An-Najah National University

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Graduation Project II

STC Friend

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Abstract

Technology has improved greatly all over the world, and the main goal of this development was to provide all means for human comfort, so it came to serve people, facilitate their lives, and reducing the amount of time and effort that they spend on daily tasks.

From here came the idea of our project to design a smart wastebasket that helps people inside their workplace or inside the home. Technology has contributed to the development of litter boxes through the use of sensory sensors to provide smart services. We developed regular trash into a mobile trash can, where it moves on commands from the user who controls it through an app on their mobile device.

The smart trash can move based on user directions through a mobile app. The map of the home is entered into the app and buttons are added to the places or rooms the person would like the litter box to come to. First and foremost, the kitchen is the reference point in the home, as it is the place where waste is disposed of the most. When pressing the living room button, the basket moves automatically and finds its way from the kitchen to the living room, and then the required task can be done, so that the person can manually control the movement of the basket inside the room through buttons in the application and direct its movement to suction dirt from the floor or empty the waste in basket. After that the basket return to the kitchen automatically.

Also, the basket can bypass barriers in front of it and move away from objects that fall in its path. In addition, the basket offers the advantage of opening without touching the cover. As soon as the hand approaches the cover of the basket, it opens automatically, in addition to the feature of suctioning dirt through the use of a fan at the bottom of the waste basket.

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1. Introduction

The global industry is undergoing major transformations with the emergence of a new paradigm known as the Internet of Things (IOT) with its underlying technologies. With the latest developments in the Internet, including the use of basic technologies, smart sensors, and communication technologies, it is now possible to link machines, devices, programs, and things without human intervention, and this is the Internet of Things. Where many companies are investing more effort and money in transforming their services to take advantage of offered by the Internet of Things.

Recently, many devices use the Internet to facilitate their work, including garbage cans. In North America, the smart litter box market will be valued at US$12.3 million by 2025 and is expected to grow at a compound annual growth rate (CAGR) of 6.9% during the forecast period. Touch less litter boxes rely on sensors and can operate without making any physical contact. The growing demand for efficient waste disposal and smart waste management is one of the major trends driving the growth of the smart trash bins market.

With welfare organizations and local government agencies increasingly interested in creating initiatives to ensure a cleaner environment in urban areas, touch less litter box manufacturers are stepping up their efforts to encourage adoption of their offering. As a result, residents are encouraged to use touch less trash cans for daily waste disposal.

From here came the idea of our project to design a smart garbage bin that relies on the Internet in its work and control it through a mobile application, and this basket is used in homes, restaurants and offices to facilitate people's lives.

2. Constrained

We needed to find a sensor to correctly determine that the robot is able to reach the target point, and we thought of using RFID, but there was a problem that the sensor had to stick to the sensor card with small distance, so we thought of replacing it with a color sensor.

We used the color sensor to make sure that the robot took the correct path and reached the target point, but at the same time the color sensor suffers from the problem of inaccuracy, so we found it difficult to determine the range for each color, and finally we came to the possibility of selecting some colors, but they are sufficient for the purpose.

We also tend to use digital compass, as one of the most important basics of how the robot walks is relying on digital compass to determine the direction of the robot's movement, we prepared the code and made sure that the wires were connected correctly, and we changed the piece twice, however the problem persisted in not giving the correct direction, Which forced us to change the idea and use the algorithm to save the path between each point and the kitchen to enable the robot to correctly reach the target room.

Finally, the problem of the Internet, as the university closed the ports on the server for security reasons to achieve security for the network, and thus the inability to connect the ESP piece in the Internet, and we switched to using 3G, but this method did not work, so the most appropriate solution was to work from home to provide a stronger and better network.

3. Earlier Work

From the microcontroller course, we gained enough experience to read the datasheets of each component and deal with it at the beginning of our project, along with our previous programming courses (C++ for coding microcontrollers, and Arduino for programming electronics).

4. Literature review

Before starting work, we read many research studies on smart trash design, and among them we came up with several features that can be combined with each other to form a bin that contains many useful tasks in indoor spaces such as the home. Offices and restaurants. Some of them support the feature of opening the basket without the need to touch the lid, and some of them contain air suction that sucks dirt and dust from the floor.

Most of these industries were in Korea due to the large population, so the government aimed to maintain cleanliness in closed public places, but it lost control due to the population's lack of adherence to hygiene laws, so it resorted to distributing smart garbage bins in many places to encourage people to throw garbage in their places. [1]. Also, this invention was used in airplane toilets to speed up the use and cleaning of bathrooms [2]. In addition to the use of LED lights on the trash can and the design of the basket with a modern and contemporary design that matches home decor.

Our idea came to make the basket move and reach the place specified by the user, and then provide the option of suctioning the dirt in the place the user wants, or even throwing the garbage in an easy and quick way. In addition to the feature of alerting when the trash can is full, as a notification is sent to the user to alert the waste container to its fullness, thus preventing the accumulation and disposal of waste directly.

5. Methodology

During this section, we define every electronic piece we use in the project and explain why we use them, as well as describe the pins we used in this piece to connect it to the ESP32.

5.1 Hardware Components

At this part, we will explain each piece that was used in the project, identified it and show the used pins.

5.1.1 ESP32-Wroom

This is the main microcontroller of the project, it is used to control the robot, so it is used as a server where it receives the API request from the mobile application, based on this request the robot performs the move action, fan hover operation, etc. We can think of it as the mastermind of the robot.

Figure 1: ESP32-Wroom

The pins that we used on ESP32-Wroom:

GPIO12 connected to stepper motor driver
GPIO14 connected to stepper motor driver
GPIO27 connected to stepper motor driver
GPIO26 connected to stepper motor driver
GPIO25 connected to stepper motor driver
GPIO33 connected to stepper motor driver
GPIO19 connected to stepper motor driver
GPIO18 connected to stepper motor driver
GPIO02 connected to color sensor
GPIO34 connected to color sensor
GPIO35 connected to color sensor
GPIO32 connected to color sensor
GPIO00 connected to color sensor
GPIO16 connected to ultra-sonic
GPIO17 connected to ultra-sonic
GPIO22 connected to ultra-sonic
GPIO23 connected to ultra-sonic
GPIO24 connected to ultra-sonic
GPIO04 connected to ultra-sonic
GPIO05 connected to servo motor
GPIO15 connected to LDR
GPIO21 connected to dht11 (Moisture sensor)
GPIO13 connected to relay

5.1.2 Chassis body

We used a piece of wood to put the components on it such as motors, battery base, fan, etc.

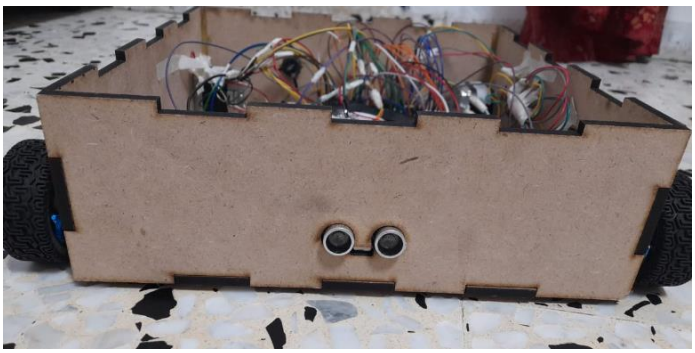

Figure 2: Chassis body

5.1.3 Stepper motors

The stepper motor converts a pulsing electrical current, into precise one-step movements of this gear-like toothed component around a central shaft. Controlled the stepper motor by stepper motor driver, Each of these stepper motor pulses moves the motor through one precise and fixed increment of a full turn.

For the connection every 2 wires make a coil and we connect them to the A4988 stepper motor driver.

Figure 3: Stepper motor

5.1.4 Stepper motor driver

We use 4 pieces of A4988 stepper motor driver, one for each stepper motor and we follow this connection for each one.

