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Ministry of higher Education and Scientific research
Emirates International University
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Design and Implementation of a Vacuuming and Mopping Smart Machine

تصميم وتنفيذ آلة ذكية للكنس والمسح

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Summary

There are many disadvantages (cost, lack of security, difficult to manage time, delay, etc.). people are becoming more career oriented and due to their irregular working schedule; it becomes challenging to maintain both home and office together. Most of the cases, they hire cleaners to clean homes, offices, hospitals, clinics, etc., but no trust in cleaners or maybe not always. To overcome the problem, robots are introduced. Robots in general are programmable machines using a computer and with minimal human intervention, complex tasks are able to be carried out. They can be completely automatic or semi-automatic. The branch of study that deals with the design, construction, operation, coding, and application of robots is called robotics .

Robotic vacuums and mopping cleaners have a certain level of autonomy and are programmed to clean according to the surroundings and the information provided by the user through the phone application. In modern era, robots are playing an important role in life of mankind with their advanced technologies, making the human life easier and comfortable. The cleaning robots are effective in assisting humans in floor cleaning at homes, hotels, restaurants, offices, hospitals, workshops, warehouses and universities etc. so they have taken more recognition in robotics research .

Fundamentally, the robot cleaners have been distinguished by their cleaning competence like dry vacuum cleaning, and floor mopping. This machine is built based on obstacle avoidance techniques using infrared sensors, camera and laser mapping technique. The operations and cleaning mechanism is relatively less time consuming, faster and energy-efficient but costly. The laser mapping technique has few drawbacks such as it requires high-end hardware and advanced software for data processing. Also the squared-shape design with the extra dust and debris collectors will guarantee efficient complete reach to targeted dirt. The mop module is simpler than this. The process starts with the help of the sprayers on the corners and the mopping roller in the between.

To conclude, this machine will save time and energy and will do both routine vacuuming and mopping tasks. All of this is with the help of the AI program the code for determining which process to be done, in addition to, the hardware added to help sensing the environment. Further features are being studied to be added such as saving rooms, deciding which areas are forbidden and environment change detection for home safety.

Authorization

We authorize the Emirates International University, faculty of engineering to supply copies of our graduation project report to libraries, organizations or individuals on request. The faculty, also authorized to use it in local or international competitions.

Student Name	Signature	Date

Dedication

To our parents who bore all the difficulties we have been through. To ourselves for not giving up. And for all the online resource providers for their generosity that made such an achievement possible. For those who helped with what they could; starting with our lovely doctors, and ending with the worker at the university student service, and the electronics market.

Acknowledgment

Example

Before and above all, we would like to record our endless thanks to **Allah** for everything he gives us.

We wish to express our deepest gratitude and appreciation to **Dr. Farouk Al-Fahaidy** for his great patience, excellent guidance, kind encouragement, scientific advice, helpful supervision and good wishes instilled the strength in us to make this work possible.

Last but not least, we owe a great deal of gratitude, thanks and appreciation to all members of our families, for their kind support, help and encouragement.

Supervisor Certification

I certify that the preparation of this project entitled

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prepared by ………………………………………………………………………

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was made under my supervision at ……………. department in partial fulfillment of the requirements of bachelor degree in ……………….

Supervisor Name

Signature

Date

Examiner Committee

Project Title:……………………………………………………………………...

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Examiner Committee

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List of Abbreviations

Acronym	Definition
IR	Infra-Red Sensor
LS	Limit-Switch
US	Ultrasonic Sensor
Li-Po	Lithium Poly Battery
Li-DAR	Light Detection And Ranging
PWM	Pulse Width Modulation
rpm	Rotation per minute

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Chapter 1

Introduction

Chapter 1: Introduction

1.1 Overview

A smart vacuum machine is a robotic vacuum cleaner that uses sensors and artificial intelligence to navigate the area and clean floors. They are typically controlled by a smartphone app, and can be programmed to clean on a schedule.

Smart vacuum machines offer a number of advantages over traditional vacuum cleaners, including: [1]

- Convenience: They can clean your floors without having to lift but a finger.
- Efficiency: They can map your home and clean it in a systematic way, ensuring that no spots are missed.
- Sensors: Smart vacuum machines use a variety of sensors to navigate your home and avoid obstacles. These sensors typically include cliff IR sensors, wheel drop sensors, and object avoidance US sensors.
- Artificial intelligence: Smart vacuum machines use artificial intelligence along with a LiDAR to map the required area and create a cleaning plan. This ensures that the floors are cleaned in a systematic way, and that no spots are missed.
- Connectivity: Smart vacuum machines connect to your home Wi-Fi network, so you can control them with a smartphone app.
- Scheduling: You can schedule your smart vacuum machine to clean on a regular basis, so you don't have to worry about it.
- Battery life: The battery life is of up to 1 to 2 hours.
- Cleaning power: The cleaning power of the smart vacuum machine is designed for light routine cleaning.

1.2 Problem Statement

- Gets Stuck: Most of the robotic vacuum cleaners aren’t programmed definitely, which makes them rely on users, and they might get stuck in between during the process of cleaning a room. Though this isn’t usual in all brands, but it seems to be one of the noticeable problems.

- Small Depot: Normal vacuum cleaners might have a larger storage while the robotic vacuum cleaners can have only one eighth of that capacity, and hence it’s one of the major setbacks to the robotic vacuum cleaners.

