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Smart Agriculture – Automatic monitoring of Soil Moisture and Irrigation control for farming land

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Abstract

In this article, we proposed an integrated application of automatic moisture and Irrigation control using Real-Time Clock (RTC) and Light-Dependent Resistor (LDR). The main idea of this paper is predicated on using as little energy as possible. In this work, we use the DS1307 real-time clock module to automatically switch on or off motor dependent on the time of day. The sensors are used for monitoring the soil conditions in agriculture field. Programming controls the timing of when the device is active. The most significant benefit of the proposed design is the reduction of risk associated with potential crashes and save water. Motors on the farm are often switched on at dry time and left OFF on wet conditions till necessity. Their operation is entirely automatic. Because of the protection of the farmers from the electrical shock during the rainy season, this proposed design intends to automate the operation of soil monitoring and irrigation in order to reduce water, power consumption and advance technological progress in agriculture farms and support in smart India. A significant amount of electricity is lost in the typical lighting system; however, this may be prevented with automatic control employing LDR.

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Introduction

Farmers can effectively manage their farming practices by using the crop yield prediction. The accuracy of the forecast is contingent upon several pre-processing tasks, such as crop picture segmentation, among others. There are a number of techniques for segmenting cropped photos, but they all have some shortcomings. The input image is filtered using a box

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blur kernel before being clustered using k-means algorithm. The histogram equalization approach is applied to the filtered image in segmentation.[1]

Fig. 1: Sensors in Farm for moisture and light

One definition of an embedded system is a computer system in which the software is physically integrated into the hardware. Both standalone and integrated applications may be considered embedded systems. An embedded system is a computer with a built-in microcontroller or microprocessor that is programmed to carry out a limited set of instructions. The system gets its moniker from the application-specific software that is built in into it. An embedded system is a software-based, real-time control system that is microcontroller -based. Microcontroller and microprocessor-based systems designed to manage and track the operation of physical devices are known as embedded systems.[1] Embedded systems have the potential to provide exceptional performance and levels of automation. Several computer vision applications, such as 3D reconstruction, video mosaicking, image stitching, etc., require knowledge of the position and orientation of the camera. Structure from motion techniques provides 3D reconstruction of the scene as well as camera location and orientation. These techniques are effective when the camera's posture varies very little between frames.[2] Embedded technologies have already shown their worth in our daily lives via the widespread appeal and unique attractiveness of branded electronic firms' robot companions. Embedded systems are likely to be the dominant technology in the future due to their wide range of possible uses and the possibility that they will allow for the creation of extremely inventive goods.[2] The Embedded market is seeing two big shifts at the moment. The amount of water in the soil is essentially measured by its moisture content.[3] For some crops, water monitoring is crucial. To automatically monitor soil moisture levels, a soil moisture sensor is employed.[4] It operates by using the soil's moisture and light control (Shown in Figure 1). A crucial step in the agricultural production process is crop monitoring, which gives farmers the ability to optimise yield through efficient management. Traditional field surveys can be labor-intensive, time-consuming, and even harmful when used for crop monitoring. The most adaptable of these platforms are Unmanned Aerial Vehicles (UAVs), which can be fitted with a variety of sensors to produce photos with a high spatial resolution that contain accurate real-time information about crops.[5]

Microcontrollers are programmed to carry out certain operations. To be more precise, this refers to use cases where the connection between input and output is explicitly stated. Some kind of processing is required, and output is provided, but this all depends on the input. Input devices such as keyboards, mice, washing machines, digital cameras, pen drives, remote controls, microwave ovens, automobiles, bicycles, telephones, mobile phones, watches, etc. Embedding these applications on a single chip is feasible because of the few resources they need.[6,7]

Materials and Methods

Soil Moisture

A soil sample has two components if its total mass is equal to mt: the mass of the soil (ms) and the mass of the water included in it (mw). This means that mt= ms+mw. The water content, or mw/ms, can be expressed as a percentage of the dry weight of the soil. The gravitational water content is a dimensionless quantity that is typically expressed as Θm, or the Greek capital letter theta with the mass subscript m. Similar ratios apply to the volumetric water content, which is represented as vw/vt, where vt is the total volume of the soil sample and vw is the amount of water. Here, vt=vs+vw+vg, where vs is the soil volume and vg is the soil's air volume. The output of the soil moisture sensor changes in the range of ADC value from 0 to 1023.This can be represented as moisture value in terms of percentage using formula given below.

