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SMART FARMING USING LORA & IOT

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ABSTRACT

Smart farming integrates advanced technologies to optimize agricultural processes, enhance productivity, and ensure sustainability. This paper presents a smart farming system leveraging LoRa (Long Range) communication and Internet of Things (IoT) technologies to monitor and manage key agricultural parameters such as soil moisture, temperature, humidity, and light intensity. LoRa enables long-range, low-power wireless communication, making it ideal for wide-spread farm areas where traditional Wi-Fi or GSM networks are impractical or costly. Sensors deployed across the field collect real-time environmental data, which is transmitted via LoRa nodes to a centralized IoT gateway. The collected data is then visualized and analyzed through a cloud-based dashboard, enabling farmers to make data-driven decisions remotely. This system not only reduces manual labor and water waste but also improves crop yield and resource efficiency. The proposed model highlights the potential of integrating LoRa and IoT for developing cost-effective, scalable, and sustainable smart agriculture solutions.

Keyword: IOT, LoRa, WiFi, GSM, Sensor etc

1. INTRODUCTION

Agriculture is the backbone of many economies, especially in developing countries, where a significant portion of the population depends on farming for livelihood. However, traditional farming methods are often inefficient and highly dependent on manual labor, weather conditions, and unpredictable environmental factors. With the growing global population and the increasing demand for food, there is a pressing need to adopt smarter, more efficient agricultural practices. Smart farming, enabled by the Internet of Things (IoT), introduces automation and real-time data monitoring into agriculture. By deploying sensors and devices across farms, farmers can gain insights into soil moisture, temperature, humidity, and crop health, enabling better decision-making and resource management. Despite the potential of IoT in agriculture, many farms are located in rural or remote areas with limited connectivity, posing a major challenge to data transmission and real-time monitoring. To address this issue, LoRa (Long Range Radio) technology offers a practical solution. LoRa is a low-power, wide-area networking protocol that allows communication over long distances with minimal energy consumption.

This makes it ideal for agricultural environments where power supply and internet connectivity are scarce. This project proposes a smart farming system that combines IoT sensors with LoRa-based communication to provide a reliable, low-cost, and energy-efficient solution for monitoring agricultural conditions. By collecting and analyzing data through a centralized platform, farmers can automate irrigation systems, detect environmental changes early, and ultimately increase productivity while conserving vital resources such as water and energy.

1.1 Project Objectives

- Designing and implementing a system that integrates a soil moisture sensor module, microcontroller, motor, and transistor to automate the monitoring and pumping processes.
- Developing a user-friendly website interface for real-time monitoring of soil moisture levels, pump status, and historical data visualization.
- Establishing a database for efficient data storage and retrieval, enabling users to access and analyze soil moisture data and pump status records.
- Improving water management practices by optimizing irrigation schedules, reducing water wastage, and ensuring optimal moisture levels for crop growth.
- Enhancing crop yield and productivity by providing accurate and timely irrigation based on soil moisture conditions.
- Promoting sustainable farming practices by minimizing manual labor, reducing resource wastage, and improving overall efficiency in irrigation processes.

1.2 Scope

The scope of the Smart Farming and Auto Pumping System project includes the design, implementation, and deployment of a system that automates the monitoring and irrigation processes in agriculture. The system focuses on accurately measuring soil moisture levels and automatically activating the water pump based on predefined thresholds. It encompasses the integration of hardware components, such as a soil moisture sensor module, microcontroller, motor, and transistor, along with a user-friendly website interface and a database for data storage and retrieval. The project aims to optimize water management, improve crop yield, and promote sustainable agricultural practices.

1.3 Overview and Benefits

The Smart Farming and Auto Pumping System project aims to revolutionize traditional agricultural practices by automating the monitoring and irrigation processes. The system utilizes advanced technologies, including a soil moisture sensor module, microcontroller, motor, and database-driven user interface, to optimize water management and improve crop yield. The system provides real-time monitoring of soil moisture levels, historical data analysis, and automated water pumping based on predefined thresholds. By accurately measuring soil moisture and automatically activating the water pump when required, the system ensures optimal moisture levels for crop growth while minimizing water wastage.

2. LITERATURE REVIEW

- **Davcev et. al. (2018):** The purpose of this idea that is highly scalable, power-efficient, and inventive. To enable long-range and low-power consumption, the system uses a LoRa WAN network to transport sensor data from the nodes to cloud services. The system uses a highly scalable data streaming approach to perform analytics. This study illustrates the useful methods that can be applied in a LoRa-based smart agriculture system. The LoRa modules in the system connect to the sensor nodes, sending the sensor data to the processing system for uploading onto a cloud platform.
- **Santosh Kumar et. al. (2015):** In their investigation, the researchers assessed several sensors and precision agriculture application methodologies. Temperature and humidity sensors were included, as well as an Arduino microcontroller board with a wireless sensor network system. The wireless sensor network's primary purpose was to gather data from far locations and wirelessly transmit it to the receiver. Early monitoring systems had a number of shortcomings, including reliability and range difficulties.
- **A. Lavric et. al. (2017):** Proposed a discussion of the difficulties and limitations involved in integrating LoRa technology into IoT systems. New solutions have been studied, and the study concentrates on high-density sensor networks employed in the IoT idea. According to the needs of IoT systems, the LoRa modules' low transmission rate allows for long-distance information transfer. The key issues experienced during IoT development are also covered in the study, along with information on the difficulties met during WSN research.
- **S. C. Gaddam et. al. (2018):** The importance and use of LPWAN (Low Power Wide Area Networks), a modern wireless technology that has proven useful for constructing various IoT systems, is discussed. The growing demand for IoT and the growing need for automation prompted the study of wireless technology evaluation. The paper presents research on LPWAN technology, which employs wireless networks and has very low power requirements while enabling long-distance communication with a low bit rate and low bandwidth.
- **M. Saari et. al. (2018):** The system main objective is to assess LoRa WAN technology for sensor network applications in the IoT space. In this case study, a thorough literature assessment was done, and more than fifty research publications were found. The questions that were developed based on the LoRa WAN study are presented in the methodology section.
- **C. Bouras et. al. (2019):** The smart monitoring system, which deals with the analysis of numerous IoT scenarios, was discussed in this research. Although Wi-Fi and LoRa have been initially contrasted as wireless technologies, end devices require substantial power consumption for computation, necessitating the use of low power network solutions. The end devices have been connected to the Internet using the LoRa-based gateway and Wi-Fi router utilized in our scenarios.
- **Hanggoro et. al. (2013):** The author designed and implemented a full-fledged system for monitoring and managing humidity in a greenhouse using an Android mobile application. It employed an Android smartphone to connect wirelessly to a central server, which was then coupled to a microcontroller and humidity sensor via serial connection. They claimed that 802.11g was the third wireless LAN modulation standard and that Wi-Fi

was widely used throughout the world. It operated in the 2.4 GHz range with a maximum raw data rate of 54 Mbit/s and net throughputs of roughly 19 Mbit/s (like 802.11b).

3. HARDWARE (COMPONENTS):-

- **LoRa Modules:-**

A LoRa module contains a LoRa transceiver chip and microcontroller, giving it all the elements needed for long-range communication. It serves as a building block to connect sensors, actuators and all kinds of IoT edge devices through a LoRa-based network. LoRa modules allow devices to connect to a LoRaWAN network to send and receive data across long distances. LoRa modules are available as readymade standalone components or integrated into development boards and sensors. Common interfaces include UART, SPI and I2C for connecting with external microcontrollers. or onboard sensors. As LoRaWAN gains popularity for LPWAN applications, the ecosystem of affordable LoRa modules has grown exponentially.

LoRa Module

This module is a type of low cost RF front-end transceiver module based on SX1278 from Semtech Corporation. It keeps the advantages of RFIC SX1278 but simplifies the circuit design. The high sensitivity (-136dBm) in LoRa modulation and 20dBm high power output make the module suitable for low range and low data rate applications. The module consists of RFIC SX1278, thin SMD crystal and antenna matching circuit. The antenna port is well matched to standard 50 Ohm impedance. Users don't need to spend time in RF circuit design and choose suitable antennas for different applications. The module operates at 1.8~3.6V with extra low standby current which makes it suitable for battery powered-up applications. Because it is purely hardware module and it adopts ±10ppm crystal which the resolution of it places a important role in calculating spreading factor, bandwidth, etc.