- Insufficient Vacuum Power: The suction power is so high in manual ones which can make the room look tidier compared to the robotic ones.

- Cannot Reach Corners: Reaching every part of the room is one of the important tasks to be done by the robotic vacuum cleaners.

1.3 Project Objectives

The main objectives of this project may be summarized in the following

1. To design a vacuum cleaner that is intelligently programmed to clean the floors.
2. To automatically detect and avoid the obstacles.
3. To collect the dust particles into the vacuum.
4. To indicate if the battery is dying.
5. To control the robot automatically.
6. To be programmed to up to 3 modes vacuuming and mopping and can be given the order automatically.
7. To have a fancy yet efficient D-shape design that leads to a complete reach to dust and debris.

1.4 Project Scope and Limitations

Project scope: The project aims to design and implement a smart vacuuming and mopping machine that can clean floors autonomously or manually, with features such as mapping, obstacle detection, dirt detection and wet recognition. The project will also test the efficiency, and usability of the prototype in different scenarios and environments.

Project limitation: The project may face some limitations such as budget constraints, availability of local resources, technical challenges, ethical issues, and user acceptance. Some specific limitations are:

The project may not be able to achieve optimal coverage area, navigation path, obstacle avoidance, and dirt detection for the smart vacuum and mopping machine, depending on the sensors and algorithms used.

The project may not be able to ensure the safety, reliability, and durability of the smart vacuum and mopping machine, especially in complex or hazardous environments.

1.5 Project Methodology

- Literature review: By reviewing the existing literature on smart vacuum and mopping machines, their features, advantages, disadvantages, challenges, and opportunities. Also, by comparing different products and technologies available in the market, such as iRobot, Ecovacs, Bissell, etc.

- Design: By designing the prototype of the smart vacuuming and mopping machine. In order to decide on the features, components, specifications, and functions of the prototype

- Implementation: By implementing the prototype by assembling the hardware components, programming the software algorithm, and testing the functionality of the prototype. In addition to debugging any errors or issues that may arise during the implementation process.

- Evaluation: The performance, efficiency, and usability of the prototype can be evaluated in different scenarios and environments. Feedback can be collected from potential users. Also, comparing the prototype with other existing products and technologies in terms of features, advantages, disadvantages, costs, etc.

1.6 Report Organization

The rest of this report is organized as follows:

Chapter 2: Introducing the Background and Literature Review

Chapter 3: Clarifies the Requirements Analysis and Modeling

Chapter 4: Shows Project Design and Operation

Chapter 5: Discusses the Implementation and the Experimental Works

Chapter 6: Displays the Conclusions and Recommendations

Chapter 2

Background and Literature Review

Chapter 2: Background and Literature Review

2.2 Background

Robot vacuum cleaners have been around for 25 years since they were invented. The first one was named 'Electrolux Trilobite' and it was produced by Electrolux, a Swedish company that made home and professional appliances. It came out in 1996 and was sold to the public in 2001.

The trilobite robot vacuums cleaner used ultrasound to sense and avoid obstacles and to map the room. The first version of the trilobite robot vacuum cleaner had some difficulties with avoiding some obstacles.

The second version improved its obstacle avoidance by adding an infrared sensor. However, still needed magnetic strips to be placed at the door and the end of the stairs as invisible walls to stop the robot from going further and to prevent it from falling or entering other areas by mistake. The 'Trilobite' robot vacuum cleaner could work for 60 minutes after charging. It had three modes: normal, fast, and spot cleaning. It also had a light warning when the dustbin was full. It was only 13 cm high and could clean under the table and bed. It could clean the room automatically, so users could leave it at home and save a lot of time. [1], [2]

2.3 Literature Review

Roomba Robot Vacuum Cleaner

This floor-cleaning robot is a first-generation Roomba, a very successful domestic robot. It was launched in 2002 by iRobot, a company founded in Burlington, Mass., in 1990 by MIT roboticists Colin Angle, Helen Greiner, and Rodney Brooks. A team of eight designed the robot. [3]

The Roomba runs on batteries and uses sensors and computer processing to react to its environment. It changes direction randomly when it hits an obstacle or detects an infrared beam, a boundary line it does not cross emitted by a separate "virtual wall" unit.

iRobot is another company that we have to mention when we talk about robot vacuum cleaners. iRobot is a robotics company that used to focus on the military robotics market.

In September 2002, iRobot made an important milestone in the history of robot vacuum cleaners. iRobot launched the Roomba series of robot vacuum cleaners. The Roomba series of robot vacuum cleaners are still popular and well-liked by consumers. The biggest contribution of the Roomba series to the industry is its patented invention-the three-stage cleaning structure. The three-stage cleaning structure is the combination of "side brush + rolling brush + dust suction port". The main difference from other two-stage cleaning products is the addition of a V-shaped roller brush between the side brush and the dust suction port. The roller brush can lift up the dust that is stuck on the ground by static electricity through its high-speed rotation. The cleaning ability is better than that of a vacuum cleaner in some ways.

Looking back at the development history of robot vacuum cleaners, from the early stages of "fake intelligence", "poor cleaning ability", and "high prices" to the current stages of "intelligent planning" and "intelligent connection", the technology of vacuum cleaners has become more advanced and more favored by consumers.

