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Solar Powered Smart Irrigation System

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***Abstract*: Over-irrigation results in water wastage, heightened energy consumption for pumping, leaching of essential nutrients such as nitrogen, and inefficiency. Employed electronic components include moisture sensors, level indicators, suction pumps, and arrays of solar panels. During heavy rainfall, if crops become submerged and the water level surpasses a set threshold detected by the level indicator, the suction pump activates, converting the tube into a suction mechanism. Pumping ceases once the water level recedes below the designated threshold. When the storage tank is empty, the motor automatically switches on to fill it until reaching the predetermined level, stopping thereafter. In light of increasing water scarcity due to population growth and deforestation, technological advancements like IoT hold significant potential across various operations. This system enables remote irrigation control by farmers from any location worldwide, enhancing effectiveness.**

***Keywords*: Internet of Things, Smart irrigation, Soil moisture sensor, Suction pump, Solar Panel, Arduino Uno board.**

1. Introduction

Farmers and agricultural communities worldwide are increasingly grappling with the dual challenges of water scarcity and climate change. As the demand for food and water resources continues to rise, the imperative to develop sustainable and efficient agricultural practices has never been greater. Solar-powered smart irrigation systems are emerging as a promising solution in this context, offering the potential to optimize water usage and bolster crop growth. By leveraging advanced electronic components, these systems empower farmers to make informed, data-driven decisions about when and how much to irrigate their crops, thereby curbing water waste and enhancing nutrient management. Moreover, the growing accessibility and affordability of renewable energy sources like solar power are making these systems more viable for farmers across both developed and developing countries. Overall, the development and deployment of solar-powered smart irrigation systems hold significant promise in revolutionizing agricultural practices and fostering sustainable food production amid today's daunting environmental challenges. This project seeks to contribute to this endeavor by developing a solar-powered smart irrigation system that integrates advanced electronic components, including an Arduino Uno microcontroller, a soil moisture sensor, a DHT11 temperature sensor, and a suction pump. These components work synergistically to provide real-time data on soil moisture and temperature, enabling timely irrigation interventions to prevent over-irrigation and promote optimal crop growth.

2. Existing System

Numerous enthusiasts have initiated projects focused on streamlining agricultural tasks, including automating seeding and fertilizer spraying. This holds particular significance for landowners in rural regions who are unable to personally attend to their fields due to urban employment obligations. Hence, there arises a necessity to develop an automated irrigation system to address this challenge. In our project, we propose leveraging soil moisture and temperature levels to facilitate automated irrigation.

Upon detecting dry soil, the moisture sensor activates our electronic board, prompting the suction pump to initiate irrigation. This setup effectively transforms our tubing into an irrigator. The irrigation process continues until the moisture sensor registers an optimal water level in the soil, at which point irrigation ceases automatically.