Features

- Frequency Range: 433MHz
- Modulation: FSK/GFSK/MSK/LoRa
- SPI Data Interface
- Sensitivity: -136dBm
- Output Power: +20dBm
- Data Rate: <300 kbps
- 127dB dynamic Range RSSI
- Excellent blocking immunity
- Preamble detection
- Automatic RF sense and CAD monitor
- Built-in bit synchronizer for clock recovery
- Packet engine up to 256 bytes with CRC
- Working Temperature: -40°C ~+80°C
- Build-in temperature sensor
- Standby current: ≤ 1uA
- Supply voltage: 1.8~3.6

- **NODE MCU esp8266**

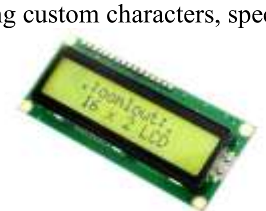
The NodeMCU (Node Micro Controller Unit) is an open-source software and hardware development environment built around an inexpensive System on- a-Chip (SoC) called the ESP8266. The ESP8266, designed and manufactured by Espressif Systems, contains the crucial elements of a computer: CPU, RAM, networking (Wi-Fi), and even a modern operating system and SDK. That makes it an excellent choice for Internet of Things (IoT) projects of all kinds.

Node MCU esp8266 Development Board

NodeMCU is an open-source firmware for which open-source prototyping board designs are available. The name "NodeMCU" combines "node" and "MCU" (micro-controller unit). The term"NodeMCU" strictly speaking refers to the firmware rather than the associated development kits. Both the firmware and prototyping board designs are open source. The firmware uses the Lua scripting language. The firmware is based on the eLua project, and built on the Espressif Non-OS SDK for ESP8266. It uses many open-source projects, such as lua-cjson and SPIFFS. Due to resource constraints, users need to select the modules relevant for their project and build a firmware tailored to their needs. Support for the 32-bit ESP32 has also bee implemented.

- **LCD Display 16*2:-**

The term LCD stands for liquid crystal display. It is one kind of electronic display module used in an extensive range of applications like various circuits & devices like mobile phones, calculators, computers, TV sets, etc. These displays are mainly preferred for multi-segment light-emitting diodes and seven segments. The main benefits of using this module are inexpensive; simply programmable, animations, and there are no limitations for displaying custom characters, special and even animations, etc.



LCD Display

These are commonly used in the screen industries to replace the utilization of CRTs. Cathode Ray Tubes use huge power when compared with LCDs, and CRTs heavier as well as bigger. These devices are thinner as well power consumption is extremely less. The LCD 16×2 working principle is, it blocks the light rather than dissipate. This article discusses an overview of LCD 16X2, pin configuration and its working.

Features:

- The operating voltage of this LCD is 4.7V-5.3V
- It includes two rows where each row can produce 16-characters.
- The utilization of current is 1mA with no backlight
- Every character can be built with a 5×8 pixel box
- The alphanumeric LCDs alphabets & numbers
- Is display can work on two modes like 4-bit & 8-bit
- These are obtainable in Blue & Green Backlight
- It displays a few custom generated characters

- **DHT 11 Sensor:-**

The **DHT11** is a commonly used **Temperature and humidity sensor that** comes with a dedicated NTC to measure temperature and an 8-bit microcontroller to output the values of temperature and humidity as serial data. The **DHT11 sensor** can either be purchased as a sensor or as a module. Either way, the performance of the sensor is 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. The only difference between the sensor and module is that the module will have a filtering capacitor and pull-up resistor inbuilt, and for the sensor, you have to use them externally if required.

DHT 11 Sensor

The **DHT11** is a commonly used **Temperature and humidity sensor.** The sensor comes with a dedicated NTC to measure temperature and an 8-bit microcontroller to output the values of temperature and humidity as serial data. The sensor is also factory calibrated and hence easy to interface with other microcontrollers. The sensor can measure temperature from 0°C to 50°C and humidity from 20% to 90% with an accuracy of ±1°C and ±1%. So if you are looking to measure in this range then this sensor might be the right choice for you.

DHT11 Specifications

- 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%

- **DS18B20 sensor:-**

This is a pre-wired and waterproofed version of the DS18B20 sensor. Handy for when you need to measure something far away, or in wet conditions. While the sensor is good up to 125°C the cable is jacketed in PVC so we suggest keeping it under 100°C. Because they are digital, you don't get any signal degradation even over long distances. These 1-wire digital temperature sensors are fairly precise (±0.5°C over much of the range) and can give up to 12 bits of precision from the onboard digital-to-analog converter.

DS18B20 Sensor

They work great with any microcontroller using a single digital pin, and you can even connect multiple ones to the same pin, each one has a unique 64-bit ID burned in at the factory to differentiate them. Usable with 3.0-5.0V systems. The only downside is they use the Dallas 1-Wire protocol, which is somewhat complex, and requires a bunch of code to parse out the communication. When using with microcontroller put a 4.7k resistor to sensing pin, which is required as a pullup from the DATA to VCC line.

