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Original Research Article

Optimized Internet of Things Model for Smart Irrigation Using the Drip Method

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Abstract: Irrigation is the regular application of water to the crops so that the water supply to the crop will assist it to grow well. Irrigation is mainly useful in areas where there is a shortage of rainfall. The aim of this study is to optimize an IoT-based model for smart irrigation using the drop method. However, the objectives of the study are to; design an IoT-based model for smart irrigation and implement the optimized IoT-based model for smart irrigation. This study achieved its target; an optimized IoT model for smart irrigation using the drip method. The program has made the following functionality: login page wireframe, dashboard wireframe, system user case diagram, actuators page wireframe, sensor page wireframe and application interface design. The model was tested and approved to fulfill its mission and objectives such as designing an IoT-based model for smart irrigation, implementing the optimized IoT-based model for smart irrigation using the drip method with Python programming language, testing and evaluating the performance of the optimized IoT-based model for smart irrigation water using drip method was then deployed to the farm. Also, helps to solve the problem of scarcity of empirical evidences in the area of the study.

Keywords: Internet of Things, Irrigation, Smart.

1. INTRODUCTION

The world is moving from an analogue or traditional method of doing things to a digital or automated system. This is a result of the impact of scientific theories being demonstrated by scientists (Dickson & Ukegbu, 2024). This scientific breakthrough could be seen in various human spheres of life including the Internet of Things, smart agriculture and irrigation water management. The Internet of Things (IoT) is one of such technologies discovered by man in communication and information technology. In 1999, IoT was launched/discovered as one of such devices found in the area of information dissemination (point, 2016). A member of the Radio Frequency Identification Development Community (RFIDC) developed it to fast-track communication in the area of cloud computing and data analytics because of its fast rate of coverage especially in radio coverage. Dickson & Okechukwu, 2024) IoT could be classified into three major categories; IoT engaging people to people, IoT engaging people to things or machines and IoT involving things and machines to things or machines. All of these are various interacting devices involving IoT through the Internet mechanism (Dickson, 2024).

Irrigation is the regular application of water to the crops so that the water supply to the crop will assist it to grow well. Irrigation is mainly useful in areas where there is a shortage of rainfall. Irrigation therefore is provided for the better yield of crops which hitherto would have died or withered away as a result of lack of water nutrients. Irrigation has many application systems.

The traditional methods of irrigation have various distribution systems, depending on the water requirements of the crops. This could be determined with the practical technological aid the Internet of Things (IoT) offers (Anind, 2021). The IoT is the interconnection of virtual objects such as farms, home appliances, vehicles other items embedded with sensors, electronic software, and connectivity which enable these virtual objects to connect for the exchange of data.

The general concept of the IoT is to effectively manage big data of physical objects on the internet.

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The IoT will help to incorporate the physical world with the Internet using smart devices. IoT is framed by keeping different technologies together which lead to the provision of innovative services in many computing environments (Dickson & Amannah, 2023) in the last few years, there has been much advancement in technologies which include the Internet of Things, Cloud Computing, Big Data and mobile computing. Today, the world is moving in the direction of smart world concepts like smart homes, smart cities, smart work, smart education systems smart agriculture and so on Dickson & Amannah 2022).

This study aims to optimize an IoT-based model for smart irrigation using the drop method. However, the objectives of the study are to; design an IoT-based model for smart irrigation and implement the optimized IoT-based model for smart irrigation.

2. REVIEW OF RELATED LITERATURES

Ogunti (2019) conducted a study on IoT Based Crop-Field Monitoring and Irrigation Automation systems. The study focused on monitoring crop-field, a system is developed by using sensors and according to the decision from a server based on sensed data, the irrigation system is automated. By using wireless transmission the sensed data is forwarded to the web server database. If irrigation is automated then that means if the moisture and temperature fields fall below the potential range. The user can monitor and control the system remotely with the help of an application which provides a web interface to the user. The current study would help to minimize the fall below the potential range of moisture and temperature.

Kaur *et al*., (2016) proposed a smart drip irrigation system. In this, an android mobile application is used to reduce the involvement of humans and it is used to control and monitor the crop area remotely. Water wastage can be reduced with a Drip Irrigation system and it works based on information from water level sensors. Some more different sensors are used to monitor the environment. This work would create a model and method to control water levels.

Kodandaramaiah and Keerthi (2015) carried out a study on implementing a centralized IoT-based greenhouse monitoring system for farm managers to monitor different environmental parameters effectively using sensor devices such as light sensors, temperature sensors, relative humidity sensors and soil moisture sensors. Periodically (30 seconds) the sensors collect information on the agriculture field area and are logged and stored online using cloud computing and the Internet of Things. The current study will help to create a decentralised system that will enable smart monitoring and effective management of farms.

