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INTELLIGENT IRRIGATION SYSTEM FOR SUSTAINABLE FARMING WITH IOT AND AI INTEGRATION

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Abstract
The world is facing an increasing environmental crisis due to rapid urbanization, which results in the destruction of numerous plants that play a crucial role in maintaining the balance of oxygen and carbon dioxide in the atmosphere. This imbalance negatively impacts air quality, contributes to climate change, and poses a threat to both plant and human life. The system is designed to monitor key environmental factors that are critical for plant growth, such as soil moisture, pH levels, temperature, and humidity. By integrating various sensors, the system can detect changes in these parameters and respond accordingly to ensure the plant receives optimal care. A soil moisture sensor continuously checks the moisture content in the soil, and when it falls below a certain threshold, the system automatically triggers a water pump using a driver relay to irrigate the plants. The pH sensor monitors the soil's acidity or alkalinity, which is crucial for maintaining healthy soil conditions, while the DHT11 sensor records the temperature and humidity levels, ensuring the environment remains suitable for plant growth.
Keywords: pH sensor, soil moisture sensor, sensor integration, soil acidity, humidity

1. INTRODUCTION

Many plants die due to irregular watering, poor soil conditions, and inadequate monitoring of environmental factors such as temperature, humidity, and soil pH levels. These conditions not only threaten plant survival but also affect agricultural productivity and biodiversity.

A smart irrigation system that allows selective irrigation of localized dry spots in an agricultural field. The proposed irrigation system uses a quad copter drone equipped with a Thermal Infrared (TIR) camera and a GPS module to generate georeferenced thermal images that indicate the area and location of the dry spots in a survey area. Drones navigate and acquire aerial thermal images, which are then processed by an on-board edge intelligence module along with flight data (GPS coordinates, altitude, and drone direction). Smart sprinklers deployed on the field can wirelessly receive the coordinates of dry spots so they can be irrigated selectively. A terrestrial edge unit generates an irrigation pattern for the smart sprinklers using a pre -trained machine learning (ML) model to generate an irrigation pattern by varying the head rotation angle (θ) and the water flow control valve rotation angle($\emptyset$) of the smart sprinkler.

The ratio of the number of turns on each coil, called the turn’s ratio, determines the ratio of the voltages. A step-down transformer has many turns on its primary (input) coil which is connected to the high system is an Arduino-based smart irrigation and land monitoring system designed to address the challenges of plant care by automating the irrigation process and continuously monitoring environmental conditions. This system incorporates a range of sensors to monitor critical A soil moisture sensor ensures that plants are watered only when necessary by activating a water pump via a driver relay when moisture levels drop below a defined threshold. This prevents over- or under-watering, ensuring optimal hydration. The pH sensor monitors the soil’s acidity or alkalinity to

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maintain optimal nutrient absorption for plants, while the DHT11 sensor measures the temperature and humidity to guarantee that the plants are in a suitable environment.

V p = primary(input) voltage	V s= secondary(output) voltage
Np=number of turns on primary coil	Ns =number of turns on secondary coil
Ip = primary(input) current	Is = secondary(output) current

The system is enhanced through IoT integration using the ESP8266 Wi-Fi module, allowing real-time transmission of sensor data to the Blynk mobile application.

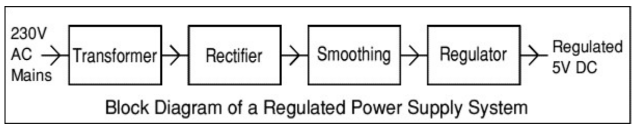

FIGURE1. Regulated power supply system

The voltage produced by an unregulated power supply will vary depending on the load and on variations in the AC supply voltage. For critical electronics applications a linear regulator will be used to stabilize and adjust the voltage. This regulator will also greatly reduce the ripple and noise in the output direct current. Transformers waste very little power so the power out is (almost) equal to the power in. Note that as voltage is stepped down current is stepped up voltage mains supply, and a small number of turns on its secondary (output) coil to give a low output voltage.

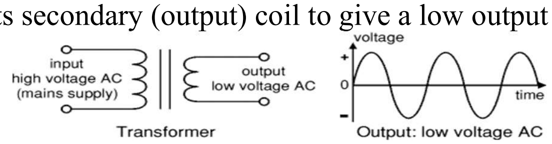

FIGURE 2. Transformer output low voltage AC

1.1 Rectifier

There are several ways of connecting diodes to make a rectifier to convert AC to DC. The bridge rectifier is the most important and it produces full wave varying DC. A full-wave rectifier can also be made from just two diodes if a center-tap transformer is used, but this method is rarely used now that diodes are cheaper.