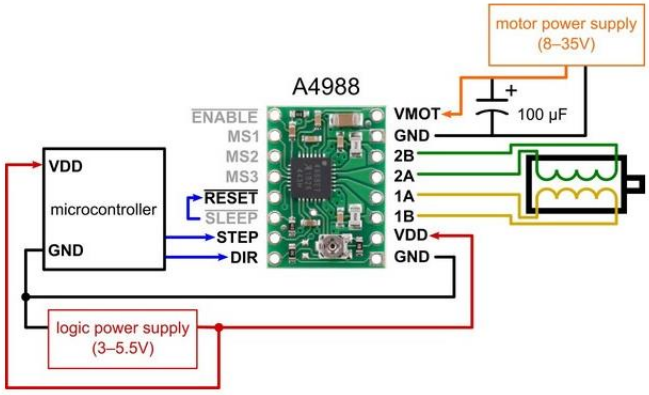

Figure 4: Stepper motor deriver connection

We connect MS1, MS2, and MS3 for all driver to 5 volt to perform 16 micro stepping that increase the stability, flexibility and reduce the noise.

At the driver 2B and 2A perform one coil of the stepper motor, and 1A, 1B make the other coil of the stepper motor.

We connect the Enable pin with 0 volt.

5.1.5 Buck convertor

Buck converter or step-down converter is a DC-to-DC converter which steps down voltage from its input (supply) to its output (load). In our project we use it to convert the 12v to fixed 5v.

Figure 5: Buck converter

5.1.6 Wheels

We used four wheels to move the robot.

Figure 6: Wheel

5.1.7 12 Volt Battery

12 volts from battery was used to supply the 17HS4401 Driver with 12 volts.

Figure 7: 3 buttery everyone is 4volt to make 12 volt

5.1.8 Servo motor

We use the mg996r servo motor to open the trash bin cover when any one pass their hand above the cover.

This module consists of 3 pins:

- Orange wire: This wire is connected with G02 with ESP32 to open the cover.
- Red wire: connect with 5 volts.
- Brown wire: connect with GND.

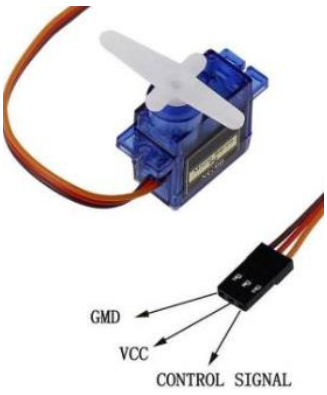

Figure 8: servo motor with its wire

5.1.9 Ultra sonic

The characteristic of the ultrasonic is:

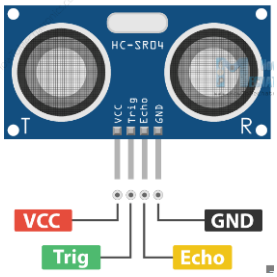

Figure 9: Ultra sonic with its pins

We connect the VCC to 5v and GND to 0v and the Trig and Echo pins is connected based on the purpose of each one as shown.

We use 3 pieces of Ultrasonic sensors to perform three objective in our project.

Firstly we used it in robotic obstacle detection systems so we measures the distance between the robot and the object it collides with. If the distance is 30 or less then turn right with 90 degree and move forward for 40cm then turn left with 90 degree and move forward for 40cm after that turn lift with 90 degree again and move forward for 40cm then turn right with 90 degree follow the detected path.

The Trig pin connected to G23

The Echo pin connected to G22

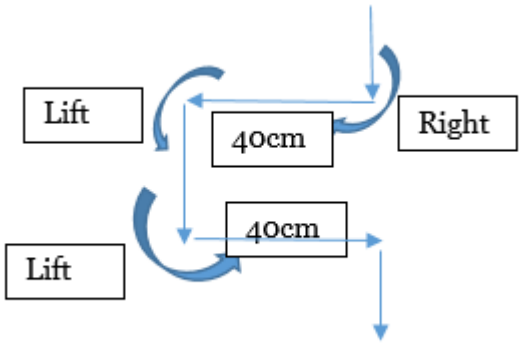

Figure 10.1: robot movement way when detect an object in front it (ultrasonic 1).

Secondly we use it to open the trash bin cover without touch it, so when the ultrasonic sense any object above the cover it will send a request to the servo motor in order to open the cover and after a many second the cover will close automatically.

The Trig pin connected to G17

The Echo pin connected to G16

Finally we use it to detect if the trash bin is completely full with the rubbish or not in order to send a message at Whatsapp to the user to empties the trash and change the bag.

The Trig pin connected to G24

The Echo pin connected to G04

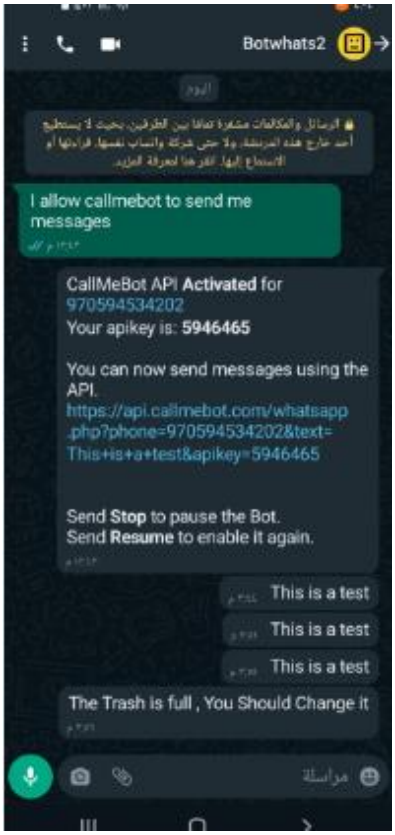

Figure 10.2: message send to whatsapp when ultrasonic detect that trash bin is full to change the bag

5.1.10 Color sensor

The TCS3200 and TCS3210 programmable color light-to-frequency converters, this sensor can detect a wide variety of colors based on their wavelength. We allocate a color card at the points in the paths then the robot can confirm that it reaches the correct point when sense a color.

We identify the frequency range of five colors red, dark blue, black, purple, and yellow.

We can find the frequency range for more colors but we think these are enough for now.

We connect the pins as follow:

GND to 0V

VCC connected to 5V

Out connected pin GPIO02 at ESP

S0 connected pin GPIO34 at ESP

S1 connected pin GPIO35 at ESP

S2 connected pin GPIO32 at ESP

S3 connected pin GPIO00 at ESP

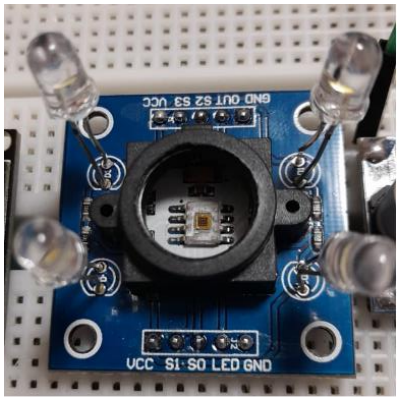

Figure 11: color sensor

5.1.11 Fan turbo

The fan is used to suck dust and dirt from the floor, as it turns on and off based on the request that generate from the app.

We connect it to the relay to control it.

Figure 12: Fan Turbo

5.1.12 Wires

Wires of different lengths and types were used to connect the components.

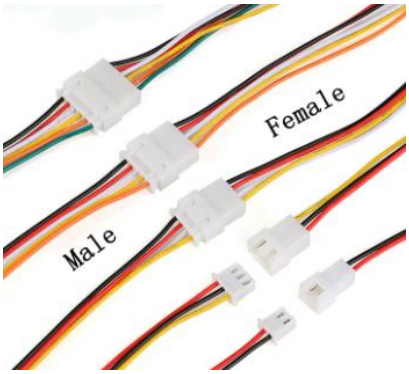

Figure 13: wires of male and female

5.1.13 Mechanical robot part

The mechanical part of the robot is in the lid of the waste bin, where the responsible arm is designed that opens and closes the lid smoothly. The opening and closing process can be controlled by a servo motor.

Figure 14: Mechanical robot part

5.1.14 Relay

We use a 2 channel relay (5V) one to control the lights and the other to control the turbo fan to turn it on and off.

