcontroller

The vacuum cleaner robot's microcontroller functions as its brain. It uses signals to communicate with the motor drivers to control the robot. The navigation algorithm and sensor data are used to generate these control signals. Microcontrollers come in various varieties, including the Arduino, Raspberry Pi, and BeagleBone. BeagleBone and Raspberry Pi are tiny computers with Linux OS on them. Python, C, or C++ can be used to program these microcontrollers.

Before selecting the microcontroller model, the total number of pins used by the motor drivers and sensors is considered. The Arduino Nano is used in this design.

Arduino nano

Since it is more compact and smaller, the Arduino Nano is comparable to the Arduino Uno. Because it can be powered by an external power source or a USB cable, it is also flexible.

- The powerful and adaptable ATmega328 microcontroller serves as the basis for the Arduino Nano.
- Fourteen digital input/output pins on the Arduino Nano are available for connecting actuators, sensors, and other devices.
- Analog sensors can be read using the six analog input pins on the Arduino Nano.
- You can store your Arduino sketches on the 32KB of flash memory that the Arduino Nano has.
- Two kilobytes (KB) of SRAM on the Arduino Nano are used to hold temporary data.
- The Arduino Nano has 1KB of EEPROM, which is used to store non-volatile data, such as settings.

An excellent option for a wide range of projects is the Arduino Nano
which includes:

Robots that can avoid obstacles and follow lines can be controlled with the Arduino Nano.
Light switches and thermostats are examples of home automation equipment that can be managed by the Arduino Nano.
Fitness trackers and smartwatches are examples of wearable electronics that can be created with the Arduino Nano.
Sensor data can be logged to a file and collected by the Arduino Nano.
Electronic musical instruments are a possible application for the Arduino Nano.
An inexpensive, user-friendly, and highly capable microcontroller board is the Arduino Nano. It is an excellent option for new and experienced Arduino users.

Fig 3.10 Arduino

3.4 Software design

A robotic vacuum cleaner's software system is designed with multiple layers and components that cooperate to provide the intended function.

A summary of the software architecture is provided below.

1. ***Hardware abstraction layer***

The Hardware Abstraction Layer functions as an interface between the robotic vacuum cleaner's hardware components and software. It provides a uniform and uniformed interface for the higher-level software components by managing low-level communication with sensors, motors, and other hardware components.

2. Navigation

The navigation system is in charge of arranging and carrying out the robot's movements in order to efficiently clean the surroundings. It makes use of motors and ultrasonic sensors among other sensors to map the area and sense its surroundings. It determines the best route for the robot to travel through all areas while avoiding obstacles based on this map.

3. Power management

To increase the robot's operating time, the power management system keeps an eye on and optimizes the battery usage. When necessary, it may involve decreasing motor power, changing cleaning patterns, or going into standby mode.

A robotic vacuum cleaner's software design is a difficult and complex task that requires the careful integration of multiple algorithms, data processing, and control mechanisms. The robot may provide effective and dependable cleaning performance while safely navigating its surroundings if these factors are addressed.

3.4.1 Remote Control design

A remote control is made to operate the water pump, vacuum cleaner, and other functions in addition to controlling the cart. Motion to the left and right, forward and backward

To run the remote control, an Arduino Nano, some batteries, and a WIFI module are fixed.