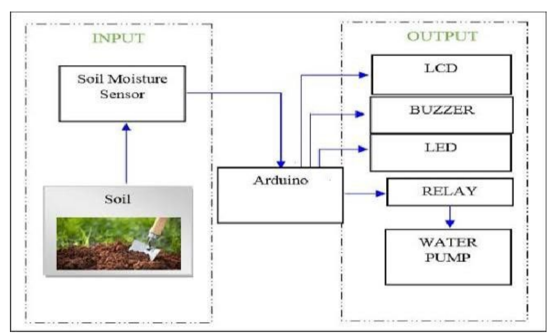

Fig. 1. Input/output workflow

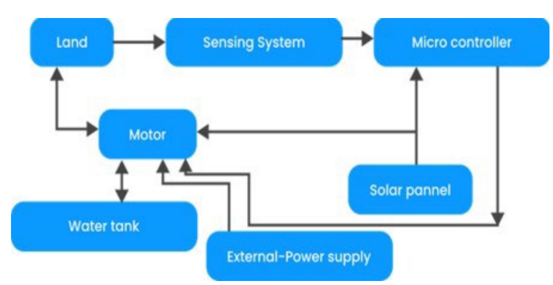

Fig. 2. Design architecture

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3. Proposed System

The irrigation concept present in this project stands out due to its unique utilization of a suction pump, which helps conserve electricity and prevent flooding during periods of heavy rainfall. An important aspect of the system is the integration of solar panels, which contribute to energy conservation. By effectively extracting excess water and storing it in a tank, the suction pump ensures that plants are not overwatered during heavy rain events. Although these techniques exist individually, this project combines them to create a comprehensive and efficient irrigation system for crops. The incorporation of a suction pump, moisture sensor, level indicating sensor, solar panels, and automatic motor guarantees effective water conservation, nutrient retention, and energy usage, ultimately providing a sustainable and cost- effective solution for irrigation needs.

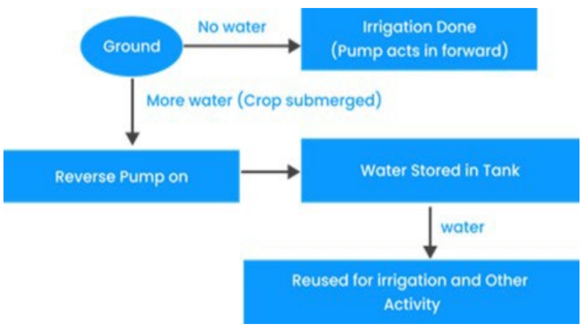

Fig. 3. Automatic irrigation system diagram

4. Working Model

To begin with our project execution we have to fix the moisture sensors at the edges of the pavements of the farmland separated by a particular distance and after fixing a number of required moisture sensors we need to install the water tube mounted with a filter at the end, that can work both as irrigator (forward push) and water suction tube (reverse pull) to avoid drowning of crops during rainy seasons we are going to fix the water level indicating sensor at a particular height from the ground level where the plants are considered to be submerged.

Coding Snippets and Prototype Design:

Using our code we can make these components work as mentioned below:

If the moisture sensor detects the ground to be dry, it triggers the suction pump using our electronic board to make our tube work as an irrigator .The irrigation will be stopped once the moisture sensor detects if there is a needed amount of water in the ground. During heavy downpour, if the crops got submerged in the flooded water and the water level indicating sensor senses that the level has been achieved, it triggers the suction pump to make our tube work as a suction tube. The suction tube will stop its functioning once the water level goes below the level. .If the storage tank is empty, then the tank will be filled by automatically switching on the motor and it will be stopped once it reaches the marked level.

