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IoT BASED MONITORING SYSTEM FOR PRECISION AGRICULTURE

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ABSTRACT

Precision agriculture uses accurate, site-specific details for controlling production inputs including soil, fertilizers, and pesticides. The optimization of output resources within specific field areas is based on the particular crop and soil requirements of each field region. The concept behind precision agriculture is implementation of plant inputs only when and where appropriate for the most economical crop growth. The tools and technologies that are used to implement precision agriculture include Internet of Things (IoT), Arduino and remote sensing (RS). The management decisions are made from the analysis of the data got from the field. The agricultural crop production costs and agricultural field damage can be potentially reduced by following precision farming which thus enhances the good yield and profit for the farmer.

Key word: precision agriculture

INTRODUCTION

Temperature and humidity are two important element of the soil. While humidity can be viewed simply as the quantity of liquid (water) contain in the atmosphere, soil or in a gas and temperature representing the amount of heat affecting the soil, they are therefore inversely proportional to each other. The quantity of water present in the soil is solely responsible for respiration, photosynthesis, transpiration and transportation of minerals and other important food components through the plant. This therefore, informs on us that adequate irrigation system is very important for soil plant growth. On the other hand, it is also important to create a balance between both; temperature and humidity. Shampa, (2018) has noted Humidity that is the volume of water vapor that may be present at the given temperature in the atmosphere. Relative humidity is the quantity of water moisture in the air measured at the same temperature as a percentage of the amount required for saturation. As temperature increases, the amount of water vapour in the air also increases.

As the temperature rises, the amount of water vapor in the atmosphere also rises. During dry season, the amount of water moisture present in the air can be so low during the dry season to cause itching of human tissue because at low humidity the air is dry and the barometer rises. The barometer is an instrument used to measure atmospheric pressure, particularly in weather forecasting and altitude determination. Clear weather is an indication that the atmospheric pressure is high and low atmospheric pressure signifies a stormy weather. Relative humidity which is not same as absolute humidity decreases as temperature rises; Relative humidity depends on the water vapor as well as the air temperature. Therefore, a rise in temperature will lead to a corresponding reduction of the relative humidity provided no moisture is added. A pH sensor measures simply the hydrogen ion concentration in the soil Ananthi et al, (2017). It is used to indicate the presence of acidic or alkalinity content of the soil. The value ranges from 0-14. If the pH value is lower than 7 (<7), it is acidic and if the value is higher than 7 (>7) shows it is base or alkaline. Furthermore, the Internet of Things (IoT) also called Ubiquitous Computing is providing a rare platform for technology to assist many companies especially agricultural sector. The agric-food sector have not taken the full advantage of this emerging technology as regards the benefits of information and communications technology (ICT) which has the Capacity to reduce high cost of obtaining data. The technologies deployed in IoT include sensors, actuators, drones, navigation systems, cloud data services, various analytics and decision support tools, but not limited to them. Brewster et al,(2017).

Wikipedia pointed out the concept of IoT as the installation of sensors in electricity grids, highways, bridges, tunnels, roads, houses, water supply networks, reservoirs, oil and gas tubes, appliances and connecting them all to the Internet in order to run those programs a nd carry out remote control. The server (a computer) is then use to manage and control the machine, equipment and give instruction to human workers based on the expert decision and deductions, this has led to improve and efficient working resulting also is better production. An IOT application encompasses various areas of human endeavours which security, luxury homes, health, transport, agriculture, retail, environment, supply ware housing, infrastructure management etc. IoT applications in the agro sector include monitoring and prediction for soil and plant, greenhouse control, monitoring of poultry and ranch for animals, etc. The potential benefits of IOT include but not limited to

- ❖ Improved knowledge and better yield
- ❖ Cost reduction services
- ❖ Sequence of operational flows and detailed information per stages of production
- ❖ Efficiency and accurate human intervention.
- ❖ Automated process.
- ❖ Profit maximization.

In addition to the above, the Internet of Things (IOT) is also a global network of networks of communicating devices. It combines ambient intelligence, ubiquitous communications and pervasive computing. IOT is a vision where “things”, usually things that are everyday use for man, examples are clothes, home electronics, furniture, cars, highways and smart devices, etc. are operated, monitored and or controlled through the Internet. This is providing the platform for many new frontiers in the power sector for monitoring energy supply and consumption, rail, tunnel and road transport safety systems and facility security. The synergy between several Technologies such as Wireless Sensor

Networks, Intelligent Devices and Nanotechnology will lead to development of several advanced applications. The Innovative and creative use of old and modern technologies such as RFID, NFC, ZigBee and Bluetooth, are helping to give value for stakeholders in the area of IOT. IoT will ensure connection of global objects in a sensory and intelligent way through the combination of technological breakthrough in identifying objects (“tagging things”), wired and wireless sensor network (“feeling things”), micro controller systems (“thinking things”) and nanotechnology (“shrinking things”). In 2005, the United State defense department in conjunction with Wal-Mart compelled all suppliers to use Radio Frequency Identification (RFID) tags with their supplies for easy inventory taking. The success of the RFID for this operation in 2005 gave a new interest in the area IoT.