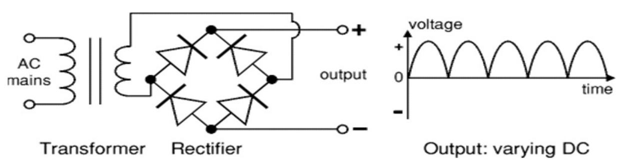

FIGURE 3. Rectifier output varying DC

The varied DC output is suitable for lamps, heaters and standard motors. It is not suitable for electronic circuits unless they include a smoothing capacitor.

1.2 Bridge rectifier:

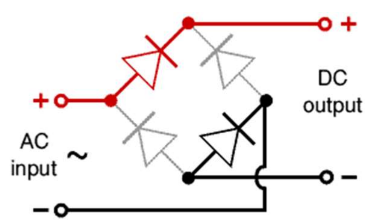

FIGURE 4. Bridge rectifier

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A bridge rectifier can be made using four individual diodes, but it is also available in special packages containing the four diodes required. It is called a full-wave rectifier because it uses the entire AC wave (both positive and negative sections). 1.4V is used up in the bridge rectifier because each diode uses 0.7V when conducting and there are always two diodes conducting, as shown in the diagram above.

Alternate pairs of diodes conduct, changing over the connections so the alternating directions of AC are converted to the one direction of DC.
Output: full-wave varying DC: (using the entire AC).

1.3 Single diode rectifier:

A single diode can be used as a rectifier, but this produces **half-wave** varying DC
Output: half-way varying DC(using only half the AC
Wave).

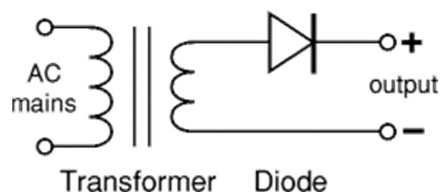

FIGURE 4. Single diode

1.4 Smoothing:

Smoothing is performed by a large value electrolytic capacitor connected across the DC supply to act as a reservoir, supplying current to the output when the varying DC voltage from the rectifier is falling. The diagram shows the unsmoothed varying DC (dotted line) and the smoothed DC (solid line). The capacitor charges quickly near the peak of the varying DC, and then discharges as it supplies current to the output.

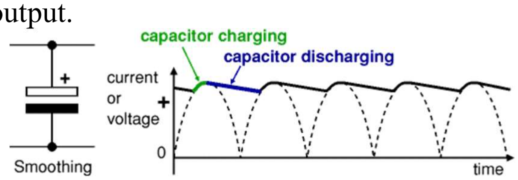

FIGURE 5. Smoothing

Smoothing is not perfect due to the capacitor voltage falling a little as it discharges, giving a small ripple voltage. For many circuits a ripple, which is 10% of the supply voltage is satisfactory and the equation below gives the required value for the smoothing capacitor.

1.5 Soil Moisture Sensor (YL-69)

Soil moisture sensor measures the water content in soil. It uses the property of the electrical resistance of the soil. The relationship between the measured property and soil moisture is calibrated and it varies depending on environmental factors such as temperature, soil type, or electric conductivity.

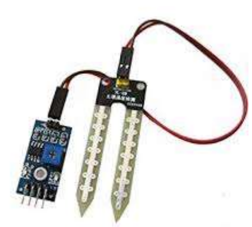

FIGURE 6. Soil Sensor

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Soil Moisture Sensor is used for measuring the moisture in soil and similar materials. The sensor has two large, exposed pads which functions as probes for the sensor, together acting as a variable resistor. The moisture level of the soil is detected by this sensor. When the water level is low in the soil, the Analog.

Table 1. Pin identification and configuration

No:	Pin Name	Description
For DHT11 Sensor		
1	V cc	Power supply 3.5V to 5.5V
2	Data	Outputs both Temperature and Humidity through serial Data
3	NC	No Connection and hence not used
4	Ground	Connected to the ground of the circuit
For DHT11 Sensor module		
1	V cc	Power supply 3.5V to 5.5V
2	Data	Outputs both Temperature and Humidity through serial Data
3	Ground	Connected to the ground of the circuit

1.6 Humidity Sensor

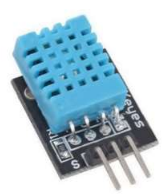

FIGURE 7. Humidity Sensor

The **DHT11 sensor** can either be purchased as a sensor or as a module. Either way, the performance of the sensor is the same. The sensor will come as a 4-pin package out of which only three pins will be used whereas the module will come with three pins as shown above.