A study by Dickson and Amannah (2020) explored smart irrigation water management using the Internet of Things, the objectives of the study were to evaluate IoT-enabled irrigation water management (IoTsIWM) and methods, applications of IoT about irrigation water management, deliverables of IoT in the irrigation farming, challenges and practicality of the IoT in smart irrigation water management and Prospects of IoT in smart irrigation water management, the outcome indicate that the automated method of irrigation water management among available resources will increase food production against the manual existing method of irrigation water management. The current study would help to minimize water wastage by creating a drip smart irrigation system.

Vineela *et al*., (2018) in their research devised that information must be collected from different sensors and live monitoring should be done but in this research, the stress is laid on getting things automated. In this study, the writers aim to increase the crop yield by using different technologies. It also presents a cost-efficient WSN for getting information from humidity sensors, soil moisture sensors and temperature sensors. The study suggests an automated system for better crop production. The authors suggested a methodology that does sensing of data smartly and also proposes a smart irrigation system. The current research will develop a method to collect and store cloud data.

Chandan and Pramitee (2015) carried out a study on A Low-Cost Smart Irrigation Control System, in this research, the author proposes a model where the flow and direction of water are supervised and controlled. This is done with the help of DHTT11 and soil moisture sensor. This method also proposes a way to select the direction of water and this information is also sent to the phone and Gmail account of the farmer. This model also enables the farmer to switch on and off the motor with a single click. This study proposes a prototype where several sensors are deployed at different positions in the field. This study also shows how the proposed model makes the traditional irrigation system more effective and sustainable. This study also suggests an efficient energy and network model. This present study would help to develop a model that is energy efficient, sustainable, optimized and cost-effective.

The study conducted by Laura, *et al*., (2019) focused on the answers to the following research questions; what are current IoT solutions in smart irrigation for agriculture? What sensors, actuators, nodes, and wireless technologies are being utilized to develop IoT irrigation systems? Search engines and digital libraries were utilized by the authors to search manually for papers suitable for this survey. A total of 283 papers were obtained from Google Scholar 24, IEEE Explore 25, Scopus 26 and the digital library of Sensors 27. The keywords employed to obtain the total number of papers to be analyzed were IoT irrigation, IoT irrigation system, and smart irrigation. Furthermore, all papers were checked to ensure they included the keywords irrigation or water and IoT or smart in their content. This new research would help to provide answers for the current IoT solutions in smart irrigation.

3. METHODOLOGY

The method used in this system is the prototyping model. The prototyping model is the rapid development and testing of working models (prototypes) of new applications through an interactive and repetitive process that is commonly used by information system experts. The phrasing of the study work involved breaking down the overall development plan into bite-sized chunks. First, it concentrated on the most critical aspects and then worked its way through the whole project. By prototyping the study into smaller parts it concentrated on independently optimizing each section. Using this approach, enables study creation, identification of errors and schedule monitoring**.**

4. RESULT AND DISCUSSION

This system is an optimized IoT-based model for smart irrigation using the drop method. It is a decentralised system and it enables smart sending, receiving and sharing of data to the server. This is done with the help of sensor-based variables such as light, humidity, temperature, and soil moisture sensors. The system is built for monitoring the crop field and automating the irrigation system.

Data read from every sensor is sent to the cloud through the gateway for processing, analytics and storage. Local automation is achieved at the gateway level while the farm-state is continuously synchronized with the cloud. The system is designed such that two different authorized users one as a farm admin while the other serves as farm manager. Farm admin has the role of adding both sensor and actuator nodes to the platform and setting operation from an automated operation or operated by a farm manager user. The farm manager user has the role of controlling both the sensor and actuator nodes as well as receiving either SMS or Email notifications about any changes made in the farm's operation. A dynamic responsive web application is designed to serve as the interface for viewing readings from the sensors and also provides farm manager access to locally or remotely activate the irrigation system of the farm. The irrigation system consists of a (main) intake structure or (main) pumping station, a conveyance system, a distribution system, a field application system, and a drainage system.

1. System Design

The design of this system was done using the Balsamiq application. The system would have a login page, dashboard, system user case diagram, actuators page, sensor page and application interface design. Justinmind tool was used to show the flow of information in the system, which includes data input and output, data stores and all the sub-processes the data moves through. This was carried out by using Figma symbols and notation to describe various entities.

