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Automatic Soil Management System for Household Purposes

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Abstract

Objectives: The main objective of the paper is to develop an automatic system for a domestic environment that monitors and regulates agricultural factors. **Method:** Arduinoboard is used which is programmed to detect the moisture content and pH content in the soil and take necessary actions to balance it. The system collects the readings of soil moisture using a soil moisture sensor and pH of soil using a pH sensor and sends it to the Arduino microcontroller. The microcontroller is coded to water the plants whenever the moisture reading of the soil goes below the standard value and spray hydrated lime to make the soil neutral. **Findings:** Early works have used a technology intervention was needed to predict droughts. A wireless monitoring system promises to enable real-time monitoring system for drought remotely. It can recognize droughts at early stages so that necessary actions can be taken accordingly. Due to global warming, soil conditions are affected. As a consequence, a system is made that can be a modern agriculture which differs from traditional method of agriculture. The proposed system is made in way such that the end-users are provided with real-time information about the farm by monitoring various agricultural parameters in a farm. The wireless system which is used is consists of five wireless sensor modules that are distributed over a farm. The key environmental parameters that are collected are humidity, moisture content of the soil, sunlight (luminance levels), and ambient temperature. This data that is collected by each individual sensor is transmitted to the base station through a Zig Bee radio which is wireless communication. With the help of Raspberry Pithe recorded data is displayed on Google Apps which is connected to the internet. **Applications/Improvement:** Making a system that is completely autonomous and caters household needs.

Keywords: Agricultural Factors, Arduino, Hydrated Lime,pH, Watering Systems

1. Introduction

Latest technology using various sensors for precision agriculture has become a popular research. The advantages of embedded system put into monitoring and control system for agriculture framework is being utilized by people these days. Monitoring parameters of pH and humidity is an important means for obtaining high-quality environment[11]. The traditional way of analyze the soil parameters is doing an on-the-spot evaluation, which is always requires additional labor which is very inconvenient method. In order to overcome these problems, we designed a monitoring system[10] which is Arduino based.

Irrigation is the process of artificially watering the plants which helps for its growth. Soil pH is the most commonly measured agricultural parameters. Because pH of the soil is related to its fertility and plant growth, hence it is essential and edifying soil parameters.

When the pH of the soil is near neutral, there will be ideal absorbing of most nutrients by the soil. The availability of most micronutrients decreasesas there is

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rise in acidic nature of the soil. Therefore, application of lime to acidic soil tends to rises the accessibility of these nutrients by the soil. Soil pH is considered a master component in soils as it controls many chemical processes that take place in the soil. The most favourable pH range for most plants is between 5.5 and 7.0[2].

The previous include a sensors network for monitoring and predicting droughts and doing soil analysis[1]. The wireless sensor monitoring system for drought was capable monitoring for extended periods on real–time basis and also capable of identify drought conditions at the earliest as possible and therefore we can take corrective measures accordingly. The soil conditions are monitored by the sensors in the network. These sensors in the network collect different environmental parameters and send this data to a base station wirelessly. For every two seconds the data collected from base station are uploaded to the cloud for study purposes. After analyzing the soil parameter if a drought condition of the soil is predicted[3] by the drought monitoring system then the user is alerted via text message or electronic mail. In soil analysis[2], pH sensors have been used to detect the type of soil it is i.e. either acidic or alkaline. After determining the type of soil, the kind of fruit or vegetable that is most suitable for that type of soil is displayed on LCD screen.

2. Problem Statement

Tracking agricultural environment for various factors such as soil moisture and pH along with other factors is of great significance. Be it nursing plants at home or growing crops in an agricultural land, it is a tedious task to manually measure these parameters and control the moisture or pH levels. To overcome this challenge, theautomatic system is developed as a solution to keep the plants blooming without any man power required**.**

3. Proposed System

The proposed system includes Arduino Uno microcontroller as the heart of the system. The soil moisture and pH sensor are connected to it. The microcontroller takes necessary actions to regulate the factors if required. This makes the system completely autonomous without any man power required.

3.1 System Architecture

There are two modules in this paper. First module includes the soil moisture sensor and water pump and the second module includes pH sensor and hydrated lime.