IoT is an ecosystem in which objects, animals or people are fitted with unique identifiers capable of transmitting information over the Internet without the need for communication between humans and computers Gluhak et al,(2011) states that more than 13.4 billion devices were connected to the internet as part of IoT and by 2020 a rise of 185 million is expected to reach 38.5 billion devices. IoT is used in nearly every area of modern society

Precision agriculture (both plant and animal) is the process of making farm activities and procedures controllable, accurate and seamless. In precision agriculture approach of farm management, the use of information technology tools and several other equipment like sensors, AI (Artificial Intelligence) systems, autonomous vehicles, automated hard and software, variable rate technologies, control systems, robotics, etc. is use to achieve the purpose of a smart farming process. Precision agriculture is a data-driven approach to agriculture and it has strong connection to lots of data mining issues. Yield prediction is an important consideration in agriculture and data mining come in useful to solve the challenges Ruß et al.,(2010). Data mining techniques are aimed at discovering and isolating patterns available in the data which have direct correlation to crop management. Yield prediction is a common specific agricultural problem. The expected yield of the crop or live stock is very important to the farmers hence yield prediction is key in precision agriculture.

In the recent years, new technologies such as, the new developments in the field of wireless sensor and micro processor/ controller have emerged in the agric sector thereby giving boost to precision agriculture. Precision agriculture dwells mainly on providing the platform use in monitoring, evaluating and controlling all the processes involved in crop or livestock management. One aspect precision agric concentrates on is site-specific crop management. This involves various stages, such as knowing the soil condition, particular crop and climate in area, taken the results as a sample for a particular parcel of land, providing a decision support system (DSS) to suggest best treatments and possible interventions for the entire field or for specific parts of a field; for example, when and where to apply in real-time fertilizer, lime and pesticide. Precision agric encompasses both plant and livestock aspect of agriculture which can be from hourly/daily management of livestock through the monitoring of the growth of plants on the field and predicting the expected yield from a field. It also involves itself with pre- production activities that will aid the eventual outcome of agricultural process.

This mode of farming is also called smart farming because the various tools employed and deployed makes the farmer smart; labor and human manpower is reduced to the barest minimum if not totally eliminated. Furthermore, production processes could be automated; irrigation, fertilization, pest control and almost every other agricultural process can be equally automated for optimal performance of the farm and high crop yield. Smart farming involves high capital and it is an hi-tech system of cultivating hygienic and sustainable food for the population by the applying information technology tools into agriculture. In this hi-tech system, the system modeled monitors the yield using all the variables of the soil and plant such as sunlight, temperature, humidity, and more often than not, automating the entire agricultural process.

Precision agricultural services as seen by Khattab, (2016), provides avenue to

- Combat infectious diseases at the right time by applying the correct forms and quantities of fungicides, pesticides and organic fertilizers.
- Efficient water consumption can be accomplished by watering the plants with only the correct amount of water and the right time.

- Reduce environmental harm by knowing when to spray a pesticide not only contributes to the successful killing of harmful pests, but also decreases pesticide usage.
- Produce high-value production of agriculture by growing crops that are non-toxic, safe and healthy.

The efficient, effective and productivity of many methods of agricultural production can be increased by using the wireless sensor networks in monitoring the soil system. Real-time climate/weather data can be obtained from the fields remotely and passed to a computer system where it processed and the information obtained will show the problems identified on the field. The data and the information are stored for immediate or future actions. This method is not in tandem with conventional methods of agriculture in which decisions are taken on the basis of certain cultural or historical believed.

Statement of the Problem

Due to continuous and persistent farming on a land, the soil nutrients depreciate and this affect subsequent yield of the land, in applying nutrient for the next planting season this is either overdone or under done due to non scientific methods and approach used. for food sufficiency and to ensure farmers have adequate returns for their efforts, a more technological approach to determine suitability of soil for a particular crop and to continue to monitor the soil for greater yield is of essence, there is therefore a need to develop and deploy an efficient system that is both scalable, optimal and cross-platform in the field of agriculture especially soil monitoring in order to increase overall performance and keep the farmer abreast on the general performance of the farmland. This system will ensure food sufficiency and reduce our dependence on foreign nations for food and ultimately make us a food exporting nation, thus increasing the nation Gross domestic product (gdp)

Aim and Objectives

The aim of this dissertation is to implement an IoT based smart monitoring system for precision

The specific objectives include:

I. To design monitoring modules (temperature, moisture and PH) for precision agriculture.

II. To implement the design in I above.

III. To Evaluate the precision system

Methodology

In order to achieve the objectives highlighted above, the following procedures were adopted

i. The proposed system was developed using Arduino based Microcontroller, temperature sensor, humidity sensor and Ph sensor.

ii. C++ was used as an interface with the Graphical User Interface (GUI) of the blynk platform.

iii. The minimum and maximum threshold for all the sensors was set in the C++ program

iv. The system was evaluated by comparing the amount of water used and the yield on the monitored field and the field watered traditionally.

