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Smart Irrigation System Using Soil Moisture Sensing and Arduino Automation

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ABSTRACT
With the combination of real-time soil moisture, the Smart Water Irrigation System is an automated irrigation system based on a microcontroller that effectively supplies water to plants. Using a submersible pump, an Arduino microcontroller, a relay module, and a soil moisture sensor, the system senses and reacts to the water need of the plants. To make sure that there is maximum irrigation with minimum human interaction, the sensor checks soil moisture levels and activates when the levels decrease below a set threshold. The Arduino activates the pump to irrigate the soil. This study not only shows the affordability and usability of automation in home gardening and agriculture but also the potential of automation in tackling global issues such as environmental sustainability, water shortages, and wasteful irrigation. The system is scalable and flexible, and a giant leap towards intelligent environmental management and precision agriculture.

KEYWORDS
Arduino Uno, Irrigation, Smart Water system, IOT, automation, agriculture, sensor

I. INTRODUCTION

Since nowadays, in the age of advanced electronics and technology, the life of human being should be simpler and more convenient, there is a need for many automated systems that can replace or reduce human effort in their daily activities and jobs. Here we introduce one such system, named as automatic plant watering system, which is a model of controlling irrigation facilities that uses sensor technology to sense soil moisture with a microcontroller to make a smart switching device to help millions of people. "Automatic irrigation and plant watering system is actually a model of controlling irrigation facilities that uses sensor technology to sense soil moisture with a microcontroller in order to make a smart switching device to help millions of people." [1] Can we automatically water our home and garden plants without bothering our neighbours when we decide to go on vacation or somewhere else for a long period? Since irregular watering leads to the mineral loss in the soil and may end up with rotting the plants, can we then somehow know if the soil really needs to be watered and if so, when exactly dowel must water the plants? Is it possible in any way from remote location to manage our plants to be watered?

These are some questions that can be heard quite often and answer on all of them is encouraging and affix amative, because advanced technology provides us very wide range of possibilities nowadays. "By adding an automated plant irrigating system to the patch or agricultural ground, you will help all of the plants spread their fullest potential as well as preserving water." [2] Actually, there is a very simple and economical solution for all these questions and perplexities. In the form of unique intersection between biological engineering and electronics, the solution requires only a little bit knowledge of electronics as well as that knowledge related to botany and plant physiology.

II. COMPONENTS USED IN PROJECT

A. Arduino Uno:

The Arduino Uno is a microcontroller board based on the ATmega328 (datasheet). It has 14 digital Input/output pins, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC to DC adapter or battery to get started.

Power:

The Arduino Uno can be powered via the USB connection or with an external power supply. The power source is selected automatically. External (nonUSB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm centre-positive plug into the board's power jack. Leads from a battery can be inserted in the Gnd and Vin pin headers of the POWER connector. The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts.

B. The power pins are as follows:

•The input voltage to the Arduino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). You can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin.

•5V: This pin outputs a regulated 5V from the regulator on the board. The board can be supplied with power either from the DC power jack (7 - 12V), the USB connector (5V), or the VIN pin of the board (7-12V). Supplying voltage via the 5V or 3.3V pins bypasses the regulator, and can damage your board. We don't advise it.

• 3.3V: A 3.3-volt supply generated by the on-board regulator. Maximum current draw is 50 mA.

•GND: Ground pins.

C. Memory

The ATmega328 has 32 KB. It also has 2 KB of SRAM and 1 KB of EEPROM (which can be read and written with the EEPROM library).

D. Input and Output

Each of the 14 digital pins on the Uno can be used as an input or output, using pin Mode (), digital Write (), and digital Read () functions. They operate at 5 volts. Each pin can provide or receive a maximum of 40 mA and has an internal pull-up resistor (disconnected by default) of 20-50 k Ohms. Some pins also have specialized functions like:

Serial: 0 (RX) and 1 (TX). Used to receive (RX) and transmit (TX) TTL serial data. These pins are connected to the corresponding pins of the ATmega8U2 USB-toTTL Serial chip.

External Interrupts: 2 and 3. These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value. See the attach Interrupt () function for details.

PWM: 3, 5, 6, 9, 10, and 11. Provide 8-bit PWM output with the analog Write () function.

SPI: 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK). These pins support SPI communication using the SPI library. Reset. Bring this line LOW to reset the microcontroller. Typically used to add a reset button to shields which block the one on the board.