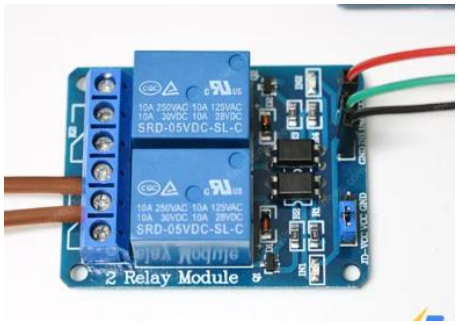

Figure 15: Relay

5.1.15 Led

I used a LED lighting strip around the outer structure of the basket. It is connected to the relay and it is controlled in two ways, either manually through the application. It contains an on and off button on the main page, or through the LDR sensor, where if the reading of the indicator is dark, the LED is turn on, but if The room was light then the led will turn off.

Figure 16: Led

5.1.16 LDR (Light sensor)

We are using LDR sensor to detect light so if it's dark the lights will turn on and if it's dark the lights will turn off.

We connect the LDR with the ESP32 at pin G15.

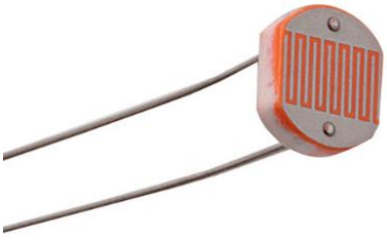

Figure 17: LDR

5.1.17 HDT11 sensor (temperature and humidity sensor)

We use hdt11 to read the temperature and humidity so that it measures the room temperature and shows it in the application as an IOT system and we use it to measure the humidity inside the trash can to detect any liquid leakage inside the trash can and send a message to alert to change the bag. The piece contain four legs connected to GND, 5V, and one to the ESP32 at pin G21 and other not connected.

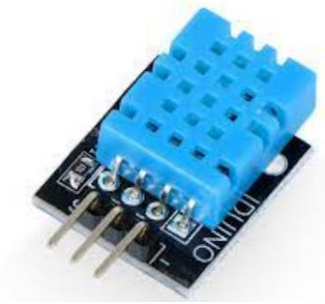

Figure 18: HDT11

5.2 Frameworks

We built a flutter application to control the robot actions of moving, and turn on or off the fan and other.

1- Main page

This is the main page of the application

It enable the user to control the movement of the robot and its action so when click at Home button the robot will return to its home point which is the kitchen at the house.

For come here button it will open another screen to choose where the user wants the robot to come.

Light button is used to turn on/off the light.

Finally the switch used to turn on or off the vacuum.

Also the setting button which is enable just for the robot owner and for specific user, so not any user can change the sitting of the robot.

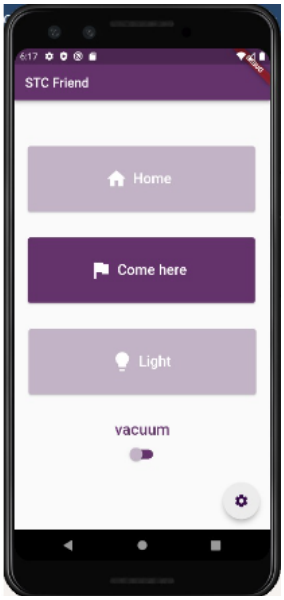

Figure 19: Main page at the application

2- Setting page

This window appears when you click the setup button on the home page. At this page you learn the robot in all the paths that the user wants the robot to come to. To learn the robot on the tracks, you need to log in the learning mode, so only the programmer and a certain user with a password can log in and learn the robot.

Figure 20: Setting page

3- Save paths page

At this page, we first choose the name of the track (path) on which you want to learn the robot. Then choose the number of points in this path and then click on the start save path button to start learning the robot in this path by controlling the movement of the robot in real life by the arrow buttons. After knowing the discovered path, you have to save the path, and if you want to save the path before all the points are finished, an alert box will appear to alert you to finish all the points you choose.

Figure 21: enter the name of The path and the point numper

Figure 22: control page of the Robot at the learning mode

Figure 23: save path alert box.

Figure 24: alert box show that not all point used.