Scope and Limitation

The scope of this work is the design and implementation of a smart IoT irrigation system that controls and monitors the irrigation of cultivation over the internet with respect to its soil moisture, temperature and PH.

SMART SYSTEM

Smart system combines sensing, actuation and control functions to efficiently interpret and identify any given situation, then makes decisions in an adaptive or predictive manner from the information deduced from the data, thus acting autonomously. Many smart systems evolved from Microsystems, integrating micro system engineering technologies and components such as reduced electrical, mechanical, optical and fluidic devices with other disciplines such as biology, chemistry, cognitive sciences.

Smart systems address economic challenges, societal, environmental like climate change, limited resources, population ageing, and globalization. There use cut across different sectors like automotive sector, Internet of Things, healthcare sector, among others for these reasons.

PRECISION AGRICULTURE OR SMART FARMING

The implementation of modern technologies or ICT applications such as geo-positioning systems, the Internet of Things (IoT), sensors and actuators, precision devices, Big Data, Unmanned Aerial Vehicles (UAVs, drones), robots, etc. to agricultural systems, leading to "Third Green Revolution" **"***which is a set of research technology transfer initiatives occurring between 1950 and the late 1960s, that increased agricultural production worldwide, particularly in the developing world, beginning most markedly in the late 1960s, the initiatives resulted in the adoption of new technologies*(Green Revolution)*"*.

Smart Farming can lead to a higher production and effective crop and livestock farming based on a more scientific and result oriented approach.

Precision Farming provides farmers with many advantages and principles in the form of better decision-making and more productive process and management operations. Precision agriculture is analogous to three interconnected technologies in this respect, which are:

Management Information Systems: This is the collection of data and processing it to obtain information for decision making, coordination and control in the effective management of farm process.

Precision Agriculture: Decision Support Systems (DSS) are used for farm management in order to maximize returns on inputs with limited resources. It is made possible by integrating the use of different technologies, including GPS, GNSS, aerial photos by drones, which are used to map the spatial variation of all variables (e.g. soil nutrient, moisture, acidity, nitrogen level, the expected crop yield).

Agricultural automation and robots: This process involve applying robots, automatic process control using AI techniques at all levels of planting ,monitoring and harvesting in crop production and rearing of livestock.

Justification/Significance of the Research

The global population is estimated to reach 10 billion by 2050 is posing a challenge already as to the issue of sustainability. Amidst this conundrum is also the issue of extreme and unfavorable climatic conditions due to a rising climate change problem and a negative impact it has on the environment arising from traditional and rigorous cultivation of the land intensive and stern abuse of the land. Food demand is also increasing and for practitioners to meet up with this projected teeming population, a newer and smarter way of farming has to be deployed.

Theoretical Framework and Review of Related Works

In the agricultural domain, as noted by Rajeswari, (2018), IoT plays a major role in the development and growth of a nation's agricultural, ecological and economic conditions, particularly those that tend to modernize the agricultural systems, the quantity of resources deployed to the plantation and the field experiments are use to provide the information required to aid efficient farming and to highlight appropriate management and effective procedures. Decision Support Systems (DSSs) have been previously used to generate information about pest attack, control and management. The systems rarely use sophisticated techniques for data processing. As a result of this, the use or deployment of smart agricultural techniques or concepts to take the decisions for such systems is an effort in the right direction.

In the meantime Sanjay D. Sawaitul et al. (2012) proposed a new way to characterize and predict future weather using the Back Propagation Algorithm and climate parameters such as wind speed, wind direction, precipitation intensity, weather temperature and weather forecast data. To forecast the weather conditions, the researchers applied three models. A model was used to gather weather forecasting techniques, another model implemented the Data Collection Wireless Sensor Network Tool Kit, and the last model used the Back Propagation Algorithm that was applied to different climate variables.

In another development Jagielska, et al (2012), a way of predicting expected harvest using the theory of fuzzy set and probability theory has been postulated. The hopes of the farmer and the yield expected are based solely on the prevailing conditions.

In addition, Ramesh D et al (2015) suggested a study of crop yields using data mining techniques in their research work. Statistics was collected in India (East Godavari district) over a period between 1965 to 2010. The data collected are the year, the amount of rain, the location of the plant and the yield. Multiple Linear Regression (MLR) and K-Map techniques have been used to forecast crop yields based on rainfall intensity or number. This model was reportedly used and it achieved higher accuracy and predicted yield of the crop was equally high.

