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IRRIGATION ROBOT : A RESEARCH

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ABSTRACT

Nowadays, because of busy routine life, peoples forget to water their plants. during this project, we tend to present an autonomous and economical system for watering indoor potted plants placed on a fair surface. The system contains a mobile robot and a temperature-humidity sensing module. The system is adjustive to any atmosphere and takes into consideration the watering desires of the plant's victimization of the temperature-humidity sensing module. It describes the hardware design of the machine-controlled watering system that uses wireless communication to speak between the mobile golem and also the sensing module. This agriculture golem is transportable and is supplied with a frequency Identification (RFID) module, a microcontroller, an Associate in Nursing onboard water reservoir Associate in Nursingd a hooked-up pump. it's capable of sensing the watering desires of the plants, locating them, and at last watering them autonomously with no human intervention. Mobilization of the golem to the potted plant is achieved by employing a predefined path. For identification, an Associate in RFID tag is hooked up to every potted plant. It conjointly discusses the elaborate implementation of the system supported with complete electronic equipment. It concludes with the system performance together with the analysis of the water carrying capability and time needed to water a collection of plants.

1.INTRODUCTION

Irrigation is the artificial method of watering a plant. Irrigation is the most important factor in the agriculture sector. Irrigation is important in the modern agriculture industry due to insufficient and uneven distribution of rainfall. Due to poor irrigation facilities irrigation in desert lands are limited. To overcome these problems we are going to develop an irrigation robot that can be useful for indoor farming as well as research purposes.

1.1 OBJECTIVES

These are the main objectives of our project.

1. To study agriculture robot.

The technologies used in agriculture robots. Mainly focusing on the navigation, control, self-watering mechanism, etc.

2. To design an autonomous irrigation robot.

By studying the latest we are going to design an autonomous robot used in indoor farming and research applications.us irrigation robot.

After the design process, we are going to fabricate a model of this irrigation robot.

Fig.1. Irrigation in Plant

2.PROPOSED METHODOLOGY

2.1 Design

To achieve the precise project objectives we are shown that using Arduino because the software during this project is that the best option, it contains several open provide hardware and software.

2.1.1 Alternative Materials

The primary step of this method of building the example of the machine-driven irrigation system was the selection of materials for this project area unit notable, that area unit appropriate and important to agriculture, analysis was undertaken to pick out materials.

2.1.2 Field Control System

This step depends on the operating of various devices utilized in this project that area unit (Soil wetness sensor, IR sensor)

2.1.3 Project Preparation

To create an ideal structure, size was measured for every half which will be utilized in the project anon. Places of (pumps, RFID Reader, and tag), types of totally different sensors supported the surroundings which will work on, 2 batteries, a little plastic tank, various sorts of connecting wires, and controller (Arduino ATmega 328V).

2.1.4 Mechanical Design

In the starting, a sketch design for the project was created, then measurements and size were required for designing the project.

Fig.2. Side View

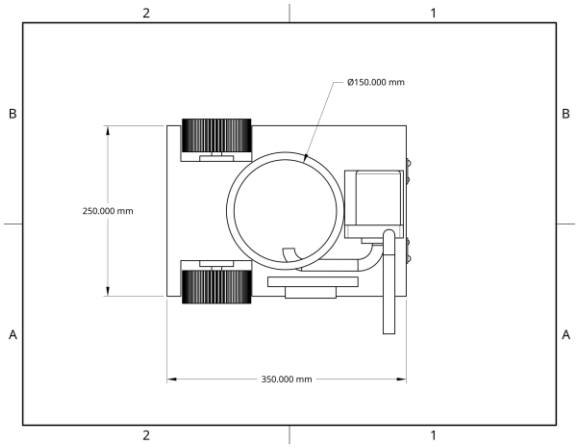
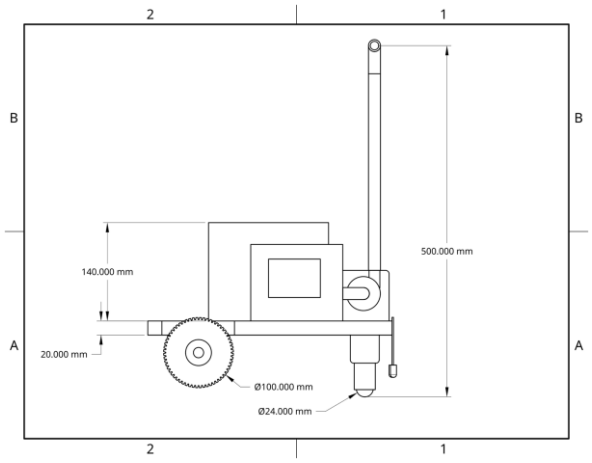
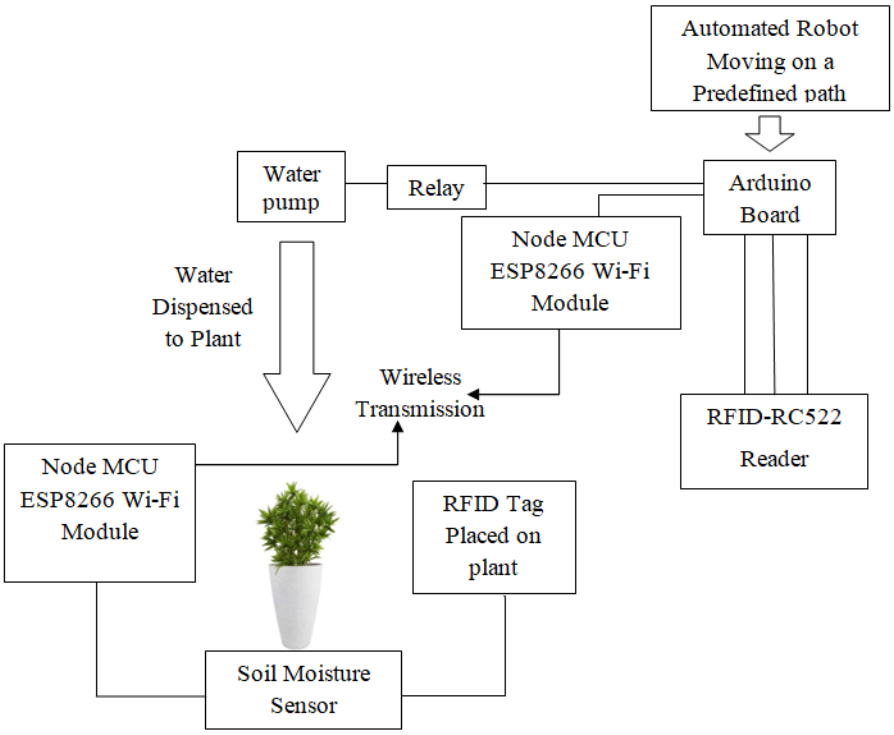