2. Architecture of the System

An optimized IoT-based architecture is made up of a cloud layer, an IoT layer, and a physical layer. An optimized IoT system allows any node within the physical layer to communicate with one another without the need for a central system (gateway). An actuator node can receive commands from the user through a gateway or directly from another sensor node to either start or stop the irrigation system. Water wastage can be reduced with a drip irrigation system and it works based on information from water level sensors. Some more different sensors are used to monitor the environment. This gives the system more reliability and reduces network (Internet) dependency. Nodes communicate with one another and the gateway using Long Range (LoRa) radio communication network. That is the physical layer and the IoT layer can interact without relying on a TCP/IP network. Automation of the farm activities can also be archived easily with this architecture.

The physical layer is a layer of automation to control the smart agriculture system. It is designed to manage and control the sensors and actuators. The sensors used in the process of automation are soil moisture sensor, temperature sensor and humidity sensor. These sensors are intended to check the moisture level of soil, the amount of water required for the crop, the temperature of the plant and the humidity of the environment. The actuators are used for controlling the water supply of the farm irrigation system.

The IoT layer is the layer where the data from the physical field is collected and sent for further processing in the cloud layer. In this layer, a system controller is used as a local storage/server as well as a network gateway to the cloud layer. This layer is connected to the physical layer through the LoRa radio network and also to the cloud layer to secure the TCP/IP network. The IoT devices alert every second, notify every change and send data to the controller. The data is then forwarded to the cloud for analysis. While in the cloud layer, security-level protocols are used to transfer data securely within the cloud services. It acts as a compute, storage area and Application Programming Interface (API) gateway for Desktop/Mobile applications to interact with the system. It also provides analytic services and an email/SMS notification system.

The Schematic Optimized IoTs Model

Figure 1 shows the block diagram of the overall process including the irrigation control system, surveillance live feed, water tank, sensor node, actuator node wireless sensor network, the cloud and user terminal. An edge device is used to collect data from the environment. The sensors sense the physical parameter and collect the data, which then relays to the microcontroller for further processing. It is a central hub of the IoTs system that acts as a bridge between the nodes and the Internet. The actuator, an edge device that acts on the environment upon receiving the inputs (e.g. humidity, soil water level) can autonomously take decision based on the program installed. It turns ON or OFF (e.g. the pump) depending on the need of the moment.