The authors in Veenadhari.S et al, (2011) projected in their research work “Agricultural field using decision tree algorithm”. The soybean crop productivity yield was increased using the algorithm. Using Naves Bayes classification algorithm for the prediction which was predicated on weather (temperature and rainfall) conditions

In another similar initiative Wen-Yaw Chung et al, (2013) merged both cloud technology and wireless sensor network to track and collect data such as farmland temperature, humidity, pH quality. The sensor nodes were used to collect the data faster. It comprises the hardware and smart devices which has capacity to store adequate data and they are use for monitoring from remote location through the cloud service.

Hemlata Channe, *et al* (2015) They stored the data of the land, farmers, merchants in Agro cloud and it has an e-governance support platform. The various prices of agric product used are stored in the cloud. They used the Beagle black bone sensor tool kit to collect samples of the soil, environmental properties and attributes. Data mining techniques were further for predicting the outcome.

Duncan Waga, (2014) described in their work in the "cloud computing based environmental factors". The cloud computing analysis was found to have taken prominent role in agric sub sector. It assists the farmers to have easy access to information. The private cloud is used for both storage and retrieval of the data and information. The services of the HDFS being flexible were both used to distribute and efficiently collect and aggregate the data. Performance, capacity, and scaling which are the challenges of using big data and cloud were adequately taken care of. Rainfall temperature and wind were the parameters used.

Rao et al. (2013) noted that together IoT and cloud computing are addressing big data challenges. He found the cloud-based sensing platform which use few applications such as tracking agro eco system. A new prototype system was introduced to provide the sensing information as a cloud service. Wireless Sensor Network allows applications and services to communicate with the physical world more and more. Such services can be situated from the sensing network across the Internet. Using big data technologies and cloud services technology, it is possible to store and analyze data. These can also be used to enhance cloud services' scalability and accessibility.

In their research Rajesh et al (2010) Agricultural sector, they incorporated sensor information as well as cloud computing techniques. Using the service-oriented architecture, the sensor node was integrated and managed, cloud computing software also made the data stored accessible to users. The sensor networks have been incorporated into cloud system and internet, by using the sensor network, industrial processes were also recorded, the information collected is essential for the industry, providing the data as soon as possible.

Rajesh Kumar G et al., (2015) were able to apply machine learning techniques in order to maximize crop yield rate. Emerging and new mobile computing technologies also aid in incorporating IoT, cloud base and big data analytics, mobile computing technologies also help in providing predictive results to the mobile phones of the farmer, this in itself accelerates the farming cycle by keeping the farmer updated about the quality of his goods, etc.

The further review of other related literatures and their theoretical frameworks will occur within the following heading: IoT, Precision agriculture, Application of IoT in precision agriculture, soil monitoring systems.

Internet of Things

Atzori et al (2010) identified IoT as being in three phases – the middleware referred to as internet-oriented, the sensors referred to as things-oriented and the knowledge referred to as semiconducting. This categorization is necessary because of the wide nature of the subject that cuts across different disciplines; IoT's merit can only be realized in an area that relates to the three categorizations. Cluster H. Sundmaeker, et al (2010) Things are active participants in enterprise, knowledge and social processes where they can engage and connect with each other and the environment through the sharing of environmentally sensitive data and information, while responding autonomously to real / physical world events and manipulating them through processes that activate behavior and build services with or without a direct human being.

"The IoT (Internet of Things) is a network of Internet enabled objects, together with web services that interact with these objects". The technologies behind the Internet of Things include Radio frequency identification (RFID), smart phones and sensors. The major aim behind the IoT is that almost all physical things that man uses in their day to day life can be made a computer which can be connected to the Internet. Whether this is feasible or not is an open discuss. To be more precise, these things do not become computers, but they can be embedded with small or micro computers. When this is done, they are referred to as smart thing; this is so because they can now be remotely operated more easily than things which have no element of a computer in them. Example tagging a commodity with a barcode in a supermarket makes it have a sense of smartness because a machine can easily read off the code attached to such a commodity. This is where the RFID technology comes in handy.

Internet of Things is define as – "The worldwide network of interconnected objects uniquely addressable based on standard communication protocols" (Gubbi, Buyya, & Marusic, n.d.). Radio waves are used to identify items in this technology Zhao, et al (2010) named this software as the next generation of bar codes RFID systems find application in many fields, real time object can be monitor using RFID to obtain vital information about their location and element status. Continuing with this line of thought, Zhao et al., (2010) identified that the early use of RFID include automated expressway toll collection, supply-chain management (for major distributors), prevention drugs counterfeiting) and for monitoring of patient in critical intensive unit. Mobile phones now comes with RFID.

According to Juniper Research (2015) "over 13.4 billion device were connected to the internet as part of IoT in 2015 and there is an expected increase by 185% to 38.5 billion devices by year 2020".