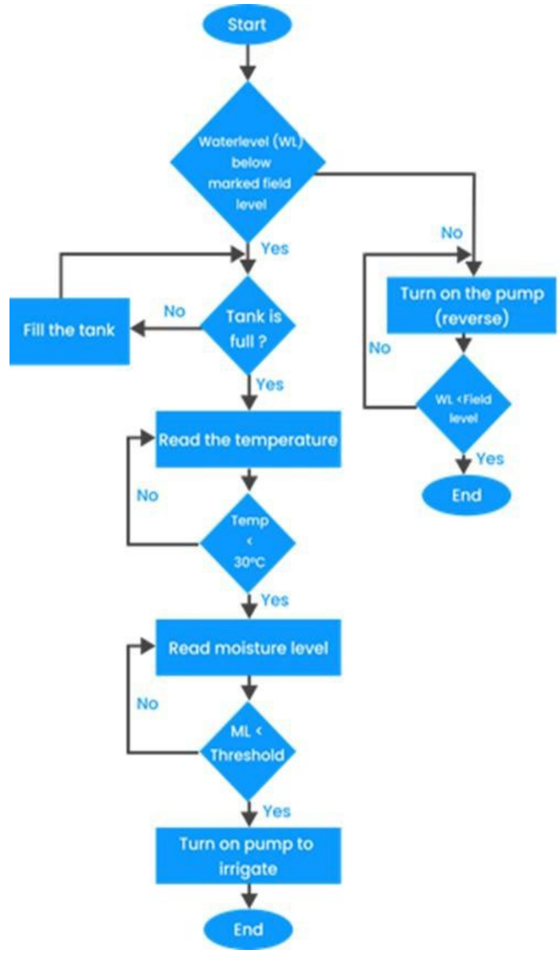

Fig. 4. Working flow diagram

Fig. 5. Code snippet

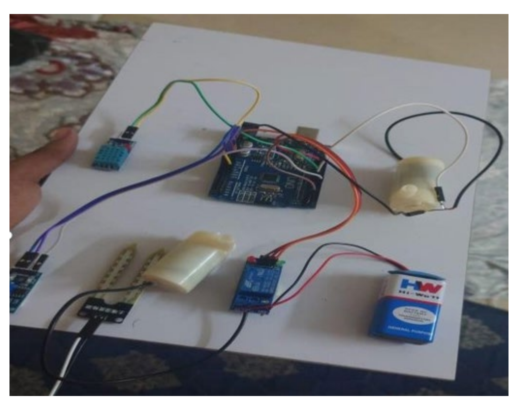

Fig. 6. Prototype diagram

Prototype Video:
https://drive.google.com/file/d/1jdvmKjRNV5IgpxlMg6m59NbEebf_RlVG/view?usp=drive_link

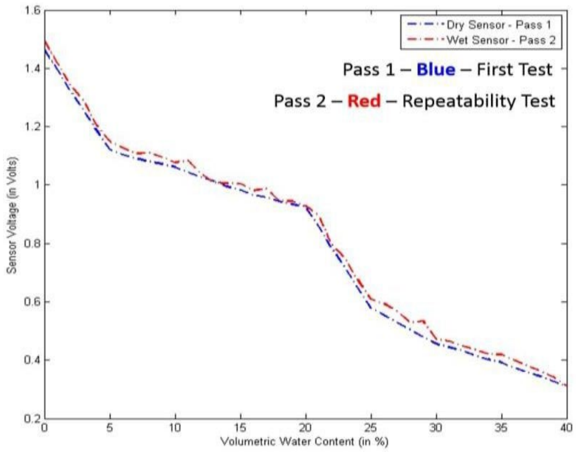

Fig. 7. Moisture sensor readings graph

5. Hardware Components

A. Arduino Board

The Arduino board stands out as a widely embraced open-source microcontroller platform tailored for constructing interactive projects. Comprising a programmable microcontroller unit (MCU) alongside a set of input/output (I/O) pins, it empowers users to link an array of electronic components and sensors, fostering the creation of interactive devices and prototypes. At its core lies a microcontroller chip, such as the Atmel AVR series or the ARM-based SAMD series. Typically, Arduino boards offer digital input/output pins, configurable as either inputs or outputs, facilitating communication with digital devices like buttons, switches, LEDs, and relays. Additionally, these boards commonly feature analog input pins capable of reading analog signals from sensors such as temperature sensors, light sensors, and potentiometers. These pins play a crucial role in converting analog signals into digital values for processing. Notably, Arduino operates under an open-source framework, meaning its hardware and software specifications are freely accessible. This open nature has fostered a vibrant and engaged community of users who actively share projects, tutorials, and libraries, thereby facilitating learning and exploration within the Arduino ecosystem.

B. DHT11 Temperature Sensor

The DHT11 sensor serves as a widely employed digital temperature and humidity sensor renowned for its affordability and accuracy. This sensor delivers precise readings for temperature and relative humidity at a low cost.

Operating within a temperature range of 0°C to 50°C (32°F to 122°F) with an accuracy of ±2°C, and measuring relative humidity within a range of 20% to 90% with an accuracy of ±5%, the DHT11 sensor is highly reliable. Employing a single-wire digital communication protocol, it transmits data in a 40-bit digital output signal comprising 16 bits for humidity data, 16 bits for temperature data, and 8 bits for parity checking. Utilizing a straightforward single-wire communication protocol, the DHT11 sensor necessitates a microcontroller or a digital circuit equipped with timing and data interpretation capabilities to retrieve temperature and humidity values. Widely utilized across various projects and applications, including home automation systems, weather stations, greenhouse monitoring, HVAC control, and environmental monitoring, the DHT11 sensor proves indispensable for its versatility and performance.