Fig.3. Top Vie



Components	Specification	Dimension (L x W x D)	Unit
DC Motor	12V, 30 RPM	40 x 40 x 50	mm
Caster Wheel	Mounting hole- Three 120 degree apart, 3.4mm diameter	Base plate Dia. 34mm Caster Wheel Dia. 21 mm	mm
Robotic wheel	• Power Source: DC, Material: Rubber	100x40	mm
L298N motor Drive	5V-35V, 2A , 25W	43 x 43 x 26	mm
Arduino UNO	5V, Processor- Atmega 328P	80 x 20 x 8	mm
Wi-Fi Module	Node MCU ESP 8266, 3-3.3V	49 x 26	mm
RFID Reader RC522	Range- 5cm, 2.5- 3.3V	60 x 40	mm
RFID Tag	1-3V	20 x 30	mm
IR Sensor	5V, Range-2-30 cm	58 x 17.6 x 22.5	mm
Soil Moisture Sensor	3.3-5 V, Range 30-150 cm	• Sensor probe board- 60 x 20 • Sensor electronics board- 30 x 15 • Cable – 20 cm	mm
Water Pump	DC 12V 5.5M 1000L/H	3.94 x 0.39 x 0.39	Inch
Relay Module	5-30V	8 x 4 x 10	Cm
Battery	Li-ion rechargeable battery	• 3.7V- 18 x 65 • 11.1V- 42 x 60 x 70	mm

Table.1. Components Required



2.2. WORKING

Fig. 4. Architecture of the Autonomous System

The area to be watered by the Autonomous Mobile robot may be any field with plants placed during a line on the predefined path that the robot can follow. The trail to be followed by the plant has got to be black on white background due to the two IR sensors that absorb light and differentiate between the colors on the basis of quantity of sunshine absorbed by them. every plant has an associate RFID tag placed on it. The vary of the RFID – RC522 Reader Module is regarding 5 cm. The plant has to be among 5cm of the autonomous robot. The RFID tag has got to face the RFID Reader Module. ESP8266 Node MCU Wi-Fi Module used square measures organized to move with one another forming a network. The pump is triggered by employing a 6V relay that acts as sort of a switch however rather than physically touching it to change it on/off we tend to offer voltage to toggle it. The soil-moisture device is to be placed close to the plant so that desired values may be obtained for a correct functioning of the system. the peak of the potted plant is taken as per the peak of the mobile robot so that water may be simply distributed to the plant exploitation the pipe.