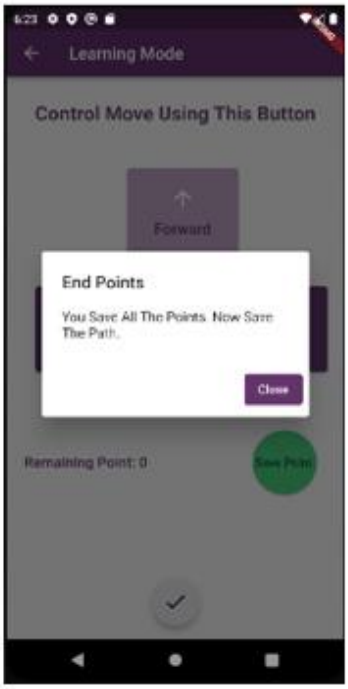

Figure 25: alert box show that all point used and the path saved

For example the user detect the bedroom1 and choose 3 points like this.

Then by arrow button the user control the robot movement to move forward to reach the first point then save the point after that turn right with 90 degree and move forward to reach second point then turn right with 90 degree and move forward again to reach bedroom1 then save all the path.

Figure 26: Bedroom 1 path with 3 points

4- Come here button

When you click on the Come here button on the main page, this page appears to show the house plan, each room is a button, so when you click on the room, the robot will automatically move from the kitchen to the detected room, then when the robot reaches the detected room, you can control the movement of the robot inside the room through the control page that appears. Where the control page don't appear until the robot reach the target room. When the robot surly detect that it reaches the target room by scanning the color at the card then the robot will open the control direction page.

Figure 27: the house plane Page appear (Dynamic plane)

Figure 28: alert box appear when robot reach the target Room

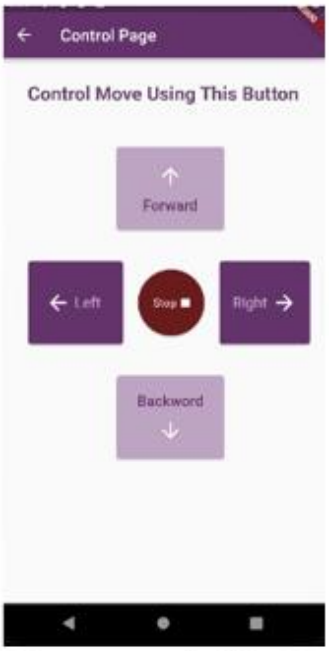

Figure 30: control direction page inside the detected room.

5.3 Project explanation

The user uses the robot and controls it through the application, where the main task of the programmers is to apply the learning mode to the robot and teach it on the paths inside the house, so that the programmer enters the map of any house and writes the names of the rooms so that they represent the names of the paths, then you teach the robot on each path through control in motion. The robot move from the kitchen, as it is the most used place for the wastebasket, and directs the robot to the desired room, memorizing this path, and so on until all the paths that the user wants are saved. The user who has the password can change the path by repeating the learning mode steps.

When the robot reaches the required room automatically, the user can control its movement inside the room, for example, to suck dust and dirt off the floor or throw garbage, and when its task is completed, the robot must be returned to the point specified for it in the room, then the robot will return to the kitchen automatically.

Programmatically, we save the route by saving the number of steps taken by the robot in learning mode in one array, and also save the direction of movement in other array, and store these arrays in memory on the ESP and the robot confirm that it reaches the correct point when it detect a color by the color sensor then it can move successfully to the next point.

We program it to go forward in a straight line and when right or left clicked it will always turn 90 degrees, at project start time we aspire to move it at angles based on digital compass readout and we wrote the code correctly and We made sure the wiring is connected 100 percent correct, but when we connected it to the whole circuit it didn't worked and we disconnected, so We replaced it with another one but unfortunately it didn't work either, so we were tempted to look for another way to move the robot due to lack of time and we were able to make the robot walk in straight lines.

6. Conclusion and Future works

Cleanliness has always been one of the most important elements of life and one of the most important things that a person must maintain in his daily life, so what if it is related to the cleanliness of the house or the place where a person spends most of his time and needs? From here came the idea of our project to provide a clean and healthy environment and place, and thus provide a means that helps you in cleaning and encourages people to keep their place clean, so we accomplished this invention that facilitates the cleaning process in closed places such as homes, offices, and others.

In the future, we aspire to find a solution to the problem of the digital compass and make the robot move freely with zigzag lines and different angles and search for its path by itself instead of keeping the paths in memory and also an improved algorithm can be used to calculate the distance between points instead of the number of steps in the stepper motor.

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