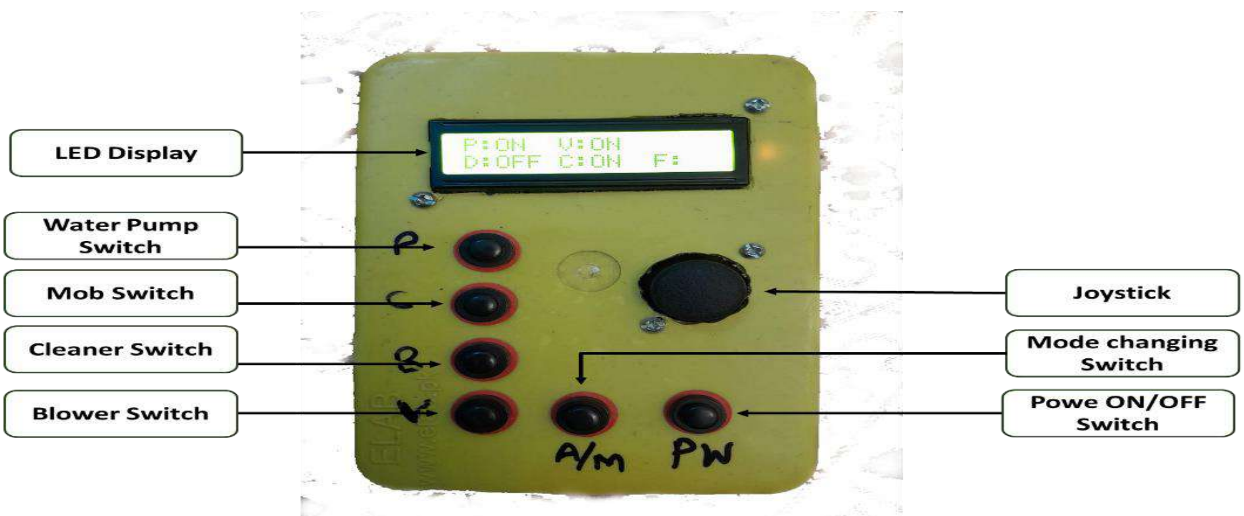

Fig 3.11. Remote control design

3.5 Switching between remote control and autonomous modes

The user wants to be able to switch between autonomous mode and the remote control as quickly as possible, so this process must happen quickly. To switch between modes, the Bluetooth connection needs to be verified each time. When moving from the remote control mode to the autonomous mode, there is no switching delay. This cart has remote and autonomous control capabilities. The vacuum cleaner is unique because of this feature

3.6 Overall system of the cleany-bot

The robot chassis carried all of the electrical components without deforming when the mechanical and electrical portions were joined

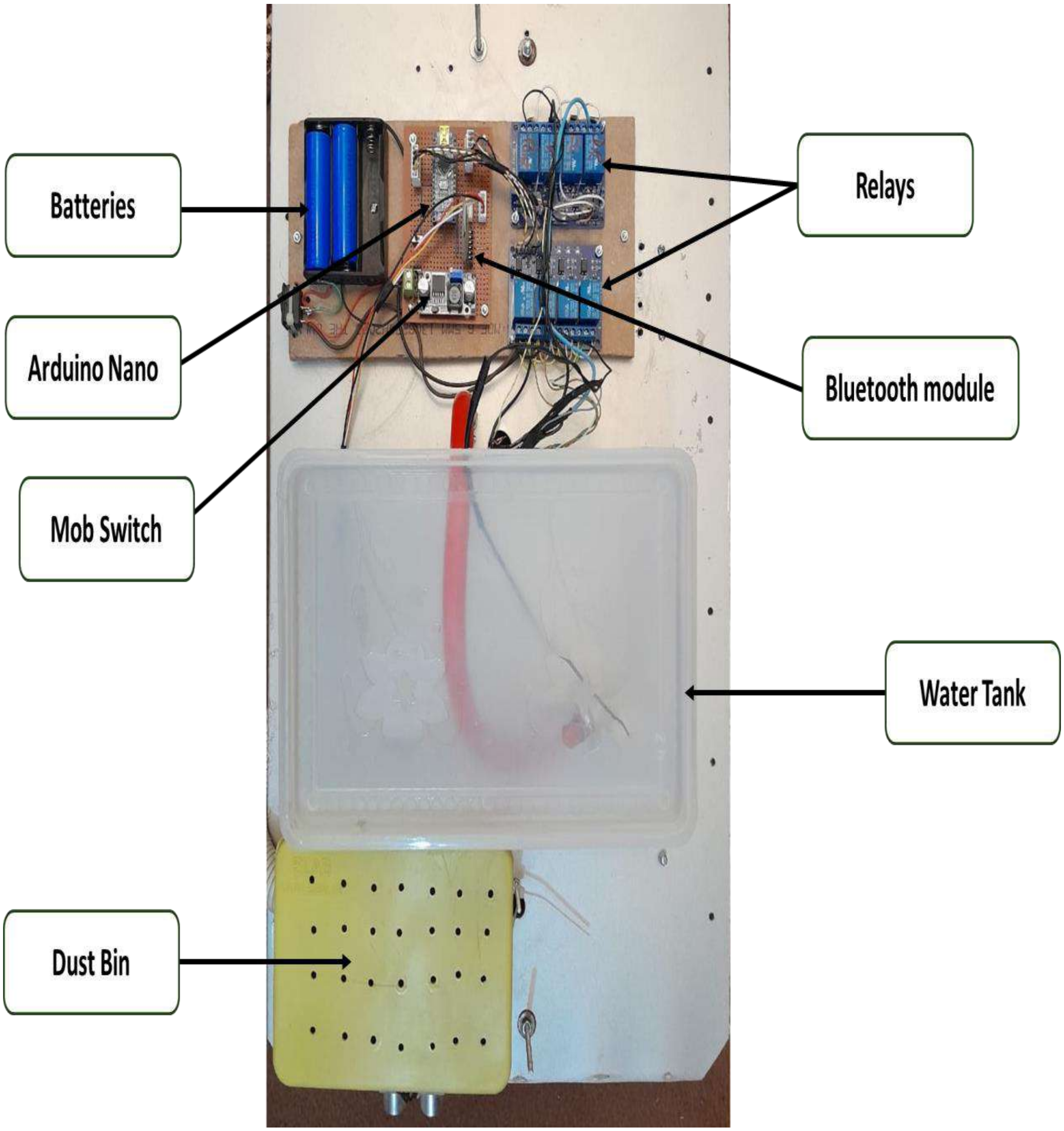

Fig 3.12 Front view of the robot

The device's back side as shown comprises the WIFI module, batteries, motor driver, and microprocessor. These are the connections made between the modules and the microcontroller.