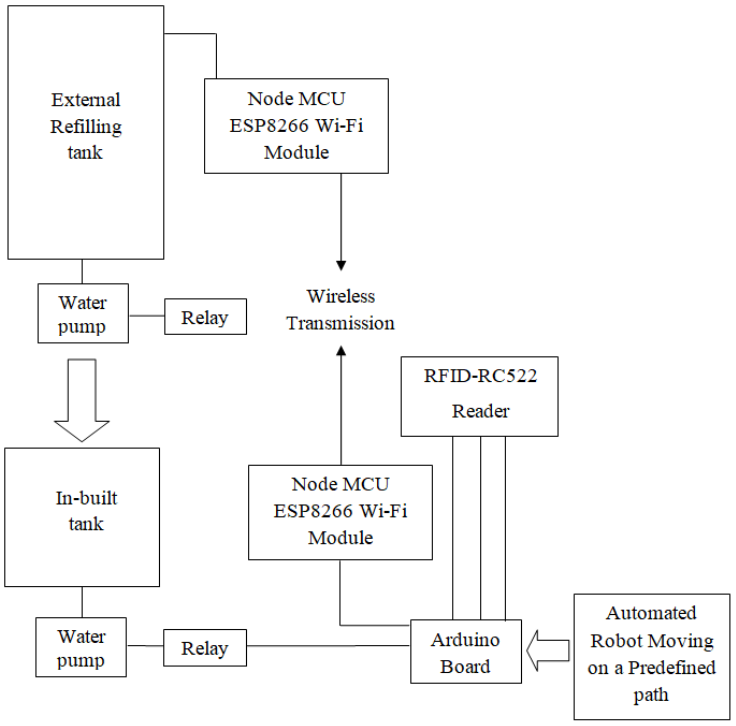


Fig. 5. Architecture of the Refilling System

Apart from these systems, we are using an external refilling tank for the robot. It is used to refill the tank in the robot if the required amount of water is not present in the robot. The refilling tank is placed across the path. The refilling tank consists of a Node MCU Wi-Fi Module, Water pump, Relay module, and RFID tag. If a request signal from the Wi-Fi module in the robot sends to the Wi-Fi module in the refilling tank send a feedback signal with its RFID tag number. After getting the feedback signal the robot will move and identify the tank using an RFID tag number then the robot sends a signal to the Wi-Fi module in the refilling tank. The Wi-Fi module will send a signal to the relay to trigger the water pump. Then the water from the refilling tank will transfer to the tank in the robot with the help of a water pump and relay module. The whole system is powered using three 3.7V Li-ion batteries in series.

2.3.MATERIALS AND METHOD

The Plant Watering autonomous Robot includes of Arduino UNO R3 controller that encompasses an Atmega 328P microcontroller that has a pre-installed boot loader, therefore one will transfer code to the board using only a USB-serial connection. The code written in Arduino software code will be uploaded to the microcontroller using A-B USB cable.

Radio Frequency Identification (RFID) Reader Module provides an solution to scan passive RFID electrical device tags from up to 4 inches away. RFID tags area unit placed at every potted plant. Soil wet device is placed on the plant to sense the water content on the plant and analyze its watering wants consequently.Node MCU could be a wireless communication module that's AN open supply computer code and hardware development surroundings designed around a reasonable System-on-a-Chip (SoC) known as the ESP8266. The Arduino project created AN ASCII text file hardware style and computer code SDK for there versatile IoT controller. It's wont to transmit the water content level of the plant to the mobile vehicle wirelessly. Since we tend to area units employing a Node MCU ESP8266, the doors RF line-of-sight ary is 300 m, and also the Indoor/Urban vary depends on the no of windows and walls.The Plant Watering Autonomous Mobile robot can follow a preset path that may bring it in shut proximity to plants. Using an RFID (Radio Frequency Identification) tag on that, it'll discover the near potted plant placed at intervals 5cm. The tag is detected by the RFID reader module RC522 placed on the mobile robot. The robot senses the plant's water content locates it, waters it, and continues to follow the plant. The plant's area unit is placed on the trail the autonomous robot can follow. Wireless device nodes area unit placed each on the robot and within the plants being cared for. The soil wet device within the plants gives a nonstop stream of information reflective of their state whereas the device node on the robot that receives the information acts consequently. A small electrical pump triggered by a relay is employed to deliver water from the onboard water reservoir to the plant. Once the robot has watered all the plants it'll come back to a given purpose at the top of the trail within the reverse position so it will once more begin the watering if it senses that the plant is once more in want of water. Within the case, once the water carried by the robot has exhausted it'll quit examining the plants and return for automatic renewal of water within the water reservoir. An elaborate description of the system is given below.

- Module 1 includes: Node MCU ESP8266 Wi-Fi Module, RFID Tag, and Soil wet device.
- Module 2 includes Node MCU ESP8266 Wi-Fi Module, a System with robotic wheels carrying water, 2 DC Motors, Arduino UNO R3 board (Microcontroller), RFID reader module RC522, Relay (For triggering the water pump), DC pump, and a water reservoir.
- Module 3 includes: refilling tank, DC pump, Relay (For triggering the water pump), Node MCU ESP8266 Wi-Fi Module, RFID Tag.

In the 1st module, the soil moisture device module attached up at the plant senses the water content within the plants in scrutiny. With the assistance of a attached microcontroller i.e. the Arduino board, it determines whether or not the plant wants water or not. The water demand is set using predefined C code uploaded on the Arduino Board using the Arduino software. Module 1 component provides a continous stream of information reflecting the state of the plants to be watered. If the plant wants water in line with the predefined value on the soil moisture device then a 'Y' is transmitted to the mobile robot using Wi-Fi Module placed on the plant to the Wi-

Fi Module which on the moving robot. If in line with the perceived water content values, the plant doesn't need water then the Wi-Fi Module sends an 'N' to the robot. Figure 6 shows the summary of the system.