Application of IoT

Precision Agriculture

The general intent of precision agriculture according to Corwin D. L, (2003) “is to optimize crop production while minimizing detrimental environmental effects”. This idea was first conceived around the1980s, but the technological breakthrough did not come until the mid-1990s with the introduction of global positioning systems (GPS) and geographical information systems (GIS) technology. So it can be said that precision agriculture is driven by technologically breakthrough in other inter related areas. As the world population continues to explode, man is stared in the face with a major and undaunting challenge of meeting the world’s population food production demand, only a sustainable efficient and effective agricultural practice can guarantee this. Sustainable agriculture demand a precise balance between all factors of food production which include Land, Environment and Environmental Factors, natural use of available resources, impact analysis of the crop on the land and both macro and micro-economics. The major advantage of sustainable agriculture is to maximize profit for farmers and optimize food production and avoiding adverse effect of continuous wrongful use of the land.

Unarguably, the advent of Precision agriculture has led to gradually stands attaining sustainable agriculture. One can thus infer from the above that, the future of precision agriculture depend on the effectiveness, innovation, dynamic and continuous improvement and upgrading of the technology behind precision agriculture.

IoT has been well developed in agricultural precision, but only proprietary solutions are being introduced, leading to compatibility and synchronization problems between various devices Ojha T et al, (2015). Due to this Compatibility issues with connecting of such devices Masner, & Pavlík, (2016), this has resulted in the creation of numerous alliances focused on addressing compatibility issues and attempting to enforce their solution and general-use technologies Open Ag Data Alliance, (2016). In addition to commercial solutions, many community efforts are being made to exploit open source software and open hardware. Carrascosa-Mesas, et al, (2015).

An example of using open IoT software and hardware in agriculture is the Farm Bot project FarmBot, (2016), which aims to create an open-source automated precision farming machine for humanity.

Furthermore, precision agriculture also known and called precise farming is often describe the process of making the act of farming practice have less of human intervention which does lead to a more accurate measurement of all the factors that contributes to bumper harvest to be efficiently and effectively managed and controlled. This is achieved with the use of various IT devices such as sensors, actuators, robots or an automated process that combine various devices.

High-speed internet connectivity, mobile technology phones, global positioning systems (GPS) and geographic information systems (GIS) software for reliable and cheap satellite imagery and location identifiers are the innovations that have contributed immensely to the success reported in precision farming so far.

Precision farming is an example of the success of IoT technologies in the agricultural sub-sector and several other companies and organizations around the globe are interested in innovation. Crop Metrics for example, is an organization which focuses on providing modern and latest agronomic solutions for precision Farming especially in irrigation activities. Some of their product includes:

Optimization of Variable Rate Irrigation (VRI) ensures profitability on irrigated farmland with varied topography and soil conditions, improving overall field output while managing water use efficiently.

The soil moisture probe technology provides farmers with extensive guidance and support throughout the year and makes recommendations on how best to maximize farm water use for higher yield.

Drones in Agriculture

Technology has been very dynamic in recent time due mainly to more discoveries and innovation in IT, drones which were first deployed for where human access is restricted or dangerous places has now find use in agriculture. Farmers in large fields have incorporated drones as a means of monitoring and obtaining data from the field without necessarily having to traverse the field. To enhance various agricultural practices drones are now being deployed. Ground-based and Aerial based drones are used to collect assessment on crop growth, crop health, temperature, soil moisture, soil PH, irrigation, crop monitoring, pesticide spraying etc.

The advantages of using agricultural drones include field imaging to assess the growth and the health of the crop, integrated GIS mapping, ease of data collection and the capacity to increase yields based on intervention from the collected and analysed data. Encompassing strategic planning based on real-time data collected by the drone will ensure higher yield of the farm land than if the traditional method of farming is employed.

Multiple sensors connected to the drone are used for imaging, surveying and mapping of agric fields, the farmer collect the data and process it to obtain information. Valuable data are gathered with the help of the drone which can be flown at various altitudes for the desired ground observation.

Using the data collected by the drone, inference can drawn regarding the health of the plant, crop counting and crop yield prediction, crop growth measurement, mapping, irrigation water position mapping, scouting reports, stockpile measuring, chlorophyll detection, etc

"An agricultural drone is an unmanned aerial vehicle applied to farming in order to help increase crop production and monitor crop growth." The data collected by the drone include a multidimensional, wide spectral, thermal, and visual imagery during its flight and it has the capacity to land where it took off from, this is due to the flexibility in the program of the drone.

Livestock Monitoring

Industrial farmers may find wireless IoT applications useful to gather data about their flocks movement, destination, well-being, and health. This data helps the farmer to identify and locate injured or flocks with failing health for prompt attention and to isolate from the others, thus stopping any outbreak of infectious disease. Livestock monitoring apps reduces cost of labour because ranchers can use IoT-based sensors to find their cattle.

JMB North America, for example, is a company that also offers cow tracking tools to cattle farmers. One approach allows livestock owners to monitor pregnant cows and are about to give birth from the heifer, when their water breaks, a battery-powered sensor is expelled. It gives the farmer or rancher a description. The sensor helps farmers to be more concentrated in the time spent with heifers giving birth.