Operating Voltage: 3.5V to 5.5V

- Operating current: 0.3mA (measuring) 60uA (standby)
- Output: Serial data
- Temperature Range: 0°C to 50°C
- Humidity Range: 20% to 90%
- Resolution: Temperature and Humidity both are 16-bit
- Accuracy: ±1°C and ±1%

1.7 PH Sensor

FIGURE 8. pH Sensor

A **pH meter** is a scientific instrument that measures. The hydrogen-ion activity in water-based solution, indicating its acidity or alkalinity expressed as pH . The pH meter measures the difference

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in electrical potential between a pH electrode and a reference electrode, and so the pH meter is sometimes referred to as a "potentiometric pH meter".

The electronic amplifier detects the difference in electrical potential between the two electrodes generated in the measurement and converts the potential difference to pH units. The reference electrode is insensitive to the pH of the solution, being composed of a metallic conductor, which connects to the display.

2. PROPOSED DIAGRAM

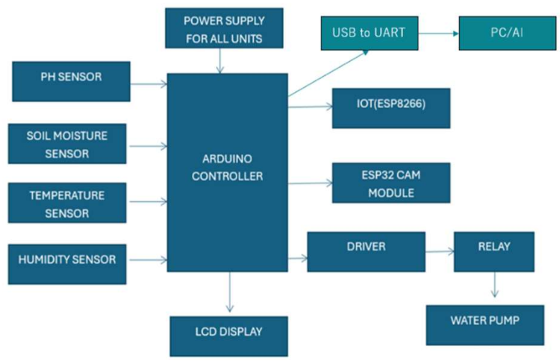

FIGURE 9. Methodology of Process

3. Software Description

Get the latest version from the download page. You can choose between the Installer (.exe) and the Zip packages. We suggest you use the first one that installs directly everything you need to use the Arduino Software (IDE), including the drivers. With the Zip package you need to install the drivers manually. The Zip file is also useful if you want to create a portable installation.

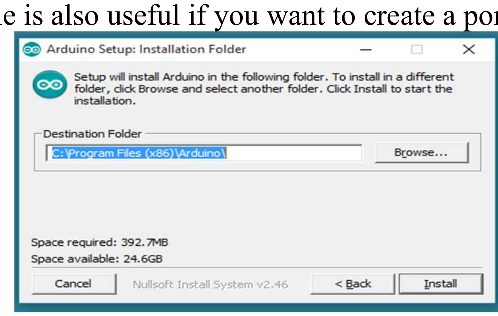

FIGURE 10. Software Page

3.1. Arduino Boot loader Issue

The current boot loader burned onto the Arduino UNO is not compatible with ROBOTC. In its current form, you will be able to download the ROBOTC Firmware to the Arduino UNO. But you will not be able to download any user programs.

3.2. Hardware Needed

To burn a new version of the Arduino boot loader to your UNO, you'll need an AVR ISP Compatible downloader.

Using an AVR ISP (In System Programmer)

- Your Arduino UNO (to program)
- An AVR Programmer such as the AVR Pocket Programmer
- An AVR Programming Cable (the pocket programmer comes with one) If you have extra Arduino boards, but no ISP programmer.
- Your Arduino UNO (to program)

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- A Working Arduino (doesn't matter what kind)
- Some Male-to-Male Jumper Cables

3.3. Software Needed

ROBOTC is not currently able to burn a bootloader onto an Arduino bard, so you'll need to download a copy of the latest version of the Arduino Open-Source programming language.

Table 2. Summary

Microcontroller	Arduino UNO
Operating voltage	5v Input Voltage (recommended)
Input Voltage (Limits)	6-20V
Digital I/O Pins	54(of Which 14 provide PWM output
Analog Input Pins	16
DC current per I/O Pin	40mA
DC Current for 3.3V Pin	50mA
Flash Memory	256KB of which 8KB used by bootloader

3.4. Arduino UNO

Arduino Uno is a microcontroller board based on the ATmega328P (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 Analog inputs, a 16 MHz quartz crystal, 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.

"Uno" means one in Italian and was chosen to mark the release of Arduino Software (IDE) 1.0. The Uno board and version 1.0 of Arduino Software (IDE).

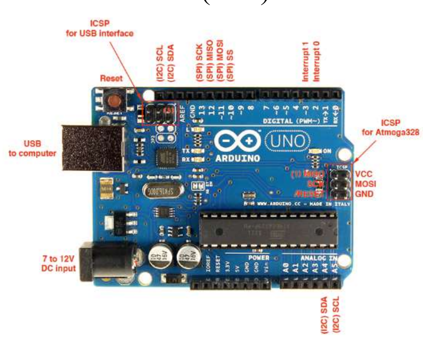

FIGURE 11. Arduino UNO

Input and Output:

Serial: pins 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-to-TTL Serial chip.

External Interrupts:

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.

LED: 13. There is a built-in LED connected to digital pin 13. When the pin is HIGH value, the LED

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is on, when the pin is LOW, it's off.
TWI: A4 or SDA pin and A5 or SCL pin. Support TWI communication using the Wire library.

3.5. Algorithm Design

Machine Learning (ML) algorithms are a set of mathematical models and techniques that allow computers to learn from data without being explicitly programmed. ML algorithms are widely used in various applications such as image recognition, natural language processing, fraud detection, and recommender systems. There are three main categories of ML algorithms.

3.5.1. Design Tree Algorithm

The decision tree algorithm is a popular ML algorithm used for classification and prediction tasks. In the context of a seed suggestion system, the decision tree algorithm can be used to predict the type of seed that a customer is likely to purchase based on their preferences. The first step in using the decision tree algorithm for seed suggestion is to gather data about customers and their seed purchasing behavior. This data can include information such as customer demographics, previous purchase history, and any seed preferences or specifications they have provided.

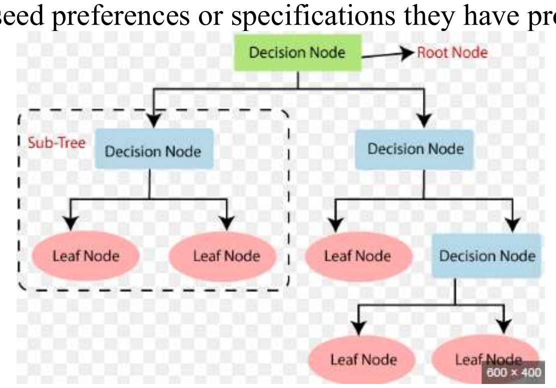

FIGURE 12. Decision Tree Algorithm

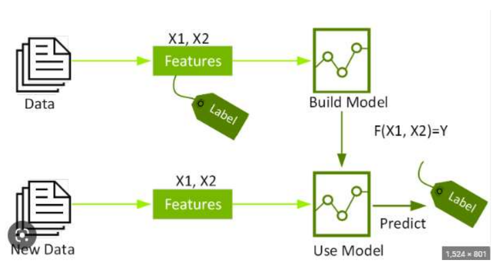

FIGURE 13. Data System

Hardware Specification
System : PC OR Laptop
Processor : INTEL I5
RAM : 4 GB Recommended
ROM : 2 GB
Software Specification
Operating System : Windows 7/10/11
Language used : Python

4. RESULT AND DISCUSSION

The Arduino-based smart irrigation and land monitoring system has demonstrated significant results in improving plant care and water management through automation and continuous

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environmental monitoring. By utilizing various sensors, the system effectively measures critical parameters such as soil moisture, pH levels, temperature, and humidity, ensuring plants receive optimal care without manual intervention. The soil moisture sensor automatically triggers the water pump when needed, preventing over- and under-watering. This not only reduces water waste but also optimizes plant growth by providing the right amount of water at the right time. The integration of IoT through the ESP8266 Wi-Fi module.

A unique feature of the system is the ESP32 camera module, which periodically captures images of the plants, offering a visual representation of plant growth.

Accurate sensor calibration, particularly for soil moisture and pH sensors, was critical but required regular adjustments, especially in diverse soil types. Furthermore, the reliance on Wi-Fi connectivity posed limitations in areas with unstable or limited internet access, which could disrupt remote monitoring. Despite these challenges, the system significantly reduced manual Labor, automating tasks like irrigation and real-time monitoring, thus making plant care more efficient and less time-consuming.

5. CONCLUSION

In conclusion, this system has proven to be a valuable tool in automating plant care, promoting water conservation, and ensuring optimal growing conditions. Its IoT-enabled remote monitoring, combined with automated irrigation and visual tracking, makes it a powerful solution for various applications, from home gardens to large agricultural fields. While challenges like sensor calibration and connectivity need refinement, the overall results highlight the system's potential in advancing sustainable plant management and optimizing resource use.

6. ACKNOWLEDGEMENT

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7. REFERENCES

[1]. Sangeetha Kurundhar. Pranav Dhandar and Manoj Lahudkar. "*IOT-Enabled Smart Irrigation System for Precious Farming using Microcontroller*". Soft Computing Research Society (SCRS). Data science and intelligent computing techniques, (pp.945-952). Jan-2024. doi:10.56155/978-81-955020-2-8-80.

[2]. Abdennabi Morchid, Rachid Jebebra and Haris EI Alami. "*IOT Based smart irrigation system to enhance agricultural water security using embedded systems, telemetry data, and cloud computing*". Elsevier B.V, Results in engineering. Vol 2023. No 102829. (pp.1-15). Sep-2024.doi: 10.1016.

[3]. Vijendra Kumar, Kul Vaibhav Sharma and Naresh Kedam, "*A Comprehensive review on smart and sustainable agriculture using IOT Technologies*". Elsevier B.V, Smart agricultural technology. Vol 8. No 100487. (pp.1-22).June-2024.doi:10.1016.

[4]. Yahya Faqir, Abdul Qauoom and Elizabeth Erasmus, "*A review on the application of advanced soil and plant sensors in the agriculture sector* ". Elsevier B.V. Computer and Electronics in agriculture (109385). Vol.226. (pp.1-14). Aug-2024. Doi:10.1016.

[5]. Asif Raihan, Mohammad Ridwan and Mid Shoalibur Rahman, "*An exploration of the latest developments, and potential future pathways for climate-smart agriculture*". Elsevier B.V. Climate smart agriculture (100020). Vol.1. (pp.1-13). Sep-2024. Doi:10.1016.

[6]. Bouali Et-taibil, Mohammad Riduan Abid and Abdennabi Morchid, "*Enhancing water management in smart agriculture A cloud and IOT based smart irrigation system*". Elsevier B.V. Results in Engineering (102283). Vol.22. (pp.1-15). May-2024. Doi:10.1016.

DOI:10.46647/ijetms.2025.v09i02.044 **ISSN: 2581-4621**

[7]. Sambandh Dhal, Jorge Alvarado and Ulisses Braga-Neto, "*Machine learning-based smart irrigation controller for runoff minimization in turfgrass irrigation*". Elsevier B.V. Smart agriculture technology (100569). Vol.9. (pp.1-13). Sep-2024. Doi:10.1016.
[8]. Anis Ur Rehman, Yasser Alamoudi and Haris M Khalid. "*Smart agriculture technology: An integrated framework of renewable energy resources, IOT-based energy management and precision Robotics*". Elsevier B.V. Cleaner energy system (100132). Vol.9. (pp.1-20). Aug-2024. Doi:10.1016.
[9]. Amit Kumar Yadav, Vibha Yadav and Hasmat Malik, "*Design of novel IOT-based solar powered PV pumping systems for agricultural applications in reverse climatic zones of India*". Elsevier B.V. Results in Engineering (102584). Vol.23. (pp.1-11). Jul-2024. Doi:10.1016.
[10].Abdennabi Morchid, Ishaq G and Muhhamad Alblushi, "*High-technology agriculture system to enhance food security: A concept of smart irrigation system using Internet of Things and cloud computing*". Elsevier B.V. Journal of the Saudi society of agriculture sciences (001). Vol.02. (pp1-17). Feb-2024. Doi:10.1016.
[11].Itumeleng Lephondo, Arnesh Telukdarie and Indersan Munien, "*The Outcomes of smart irrigation system using machine learning to minimize water usage within the Agriculture Sector*". Elsevier B.V. Procedia computer science (136). Vol.237. (PP.525-532). Mar-2024. Doi:10.1016.
[12].Dattatray Sambhainrao Waghole, Purva Rjesh Morey, "*Smart Agriculture system using IOT and AI/ML: A Survey*". IJERT, Vol.13. (pp.1-9). May-2024. Doi: 10.17577/IJERTV13IS050222.
[13].Sitharthan R, Rajesh M and Vimal S, "*A novel autonomous irrigation system for smart agriculture using AI and 6G enabled IOT network*". Elsevier B.V. Microprocessors and Microsystem (104905). Vol.101. (pp.1-10). Jul-2023. Doi:10.1016.
[14].M. Benzaouia, B. Hajji and A. Mellit, "*Fuzzy-IOT smart irrigation system for precision scheduling and monitoring*". Elsevier B.V. Computer and electronics in agriculture (108407). Vol.215. (pp.1-16). Nov-2023. Doi:10.1016.
[15].Vinod Kumar S, C D Singh, K V Ramana Rao and Mukesh Kumar, "*Evaluation of IOT based smart drip irrigation and Etc. based system for sweet corn*". Elsevier B.V. Smart agriculture technology (100248). Vol.5. (pp.1-9). Apr-2023. Doi:10.1016.