$$\text{Analog Output}=\text{ADCvalue}/1023 \quad \text{...(1)}$$

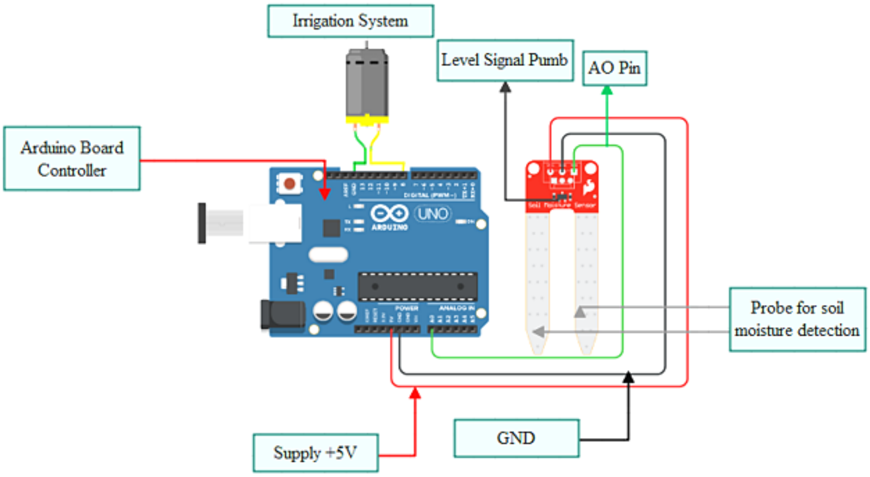

Fig. 2: Interfacing unit

Moisture in percentage = 100 – (Analog output * 100)
When describing the water content by mass, the gas's negligible mass might be ignored, but its volume—that is, all of the pore space between the soil grains—must be taken into consideration. The standard unit of measurement for the volumetric water content is Δ. Other soil parameters, such as bulk density (ρb=ms/vt, or lower case Greek letter rho with subscript b) and porosity (f={vw+vg}/vt), can be determined using these different masses and volumes. For zero moisture, we get maximum value of 10-bit ADC, i.e. 1023. This, in turn, gives 0% moisture. We are aware that neither pure water nor the solid salt found in the soil can carry electricity alone; nevertheless, when combined, they can. The salt content of the soil's moisture aids in the conductivity of electricity.[6] However, because to the water content in water (Resistance), it can only conduct a certain amount of electricity. This resistance aids in estimating the approximate water content. When there is a lot of water present, the resistance between the probes is low. The resistance between the two probes is strong if the water content is low. Here, an ADC is used to process the analogue output of a soil moisture sensor. On the serial monitor, the moisture content is shown as a percentage. The interfacing soil moisture sensor with Arduino given in Figure 2. You must be able to accurately analyze the information once it has been retrieved. Different approaches are needed because different types of sensors produce different types of data.[8,9] Furthermore, it could be challenging to distinguish between a fully working soil moisture sensor and one that is supplying worthless data.

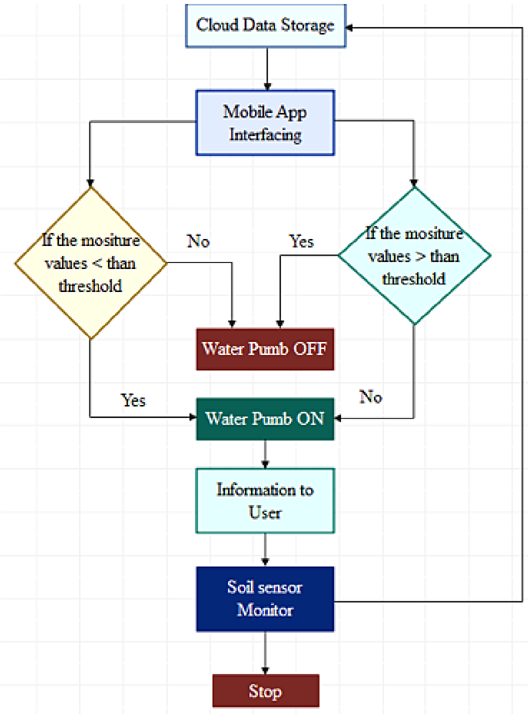

Fig. 3: Flow chart of soil moisture monitoring unit

In Figure 3, flow chart of the suggested irrigation system. The key benefit of the suggested irrigation system is that it may provide users with soil information via an IOT network for irrigation. The circuit receives power supply in the form of current or voltage. Here, a soil moisture sensor determines the amount of water in the soil, and its output is supplied to an amplifier to raise the gain value. And the Arduino Uno receives this measured value as an analogue input. The Arduino's second input is provided by a laser and LDR. The Arduino Uno transforms the values of these two analogue inputs into digital outputs. Use a lot of water in vain. Because there is not enough water available, some crops have been lost10,11. Additionally, excessive watering causes plants to perish. Our project tries to cut down on irrigation water waste. It will result in cost savings because the controller will switch the engine, without the need for employers.

Using capacitance/frequency domain technology, the soil moisture sensor measures the media's dielectric constant to determine the Volumetric Water Content (VWC).[12] There will be less resistance and more power transfer when there is water in the soil. However, dry soil conducts power on a weekly basis, requires less power, and exhibits greater resistance.

Components Required

- Arduino UNO
- Soil Moisture Sensor Module
- 16×2 LCD Display
- 10KΩ Potentiometer (for LCD)
- Breadboard
- Connecting wires
- Power Supply
- Test setup with 3 cups of soil

Automatic Irrigation Control Architecture

Nonetheless, in today's hectic world, nobody thinks to turn it off or on until absolutely necessary.[13] Poor lighting causes unhealthy environments and wastes thousands of dollars annually. Lighting for farm may be made much more affordable with the use of energy-saving technology and layout. The three factors of automation, power consumption, and cost effectiveness are now at the forefront of technological development. The goal of automating tasks using computers and other smart technologies is to lessen the need for human labor. While electricity generation is becoming more difficult for a variety of reasons, reducing energy consumption must always be a top priority. When the demand increases, it becomes more critical to design a system that minimizes costs. We implemented automated street light control based on an RTC and LDR to address this issue. In this age of automation, humans are restless and unable to regulate the manual operations of any field, a rapid advancement in embedded systems has paved the way for the design and development of a microcontroller-based automatic irrigation using a Real-Time Clock (RTC). These strategies were developed to address deficiencies in previously used approaches.[9] Our proposed design's power supply will draw from 230V ac, and after passing through a step-down transformer, 5V and 12V dc will be produced for use in the circuitry. The LDR and RTC get their power from this 5V source. LED strips, model ULN2003, need a 12V supply. The microcontroller will get the current time from the RTC, which will keep accurate time using a quartz crystal.[14] There are a total of 30 pins on the node MCU v3, but we only make use of a subset of them.

In Figure 4, at all times throughout the day, the LDR sends its analog-to-digital converter (ADC) readings to the controller, which then checks the conditions we've specified in the code to determine whether or not to activate the Motor.[15] We have now integrated RTC and LDR since we have specified in the code that the RTC should keep time in accordance with our plans. In order to determine whether or not the Motor should come on, the controller first verifies that the time set in the RTC corresponds to the time the user has specified. If this is the case, the controller then checks the light intensity using the ADC value read from the ADC, if the value is below 400, the Motor will come on for 5 seconds before turning off automatically.[16]