The water tank and pump are located in the middle of the device as. Pipes are used to spray water onto the ground.

The device has a dustbin on the front side of the device where wastes from the vacuum are stored and a ultrasonic device that detects obstacles.

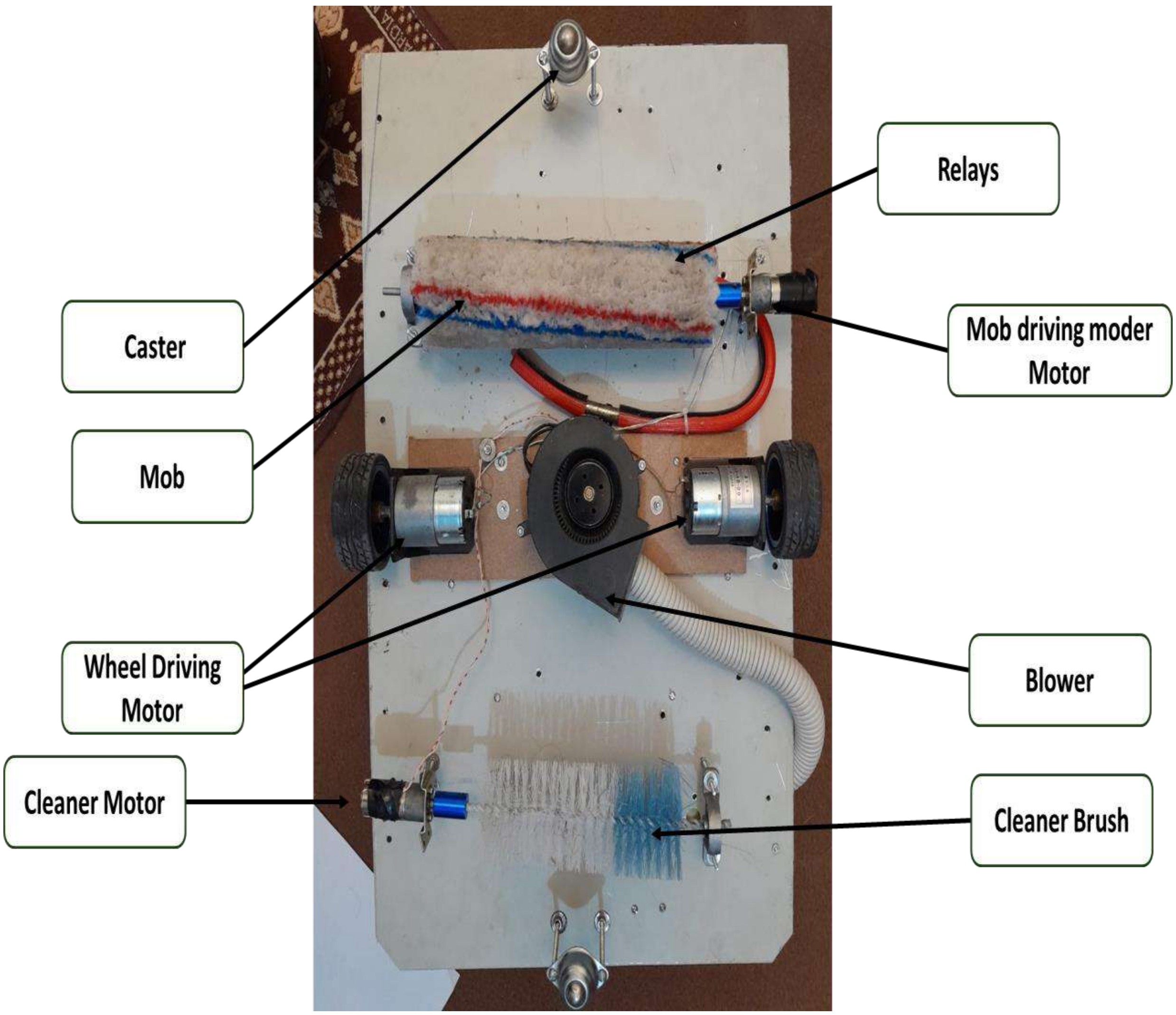

Fig 3.13 Rear view of the robot

CHAPTER 4

RESULT AND DISSCUSION

We used Cleany Bot to conduct many tests on the BUETK roads and corridors, and the results were good. The cleany bot operated without any problems and cleared the BUETK road. The original remote control has been used to test the remote-control mode. As a result, this mode has operated as expected. The particles lying on the ground have been successfully gathered by the vacuum cleaner robot as shown in figures.

Fig 4.1. Cleaning of the corridor of BUETK

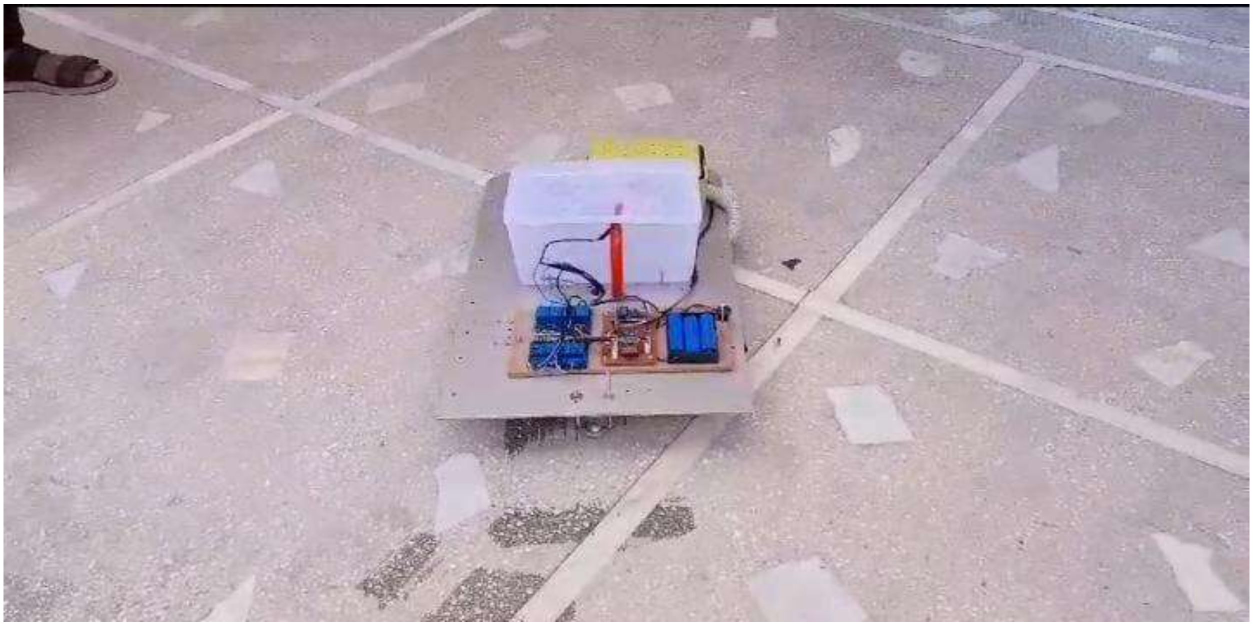

Fig 4.2. Cleaning on corridors

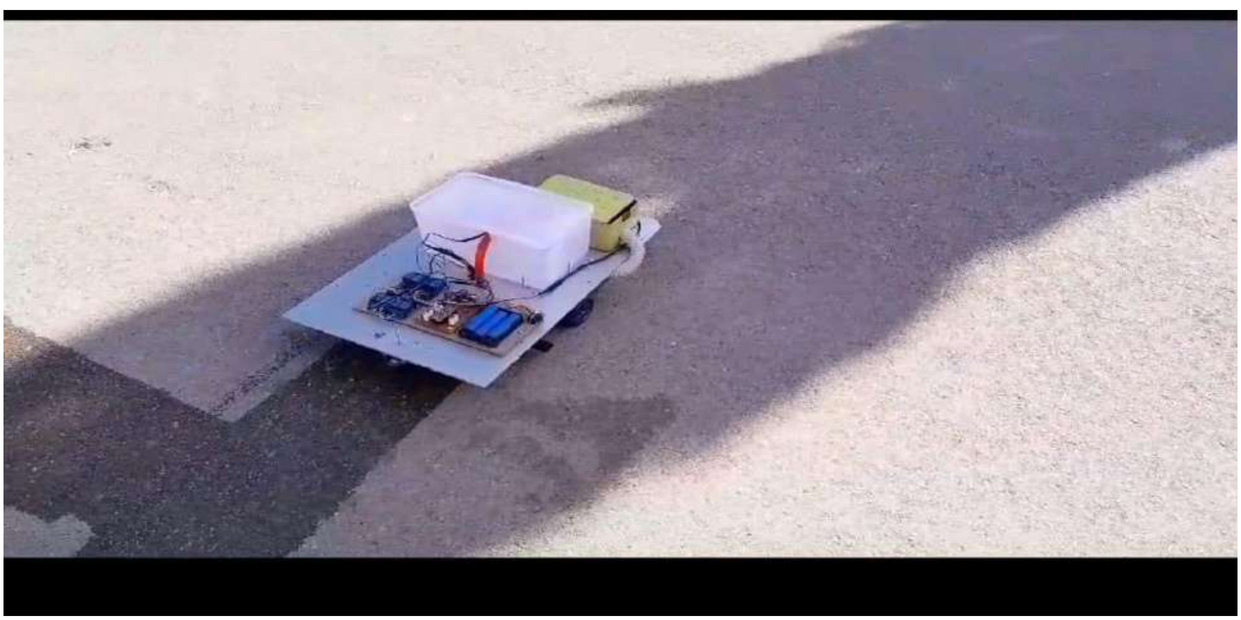

Fig 4.3. Cleaning on roads of BUETK

Fig 4.4 Remote control

The comprehensive investigation of the precisely built software code managing the robot vacuum cleaner's autonomous mode provided astonishingly good results. The robot's algorithmic prowess in properly gathering dropped crumbs demonstrates the sophistication and efficiency of the algorithms used in both cleaning and navigation tasks. This result demonstrates not just the precision of algorithm development, but also a potential step forward in the domain of household automation.