C. Moisture Sensor

A moisture sensor, alternatively referred to as a soil moisture sensor, functions as a tool employed to gauge the moisture content within soil or similar substances. Its application spans across gardening, agriculture, and the realm of automated irrigation systems. These sensors adopt diverse sensing techniques to assess soil moisture levels. One prevalent approach relies on electrical conductivity, wherein the sensor measures the resistance between two electrodes implanted in the soil. Another method involves capacitive sensing, which detects alterations in the soil's dielectric constant to determine moisture content. Typically, moisture sensors comprise one or more probes inserted into the soil, typically fashioned from conductive materials like metal. The quantity of probes utilized may vary depending on the sensor's design and intended use. Widely embraced across agricultural, horticultural, and gardening domains, moisture sensors play a pivotal role in monitoring soil moisture levels. They aid in optimizing irrigation practices by furnishing data to automate watering systems, aligning with the moisture requirements of plants. Beyond these sectors, moisture sensors find utility in environmental monitoring, scientific research, and diverse industrial applications.

D. Suction Motor

A suction motor, also known as a vacuum motor, is an electric motor specifically designed for generating suction or vacuum in various applications. It is commonly used in vacuum cleaners and other devices that require the removal of air and particles from a particular area. The motor's design allows it to create a pressure difference, drawing air and debris into the device, which is then collected in a dustbin or filter. Suction motors play a crucial role in the effective functioning of vacuuming equipment, making cleaning tasks more efficient and convenient. Suction motors in agriculture come in various sizes and capacities, allowing them to be adapted for specific tasks and applications. They are essential tools for improving efficiency, hygiene, and productivity in modern agricultural practices.

E. Solar Panels

Solar panels, also known as photovoltaic (PV) panels, are devices that convert sunlight into electricity through the photovoltaic effect. They consist of multiple solar cells made from semiconductor materials, typically silicon. When sunlight hits the solar cells, it generates an electric current, which can then be harnessed and used as a source of clean and renewable energy. Solar panels are widely used to generate electricity for residential, commercial, and industrial purposes, as well as in off-grid and remote areas where access to traditional power sources is limited. They offer a sustainable and environmentally friendly solution to meet energy needs while reducing carbon emissions and dependence on fossil fuels.

6. Software Components

A. Arduino IDE

The Arduino Integrated Development Environment (IDE) serves as software designed for programming Arduino boards, offering an intuitive platform for coding, modifying, and transferring code to Arduino microcontrollers. Equipped with a code editor featuring syntax highlighting and a serial monitor for debugging purposes, the IDE boasts a straightforward interface for library and board management. Supporting the Arduino programming language, derived from C and C++, it caters to users of all proficiency levels, from novices to seasoned developers. Integral to the development of Arduino projects, the IDE empowers users to effortlessly craft a diverse array of electronic applications and devices.

7. Conclusion

The utilization of solar energy in various forms holds significant promise for fostering sustainable development and addressing multiple challenges in India. The excess energy generated by solar panels can be seamlessly integrated into the grid, offering an additional revenue stream for farmers while contributing to the country's energy needs. Solar pumps, which operate without the risk of borehole contamination, provide a clean and efficient solution for water resource management, benefiting both domestic and agricultural sectors. Furthermore, the advancement of organic solar cells, a cutting-edge photovoltaic technology, not only harnesses energy from both outdoor and indoor light sources but also demonstrates the potential to produce electricity from sunlight through the photovoltaic effect. These innovative approaches represent a forward-looking and environmentally friendly means of addressing India's energy requirements, promoting agricultural growth, and ensuring a sustainable and eco-conscious future.

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