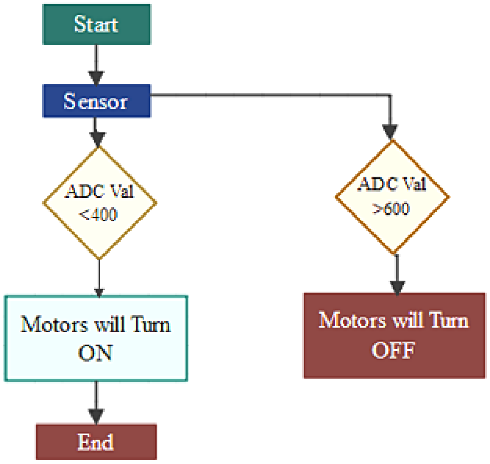

Fig. 4: Flow Chart for LDR

Results and Discussion

Experimental Analysis 1

In Figure 5, Correct Soil Moisture Sensor Use helps to alleviate the discomfort by monitoring and recording changes in soil moisture from crop production to harvesting. The design of the sensor will determine how it is installed. Observe the manufacturer's installation instructions. One of two methods is typically used to install soil moisture sensors: either by excavating a pit or trench and laying sensors out horizontally at various depths, or by vertically installing sensors after boring a hole with an auger or soil sampling probe. The hole must be drilled carefully. Installing the sensor in an excessively large hole could result in voids and air gaps. In the field, sensors should be positioned at a variety of depths and positions. Typically, sensors are positioned in pairs at depths of one-third and two-thirds of the crop root zone, as well as at two or more locations across the field, preferably in the representative soil type away from high spots, depressions, and slopes. Some users utilize a soil-water mixture (soil slurry) during installation to prevent air gaps, but frequently the slurry's structure does not match the surrounding soil, which could negatively impact the sensor reading. However, not all landowners have the financial means to do so, and as we will see, they are not necessarily required to. Apps for online monitoring make the job easier. For any date and any field that you choose, you obtain the water content numbers.[17.18]

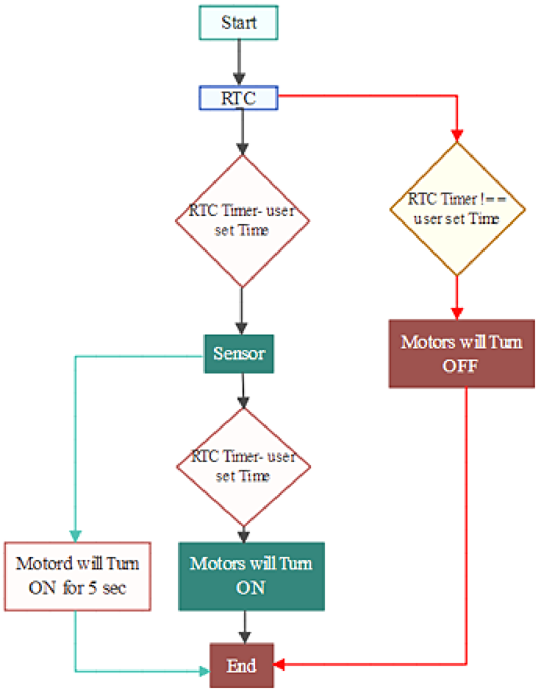

Fig. 5: Flow Chart using RTC and LDR

Experimental Analysis 2

As soon as the device is turned on, the LCD screen will display the Farm areas (shown in Figure 6) so long as a wifi connection is accessible, and then it will display the wifi connection status after it has been established. The next step is to wait for the card to be read while the LCDs the current temperature and humidity. Transfer to the IoT application.

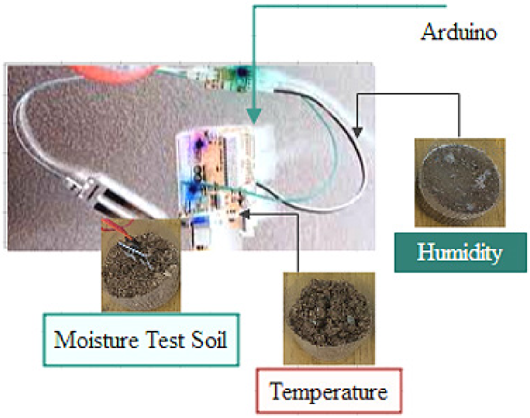

Fig. 6: Soil moisture analysis

Conclusion

The design and testing of our proposed paper have proved fruitful. Effective irrigation management can decrease nutrient leaching, increase yields, enhance grain quality, and save water and energy. Implementing soil sensor technology in irrigation scheduling is one of the simplest and most efficient ways to increase irrigation efficiency. This article offers fundamental information and helpful suggestions for using

soil moisture sensors to plan irrigation. A significant amount of electricity is lost in the typical lighting system, however, this may be prevented with automatic control employing LDR. The constructed control circuit is used to examine the automated switching function, which is proven to be extremely efficient with very low maintenance costs.

Future Scope

Modern soil moisture monitoring sensors, offer readings that are much more accurate and show results almost instantly. These data enable users to easily alter watering for the best possible crop development. In the long run, the proposed design to expand this effort into different optimization algorithms for big farming lands.

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Conflict of Interest

All authors declared no conflict of interest.

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