III. PHYSICAL CHARACTERISTICS

The maximum length and width of the Uno PCB are 2.7 and 2.1 inches respectively, with the USB connector and power jack extending beyond the former dimension. Four screw holes allow the board to be attached to a surface or case. Note that the distance between digital pins 7 and 8 is 160 mil (0.16"), not an even multiple of the 100-mil spacing of the other pins [3].

The figure given below [Fig.1] explains the structure of the board.

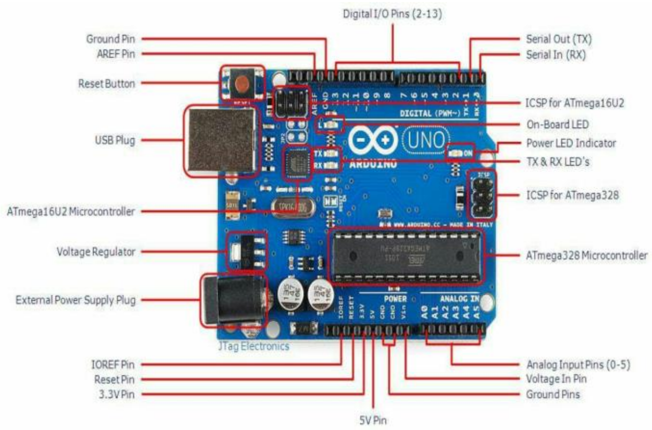

Fig. 1 Arduino Uno Structure

I. SOIL MOISTURE SENSOR

II. FEATURES & DETAILS:

Operating Voltage: 3.3V ~ 5V

Sensing Probe Dimensions: 60x30mm

Panel PCB Dimensions: 30 x 60mm

On-board LM393 comparator

On-board power indicator LED

On-board digital switching indicator LED

Watering with Soil Moisture Sensors:

Studies have shown that a properly configured soil moisture sensor can reduce outdoor water use by up to 62 percent or more over traditional irrigation methods. By watering your plants when needed, you can increase landscape health, promote deeper root growth, and make your plants more disease resistant. If something as simple as a soil moisture sensor delivers all these benefits, then why isn't this valuable tool used on every irrigation system? Unfortunately, professional irrigators are often familiar with inferior soil moisture sensors that do not deliver expected results, and this experience has discredited the value of all soil moisture sensors. Additionally, when deciding how to irrigate, people don't always consider how water moves in soil, how the various types of soil retain moisture, and how plants' needs differ. [4] The purpose of this document is to establish the reputation of the Baseline soil moisture sensor as a valuable irrigation tool and to help professional irrigators meet their challenges by raising their awareness of the issues related to effective Watering.

Baseline Soil Moisture Sensor Technology:

Soil moisture sensors have been used for many years to measure how much water is held between the soil particles. This is no easy task because not all soils are created equal, not even close. (For more information about soil characteristics, read Not All Soils Are Created Equally below.) Many sensors on the market use a variation of conductive or capacitive technology. Baseline's patented soil moisture sensors use TDT (time domain transmission) technology to provide sensors that are so much more sensitive (which means they are highly responsive to changes in moisture levels) than previously available sensors — they change the rules of the game. TDT sensors are the most advanced sensors available as well as the most accurate and sensitive soil sensors on the market [5]. Baseline's patented design is not only sensitive to small changes in moisture content, but they are also extremely durable and reliable, easier to install (over new or existing wire), and they are maintenance free and cost Effective.

What does it take to make a great soil moisture sensor?

Consider the following factors when you are evaluating the quality and usability of a soil moisture sensor:

•Sensitivity: is the sensor's ability to monitor small changes in soil moisture content. Many sensors on the market are ± 2-3 percent; however, Baseline sensors can reliably track less than 1/10th of a percent of change volumetrically. Sensitivity is very important in light soil such as sand or engineered soils[6].

•Repeatability: refers to how well the sensor can report the same value when measuring the same moisture content. You cannot have repeatability without sensitivity. Often this number is reported as the same value as sensitivity. Baseline's repeatability and sensitivity is outstanding at less than 1/10th of a percent [7].

•Accuracy: is sometimes used to describe sensitivity and repeatability; however, it can also describe the sensor's ability to report true volumetric moisture content (VMC). Not all sensors report in VMC: some use a scale of 1-100, while others simply display a graph. Baseline has chosen to standardize on the VMC method of reporting, and consequently, accuracy is a measurement of our ability to accurately report VMC. Baseline's soil moisture sensors are ± 3 percent in accuracy within most soil types [8].