Smart Greenhouses

Smart greenhouses are Agricultural greenhouse production environments that both measures and control systems. Smart greenhouses in agriculture are classic examples of the application of IoT technology. Important temperature, humidity and soil signals are obtained in real time during the agricultural production process, which is transmitted by wireless networks via M2 M (machine-to-machine) support system. It is necessary to obtain data on the agricultural production environment in real time using SMS (Short Messaging Service), internet, WAP (wireless application protocol) prototype, so that the terminal can master the information to guide the production process.

Greenhouse agriculture is a process that helps to increase the production of vegetables, fruits, grains, etc. Greenhouses use manual intervention or a proportional control mechanism to control the environmental parameters, Such approaches are less successful because manual interference results in loss of productivity, loss of resources and labor costs. With the aid of IoT, a smart greenhouse can be designed; this model tracks and regulates the environment intelligently, removing the need for manual intervention. Different sensors that calculate environmental parameters are used to control the environment in a smart greenhouse according to the plant requirement. When linked to IoT, we can create a remote access to the device cloud server.

It reduces the need for manual control continuously. The cloud platform also allows greenhouse data processing and a control action is implemented. It reduces the need for manual control continuously. The cloud database also enables data processing within the greenhouse and applies a control action. A network connection, business link and support platform for M2 M can be integrated into its structure, Wire sensors can directly connect to the contact terminal and then communicate with the support platform for M2M. Wireless sensors can communicate via Radio Frequency to the M2 M support platform, the network support platform management module can be added and the agricultural development monitoring system can receive real-time data from the greenhouse that can send information or signals via an SMS gateway to the mobile terminal.

The greenhouse IoT sensors can provide light, pressure, humidity, and temperature data. Such sensors will automatically activate the actuators by opening a window, switching on lights, controlling a heater, turning on or off a fan, all powered by a wireless (wireless) signal. These temperature and humidity sensors can be of different voltage ratings and measurements

METHODOLOGY

Soil Monitoring Systems

Agricultural companies were now processing not just crops, but also growing data volumes. Ruß and Brenning, (2010). Those data are site-specific, which is why GPS, agriculture and data combinations are called site-specific plant management (SSM). Such data often contain a large amount of information on soil and plant properties allowing for greater operational efficiency, which is why correct techniques are used to find this information.

Figure 1 below shows the relationship that exists between dew point temperature and relative humidity. The humidity levels has been shown in the form of percentages while the temperature is showed in both Celsius and Fahrenheit scales. Figures 2, 3, 4 on the other hand, shows sample pH, humidity and temperature sensors that can be used accordingly in monitoring the state of the soil.

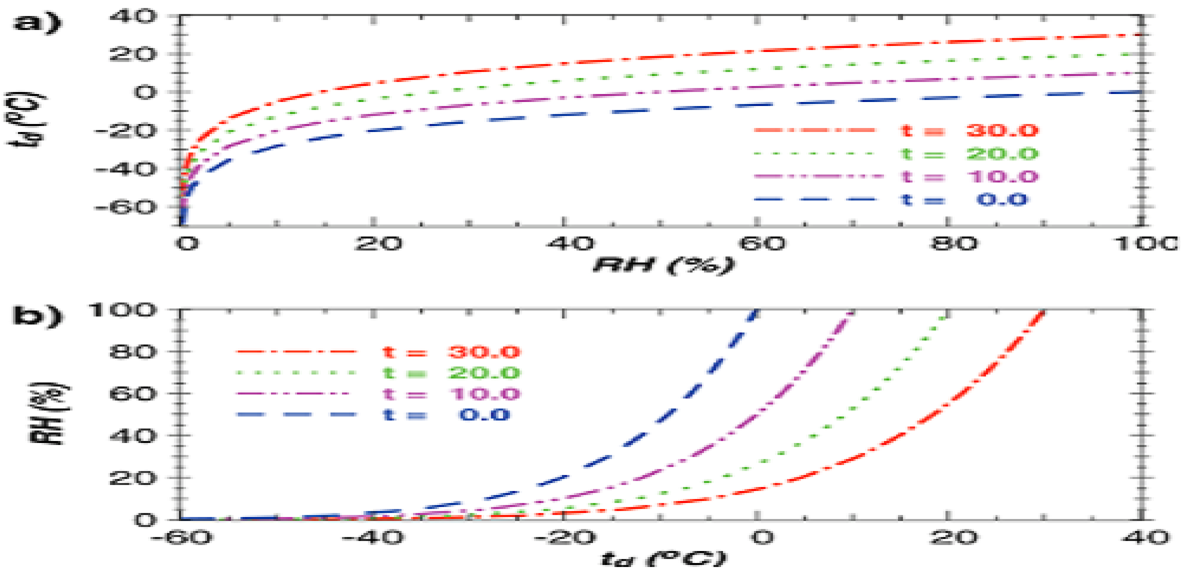


Figure 1: Relationship between dew point temperature and relative humidity (Shampa, 2018)