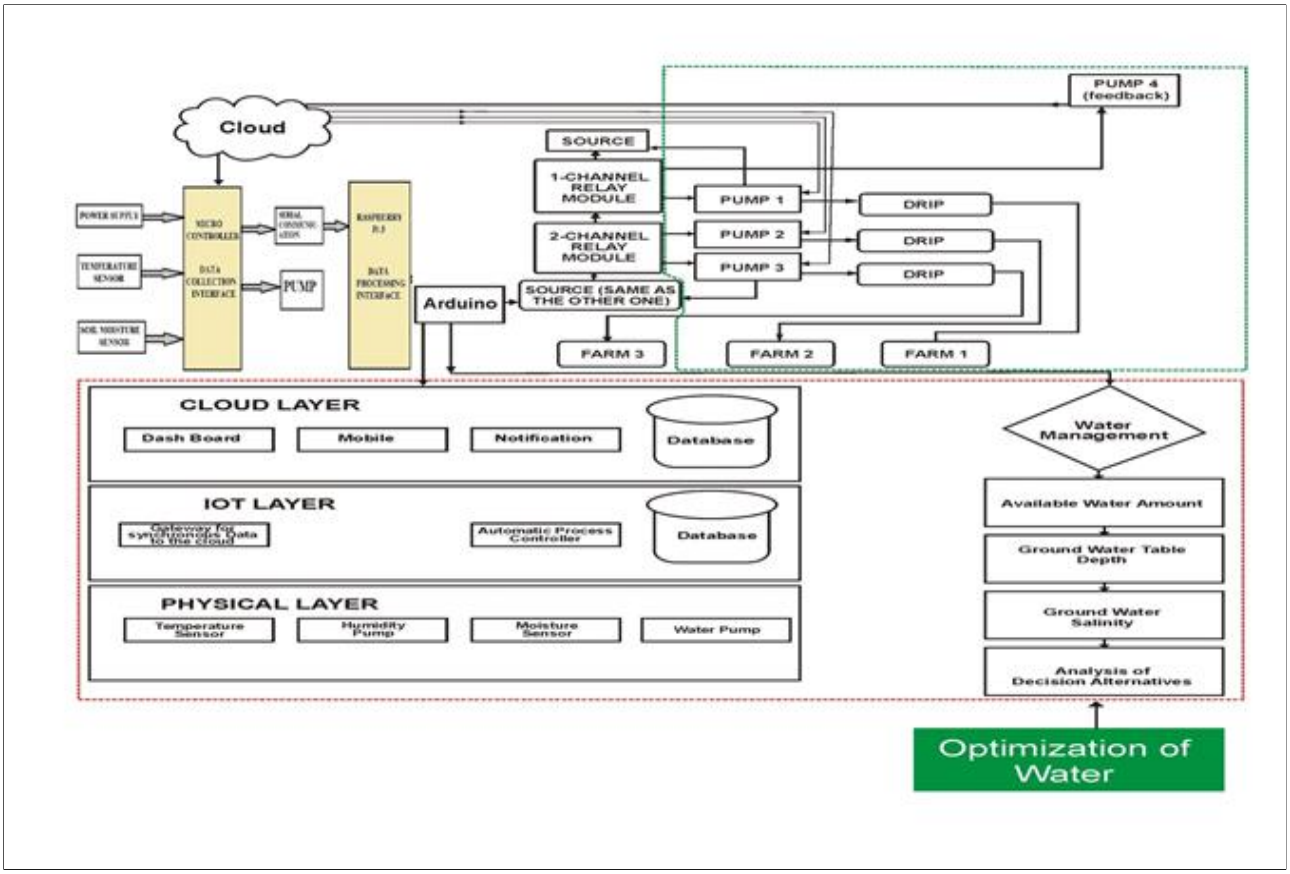

Figure 1: Architecture of the system

The communicating with the underlying physical layer through the LoRa radio network, this layer also establishes a connection to the cloud via a private TCP/IP network. IoTs gadgets provide the controller with data and alarms at regular intervals. The information is sent to a remote server for further examination. Information sent between cloud services is encrypted using security-level protocols while in the cloud layer. It processes data, stores it, and provides access to the system through an API for use by desktop and mobile apps. It offers analytical services and an email/SMS alerting system as well. Figure 2 highlights the irrigation gateway for smart agricultural system**.** A central hub of an IoT system that acts as a bridge between the nodes and the internet. The actuator, an edge device that acts on the environment upon receiving the inputs (e.g. humidity, soil water level) can autonomously make decisions based on the program installed. It turns ON or OFF (e.g. the pump) depending on the need of the moment.

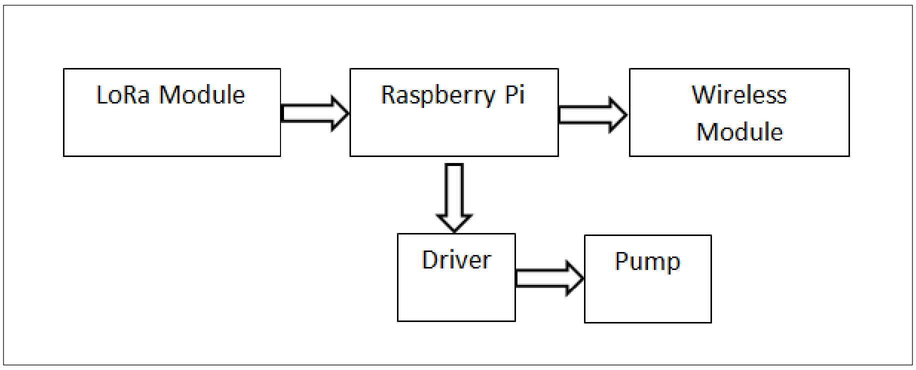

Figure 2: Irrigation Gateway

Figure 3 shows the pictorial diagram of the overall process of an Optimized IoT-Based Model for Smart Irrigation Using Drip Method which include the irrigation control system, surveillance live feed, water tank, sensor node, actuator node wireless sensor network, the cloud and user terminal.