• Durability: or reliability is arguably the most important factor in a commercially used soil moisture sensor. Baseline has been building soil moisture sensors for over 13 years. Our sensors are used all overt globe — from Death Valley where soil temperatures can be more than 100° to northern environments with freezing conditions. Baseline sensors are expected to last 25 years in the soil. [9]

How can soil moisture sensor readings affect irrigation schedules?

Fortunately, a Baseline soil moisture sensor is much more than a reporting device. It sends the soil moisture readings to the Baseline controller, which then interprets the soil moisture data and uses that information to automate when/how often to turn on the sprinklers and how long to run/when to shut off the sprinklers. Here's an analogy to explain how a soil moisture sensor works with a Baseline irrigation controller. Think of the soil moisture sensor as a thermometer and the controller as a thermostat. When you set your thermostat to turn on your air conditioning, the temperature you set it at is the threshold. If the air surrounding the thermostat is cooler than the threshold, the air conditioner remains off. [10] When the air temperature rises to the threshold, the A/C turns on and remains on until the temperature drops back below the threshold. Similarly, you set a soil moisture threshold in the Baseline irrigation controller. The sensor monitors the soil moisture, and when the threshold is met, the system can be set to either turn on the irrigation at the next scheduled start time or shut off irrigation.

What is a good irrigator trying to accomplish?

To be a good irrigator, your number one goal is to use the least amount of water possible to keep the soil moisture content in the root zone at the appropriate levels. To meet this goal, you must turn on the water before the moisture content drops below the lowest allowed level (maximum allowed depletion) and shut off the water before it goes above the highest allowed level (field capacity). Read more about Soil Moisture Content Levels below. Your second goal should be to water as infrequently as possible because this strategy will promote deeper plant roots while minimizing the incidence of disease. Maximizing the rooting potential of the plant allows it to access as much water and nutrients as possible. Many scientific studies have examined the potential for improving a plan's water-use efficiency (usually referred to as WUE), and it is widely accepted that a plant's water use can be optimized with good irrigation Practices [11].

VI. WORKING PRINCIPLE

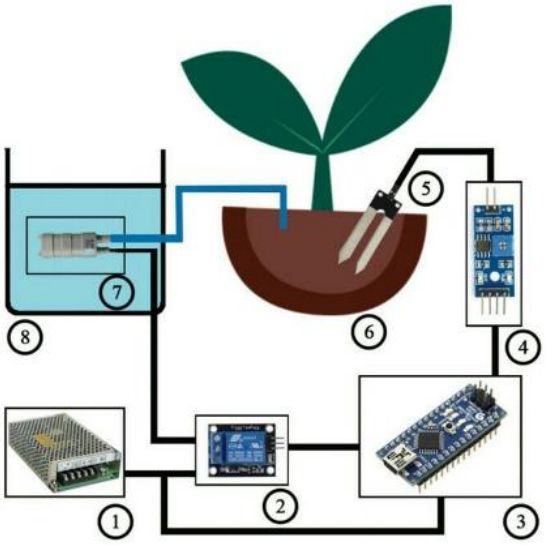

Fig. 2 Workflow of project

The main working principle behind this system is in connecting the soil moisture sensor, which was previously embedded into the plant, to the, which is also connected to other electronic components listed above as shown in Figure. Measurement of soil moisture is done by the sensor which forwards the information and parameters regarding the soil moisture to the microcontroller, which controls the pump. If the level of soil moisture drops below a certain value, the microcontroller sends the signal to the relay module which then runs a pump and certain amount of water is delivered to the plant. Once the enough water is delivered, the pump stops doing its work. Power supply has a task to power the complete system and the recommended voltage should respect the input supply range for the microcontroller. Relay module is a simple circuit consisting of a single transistor, several resistors, diodes and a relay and it is controlled digitally by microcontroller [12]. Since the complete system should be embedded in a small box, Arduino Nano is a perfect microcontroller for this purpose because of its dimensions and its work performance. Soil moisture module is consisting of the two parts: amplifier circuit and probes. This module has digital and analog outputs, where digital output is set to logical 1 when the threshold is activated. The threshold is set by potentiometer. Analog output gives the real time information regarding the moisture in the plant and this output is used in the system. Water pump is connected to the relay module and it only works when the relay module gets a command from the microcontroller [13] [14].

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