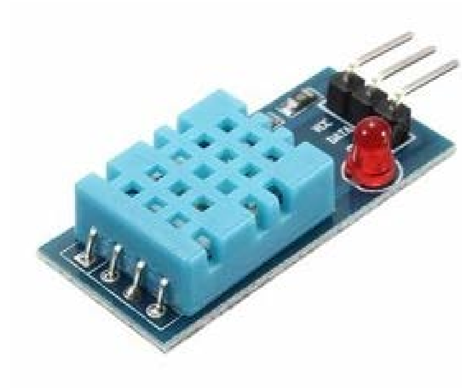


Figure 2: pH sensor Figure 3: Humidity sensor Figure 4: Temperature sensor

A pH sensor measures simply the hydrogen ion concentration in the soil Ananthi et al., (2017). It is used to indicate the presence of acidic or alkalinity content of the soil. The values ranges from 0-14. If the pH value is less than 7 (<7), it is acidic while a value greater than 7 (>7) shows it is base or alkaline.

This enables users to monitor the irrigation cycle through cellular technologies in more advanced systems such as the device described in Hari Ram V.V et al, (2015). The method proposed in Navarro-Hellín H. et al, (2015) is also using cellular technology to move the data of the sensors to a database system. While the proposed platform Sales N, et al,(2015) directs data through HTTP to a cloud service.

For a long time now, as stated by farmers and industry practitioners, soil testing practice has become widely accepted in agribusiness Ananthi et al., (2017). The obvious motivator for the keen interest in this soil testing activity was the varying potential for increased yield and overall gain. Soil test reports produced from these practices typically provide the consumer with acceptable recommendations for nitrogen, phosphorus, potassium and calcareous application of fertilizers. This soil test also allows the micronutrient needs of the crops to be calculated. Applying too little fertilizer could result in a lower yield, among many others, while, on the other hand, applying an excess of the same fertilizer would not only waste time and money, but also risk environmental damage due to nutrient runoff. Additional benefits to this method of soil monitoring include, but not limited to:

1. Increases productivity by recognizing soil nutrients or chemical factors that limit the growth of plants.
2. Protects the ecosystem by preventing problems with over fertilization
3. Increases the correct use of fertilizers by determining acceptable rates for different soils and crops
4. Identifies polluted and contaminated soils
5. Leads to an improved crop maturity and quality
6. Increased growth, disease and pest damage control
7. Increased yield reduced operating costs and enhanced environmental risk management practices.

A normal soil test practice generally includes, but not limited to, the assessment of available phosphorus (P), exchangeable potassium (K), calcium (Ca), and magnesium (Mg), their saturation levels, cat-ion exchange capability (CEC), pH, and lime specifications. In addition, several laboratories will track the consistency of organic matter (OM), salinity, nitrate, sulfate and other micronutrients

However, soil texture (clay, sand and silt), soil compaction, amount of moisture, and other physical and mechanical properties of soil influence the plant growth environment.

A number of researchers and producers have attempted to create soil sensors that track and quantify the physical, mechanical, and chemical soil properties. Such instruments are based on electrical and electromagnetic, optical and radiometric, electronic, acoustic, pneumatic and electrochemical measurement theories. Thus;

- Electrical and electromagnetic sensors measure the electrical resistivity, power or inductance of the measured soil.
- Electromagnetic waves are used by optical and radiometric detectors to measure the energy level absorbed / reflected by soil particles.
- Mechanical sensors measure the strengths of a device that is engaged with the ground.
- The sound produced by a tool interacting with soil is quantified by acoustic sensors.
- Pneumatic sensors test the ability to pump air into the ground.

- Using ion-selective membranes, electrochemical sensors produce a voltage output in response to selected ion activity (H^+, K^+, NO_3^-, Na^+, etc.).

Design architecture

The system design architecture of this project consists of four units, the power supply, the sensing/input unit, the processing Unit and the IoT platform.

The power supply unit

The system is powered by an external 24 volts DC adapter charger.

The sensing / input unit

This consists of soil moisture and soil temperature sensors that senses the soil parameters, these parameters serve as the input to the control unit.

The processing unit

This consists of an Arduino microcontroller integrated with wifi module ESP8266, this processes the data obtained by the sensors with respect to the program loaded in it through the Arduino IDE software. Also connected to the microcontroller is a DC water pump and the IoT platform which both serves as the outputs. Here, the program in the microcontroller is to compare the obtained sensors values with predefined values of threshold needed by the plant to control the switching of the pump, same time push the data to the IoT platformin real time for monitoring and control. This is the central processing unit of the whole design.

THE IoT PLATFORM

The platform used for the deployment of the project isBlynk IoT platform. The platform uses authentication code for connectivity. This has the features like the real time visual monitoring of the system over the internet, widgets to add controls send and receive commands from the system.