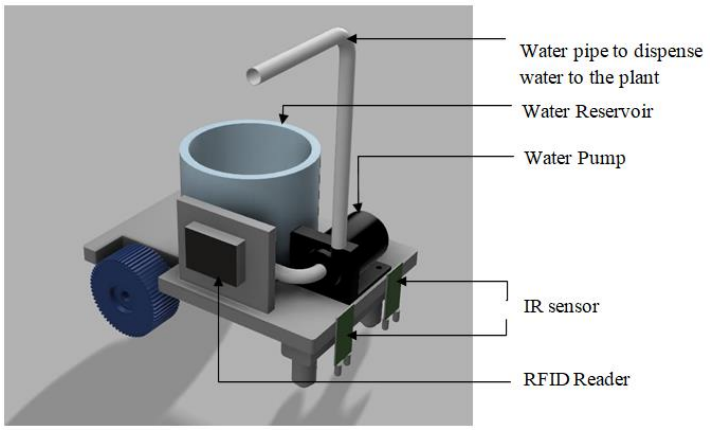


Fig.5. System Overview of the Autonomous Irrigation Mobile Robot

In the second module, on receiving a 'Y' the system starts moving on the predefined path with the assistance of IR sensors placed at the bottom of the autonomous vehicle. the trail is formed by employing a black line that the robot follows until it detects the Associate in detects an RFID tag. If the associate in RFID tag is known by the RFID reader module, the robot stops for concerning 10 sec to water the detected plant in want of water. As presently because the tag is known the connected relay is triggered by giving it a high voltage that activates the connected pump. This pump fetches water from the onboard water reservoir of the robot for concerning 7 seconds and dispenses water to the plant. When the water is distributed to the plant, the autonomous vehicle waits for 3 seconds and moves once more on the trail to continue watering the remainder of the plants. Thus, during this manner, this Plant Watering Autonomous Mobile Robot waters every plant that comes on the manner.

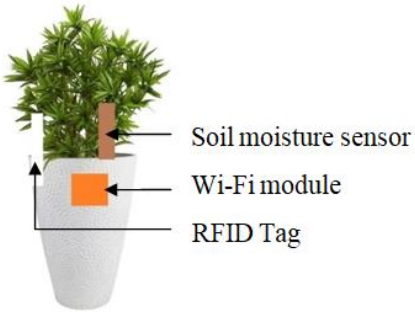


Fig.6. System Overview of the Plant

In the Third module, on receiving a 'Y' from the filling tank the system can begin to move on the predefined path with the assistance of IR sensors placed at the bottom of the autonomous vehicle. the trail is formed by employing a black line that the robot follows until it detects an associate RFID tag. If the associate RFID tag is known by the RFID reader module, the robot stops for regarding 10 seconds to refill the tank within the robot. Before long because the tag is known the hooked-up relay is triggered by giving it a high voltage that activates the attached pump. This pump fetches water from the onboard water reservoir of the robot for regarding 7 seconds and dispenses water to the robot tank. Once the water is distributed to the tank, the autonomous vehicle waits for 3 seconds then moves once more on the trail to continue watering the rest of the plants. Thus, this Plant Watering Autonomous Mobile Robot refills its tank.

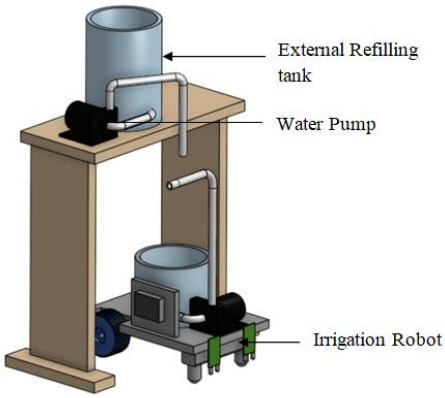
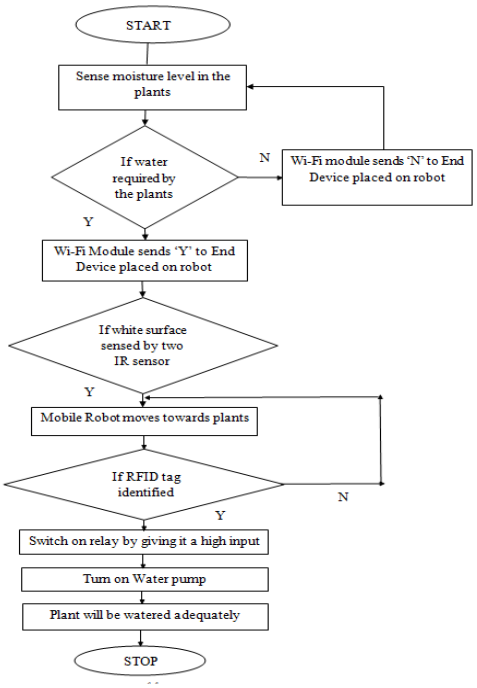


Fig.7. System Overview of Refilling Tank

The control flow diagram in Figure 8 and 9 summarizes the working of the Plant Watering Autonomous Mobile Robot. The Figure 10 shows circuit diagram that has been implemented for the Plant Watering Autonomous



Robot.ig.8. Control Flow Diagram of Robot

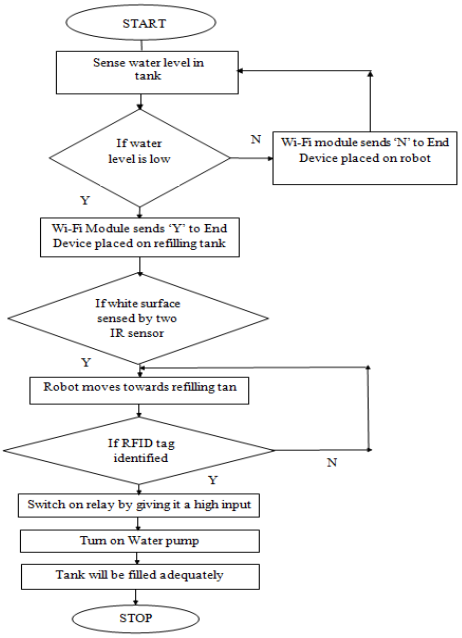


Fig.9. Control Flow Diagram of Refilling Tank

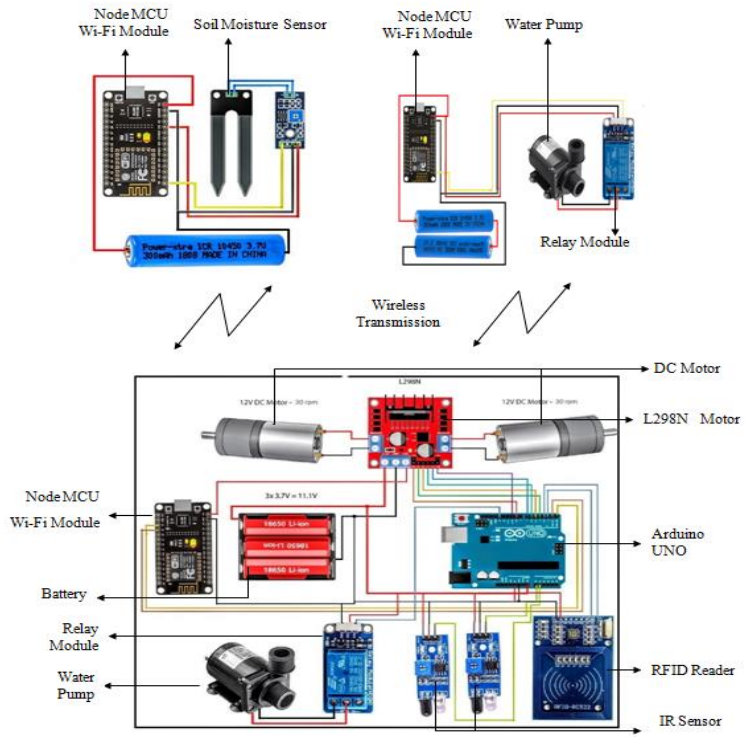


Fig.10. : Circuit Diagram of the System

2.4. HARDWARE REQUIREMENT

2.4.1. DC Motor

An electric motor is an electrical machine that converts electrical energy into mechanical energy.

Fig.11. DC Motor

Two DC motors are used in the robot for the wheels. It is working in 12V and it is rotating in 30RPM. To control the motion of the motor we are using a L298N dual H Bridge motor drive.

2.4.2. Motor Drive L298 N

The motor driver is a module for motors that allows you to control the working speed and direction of two motors simultaneously.

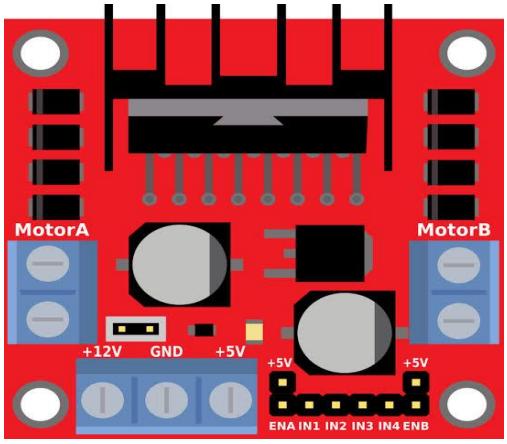


Fig.12. Motor Drive L298N

We are using a double H bridge L298N motor drive where L298N is the name of the motor drive. It consists of two motor connectors on both left and right sides named motor A and motor B. At the bottom, there are mainly three pins. A 12V pin for giving 12V input to motor drive through the battery. The second one is GND. The third one is to provide 5V output. It can be used for powering the Arduino board or Wi-Fi Module. Apart from these three pins, we can see 6 pins at the bottom. It consists of 2 enable pins and 4 data pins. Enable pins are used for the ON and OFF control of the motor. IN1 and IN2 pins for motor A and IN3 and IN4 for motor B. These pins are controlling the clockwise and anticlockwise rotation of the motor. If IN1 is HIGH and IN2 is LOW then the motor will rotate clockwise otherwise it rotates in an anticlockwise direction. Similarly, Motor B rotates clockwise when IN3 is HIGH and IN4 is LOW otherwise rotates in an anticlockwise direction. The HIGH and LOW values are given to the motor drive through Arduino Board using Arduino coding.

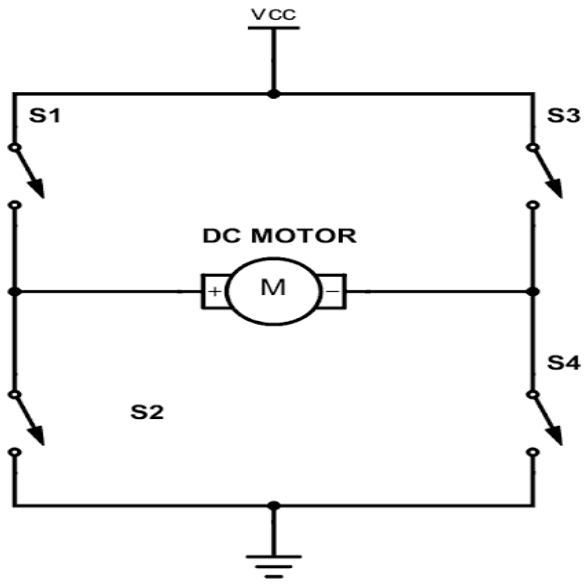


Fig.13. L298N H Bridge

These motions are happened because of the double H Bridge L298N in this motor drive. The diagram of the H Bridge is shown in fig. Fig VCC represents 12V input from the battery and GND is marked at the bottom. If the Supply flow from VCC to GND the motor will start to rotate. If S1 and S4 are closed then the current passes through the motor and the motor rotates clockwise. If S3 and S2 are closed motor rotates anticlockwise. If all the switches are open the motor will be stopped. There are two H bridges are included in the motor drive for operating two DC motors.

2.4.3. Arduino

Arduino is an “open source electronics platform primarily based whole on clean-to-use hardware and software". The Arduino panel programmed by Arduino c and is based on C and C++ Arduino is an open source operating system that depends on easy-to-use hardware. Arduino will browse the quantitative relation of light input to the detector and convert it to output. For example, exploitation of Arduino we can manage the area by turning on or off the light or air conditioning. This is often done by causation a collection of instructions to the management unit on the Arduino board.

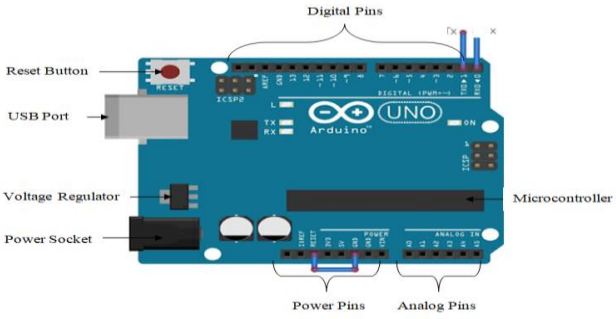


Fig.14. Arduino

2.4.4. IR Sensor

There are two IR sensors are used in this robot for navigation purpose.

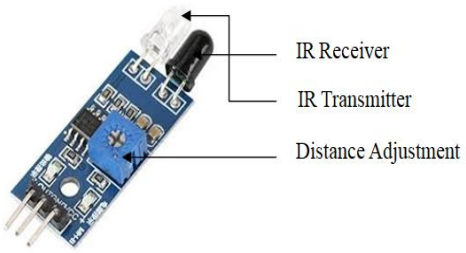


Fig.15. IR Sensor

IR detector encompasses two components IR electrode and Detector. The electrode is an associate IR junction rectifier and therefore the detector is an associate IR photodiode. The photodiode is sensitive to IR light of the constant wavelength emitted by the electrode. The IR light falls on the pic diode the resistance and output voltages modification in proportion to the magnitude of IR light received by the photodiode. The variation of the IR detector will be adjusted by adjusting the screw within the IR detector and by dominating the ability offered to the IR detector.

2.4.5. RFID Reader and tag

Radio frequency identiification uses electromagnetic fileds to automatically identify and track tags attached to object.

Fig.16. RFID Reader

Fig.17. RFID Tag

RFID is radio frequency identification. RFID Reader continuously emits radio waves. When the RFID Tag is in the range of the radio wave it will transmit a feedback signal to the reader. It consists of a radio frequency signal generator. Signals are transmitted through the antenna and a microcontroller is also inside it to read the signal. We are using RFID passive tag. Because it is cheaper and it does not require any power source. An RFID tag consists of a transponder that receives the radio wave from the reader and sends a feedback signal back to the reader. Passive tags do not have a power source. So they use the energy of the radio wave to operate the parts in the RFID tag. Energy is stored in the capacitor in the rectifier circuit. The frequency range of the radio wave is 125KHz to 134KHz and the range is up to 10cm. The working principle is inductive coupling. The signal from the RFID tag and voltage will be induced on the RFID tag. Some portion of the voltage will be induced on the RFID tag. Some portion of the voltage is rectified as a power source for the controller and memory elements.

2.4.6. Soil Moisture Sensor

Soil moisture sensor measure the volumetric water content in the soil

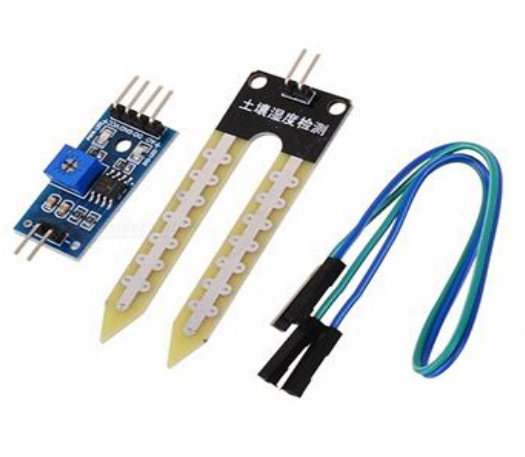


Fig.18. Soil Moisture sensor

Soil moisture sensors consist of two long conductors separated at a distance called an electrode. The output signal will provide an analog value of the moisture level in the soil. For this robot, we cannot need the exact value of the moisture. By measuring the change in the analog value we can decide whether the water supply is a need or not. If more moisture more conductivity by the electrode.

2.4.7. Water Pump

A water pump is a device for moving water

.

Fig.19. Water Pump

The water pump used in this robot is working at 12V and has a valve diameter of 5.5mm. It is 100L per hour.

2.4.8. Relay Module

A power relay module is an electrical switch that is operated by an electromagnet. The electromagnet is activated by a separate low-power signal from a microcontroller. When activated, the electromagnet pulls to either open or close an electrical circuit.

Fig.20. Relay Module

Relays are used to provide time delay functions. They are used to time the delay open and delay close of contacts. Relays are used to control high voltage circuits with the help of low voltage signals. Similarly, they are used to control high current circuits with the help of low current signals.

2.4.9. Node MCU Wi-Fi Module

The ESP8266 Wi-Fi Module is a self-contained SOC with an integrated TCP/IP protocol stack that can give any microcontroller access to your Wi-Fi network. The ESP8266 is capable of either hosting an application or offloading all Wi-Fi networking functions from another application processor.

Fig.21. Node MCU Wi-Fi Module

In this project there is one Wi-Fi Module is placed in the pot and another Wi-Fi module is placed in the robot. These two Wi-Fi modules are connected. When the soil moisture sensor senses the water level an analog signal will go as an output from the soil moisture sensor to the Wi-Fi module in the pot. The Wi-Fi module in the pot is connected to the Wi-Fi module in the robot. So the Arduino board gets the information about the water level. So the Wi-Fi module acts as a medium for the proper communication between the pot and robot.

There is another wireless transmission is held between the robot and the refilling tank. If the water level in the tank is low then the Wi-Fi module in the robot sends a signal to the Wi-Fi module in the refilling tank. The Wi-Fi module in the refilling tank sends a feedback signal to the robot Wi-Fi module along with its RFID tag number. After identifying the refilling tank the relay module is working based on the signal from the Wi-Fi module.

2.4.10. Battery

A battery is a power source consisting of one or more electrochemical cells with external connections for powering electrical devices

Fig. 22. Li-ion Battery 11.1V

Fig .23. Li-ion Battery 3.7V

There are two batteries in this project. A 3.7V battery for powering the Node MCU Wi-Fi module and Soil moisture sensor present in the pot.11.1V battery is used in the robot for powering the DC motor and water pump. It is used to pump water from the external refilling tank to the robot tank. The type of battery used is Li-ion 18650 rechargeable battery. The battery used in the robot has 3200mAh power and the pot has 2400mAh power. The battery is rechargeable using a Li-ion battery charger.

2.4.11. Wheel

A wheel is a disc-or circle-shaped mechanical device and objects on the wheels move more easily along the ground.

Fig.24. Caster Wheel

Fig.25. Robotic Wheel

In this robot there are two kinds of wheels are used. The back wheel is used as a normal robotic wheel which is attached to the DC motor. Using the power of the motor the wheel is rotating and the turning of the wheel is due to the coding included in the Arduino through Motor Drive. The front wheel is not motor driven. Because of that, we are using a caster wheel as the front wheel. The caster wheel is different from the normal robotic wheel because it can turn *360*°.

2.5. SOFTWARE REQUIREMENT

2.5.1. Arduino IDE

The Arduino Integrated Development Environment (IDE) is a cross-stage application
that is written in the capacities of C and C++. It is used to compose and transfer coding to the Arduino UNO board.

2.5.2. Onshape

Onshape is the only Software-as-a-Service(SaaS) product development platform that combines CAD, built-in data management, real-time collaboration tools, and business analytics.

2.6. TEST PROCEDUDE

The test setup consists of four pots that are placed in a rectangular path. The path is black color and the background is white because we use an IR sensor for navigation. Black cross lines are provided for each pot to stop the irrigation robot.

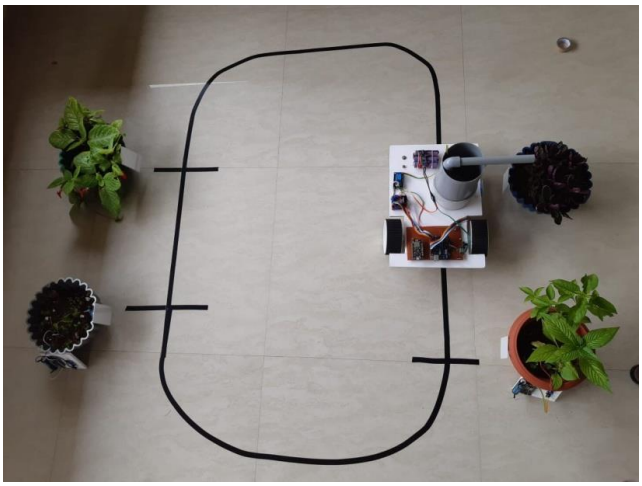


Fig.26. Irrigation Robot Test Setup

The above figure shows the actual test setup that we conducted on the irrigation robot. By using this test setup we can calculate the time taken to read the RFID tag. Before the test, we should verify the RFID tag and reader are on the same level when the robot is stopped.