DS18B20 Sensor Features:

- Usable temperature range: -55 to 125°C (-67°F to +257°F)
- 9 to 12 bit selectable resolution
- Uses 1-Wire interface- requires only one digital pin for communication
- Unique 64 bit ID burned into chip
- Multiple sensors can share one pin
- ±0.5°C Accuracy from -10°C to +85°C
- Temperature-limit alarm system
- Query time is less than 750ms
- Usable with 3.0V to 5.5V power/data

- **LDR Sensor:-**

LDR (Light Dependent Resistor) as the name states is a special type of resistor that works on the photoconductivity principle means that resistance changes according to the intensity of light. Its resistance decreases with an increase in the intensity of light.

LDR Sensor

It is often used as a light sensor, light meter, Automatic street light, and in areas where we need to have light sensitivity. LDR is also known as a Light Sensor. LDR are usually available in 5mm, 8mm, 12mm, and 25mm dimensions. It works on the principle of photoconductivity whenever the light falls on its photoconductive material. It absorbs its energy and the electrons of that photoconductive material in the valence band get excited and go to the conduction band and thus increasing the conductivity as per the increase in light intensity. Also, the energy in incident light should be greater than the bandgap gap energy so that the electrons from the valence band got excited and go to the conduction band. We have a detailed article on working, circuit, and construction of LDR. The LDR has the highest resistance in dark around 1012 Ohm and this resistance decreases with the increase in Light.

- **Water Level Indicator:-**

The water level sensor is a device that measures the liquid level in a fixed container that is too high or too low. According to the method of measuring the liquid level, it can be divided into two types: contact type and non-contact type. The input type water level transmitter we call is a contact measurement, which converts the height of the liquid level into an electrical signal for output. It is currently a widely used water level transmitter. The working principle of the water level sensor is that when it is put into a certain depth in the liquid to be measured, the pressure on the sensor's front surface is converted into the liquid level height. The calculation formula is $P=\rho.g.H+Po$, in the formula P is the pressure on the liquid surface of the sensor, ρ is the density of the liquid to be measured, g is the local acceleration of gravity, Po is the atmospheric pressure on the liquid surface, and H is the depth at which the sensor drops into the liquid.

Water Level Indiacator

The level sensor is a device designed to monitor and measure liquid (and sometimes solid) levels. When the liquid level is detected, the sensor converts the sensed data into an electrical signal. Level sensors are mainly used for monitoring reservoirs, oil tanks or rivers.

- **Wiring and Connectors**

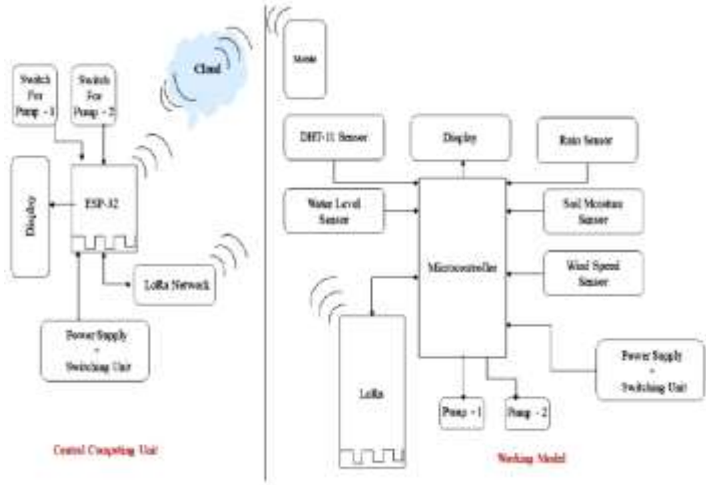
Cables and connectors are necessary to link the components, such as the power supply, motor, pump, valves, and the receiver unit. Proper insulation and weatherproofing are important for maintaining safety and reliability.

Wiring

Wiring and connectors are crucial components in electrical and electronic systems, enabling the transfer of power, signals, or data between different parts of a circuit or device. They play an essential role in ensuring the smooth, efficient, and safe operation of electrical systems, from small household gadgets to complex machinery like hydraulic jacks and remote control systems.

4. WORKING OPERATIONS:-

4.1 SYSTEM BLOCK DIAGRAM



System Block Diagram

4.2 WORKING

This system is distributed system, there are two units i.e. Transmitting unit which is fixed at the farm and another is the receiving unit which is fixed at the home. As the system is worked on the principle of WSN technology in which there are various sensor nodes are fixed at various locations so at the transmitting unit various sensors are used. The sensors are used to measure the environmental conditions like temperature, moisture of soil, Humidity of the air, Level of water at the water tank and so on. The sensors measures this quantities and sends the data to the farm unit as input. After receiving the data the farm unit process the data and the processed data is sent to the home unit or the receiving unit using LoRa Transmitter and receiver.

Another unit is the receiving unit, the unit includes ESP-32 a wifi enabled device and a LoRa device which is used as the receiver. As the data speed of the system is slow i.e. 50Kbps so the time delay between the sending and receiving the data is about 1 - 1.5s. So the data received at the receiving unit is processed by the wifi device ESP-32 and the processed data is send to the IoT platform i.e. Ubidots if the internet is available at the receiving unit or the home module. The system did not required any internet connection to send and receive the data at both the end the ESP-32 is only used to send the data at IoT platform. The data available at IoT platform is can be accessible through mobile, laptop or computers. Also the farmer can monitor the real time data on the LCD displays attached at both the ends. Also he can control the motors located at farm using the buttons fixed at the receiving unit for this operation also we don′t need to use the internet whole process can be done using the radio communication

4.2 PRINCIPLE

The Smart Farming System operates based on the principle of automated soil moisture sensing and water pumping to maintain optimal moisture levels for crop growth. The system combines hardware components and software logic to create an efficient and automated irrigation solution. The principle of operation begins with the soil moisture sensor module. This module utilizes the principle of electrical conductivity to measure the moisture content in the soil. It consists of two exposed conductors that act as variable resistors. When the soil is moist, it conducts electricity better, resulting in lower resistance between the probes. Conversely, dry soil exhibits higher resistance. By passing a small electric current through the soil via the probes, the module measures the resistance and converts it into a corresponding moisture level reading. The moisture level readings are then transmitted to the NodeMcu ESP8266 microcontroller, which acts as the brain of the system. The microcontroller receives the data from the soil moisture sensor module and processes it to determine the moisture level in the soil. It compares the moisture readings with a predefined threshold value. If the moisture level is below the threshold, indicating insufficient moisture, the microcontroller activates the water pumping mechanism. The water pumping mechanism consists of a motor and a transistor for control. When the microcontroller determines that the moisture level is below the desired threshold, it activates the motor by controlling the transistor. The motor pumps water from a water source, such as a tank or reservoir, and delivers it to the soil through a network of pipes or hoses. This ensures that the soil receives adequate moisture to support healthy crop growth. To provide feedback and data storage, the microcontroller communicates with a database. The database stores information such as moisture level readings, pump activation status, and timestamps. This data can be accessed and analyzed later for monitoring, historical analysis, and decision-making purposes.

4.3 WIRELESS COMMUNICATION NETWORK

The prototype aims to wireless control over home appliances with the technology of IOT. As discussed earlier, IOT supports various wireless communication protocols, like Bluetooth, Z-Wave, Zigbee etc. this prototype uses Wi-Fi as wireless communication network to establish remote access over home appliances. This is because Wi-Fi has its own advantages over other wireless communication protocols. Advantages of Wi-Fi over other wireless technologies like Bluetooth and ZigBee Bluetooth is generally used for point to point networks and Bluetooth operates at a much slower rate of around 720 Kbps which is very small for video transfer or moving large amount of data like the image captured from a camera, whereas the bandwidth of Wi-Fi can be up to 150Mbps and very ideal for video transmission. Wi-Fi is very much secure means of communication than Bluetooth. Wi-Fi connection to send video, audio, and telemetry operation, while accepting remote control commands from an operator who can be located virtually anywhere in the world. Robots are already being eyed for obvious tasks like conducting search- and rescue missions during emergencies or hauling gear for soldiers in the jungle or woods. The mechanics of the robot uses the concept that has been developed to ensure robust navigation, search and transportation in rough terrain

5. CONCLUSIONS

The implementation of a LoRa-based agriculture monitoring system demonstrates a reliable, low-power, and cost-effective solution for real-time environmental data collection in remote farming areas. By using long-range wireless communication, farmers can monitor critical parameters such as soil moisture, temperature, and humidity without relying on expensive cellular infrastructure. This system enhances decision-making in irrigation, crop management, and resource optimization, ultimately increasing productivity and sustainability. Although LoRa has limitations in data rate and urban interference, its advantages in range, battery life, and scalability make it highly suitable for smart agriculture applications, especially in rural and hard-to-reach regions. Future improvements could include integrating machine learning for predictive analysis, adding automated control systems, or expanding to LoRaWAN networks for cloud-based data analytics and mobile access.

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