BLOCK DIAGRAM

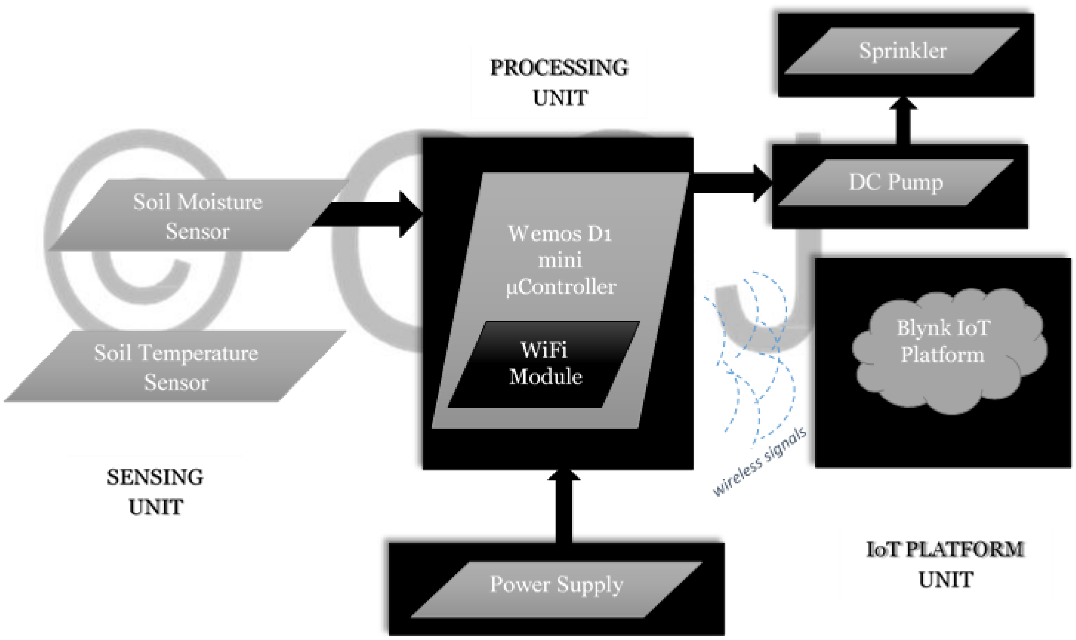


Fig. 3.3: Block Diagram

3.4 CIRCUIT DIAGRAM

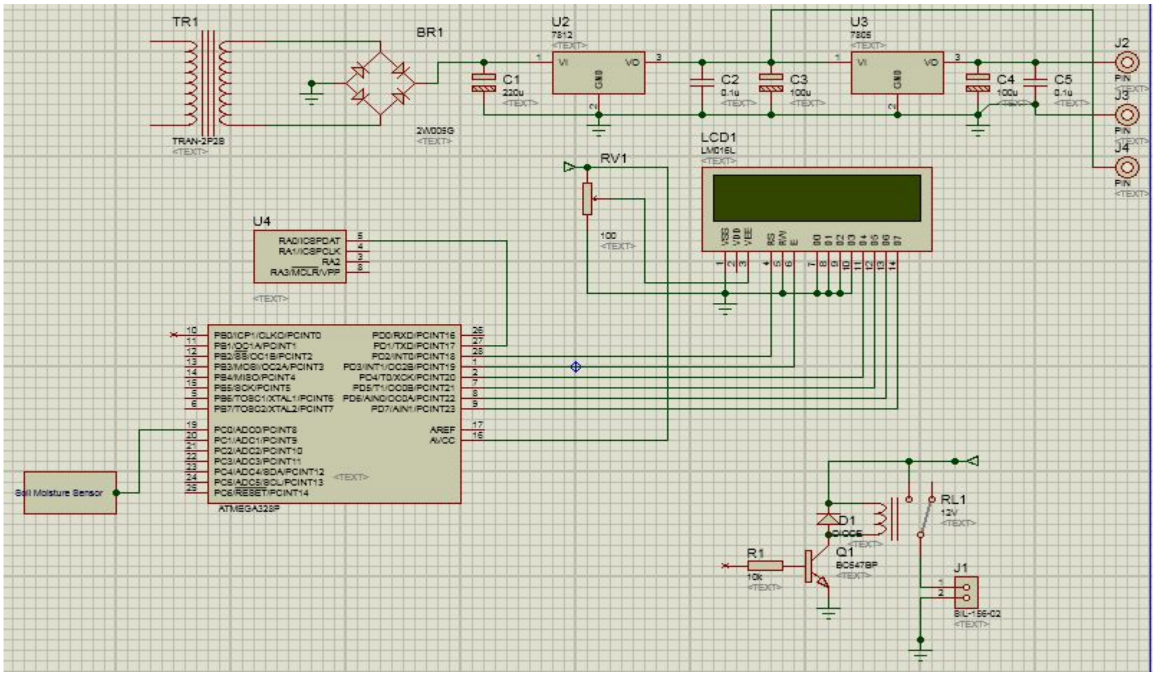


Fig. 3.4: Circuit Diagram with proteus

HARDWARE DESIGN

The hardware composition of the system includes the following:

- ➢ Bulk Converter
- ