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Design a Smart Mini Robot for Indoor Plant Watering System

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Abstract

Nowadays, people tend to forget to fulfill the watering needs and give adequate care for the plants due to their busy routine life, resulting in shorter lifespan of the plants. Here, we present the design and development of fully autonomous, cost effective and efficient system for watering indoor plants that are placed on a surface at even distance. The system comprised of a smart mini robot which is comprised of an Arduino microcontroller, wheels, motors, motor drive, water tank, water pump, a wireless communication radio. Radio Frequency Identification (RFID) module has the main functions such as navigation; carry water for watering the plants and uses wireless communication to communicate with the plant subsystem. The other main part of the system is potted plants, which is comprised of Arduino microcontroller, soil moisture sensor and wireless communication module which are responsible for functions such as sense the amount of moisture present in the soil and send signals to the smart mini robot when in need of water. As per the amount of soil moisture present in the soil, which is sensed by sensing module, the watering needs of the plants will be fulfilled by the smart mini robot. This smart mini robot is fully capable of receiving the signal from the potted plants, navigate towards plants, locating the plants and pumping the water to the plants without any human intervention. To Autonomously maneuver near the mobile robot, a predefined path is used and for identifying each plant in the system, an RFID tag is attached to each plant. Apart from the architecture this paper also describes the comprehensive implementation of the system. This paper concludes with the system performance evaluation and future project extensions where this system can be reviewed and enhanced.

Keywords: Smart mini robot; Watering system; RFID; Soil moisture sensor; Plant watering; Xbee 3; Internet of Thing (IoT); Line follower; Autonomous system.

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1. Introduction

Plants are pleasing addition to any internal environment and they make internal space more attractive, reduce stress as well as some plants help us feel better by easing mental fatigue by purifying the air that we breath, absorbing toxins which results in improvement in air quality. Due to lack maintenance of indoor plants (Insufficient watering), they might not live last longer, and prior research shows that, more than 80% of the flower's death are due to untimely watering [3]. Unfortunately, nowadays, people tend to forget to water the plants which are even inside of the house because of the accelerated pace of life. And also, gardeners/ inhabitants who are responsible for watering plant often might not have an idea about each plant's watering requirements since various plants need varied amount of water and it will be good if we water the plant considering the environmental condition such as moisture, temperature, etc. Therefore, this 'Smart mini robot for indoor plant watering system' will fulfill the requirements to be the solution for these problems. Apart from all of this, the experiments which were done before in this particular area show that, the automatic watering robot has the advantages of simple operation and convenient use, satisfied the automation and intelligent of modern life. But some of the systems are lesser in portability as the system is bulky as well as they required proper maintenance [5] and higher in cost [8].

The main objective of this study is to design a low-cost smart mini robot system for watering the indoor plant and test it in a controlled environment. The design of the 'smart mini robot' system consists of a mini moving robot with the wireless communication system and sensor module. In this study, a smart mini robot which has the ability to autonomously watering indoor potted plants without any human intervention has been designed.

2. Materials and Methods

2.1. System Design

The system designed here contains three main parts, (i) Smart mini robot system, (ii) plant system, and (iii) communication system with sensor modules. A schematic diagram of the designed system is shown in figure 1 and control flow of the system is given in figure 2.

Figure 1 and 2 as a whole clearly shows how the developed system works. The system divides into two main subsystems, namely 'Plant Subsystem' and 'Robot subsystem' (Figure 1). Two subsystems are using a microcontroller for controlling, navigation purposes and Robot subsystem has water pump, RFID attached to it in order to carry out other functions such as watering and identifying plants respectively. The plant subsystem has a soil moisture sensor and RFID tag in order to measure soil moisture and identification applications. Figure 2 shows the flow of the system from measuring the soil moisture to watering the plant. If the measured moisture level exceeds the preset threshold the microcontroller in the plant will send a signal to the robot calling for watering. Then the robot will proceed to move towards the plant searching for the RFID tag which is tagged on the plant. If the robot detects the RFID tag, it will stop the and start to release water in to the potted plant using its arm. Finally, the robot will move to the maintenance bay when the watering is done.

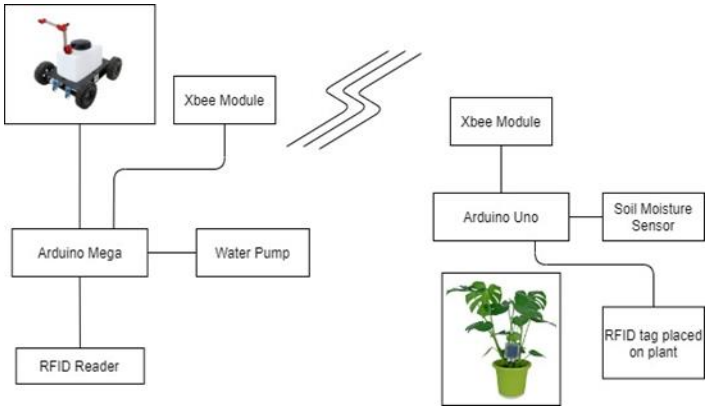

Figure 1: Schematic diagram of designed System.

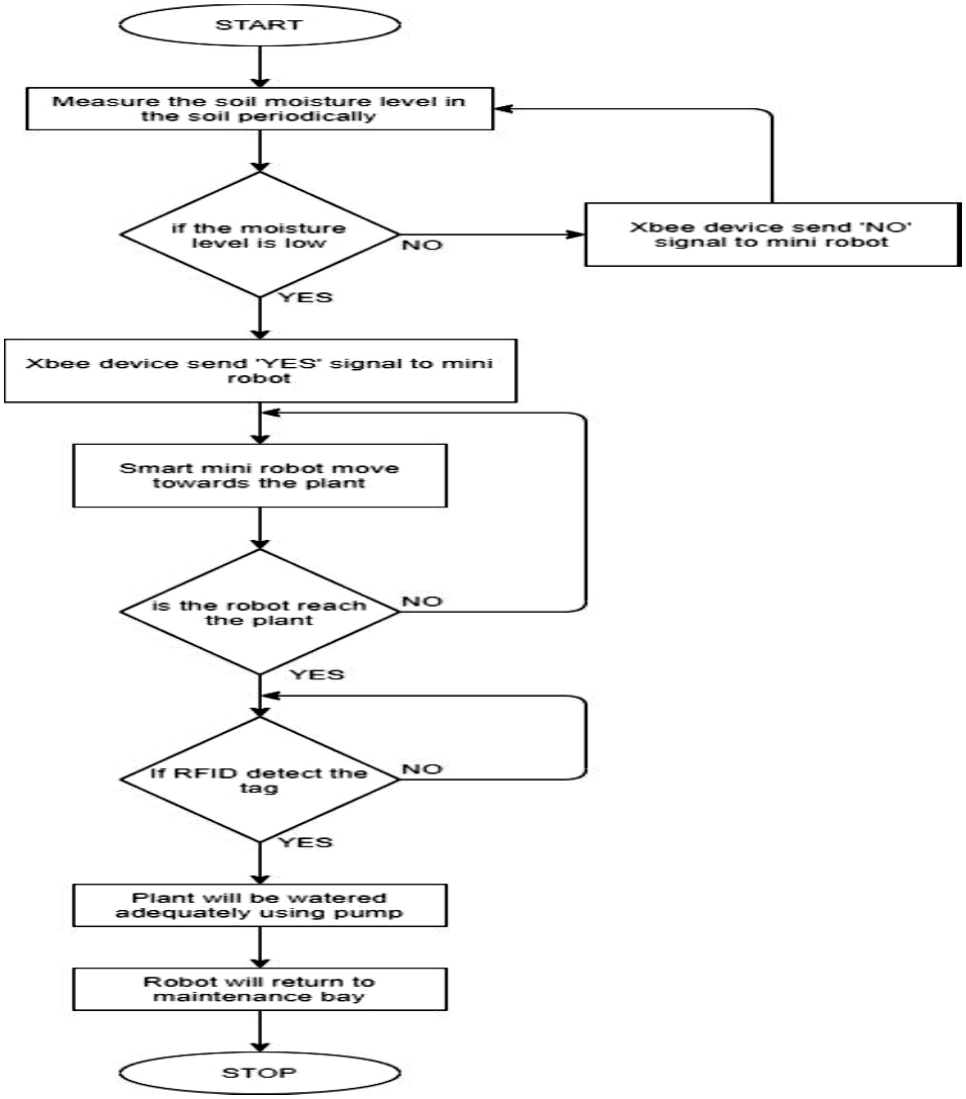

Figure 2: Control flow of the system.

2.1.1. Smart Mini Robot subsystem

The designed smart mini robot's hardware architecture comprises of an Arduino Mega (microcontroller) which responsible for controlling navigation and water dispensing system, A Xbee 3 radio for wireless communication, four wheeled robot with 12VDC motors (which can create torque up to 30Nm) and L298d motor driver for navigation, in-built 5 liters water tank and DC water pump for watering and EM-18 RFID reader module identification of each plants. It has to identify each plant using the RFID reader as it is a smart