3.2 Module 1

There are two main functional mechanisms in this work as shown in the Figure 1. They are the sensor[4] for detecting water content of the soil and once the soil dryness is detected, motor/water pump supplies water to the plants. The microcontroller called Arduino is programmed with the open source Arduino Integrated Development Environment (IDE) software. The motor can be made to operate with9 volt battery and this unit controls the motor by using Arduino Uno. As said earlier the intensity of dampness in the soil is deliberated by the soil moisture sensor and sends the aware signal to the microcontroller if watering is needed. There by motor/water pump, pumps the water to the plants until the preferred wetness level is attained.

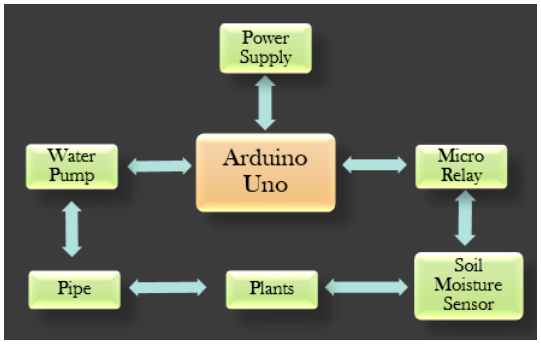

Figure 1. Architecture of Module 1.

3.2.1 Arduino Uno

The Arduino Uno is a microcontroller board based on the ATmega328P. It has totally 14 pins out of which 6 output pins functions as PWM outputs, 6 input pin as analog inputs, for power supply a 16 MHz quartz crystal oscillator, a Universal Serial Bus connection, a power jacket, an In-Circuit Serial Programming (ICSP) header and a reset button as shown in Figure 2. It contains the whole thing required to maintain the microcontroller. By simply connecting the Uno to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started[5].

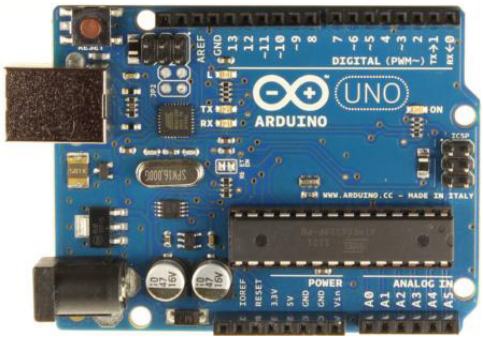

Figure 2. Arduino Uno.

The technical specifications of Arduino Uno are given in the Table 1.

Table 1. Arduino Uno specifications

Microcontroller	ATmega328P
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limit)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
PWM Digital I/O Pins	6
Analog Input Pins	6
DC Current per I/O Pin	20 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB (ATmega328P) of which 0.5 KB used by bootloader
SRAM	2 KB (ATmega328P)
EEPROM	1 KB (ATmega328P)
Clock Speed	16 MHz
Length	68.6 mm
Width	53.4 mm
Weight	25 g

3.2.2 Arduino Uno Programming

The Arduino software is completely open source software[1] that is used to program the Arduino Uno. According to the microcontroller on your board pick "Arduino Uno from the Tools > Board menu. The ATmega328 in Arduino Uno comes preburned with a boot loader so that it can reprogrammed according to our requirement without the help of external hardware programmer by having a communication with the novel STK500 protocol. We can also avoid the boot loader and we can make use of ICSP (In-Circuit Serial Programming) header[6] to program the microcontroller.

3.2.3. Soil Moisture Sensor

Soil moisture sensors given in Figure 3, determine the water content in soil. A soil moisture probe is made up of several soil moisture sensors. In our work we have used soil moisture sensor which can be used to measure the dampness of the soil if it is inserted in to the soil.

The probes of soil moisture sensor have variable resistance. When these probes are immersed in soil, they start conducting electricity. The current starts flowing in the probes when in it is water[7]. As according to the formula,

$$V = IR$$

As value for current increases, resistance decreases (inversely proportional). So when the soil moisture sensor is put in watery soil, its value becomes less because of less resistance and when it is dry soil, its value increases. Thus it can depict the soil moisture readings.