2.6.1. Procedure

- Place the robot as shown in the fig.
- Remove soil moisture sensor from the last plant.
- Read the time spend in front of all the plants other than the last plant.
- Repeat the procedure four times.

Fig.27. System Image

3.PERFORMANCE AND EVALUATION

By taking the values from the specification we can calculate the speed and time taken to spray the water into the plant.

$Diameter\ of\ the\ back\ wheel = 10cm = 10 \times 10^{-2}mm$

$Speed\ of\ the\ DC\ motor = 30\ RPM$

$Speed\ of\ motor\ in\ m/s = \pi \mathrm{DN} = \pi \times 10 \times 10^{-2} \times = 9.42 \mathrm{m/min} = 0.157\ \mathrm{m/s}$

From the above data, it is clear that the robot can move 15.7 cm in one second and travel 1 meter in 6.36 seconds.The remaining time is for watering the plant. We know that the water pump has a capacity of 1000L/H. So,

$$Amount\ of\ water\ displaced\ in\ 1\ second = \frac{1000}{3600} \times 1 = .277\ L = 277\ ml$$

227 ml of water is sufficient for the plant at a time. So,

$$Time\ taken\ for\ watering\ one\ plant = 1\ second$$

The volume of the two tanks can be calculated as follows $Diameter\ of\ in\ built\ tank, r_1 = 150\ mm = 0.15\ m$

$$Height\ Volume\ of\ in\ built\ tank = \pi {r_1}^2 h_1 = \pi \times \left(\frac{0.15}{2}\right)^2 \times .14 = .00247\ m^3 =$$

$2.47\ L of\ in\ built\ tank, h_1 = 140\ mm = 0.14m$

$Diameter\ of\ refilling\ tank, r_2 = 150\ mm = 0.15\ m$

$Height\ of\ refilling\ tank, h_2 = 240\ mm = 0.24\ m$

$$Volume\ of\ refilling\ tank = \pi {r_2}^2 h_2 = \pi \times \left(\frac{0.15}{2}\right)^2 \times 0.24 = .004239 m^3 = 4.2\ L$$

The pump used in the refilling tank is the same as in the robot. So we can take the same values of the water pump to calculate the time taken to refill the in-built tank.

$$Time\ taken\ to\ refill\ the\ in\ built\ tank = \frac{3600}{1000} \times 2.47 = 8.89\ seconds$$

The time taken to read the RFID tag is calculated using the test conducted on the robot. The test result is shown below.

	Time taken to read RFID tag		
Sl no	First Plant	Second Plant	Third Plant
1	2	2	2
2	2	2	2
3	2	2	2

Table.2. Test Result

So the time taken to read the RFID tag is calculated experimentally as 2 seconds. We build this robot for irrigation in indoor farming. Suppose there are 300 plants are planted in indoor farming within a 1-meter distance. So the robot should move almost 300 meters in a closed path so, $Time\ taken\ to\ travel\ 300\ meter = \frac{1}{.157} \times 300 = 1910.82$ S$= 31.84\ minitues$

$e\ taken\ to\ read\ the\ RFID\ tag\ number = 2\ seconds$

$$Total\ time\ taken\ for\ reading\ 300\ RFID\ tag = 2 \times 300 = 600\ seconds$$
$$= 10\ minitues$$

If all the 300 plants are requested for the water then,

$$Total\ time\ taken\ for\ watering\ 300\ plants = 1 \times 300 = 300\ seconds$$
$$= 5\ minitues$$

$$Total\ time\ taken\ by\ the\ system\ for\ watering\ 300\ = 31.84 + 10 + 5$$
$$= 41.84\ minitues$$

$$Time\ taken\ by\ the\ system\ to\ water\ one\ plants = 6.36 + 2 + 1 = 9.36\ \text{seconds}$$

4.RESULTS

By analyzing the results obtained from the test we are taken on the irrigation robot we get the details about the performance of the robot. The robot will move 1 meter in 6 seconds and the time taken to identify the pot and water the plant is about 3 seconds. So for an irrigation robot, this time delay is not an issue. If we use a 120 RPM motor for the back wheel its speed will increase and the process will be quicker. But saving 3-4 seconds in this operation is not an advantage. Because the watering is happing in 9 seconds after the request is sent to the robot. 9 Seconds is not a big time delay for that plant.

5.CONCLUSION

In this project, we presented a completely autonomous system which helps in watering indoor potted plants that are arranged along a predefined path. The mobile robot is capable of performing three main functions of sensing the watering needs of the plants in need of water, locating them and finally watering them autonomously without any human intervention. The system comprises of the autonomous vehicle, Arduino microcontroller, the RFID reader module, the water pump, the relay, Soil Moisture Sensor, and the Node MCU Wi-Fi Module for wireless communication. The performance of the individual components has been assessed in the laboratory by various experiments.

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