mini robot. Upon plant's request the smart mini robot will start to move along predefined path towards the particular plant and identify the plant using the RFID tag placed on the pot and as soon as the RFID tag got detected the smart mini robot will stop near the plant and the water pump will be triggered and start to pour water inside the pot using the pipe which is attached to the top of tank. For snake plants the water will be dispensed for around seven seconds and it's all coded in programming. In this way the watering needs of the plants will be fulfilled and the smart mini robot will return to its docking position.

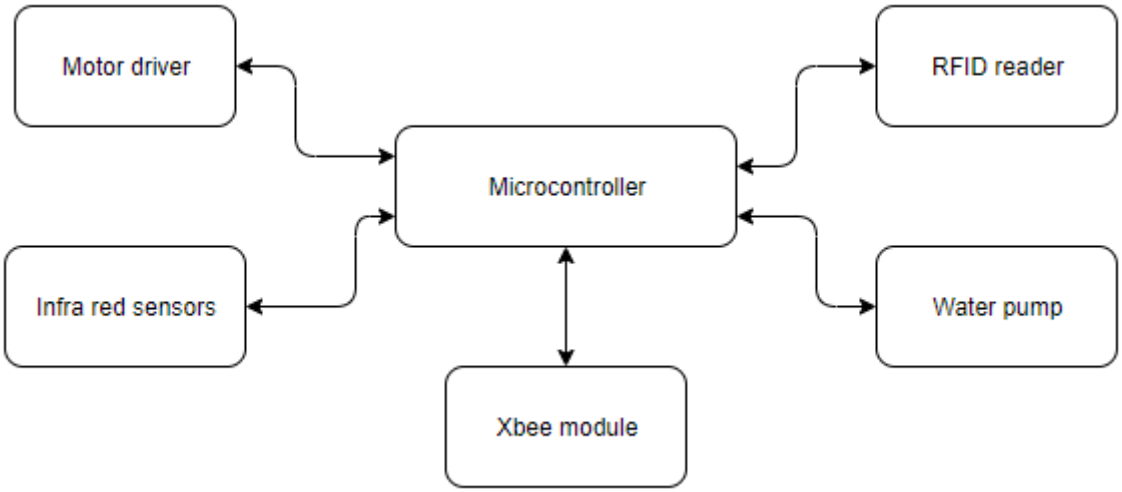

Figure 3: Schematic diagram of smart mini robot.

2.1.2. Plant subsystem

Second important part of this study is plant system. The plant's hardware architecture comprises of an Arduino Uno (Microcontroller), A Xbee 3 radio for wireless communication, moisture sensor and a dock. In pots, the moisture sensor submerged in the soil near the plant where the plants are planted in. RFID EM-18 is only capable of detecting tags in short range. Therefore the plants are needed to be placed near the predefined path. The moisture sensor's reading is processed by the Arduino Uno will be send to the smart mini robot via Xbee 3 radio, if the sensed values drop below the predefined threshold value which we decided as 30% moisture according to prior research materials, the smart robot will move towards the plant in order to water them. Which means in order to robot to proceed watering the potted plant, the sensed moisture level of the soil which is in the potted plant should drop below 30%. Until then robot will wait in the dock. Each pot which are going to be in the system will have a dock attached to it and in order to dock the smart mini robot but because of the line follower method which we are using in this project does not allow us to fully utilize the use of dock since the smart mini robot cannot be deviate or change it direction from the predefined path. Therefore, obstacles

avoidance navigation method can be easily updated in future.

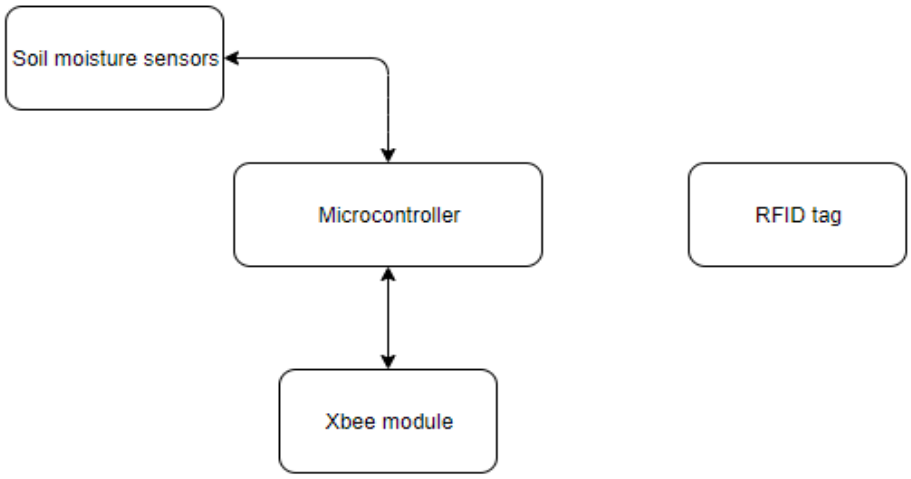

Figure 4: Schematic diagram of Plant subsystem.

2.1.3. Communication subsystem

Zigbee has been used as the communication protocol which is a low power and efficient wireless communication method compared to Wi-Fi. Xbee is the wireless module that built on Zigbee standard (IEEE 802.15.4). Latest Xbee 3 module has been selected, which has Outdoor RF line-of-sight range over 1000m which is more than enough for developing a communication between smart mini robot and the plant for developing the prototype. The Xbee 3 is configured in to API mode so there is no need of confusing between the sender receiver since any Xbee radio can send other Xbee radio messages as long as the radio has other Xbee radio's address. The Xbee 3 radio gets the required power from the 3.3V Arduino power supply pin and have Rx- Rx, Tx- Tx connection with Arduino Uno and mega in plant and smart mini robot respectively. XCTU console and Arduino IDE were used to configure the Xbee 3 radio module.

Figure 5: Schematic diagram of communication subsystem.

2.2. Navigation

As mentioned before the navigation of the smart mini robot is based on line follower method. It's important to mention about the wheels which were used to develop the prototype, they are specially designed for smooth navigation inside the house and it makes less noise when move along the surface unlike off road wheels. Wheels are connected to Arduino via motor drive which connected with Arduino's PWM pins to enabling smooth turning of corners.