Value of soil moisture sensor in different environments:

In dry soil: 550-800
In watery soil: 200-500

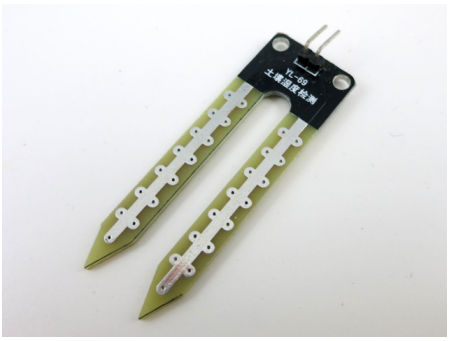

Figure 3. Soil moisture sensor.

3.2.4 Water Pump

The water pump shown in Figure 4, is used to unnaturally provide water from a reservoir. The microcontroller can be interfaced and can be used to control the water pumps electronically. As with use of relay switch we can able to make the pump to supply water or not by triggering either ON/OFF condition. This process of at supplying water is known as pumping. There are several varieties of water

pumps can be employed. In our work we have used small water pump which is usually used in aquariums.

Figure 4. Water pump.

3.2.5 Relays

Relays are like control electrical that are controlled by another switch such as microcontroller as shown in Figure 5. Relays are used to cut down the higher current flow into the circuit[8] there by it allows only small current to enter the circuit.

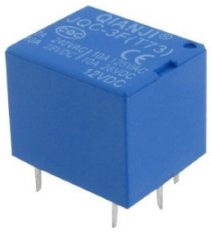

Figure 5. Micro relay 5V.

Relays are made up of circuits two circuit such as control circuit (in green) and a load circuit (in red). When the Current flows in the control circuit in the pins 1 and 3, it creates a small magnetic field that causes the switch to close, pins 2 and 4 there it makes complete circuit and the current flows through the relay as shown in Figure 6.

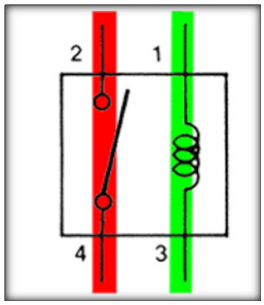

Figure 6. Circuit diagram of micro relay.

3.2.6 9V Battery

The structure of 9V batteries as shown in Figure 7, which is like rectangular prism shape with rounded edges and it is having connector located at the top called polarized snap connector. Nine-volt alkaline batteries are composed of six individual 1.5V LR61 cells that are covered in a wrapper. They are somewhat smaller than LR8D425 AAAA cells which is of shorter than 3.5mm and can hence be used in their place for some devices. The other type of battery is carbon-zinc type and is made up of six flat cells in a stack, roofed in a moisture-resistant covering to prevent drying. The microcontroller the power supply from this 9V battery[9].

Figure 7. 9V battery.

3.3 Module 2

The heart of module 2 of this paper is Arduino Uno along with a pH sensor. The architecture diagram is shown in Figure 8.

The working of all the parts remains the same only pH sensor and hydrated lime has been described.

Figure 8. Architecture of Module 2.

3.3.1 pH Sensor

pH sensor is used to measure the soil's pH content. pH sensor as shown in Figure 9, gives the value of pH as output in mill-volts. pH sensor fundamentally measures

the activity of hydrogen ion [H+]. The potential developed whenever two solutions of dissimilar pH come in contact through a thin glass membrane is the principle behind the pH measurement.

pH sensor is encompassed of glass electrode, reference electrode and one metallic electrode. pH is deliberated by examining the potential between the two electrodes. To enable the ion exchange, the tip of the sensor incorporates thin membrane. The fast and accurate response are due to the alkaline nature and low electrical resistance of the glass membrane. The pH ranges these electrodes are between 0–14. The Electrode is made up of Potassium Chloride solution and it is having cable of one meter with BNC plug. This electrode can be attached to various meters. The pH value is 7 for the neutral solution where the pH electrodes are 0mV when idyllic. The output electrode is connected to the Arduino. The Arduino Uno microcontroller receives the signal and calculates the soil pH. If the soil is acidic in nature i.e. pH <7, then a basic fertilizer like Hydrated Lime is sprayed to the soil using the pump. This makes it neutral and the nutrients are automatically restored.

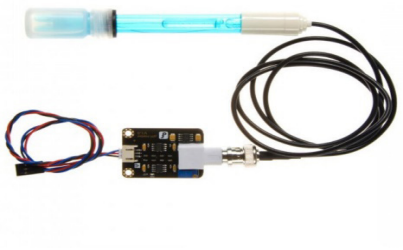

Figure 9. pH sensor.

3.3.2 Hydrated Lime

There are three main types of lime are available which are hydrated lime, ground lime and burnt lime, all of which are calcium, or calcium and magnesium compounds. Hydrated Lime has higher percentage of Calcium Hydroxide (+90%) over low grade (65% Purity) Hydrated Lime. Adding lime to garden soil reduces the acidity of the soil by increasing the pH level. Plants are not able to extract the nutrients they need from soil that is too acidic, and some materials such as aluminum can be at toxic levels in very acid soils. A sample of Hydrated Lime is shown in Figure 10.

Figure 10. Hydrated lime.

4. Algorithm

Algorithm 1: Soil moisture detection with water pumping

Input: s; Moisture value detected by the sensor.

Output: p; p=1 if the pump is on, p=0 if it is off.

1. Start
2: Set the soil moisture threshold value, t.
3: Connect soil moisture sensor to Arduino Uno microcontroller.
4: repeat
5: Read s from sensor.
6: if s>t then p=1.
7: else Set p=0 and go to step 4.
8: until 1000ms
9. End

Algorithm 2: Soil pH detection with regulation

Input: pH value detected by the sensor.

Output: p; p=1 if the fertilizer is sprayed, p=0 if it is not.

1. Start
2: Set the pH threshold value, t.
3: Connect pH sensor to Arduino Uno microcontroller.
4: repeat
5: Read ph from sensor.
6: if ph<t then p=1.
7: else Set p=0 and go to step 4.
8: until 1000ms
9. End

5. Hardware Setup

The hardware setup is shown in Figure 11. All connections are made properly. Once the soil moisture sensor is immersed in soil that is completely dry, the reading is

approximately 750. Automatically the water pump starts pumping water to the plant for 1000ms. Similarly, when the pH sensor is put in soil which was acidic, the reading of pH sensor was 3.3 Hence the hydrated lime is sprayed to make it neutral.

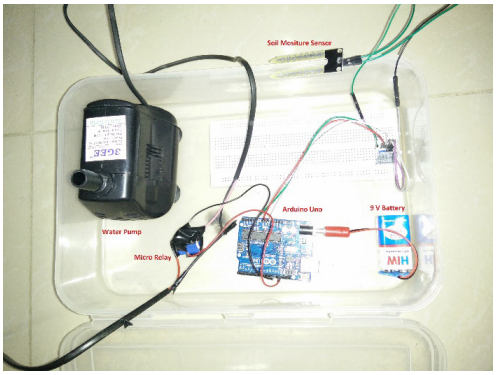

Figure 11. Hardware setup.

6. Conclusion and Future Work

A new automatic method is proposed to detect the moisture and pH levels of soil and accordingly spray water and fertilizers to control the moisture and pH of soil respectively. The soil moisture and pH sensors detect the moisture and pH parameters respectively, and send the detected data to the Arduino microcontroller. The Arduino microcontroller after receiving these parameter values takes the decision which is to sprinkle water in the case of low moisture and spray fertilizer in order to control the pH pf the soil.

The future enhancement of this method is to send an SMS to the user's mobile number using an Ethernet/Wi-Fi connection through Internet with the help of third party online messaging clients. If any activity is being carried out in this automatic system say regulating the pH, then an SMS stating the same is delivered to the user. The user thus can keep track of the process that is taking place in the automatic system.

7. Limitations

- The user does not come to know any activity that is being carried out.
- The threshold when the pump starts pumping water changes according to the temperature of that place.
- 9 V batteries drain out very quickly.

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