Nowadays, vacuum cleaners are more automated, which makes them more convenient and saves time on cleaning tasks. They are not like before, when they were mostly loud and heavy. They have become smarter and better. [3]

They have introduced technologies like WiFi (News - Alert) and Bluetooth connectivity, self-cleaning, anti-allergen filtration, cyclonic technology, smartphone control, as well as a unique design that make them vacuum cleaners that don't get clogged with hair. These technologies have changed the way vacuum cleaners work:.

Vacuum cleaners are essential for keeping your home clean and tidy, but they have also become more advanced, some are listed below:

No More Hair Tangles

Hair is inevitable in any home, but it can also be a nuisance when it gets stuck in your vacuum cleaner. Hair can wrap around the brush-roll and affect its performance, or even damage the machine over time. That's why Dyson and Shark have developed anti-hair wrap technology for their latest models. They have designed motorized brush bars that can handle hair and dirt in hard-to-reach areas.

Shark has also introduced a technology that actively removes hair from the brush-roll, so you don't have to do it yourself. Moreover, Shark's products have a unique bristle-guard and combs that separate and remove hair from the machine, keeping the bristle brush-roll free of tangles. [4]

Wireless Convenience

Cords can be a hassle when you are using a vacuum cleaner. They can get broken, tangled, or limit your reach. But now you can enjoy cordless vacuum cleaners that can run for up to 30 minutes on a single charge. And Dyson makes it even easier with its Drop-in docking feature. You can simply drop the vacuum cleaner into the wall-mounted dock, and it will charge itself while staying out of sight. [4]

HEPA Filtration

Traditional vacuum cleaners used bags as a filter medium, which were bulky and inconvenient. You had to open the bags to check the dust level, and using them could cause health problems, especially for people with breathing issues.

That's why HEPA filtration is a great improvement for modern vacuum cleaners. These filters can trap even the smallest particles (99.97 percent of particulates 0.3 microns), which ordinary cleaners might miss. [4]

Leading companies:

- iRobot: This is one of the most popular and innovative brands of smart vacuum and mopping machines, with products such as Roomba, Braava, and Terra. iRobot's products are known for their advanced features, such as self-emptying, mapping, no-go zones, dirt sensor, obstacle sensor, voice control, and scheduling. iRobot's products are also compatible with Google Assistant and Amazon Alexa. However, iRobot's products are also relatively expensive, noisy, and may not have the best mopping performance.

- Ecovacs: This is another well-known and reputable brand of smart vacuum and mopping machines, with products such as Deebot, Ozmo, and Navi. Ecovacs' products are known for their versatility, affordability, and user-friendliness. Ecovacs' products can perform both vacuuming and mopping functions, have different cleaning modes, have mapping and no-go zones features, and can be controlled via smartphone or voice. Ecovacs' products are also compatible with Google Assistant and Amazon Alexa. However, Ecovacs' products may not have the best suction power, battery life, or obstacle avoidance. [5]

- Bissell: This is a traditional and trusted brand of floor cleaning products, with products such as SpinWave, CrossWave, and Iconpet. Bissell's products are known for their quality, durability, and effectiveness. Bissell's products can handle different types of floors, have anti-hair wrap technology, have HEPA filtration, and have washable filters. Bissell's products are also relatively affordable and easy to use. However, Bissell's products may not have the smartest features, such as mapping, no-go zones, dirt sensors, or obstacle sensors. Bissell's products are also not compatible with Google Assistant or Amazon Alexa. [6] Table 2.3 summarizes the similaraties and differences between those products and this VacuuMop-bot

Table 2.3 Related works summarization

Ecovacs products	Bissell products	The VacuuMop-bot
Can perform both vacuuming and mopping functions.	Can handle different types of floors.	**Can perform both vacuuming and mopping functions.**
Can be controlled via smartphone, has mapping and no-go zones features	May not have the smartest features, such as mapping, no-go zones, dirt sensors, or obstacle sensors.	**Can be controlled via a console, and has the mapping feature.**
May not have the best suction power, battery life, or obstacle avoidance.	Easy to use.	**May not have the best suction power, battery life, but efficient at obstacle avoidance and it is easy to use.**

Chapter 3

Requirements Analysis

Chapter 3: Requirements Analysis

3.1 Requirements

As a big part of making this machine smart is its equipment; below essential devices are listed:

Raspberry Pi Microcontroller: is a versatile and powerful tool that can be used in a wide range of embedded applications. It is a great choice for projects that require a small, efficient, and affordable microcontroller. (Fig.1.1) [16]

Fig.3.1.1 Raspberry Pi Microcontroller

RP LiDAR 360: a 360-degree laser scanner that uses time-of-flight (ToF) technology to measure the distance to objects. It is a small, lightweight, and affordable scanner that is well-suited for a variety of applications, including robotics, autonomous vehicles, and 3D mapping. (Fig.1.2) [16]

RPLiDAR 360 has a number of features that make it a valuable tool for these applications, including:

360-degree scanning: RPLIDAR 360 can scan a full 360 degrees around the device, providing a complete view of the environment.

High-resolution scanning: RPLIDAR 360 can measure distances up to 12 meters with a resolution of 0.1 degrees.

Fast scanning: RPLIDAR 360 can scan up to 1200 times per second, providing a real-time view of the environment.

Small and lightweight: RPLIDAR 360 is only 40mm in diameter and 20mm thick, making it easy to integrate into small and lightweight robots.