3. Conclusion

As we already mentioned that the indoor plants are plays a major role to any building making the environment stress free, purify the air that we breath and people often tend to forget to water them and give the proper care the plants require because of their busy life schedule which often resulting in death of the plants. In this paper, we describe our experience designing and developing an autonomous indoor plant watering system with the use of smart mini robot that has the capability of watering indoor potted plants that are placed near and along a predefined black line which enable the robot to navigate in line following method without any human intervention. The smart mini robot comprised of Arduino Mega microcontroller for controlling and processing purposes, EM 18 RFID reader module to read the RFID tag placed on the plant to identify each plant from one another, a 12V DC water pump for pumping adequate amount of water to the plant with the help of pipe and Xbee 3 wireless communication device for enabling communicating between plant and smart mini robot. Briefly, it is fully capable of performing several main functions such as having a communication between plant via Xbee 3 radio which is based on ZigBee protocol, navigate to specific plant which is placed along the predefined line and can locate them by read the RFID tag which placed on the pot using RFID reader to stop at the pot upon request from the plant. After making the stop finally, it has the ability to automatically dispense adequate amount of water to the potted plants for certain amount of time and returns to its maintenance bay. The next main subsystem which is potted plant comprised of Arduino Uno for controlling and processing purposes, soil moisture sensor for sensing the amount of moisture present in the soil which is important for the plant to live, like the smart mini robot this also has Xbee 3 wireless communication module for communicating with the robot and potted plants is attached by RFID tag to differently identify them. The plant will send a signal to the smart mini robot requesting for water if the soil moisture content in the soil dropped below the predefined threshold value. We used an evaluation method for evaluating cost effectiveness of the project by comparing our system with the previously developed system. And we could be also able to estimate the time needed for watering many plants if the watering requests come from many plants and plotted a graph. Since We have to done the project amid pandemic, we faced hard time purchasing the components needed for the proposed project because of the pandemic which resulted in shortage in some components which were required for developing the project, resulting some delay in completing the prototype. Hurdling all these hurdles We could be able to finish our project and had a chance to fully run the system. We theorized the sudden resistance to work might have been due to the excessive weight it had to borne during those runs. The smart mini robot for indoor plant watering system is an ideal solution for watering the indoor plant autonomously without any human intervention by further modification and future improvements it also can be used for outdoor watering needs as well.

4. Future Works

Even though we have planned to fully complete the development of the system as we described in the design, apart from the automatic water refilling system which was proposed (refilling the tank if the water in the tank finished.) we could be able to develop all the other aspect of the proposed prototype. Since, we had to do our project amid the pandemic we were faced several problems from procuring the materials to developing the prototype and due to the time commitment, we had already made, it was very difficult for us to come to a fully completed model which was comprised with an automatic water refilling system. apart from completing the system as we proposed, we also have some future works which could improve this system very much. By providing machine learning capabilities, the smart mini robot can be used to harvest fruits and vegetables in houses as well as in farms and maintain a database of each and every plant in the system, their fruit/ vegetable and maturity of them. This future enhancement to the prototype will play a major role in autonomous farming and harvesting with the use cameras, and by equipping the smart mini robot with the DOF enabled arm will open the door for many improvements. Apart from using in plucking fruits, by doing this the smart mini robot could also be able to water potted plants with different heights [5]. Apart from that in future updates we are looking to update this smart mini robot system to be able to water outdoor plant, farm by increasing the robustness of the robot which ensure the non-dependence of the outdoor plants and crops as well. To use this in outdoor, we have to equip the smart mini robot with the obstacle avoidance capability. As we have a plan to enhance the system to be used in outdoor, it will also be a great improvement if we could power the smart mini robot by mounting a solar panel on top of the robot, since the solar panel will have the access for direct sunlight ensuring smart mini robot system self-sustained as well as more ECO friendly [8]. And also, by enhancing the system to automatically map the area will be very useful since the smart mini robot will be in motion when watering the plant, and in the meantime, resting time it also can map the area. Providing the robot with the mapping ability will be helpful to easily locate plants as well as adding new plants to the system and so on. And finally, this project can be enhanced to be able to supply the fertilizer which is needed for the plants and crops on demand basis much like automatic watering. The chemical sensors planted in the soil can measure amount of minerals in the soil and send signal to the smart mini robot if the amount drop below the threshold value.

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