These discoveries have far-reaching ramifications that go far beyond basic convenience. The robot vacuum cleaner's proficient performance in autonomous mode identifies it as a dependable and effective alternative for residential cleaning jobs. The seamless transition between remote control and autonomous modes emphasizes the system's versatility and user-friendliness, catering to a wide range of customer preferences and requirements.

This research considerably contributes to the expanding body of knowledge in robotics in the context of domestic automation. The robot vacuum cleaner's success establishes it as a technological marvel, streamlining and improving the efficiency of mundane household activities. The repercussions, however, go beyond the limits of the home. This autonomous system's powerful algorithms and navigation capabilities have the potential for broader applications in various industries.

Continuous monitoring and iterative software changes are recommended as part of a commitment to continuous improvement. This dynamic approach recognizes the ever-changing nature of robotics challenges and opportunities. The robot vacuum cleaner can not only retain its current level of performance but also adapt to meet the needs of an ever-changing technological landscape if it remains watchful and responsive to emerging difficulties

Furthermore, as technology advances, the incorporation of cutting-edge capabilities like machine learning or artificial intelligence advancements may catapult the robot vacuum cleaner to new levels of efficiency and adaptability. The importance of user experience, safety measures, and energy efficiency in achieving widespread adoption and acceptance of such creative household automation technologies cannot be overstated.

In conclusion, the good findings of this study not only establish the robot vacuum cleaner as a dependable home companion, but also pave the way for future robotics breakthroughs. This technical advancement highlights the potential of autonomous systems to transform daily life and lays the framework for future investigation and invention in the rapidly expanding field of robotics.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

This research opens a new chapter in the history of automated cleaning by revealing the thorough design and development of a low-cost, fully working robot vacuum cleaner. A clever combination of low-cost, easily available mechanical and electrical components highlights the brilliance behind the development of this cutting-edge robot prototype, which is gifted with both manual and autonomous capabilities.

In the area of autonomy, the robot moves gracefully through room spaces, avoiding impediments with the precision prescribed by a carefully chosen algorithm. This dynamic functionality represents not only a quantum jump in cleaning efficiency, but it also redefines the fundamental nature of the cleaning experience. It goes beyond time savings to bring in an era of remarkable simplicity, rethinking the norm set by traditional cleaning methods.

Apart from the inherent benefits of automation, the addition of remote-control functionality emerges as a critical component that improves user interaction. This added level of adaptability allows users to actively participate in the cleaning process, providing for more precise control and the ability to target specific areas of concern. The addition of a remote control adds a dynamic layer to the user experience, resulting in a more personalized and engaging approach to keeping a clean living environment.

In essence, this unique robot vacuum cleaner appears not just as a time-saving solution for the chronically busy, but also as a beacon of technological prowess that exceeds traditional cleaning limitations. Its meticulously constructed design, cost-effectiveness, and user-centric features all position it as a trailblazing solution poised to redefine and enrich the very fabric of the cleaning experience for consumers from all walks of life. As we see the confluence of price, functionality, and human flexibility, this automated cleaning marvel is ready to transform how we view and participate with the critical work of keeping a clean living area.

5.2 Recommendation

Looking ahead, the planned developments show a commitment to ongoing progress and advancement in technology. The use of modern sensors and artificial intelligence is expected to improve the robot's navigational capabilities, resulting in a more intelligent and adaptive response to its surroundings. Efforts to extend battery life will lead to longer cleaning sessions, addressing a critical concern for customer pleasure.

Efforts to improve garbage collection methods demonstrate a commitment to improving cleaning efficiency, offering a more thorough and strict approach to cleanliness maintenance. Furthermore, the investigation of effortless integration with smart home ecosystems sees a future in which the robot vacuum cleaner will be an integrated component of a connected and automated living environment.

The emphasis on environmental issues, as demonstrated by the search of environmentally friendly materials and energy-saving technology, ties the development of the Automatic Vacuum Cleaning Robot System with the greater societal shift toward sustainability. As customer expectations shift, the system's commitment to environmental management positions it as a responsible choice for people seeking not only convenience but also environmentally beneficial solutions.

In essence, the Automatic Vacuum Cleaning Robot System not only addresses the immediate challenges of time constraints and manual labor, but it also lays the groundwork for a future in which automated cleaning solutions integrate effortlessly into our daily lives, contributing to a cleaner, more efficient, and sustainable living environment.

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ANNEXURE PAGE

Cleany-bot operation code for remote control

```
String data = "";
#define pump_switch 9
#define motor_switch 10
#define dryer_switch 11
#define suction_switch 12
#define auto_switch 8
#define joystickfb A0
#define joysticklr A1
#include <LiquidCrystal_I2C.h>
LiquidCrystal_I2C lcd(0x27, 16, 2); // set the LCD address to 0x27 for a 16 chars and 2 line display
#include <SoftwareSerial.h>
SoftwareSerial mySerial(3, 2); // RX, TX

bool chkf = false, chkb = false, chkr = false, chkl = false, chks = false;
bool chk_motor = false, chk_pump = false, chk_suction = false, chk_dryer = false, chk_auto = false;
char rcvd;
String operation = " ";
int count = 0;
int valfb = 0, vallr = 0;
void setup() {
  // put your setup code here, to run once:
  pinMode(motor_switch, INPUT_PULLUP);
  pinMode(pump_switch, INPUT_PULLUP);
  pinMode(dryer_switch, INPUT_PULLUP);
  pinMode(suction_switch, INPUT_PULLUP);
  Serial.begin(9600);
  mySerial.begin(9600);

  HomeScreen();
  delay(3000);
  DisplayAlertScreen();
}

void loop() {
  // put your main code here, to run repeatedly:
  if (Serial.available() > 0)
  {
    rcvd = Serial.read();
    if (rcvd == 'X')
    {
      data = Serial.readStringUntil("Y");
      //Serial.println(data);
      //      digitalWrite(level_low_pin, data[2] - '0');
      //      digitalWrite(level_medium_pin, data[1] - '0');
      //      digitalWrite(level_high_pin, data[0] - '0');
    }
  }
  if (mySerial.available() > 0)
  {
    rcvd = mySerial.read();
    Serial.println(rcvd);
    if (rcvd == 'X')
    {
      data = mySerial.readStringUntil("Y");
      //Serial.println(data);
      //      digitalWrite(level_low_pin, data[2] - '0');
      //      digitalWrite(level_medium_pin, data[1] - '0');
      //      digitalWrite(level_high_pin, data[0] - '0');
    }
```

```
}
delay(100);
count++;
if (count >= 50)
{
 count = 0;
 Serial.print("Z");
 mySerial.write("Z");
}
if ((digitalRead(motor_switch) == LOW) && (chk_motor == false))
{
 Serial.print("J");
 mySerial.print("J");
 chk_motor = true;
 DisplayAlertScreen();
}
else if ((digitalRead(motor_switch) == HIGH) && (chk_motor == true))
{
 Serial.print("K");
 mySerial.print("K");
 chk_motor = false;
 DisplayAlertScreen();
}
if ((digitalRead(pump_switch) == LOW) && (chk_pump == false))
{
 Serial.print("H");
 mySerial.print("H");
 chk_pump = true;
 DisplayAlertScreen();
}
else if ((digitalRead(pump_switch) == HIGH) && (chk_pump == true))
{
 Serial.print("I");
 mySerial.print("I");
 chk_pump = false;
 DisplayAlertScreen();
}
if ((digitalRead(dryer_switch) == LOW) && (chk_dryer == false))
{
 Serial.print("L");
 mySerial.print("L");
 chk_dryer = true;
 DisplayAlertScreen();
}
else if ((digitalRead(dryer_switch) == HIGH) && (chk_dryer == true))
{
 Serial.print("M");
 mySerial.print("M");
 chk_dryer = false;
 DisplayAlertScreen();
}
if ((digitalRead(suction_switch) == LOW) && (chk_suction == false))
{
 Serial.print("N");
 mySerial.print("N");
 chk_suction = true;
 DisplayAlertScreen();
}
else if ((digitalRead(suction_switch) == HIGH) && (chk_suction == true))
{
 Serial.print("O");
 mySerial.print("O");
 chk_suction = false;
 DisplayAlertScreen();
}
if ((digitalRead(auto_switch) == LOW) && (chk_auto == false))
```

```
{
  Serial.print("A");
  mySerial.print("A");
  chk_auto = true;
  operation = "AM";
  DisplayAlertScreen();
}
else if ((digitalRead(auto_switch) == HIGH) && (chk_auto == true))
{
  Serial.print("B");
  mySerial.print("B");
  mySerial.print("G");
  mySerial.print("O");
  chk_auto = false;
  operation = " ";
  DisplayAlertScreen();
}
valfb = analogRead(joystickfb);
//Serial.println(valfb);
vallr = analogRead(joysticklr);
//  Serial.print(vallr);
if ((valfb > 700) && (chkf == false))
{
  chkf = true;
  chks = false;
  Serial.print("C");
  mySerial.print("C");
  operation = "FW";
  DisplayAlertScreen();
}
else if ((valfb < 200) && (chkb == false))
{
  chkb = true;
  chks = false;
  Serial.print("D");
  mySerial.print("D");
  operation = "BW";
  DisplayAlertScreen();
}
else if ((vallr > 700) && (chkl == false))
{
  chkl = true;
  chks = false;
  Serial.print("F");
  mySerial.print("F");
  operation = "RG";
  DisplayAlertScreen();
}
else if ((vallr < 200) && (chkr == false))
{
  chkr = true;
  chks = false;
  Serial.print("E");
  mySerial.print("E");
  operation = "LF";
  DisplayAlertScreen();
}
else if ((valfb < 700) && (valfb > 300) && (vallr < 700) && (vallr > 300) && (chks == false))
{
  chkb = false;
  chkf = false;
  chkl = false;
  chkr = false;
  chks = true;
  Serial.print("G");
  mySerial.print("G");
```

```
    operation = " ";
    DisplayAlertScreen();
  }
}
void HomeScreen()
{
  lcd.init();                      // initialize the lcd
  // Print a message to the LCD.
  lcd.backlight();
  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("  Cleaner Robot ");
  lcd.setCursor(0, 1);
  lcd.print("   Controller   ");

}
void DisplayAlertScreen()
{
  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("P:");
  lcd.print((chk_pump == true) ? "ON" : "OFF");
  lcd.setCursor(6, 0);
  lcd.print("V:");
  lcd.print((chk_suction == true) ? "ON" : "OFF");
  lcd.setCursor(0, 1);
  lcd.print("D:");
  lcd.print((chk_dryer == true) ? "ON" : "OFF");
  lcd.setCursor(6, 1);
  lcd.print("C:");
  lcd.print((chk_motor == true) ? "ON" : "OFF");

  lcd.setCursor(12, 1);
  lcd.print("F:");
  lcd.print(operation);

}
/*
  void read_water()
  {
  digitalWrite(trig_pin, LOW);  // Added this line
  delayMicroseconds(2); // Added this line
  digitalWrite(trig_pin, HIGH);
  delayMicroseconds(10); // Added this line
  digitalWrite(trig_pin, LOW);
  duration = pulseIn(echo_pin, HIGH);
  distance_f = (duration / 2) / 29.1;
  }*/
```

Cleany-bot operation code for robot

```
#define relf1 A0
#define relb1 A1
#define relf2 A2
#define relb2 A3
//#define ir_left 8
//#define ir_right 9
#define pump  9
#define brush 12
#define suction  10
#define dryer 11
#define echo_pin 4
#define trig_pin 5
#define echo_pin_back 6
#define trig_pin_back 7


#include <SoftwareSerial.h>

SoftwareSerial mySerial(3, 2); // RX, TX

char rcvd = ' ';
int auto_chk = 0;
int obj_chk = 0;
int obj_chk_back = 0;
String operation = " ";
////////////////////////////////
long duration, distance;
long duration_back, distance_back;
int turn_chk = 0;
void setup() {
  // put your setup code here, to run once:
  Serial.begin(9600);
  mySerial.begin(9600);
  pinMode(relf1, OUTPUT);
  pinMode(relf2, OUTPUT);     // initialize as output
  pinMode(relb1, OUTPUT);
  pinMode(relb2, OUTPUT);
  stop_motion();
  pinMode(pump, OUTPUT);
  pinMode(brush, OUTPUT);
  pinMode(suction, OUTPUT);
  pinMode(dryer, OUTPUT);
  //  pinMode(ir_left, INPUT);
  //  pinMode(ir_right, INPUT);
  pinMode(trig_pin, OUTPUT);
  pinMode(echo_pin, INPUT);
  pinMode(trig_pin_back, OUTPUT);
  pinMode(echo_pin_back, INPUT);

  digitalWrite(pump, HIGH);
  digitalWrite(brush, HIGH);
  digitalWrite(suction, HIGH);
  digitalWrite(dryer, HIGH);

  mySerial.flush();
}

void loop() {
  // put your main code here, to run repeatedly:


  //Serial.print(rcvd);
  if (rcvd == 'A')
```

```
{
  //auto_mode();
  auto_chk = 1;
  operation = "AM";
}
else if (rcvd == 'B')
{
  auto_chk = 0;
  operation = " ";
}
else if (rcvd == 'C')
{
  if (auto_chk == 0)
  {
    move_forward();
    operation = "FW";
  }
}
else if (rcvd == 'D')
{
  if (auto_chk == 0)
  {
    move_reverse();
    operation = "BW";
  }
}
else if (rcvd == 'E')
{
  if (auto_chk == 0)
  {
    move_left();
    operation = "LF";
  }

}
else if (rcvd == 'F')
{
  if (auto_chk == 0)
  {
    move_right();
    operation = "RT";
  }
}
else if (rcvd == 'G')
{
  stop_motion();
  operation = "ST";
}
else if (rcvd == 'H')
{
  if (auto_chk == 0)
  {
    digitalWrite(pump, LOW);
  }
}
else if (rcvd == 'I')
{
  if (auto_chk == 0)
  {
    digitalWrite(pump, HIGH);
  }
}
else if (rcvd == 'J')
{
  if (auto_chk == 0)
  {
```

```
      digitalWrite(brush, LOW);
    }
  }
  else if (rcvd == 'K')
  {
    if (auto_chk == 0)
    {
      digitalWrite(brush, HIGH);
    }
  }
  else if (rcvd == 'L')
  {
    if (auto_chk == 0)
    {
      digitalWrite(dryer, LOW);
    }
  }
  else if (rcvd == 'M')
  {
    if (auto_chk == 0)
    {
      digitalWrite(dryer, HIGH);
    }
  }
  else if (rcvd == 'N')
  {
    if (auto_chk == 0)
    {
      digitalWrite(suction, LOW);
    }
  }
  else if (rcvd == 'O')
  {
    if (auto_chk == 0)
    {
      digitalWrite(suction, HIGH);
    }
  }
  if (auto_chk == 1)
  {
    auto_mode();
  }
  rcvd = ' ';
  if (mySerial.available() > 0)
  {
    rcvd = mySerial.read();
    // Serial.print(rcvd);
  }
  else if (Serial.available() > 0)
  {
    rcvd = Serial.read();
    // Serial.print(rcvd);
  }
}
//////////////////////////functions/////////////////////////////////
void move_reverse()
{
  digitalWrite(relb1, HIGH);
  digitalWrite(relb2, HIGH);
  digitalWrite(relf1, LOW);
  digitalWrite(relf2, LOW);
}
void move_forward()
{
  digitalWrite(relb1, LOW);
  digitalWrite(relb2, LOW);
```

```
  digitalWrite(relf1, HIGH);
  digitalWrite(relf2, HIGH);
}
void move_left()
{
  digitalWrite(relb1, HIGH);
  digitalWrite(relb2, LOW);
  digitalWrite(relf1, LOW);
  digitalWrite(relf2, HIGH);
}
void move_right()
{
  digitalWrite(relb1, LOW);
  digitalWrite(relb2, HIGH);
  digitalWrite(relf1, HIGH);
  digitalWrite(relf2, LOW);
}
void stop_motion()
{
  //auto_chk = 0;
  digitalWrite(relb1, HIGH);
  digitalWrite(relb2, HIGH);
  digitalWrite(relf1, HIGH);
  digitalWrite(relf2, HIGH);
  digitalWrite(pump, HIGH);
  digitalWrite(brush, HIGH);
}

//////////////////////////////
void read_ultrasonic()
{
  digitalWrite(trig_pin, LOW);  // Added this line
  delayMicroseconds(2); // Added this line
  digitalWrite(trig_pin, HIGH);
  delayMicroseconds(10); // Added this line
  digitalWrite(trig_pin, LOW);
  duration = pulseIn(echo_pin, HIGH);
  distance = (duration / 2) / 29.1;
  //Serial.println(distance);
}
void read_ultrasonic_back()
{
  digitalWrite(trig_pin_back, LOW);  // Added this line
  delayMicroseconds(2); // Added this line
  digitalWrite(trig_pin_back, HIGH);
  delayMicroseconds(10); // Added this line
  digitalWrite(trig_pin_back, LOW);
  duration_back = pulseIn(echo_pin_back, HIGH);
  distance_back = (duration_back / 2) / 29.1;
  //Serial.println(distance);
}
void auto_mode()
{
  //  if (obj_chk == 0)
  //{
  Serial.println("Auto Mode");
  move_forward();
  //  digitalWrite(pump, LOW);
  digitalWrite(suction, LOW);
  //}
  read_ultrasonic();
  delay(100);
  if (distance <= 30)
  {
    obj_chk = 1;
    if ((turn_chk == 0 ))
```

```
    {
      turn_chk = 1;
      stop_motion();
      delay(500);
      move_right();   //turn right
      delay(8000);
      stop_motion();
      delay(1000);
      move_forward();
      delay(5000);
      stop_motion();
      delay(500);
      move_right();
      delay(8000);
      stop_motion();
      delay(500);
      obj_chk = 0;
    }

    else if ((turn_chk == 1))
    {
      turn_chk = 0;
      stop_motion();
      delay(500);
      move_left();   //turn LEFT
      delay(8000);
      stop_motion();
      delay(1000);
      move_forward();
      delay(5000);
      stop_motion();
      delay(500);
      move_left();
      delay(8000);
      stop_motion();
      delay(500);
      obj_chk = 0;
    }
    // stop_motion();
  }
  //  else if ((digitalRead(ir_left)) == LOW && (digitalRead(ir_right)) == LOW)
  //  {
  //    stop_motion();
  //    move_reverse();
  //    delay(2000);
  //    stop_motion();
  //    obj_chk = 0;
  //  }

}
```