Fig.3.1.2 RP LiDAR 360

Ultrasonic sensor:

Ultrasonic sensors work by emitting a sound wave at a frequency above the range of human hearing. The transducer of the sensor acts as a microphone to receive and send the ultrasonic sound. The time it takes for the sound wave to travel to the object and back is used to calculate the distance to the object.

Ultrasonic sensors have a number of advantages over other types of sensors, including:

- They are not affected by light or darkness.
- They can measure the distance to objects that are opaque or transparent.
- They are relatively inexpensive.

Ultrasonic sensors also have some disadvantages, including:

- They are not as accurate as other types of sensors, such as laser sensors.
- They can be affected by noise and echoes.
- They cannot measure the distance to objects that are too close or too far away.

LiPo battery:

A Lithium Polymer battery (LiPo) is a rechargeable battery of lithium-ion technology using a polymer electrolyte instead of a liquid electrolyte. High conductivity semisolid (gel) polymers form this electrolyte.

LiPo batteries are lighter and more flexible than other kinds of lithium-ion batteries because of their soft shells, allowing them to be used in mobile and other electronic devices, as well as in remote control vehicles.

LiPo batteries offer a number of advantages over other types of batteries, including:

High energy density: LiPo batteries have a higher energy density than other types of batteries, which means that they can store more energy in a smaller space.

Lightweight: LiPo batteries are lightweight, which makes them ideal for portable devices.

Flexible: LiPo batteries are flexible, which makes them ideal for devices that need to be bent or folded.

Fast charging: LiPo batteries can be charged quickly, which makes them ideal for devices that need to be used for extended periods of time.

However, LiPo batteries also have some disadvantages, including:

High voltage: LiPo batteries have a higher voltage than other types of batteries, which can make them dangerous if they are not handled properly.

Sensitive to heat: LiPo batteries are sensitive to heat, which can cause them to overheat and catch fire.

Must be stored properly: LiPo batteries must be stored properly to prevent them from overcharging or overheating.

Chapter 4

Project Design and Operation

Chapter 4: Project Design and Operation

4.1 Design

The old usual versions were not able to reach edges and corners due to their round design. Therefore, the squared design grants a better reach to walls' edges and corners. The design must be improved to have a slot for the rolling wiper and the sprayers. (Fig.4.1)

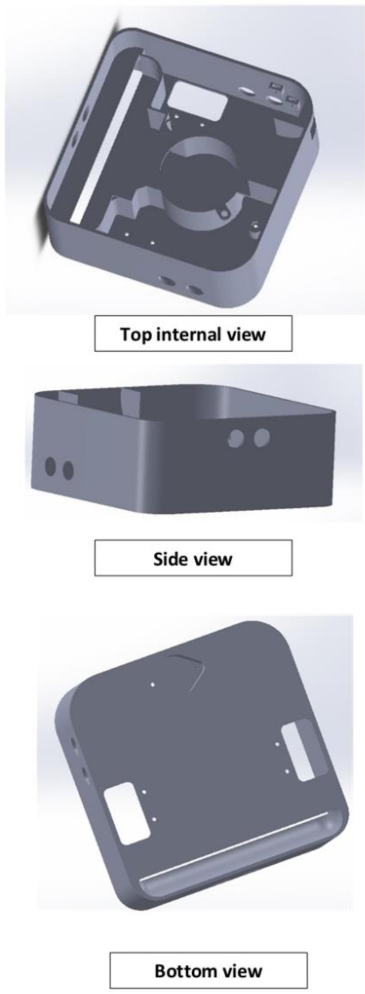


Fig.4.1 The suggested design

4.2 Operation Flow

In the figure 4.2 the process algorithm is illustrated. As the robot is fully autonomous. It starts the diagnostic process through the attached Li-DAR. The Li-DAR provides the robot with a map for the surroundings in order to know where to clean and where the obstacles are. The robot then keeps tracking the path and avoiding obstacles. The IR sensor gives a signal not to fall. More clarification can be illustrated through the following chart.

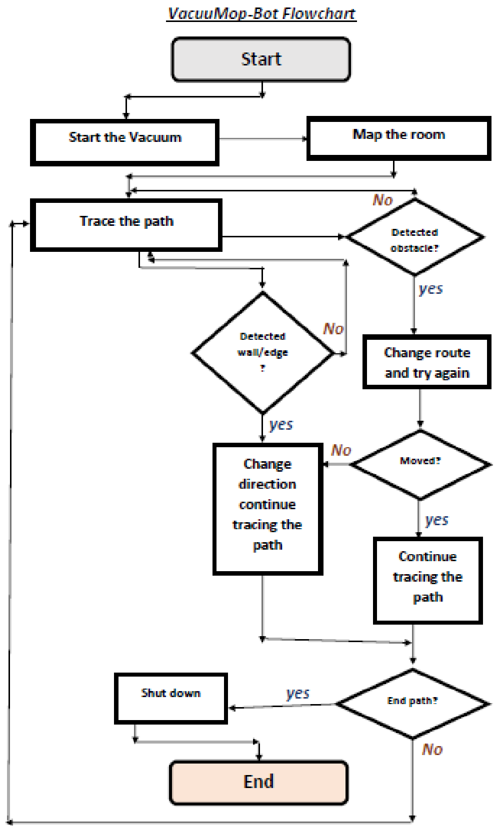


Fig.4.2 Operation flowchart

4.3 The Block Diagram

Figure 4.3 clarifies the connection followed and it can be distinguished that an Arduino also was used to control the motors' movement and special drives to control the voltage needed and current consumed.

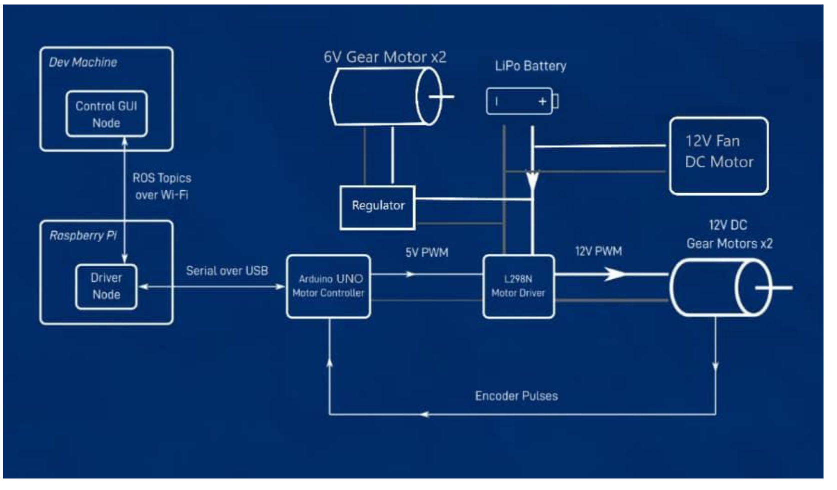
- 

Fig.4.3 The block diagram

4.4 Software

4.4.1 Gazebo software (Fig.4.4 left) is a great way to simulate robots and environments. It is used by many people who work with robots or want to learn more about them. Here are some more things you should know about Gazebo software:

- Gazebo software is free and open source. You can get the latest version from [these links] or [these links], or see the source code on [GitHub]. You can also help improve Gazebo by reporting problems, sending fixes, or adding new features. [7]

- Gazebo software lets you choose from different physics engines, such as ODE, Bullet, Simbody, and DART. You can pick the best engine for your simulation goals, or change them easily. You can also change the physical features of your robots and environments, such as weight, friction, gravity, etc.

- Gazebo software has a lot of sensors and actuators for your robots. You can simulate cameras, lasers, sonars, GPS, IMU, joints, motors, and more. You can also make your own sensors and actuators using plugins. Gazebo software makes realistic sensor data with noise and distortion models. [8]

- Gazebo software has a graphical user interface (GUI) that lets you interact with your simulations. You can move and drop models, adjust lighting, change viewpoints, record videos, and more. You can also use the command line interface (CLI) or the application programming interface (API) to control your simulations with code.

- Gazebo software works well with popular robotics frameworks, such as ROS, ROS 2, Ignition Robotics, Player/Stage, and MATLAB/Simulink. You can use these frameworks to talk to your robots, run algorithms, visualize data, and more. You can also use Gazebo software without any framework. [9], [10]

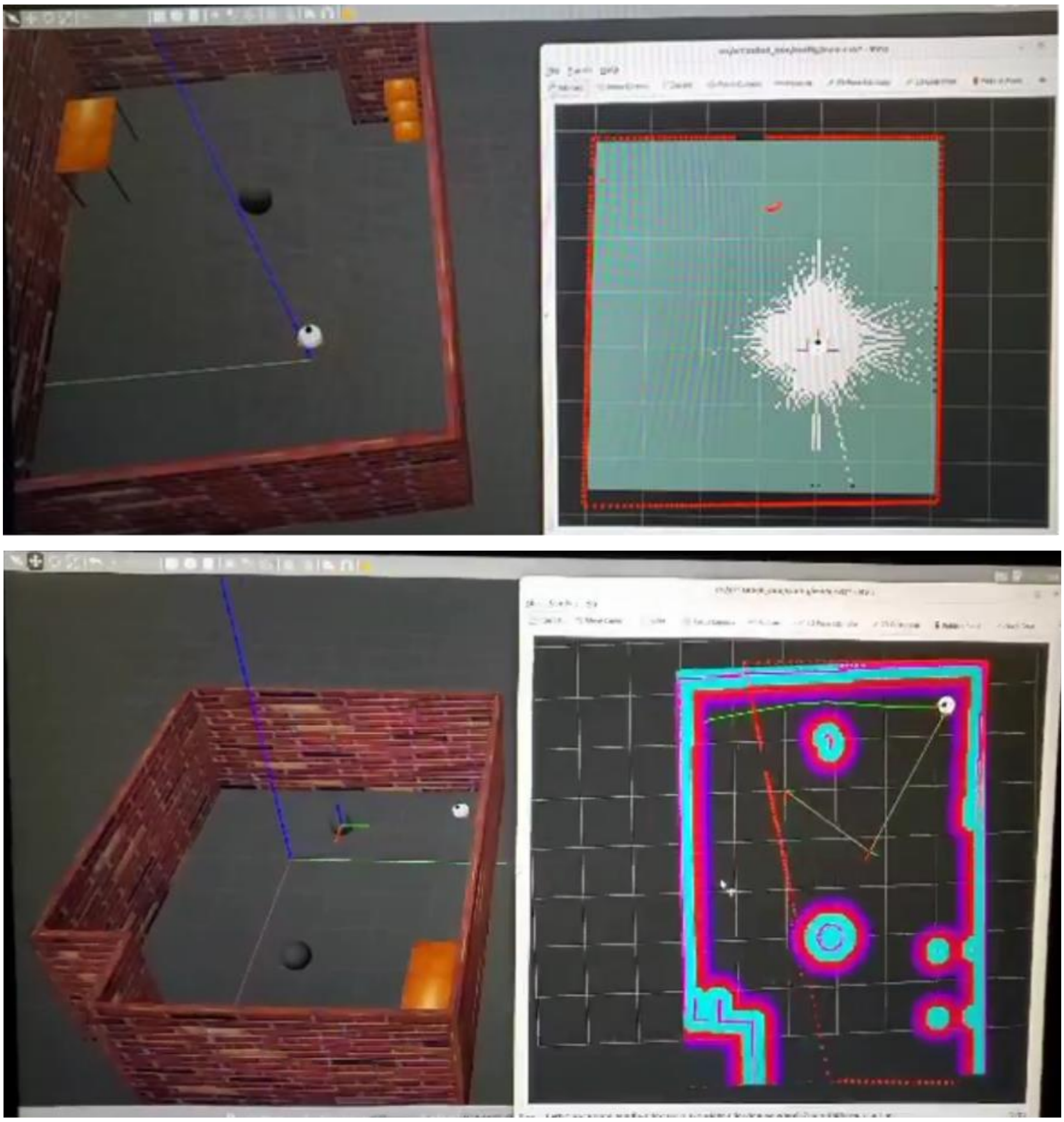


Fig.4.4 Gazebo and Rviz

4.4.2 Robot Operating System (ROS) is the name of a collection of software components and tools that enable you to create robot applications. ROS offers various features, such as abstracting hardware, controlling devices, using libraries, displaying data, communicating messages, managing packages, and more. ROS is also a free and open source project that follows a BSD license. ROS can support different kinds of robots, such as mobile robots, manipulators, drones, and more. ROS also has a big and lively community of developers and users who collaborate and help each other on the project. [11], [14], [15]

4.4.3 Rviz software (Fig.4.4 right) is a software that simulates robots and environments for research, design, and development. It is part of a robotics suite that includes open-source libraries, cloud services, and a graphical user interface. We used Rviz software to create realistic scenarios with high-fidelity sensor streams and test the control strategies in safety.

Rviz software is also a 3D visualization tool for ROS. It allowed us to see the robot's perception of its world (real or simulated). The purpose of Rviz software is to enable to visualize the state of a robot.

Rviz software supports many types of data, such as images, point clouds, maps, odometry, transforms, markers, interactive markers, and more. You can also send your own 3D markers into Rviz software from your software. [11], [12]
ROS is short for Robot Operating System. It is a collection of software libraries and tools that help you create robot applications. It offers hardware abstraction, device drivers, libraries, visualizers, message-passing, package management, and more. ROS is licensed under an open source, BSD license. [11], [13]

ROS is also a distributed framework of processes (also called nodes) that allows executables to be individually designed and loosely coupled at runtime. These processes can be grouped into packages and stacks, which can be easily shared and distributed.

ROS supports multiple programming languages, such as C++, Python, Lisp, Java, etc. ROS also works well with popular robotics frameworks, such as Gazebo, Rviz, MoveIt, etc. ROS has a large and active community of users and developers who contribute to the ROS ecosystem. [13]

Chapter 5

Implementation and Experimental Works

Chapter 5: Implementation and Test

5.1 Trials and Results:

5.1.1 introduction and background

Installing and setting ROS2 up was the starting point that took around three days; it was a completely new experience especially that it does not operate on the common Windows software operator. Therefore, Ubuntu was the software operating system used.

First, we started by setting ROS environment up. ROS 2 was used as it is the recent updated version and has more reliable features and it contains ready algorithms that help in designing and achieving targets easily. The algorithms are adjustable and editable which provides more creativity.

The Vacuum body was designed by SolidWorks and was then used as a rigid body into ROS. ROS made it easy to give that rigid body motion and gave us as users the control ability. Through the simulations, many readings were adjusted to fit the targeted goals of the vacuum motion and speed.

However, all was good during the simulation when it came to applying it in real life, it turned out that the vacuum 3D design was not but loss of money. As we needed to redesign it all. Thus, the squire-shaped design was compromised for a disc-shaped one. The motors too were not applicable as the speed control did not work properly therein. All the replaced items are discussed further as you go further in the document. Figures 5.1.1, and 5.1.2 show the first trial and fourth trial respectively.

Finally, all was good moving from the mere simulation to hardware in the loop. Setting up the network between the interface (Laptop) and the control (Raspberry PI) and Arduino) in the robot was the next step in the process. The connection between the laptop and the Raspberry PI could be attained over Wi-Fi by ROS topics (SSH) using a dedicated network. The communication between the Raspberry PI and the Arduino was over the common serial communication cable.

Arduino was used as a transducer between the Ras signal and the motors' desired speed through controlling the PWM. It was programmed to convert the speed from m/s into rpm; by controlling the voltage and current speed was controlled successfully.

The Raspberry PI was programmed to be the brain as it collects the readings and makes the last decision. The LiDAR maximum and minimum reading's ranges were set at 0.2 to 7 m respectively. As the LiDAR was fixed in the middle of the body; the 0.2 did not cause any hindrance, but the height of the body was an issue. It created a blind region for the LiDAR. This troublesome issue was avoided by attaching a pumper that sends a signal of crashing. Since the vacuum goes only forward and rotates to change direction, only 180 degrees of the RP-LiDAR with 360 samples were utilized.

The assembly and execution process was of some difficulty as in real surfaces and with real obstacles, things are pretty different. Some issues popped up as the trial-and-error process was conducted. Depression was felt and poverty struck us as the items were either broken, burnt, or stopped working. However, ultimately, all was solved and many brilliant ideas were added to the last version. The body was changed several times. Different motors and sensors were tried. And different features such as mapping, tracking, and edge recognition were provided. And here we came out with our handy mesmerizing robot that will make life easier.

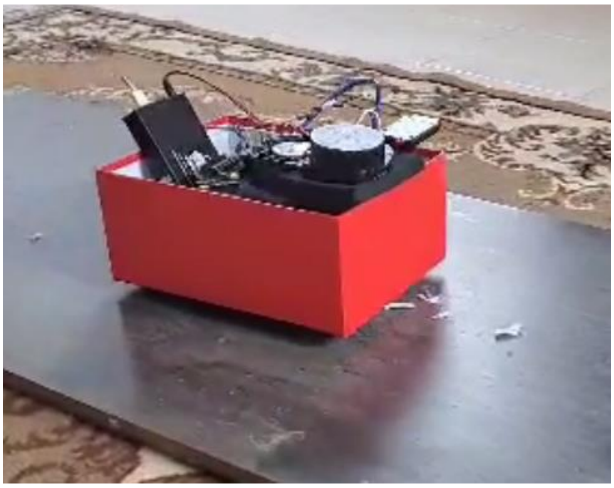


Fig 5.1.1 The first test

Fig 5.1.2 The fourth prototype

5.2.1 Design: Fig. 5.2.1

The first prototype was designed square as planned; issues appeared: -

- Pivoting was almost impossible due to losing torque and needing more energy.

2- Much energy was lost in providing current to the main wheels, apart from needing more wheels. Adding two extra motors was not an option as more motors means much energy needed.

3- Weight balancing was a big hinderance as well. A squared design means free surfaces, and free surfaces cannot be filled with redundant weights.

Fig.5.2.1 The final edition

5.1.3 Motors:

1- For the wheels a 300-rpm gearbox DC motor was used; it did not serve the purpose as it loses its torque once the speed is decreased. The torque loss caused the whole machine to stop.

2- The famous Dual Shaft mini gear 100-rpm motor was installed as it is commonly used for such robots. Torque was low, moreover it was vibrating and almost lost torque when lowering the speed. Eventually, two of the 100-rpm motor were installed as brushes prime movers.

3- Finally, a 130-rpm DC gearbox was used for the wheels' motors, and they provide enough torque and speed control along with adequate accuracy.

4- The motors are not equipped with encoders which lead to decreasing the overall speed of the robot in order to have much accurate results.

5.1.3 Sensors:

1- Ultra-Sonic was found to be disturbed with vibration and that led to lack of accurate signals and readings.
2- Limit switches were added to notify the robot of being at the edge so more cleanliness is granted.
3- The Li-Dar provides clear map but lacking of the motor encoder causes errors in the data collected after moving.

5.3 Prior Expectations not fully met: -

- Expenses and availability: The feasibility study after collecting the data required and knowing the prices and the resources was around 500$ in max.

- Design: A square 3d printed design, provided with a limit-switched bumper and a Li-Dar on the top.

- Energy: 2 to 3 working hours.

- Programming:

- 3 different modes; vacuuming, mopping, vacuuming and mopping.
- Mapping and saving rooms along with tracing the acquired map.

- The Vacuum:

- larger depot.
- Efficient suction.

5.4 Results: -

- Expenses and availability:

The trial-and-error stage consumed a lot of money that exceeded all expectations. It almost reached the triple expected amount to be 1500$ and the time was not enough to learn all about the needed programming. Lack of money and time caused compromising the design and some efficiency.

5.4.2 Design:

- As has been mentioned before lack of money and time, no more options were sensible but to use the available resources for the external body.
- The design was changed to be disc-shaped, that helped reducing the number of motors, reducing the amount of energy needed especially that the required Li-Po batteries were not available.

- Energy: Batteries with the required energy were not available in the market, furthermore, it was expensive to import it from another country.

- Programming:

- As it has been mentioned before; the programming stage needed so much time as all the programs and the programming language itself was new.

- The robot has only one mode currently which is vacuuming and mopping.

- The Vacuuming:

The design affects the amount absorbed.

Low energy affects efficiency.

Main middle brush was not added.

Chapter 6

Conclusions and Recommendations

Chapter 6: Conclusions and Recommendations

6.1 Conclusions and Recommendations:

Throughout the implementation of this project many points were concluded to be considered in the future studies. The first point was that the planning process does not take as much time as the application process. The simulation and online resources not always are trustworthy moreover the availability of the electronic items in the market takes a huge portion of the attainability of the targeted goals. The second point to take into consideration is that the size, weight, and shape of the electronic gadgets used inside the body can impact the motion either negatively or supportively. Third, to add extra efficiency the robot needs a camera that is controlled via AI to have object and dust quantity recognition moreover, the ability to recognize moving from fixed objects. Fourth, the program needs to be updated in order to give the robot the capability to shift amidst different modes according to the environment, for example, the suction power or the tracing mode in an acquired map through the LiDAR and camera. All these mentioned adjustments can be added in future works. Table 6.1 gives a summary for the conclusions.

Table 6.1 Expectations-Result- Future work Summarization

Prior	**Result**	**Future-work**
Squared design.	Disc-shaped.	D-Shaped.
Ultra Sonic for close obstacles.	Li-Dar and limit-switches.	Camera to identify objects.
Efficient vacuuming.	No efficient vacuum, with small depot.	Efficient with larger depot.

3 modes; vacuuming, mopping, and complete cleaning.	Complete cleaning only.	The 3 modes will be added.
3d design.	The available material.	3d printed
Tracing a map.	Insufficient time and money. No encoders attached causes localization problems.	Tracing a map.

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Appendices

Appendix A

Handson Technology

Data Specs

Dual Shaft Mini DC Gear Motor

3~6V DC geared motors for robotics and small industrial application. This motor can run at approximately 100-RPM when driven by a single Li-Ion cell. It is most suitable for light weight robot running on low voltage. Out of its two shafts one shaft can be connected to wheel, other can be connected to the position encoder for position control.

SKU: FAM1029

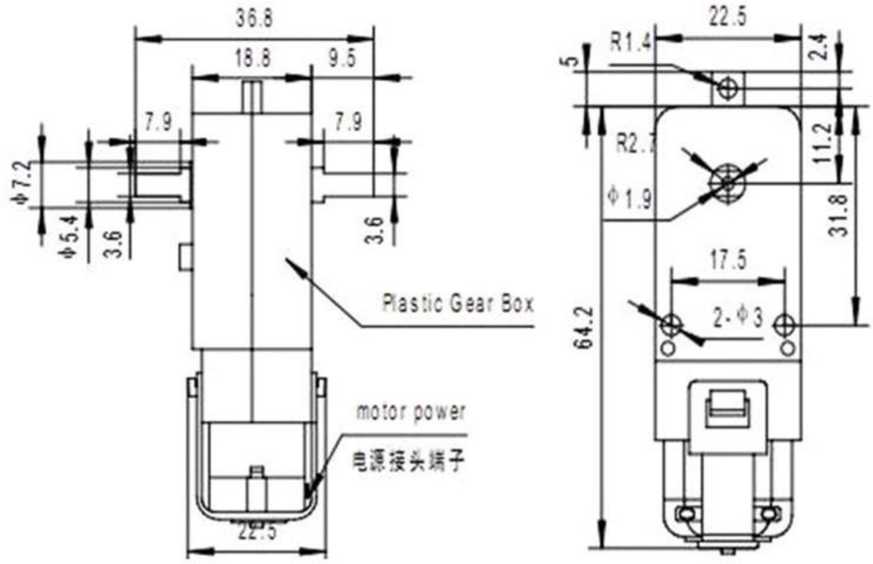
Brief Data:

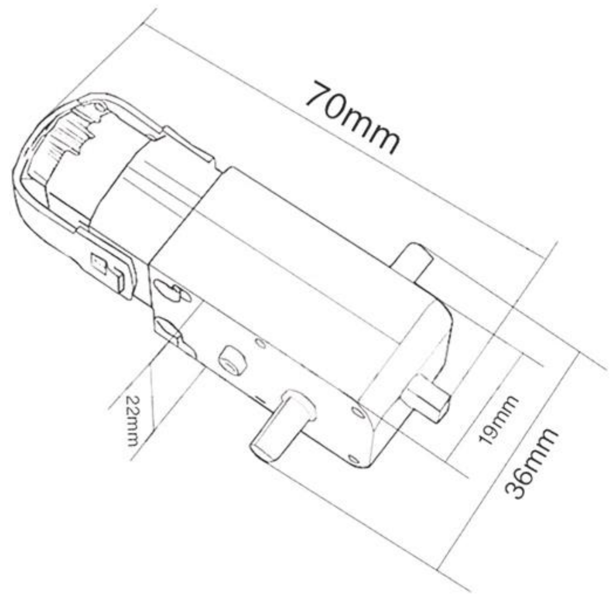
- Operating Voltage: 3.0V ~ 6.0Vdc.
- Current: (No load) 3V-150mA , 6V-200mA.
- Speed: (No load) 3V-90rpm±10% , 6V-200rpm±10%.
- Torque: max. 0.8kg/cm.
- Reduction ratios: 1:48.
- Body Size: 70mm x 37mm x 23mm.
- Shaft Size: 8mm x 2mm diameter.
- Weight: 17.5 grams.

1 | www.handsontec.com

Mechanical Dimension:

Unit: mm





DC Mini Gear Motor	TS-25GA370	Voltage	DC 12V/24V
No-load Speed	10-600rpm	Power	2.5W
No-load Current	0.1-0.15A	Continuous working time	24 Hours
Motor Size	25*51/59mm	Output Shaft	4*11mm
Adjustment Speed	Yes	CW/CCW	Yes
Application	Office automation, home automation, production automation, medical equipment, toilet lid, toilet gear box pump, home smart rotating camera, air conditioner, rice cooker, turntable, electric pen, electric toothbrush, etc.		

Dimensional drawing