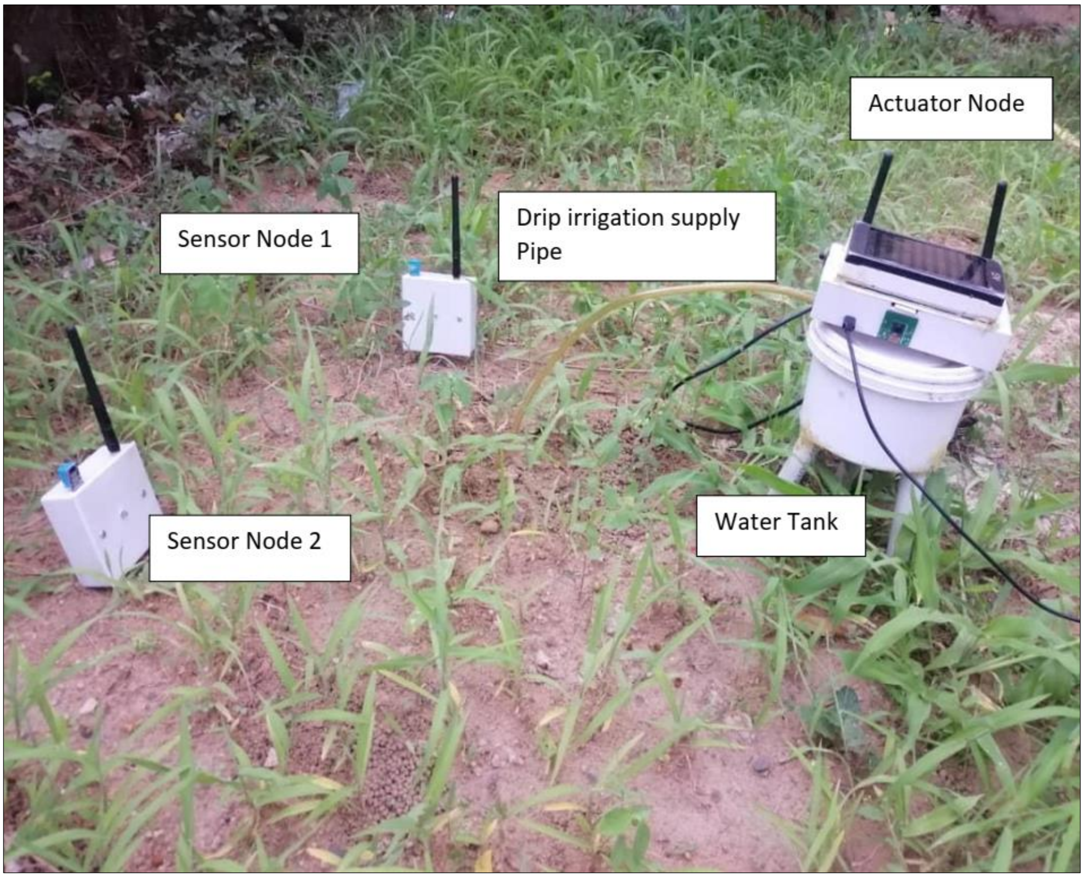

Figure 3: Optimized IoT-Based Model for Smart Irrigation Using Drip Method

3. Documentation

The system is an open system which captures an Optimized IoT-based model for smart irrigation using the drip method developed using a sequential order. The first step covers the study; the problem encountered the cause of the study, its aim and objective and so on. The second step covers the related literature of the study. The third step covers the methodology adopted in the research which is the prototype model. The program includes an electronic registration of the user/login form.

a. Architecture: A wireframe application was used for the architecture. This is a method of module description of the architecture.

b. Coding: This is the method of translating device design into a machine language format. ReactJS Frontend Application development platform, Amazon web services IoT Core backend, Arduino Development platform for developing sensor nodes and Python programming language for the actuator node based on Raspberry Pi board.

c. Implementation: Turning the concept into something concrete means that this process has steps that include gathering specifications, finding potential solutions, evaluating and those solutions.

d. Testing: The test was carried out in the following parts:

i. **Registration:** the farmer or the user shall supply the system with their information.
ii. **The web Server:** this conducts a series of operations on local server structured input data to test processing efficiently.

e. Database module: Store and save the structured data from the process module for use.

i. Deploy: these are various forms of research that involve smart irrigation using the drip method;
ii. Sign in with a local server
iii. Built on Web Server
iv. Type or select the address.

The user will need little knowledge of mobile phones or computers, as the assigned smart agriculture and irrigation water management are viewed using mobile phone or computer.

4. CONCLUSION

This study achieved its target; an optimized IoT model for smart irrigation using the drip method. The program has made the following functionality: login page wireframe, dashboard wireframe, system user case diagram, actuators page wireframe, sensor page wireframe and application interface design. The model was tested and approved to fulfill its mission and objectives such as designing an IoT-based model for smart irrigation, implementing the optimized IoT-based model for smart irrigation using the drip method with Python programming language, testing and evaluating the performance of the optimized IoT-based model for smart irrigation water using drip method was then deployed to the farm. Also, helps to solve the problem of scarcity of empirical evidences in the area of the study. Through this study, an optimized model for smart irrigation farming was developed which has better functionality and flexibility when compared to that of the existing system.

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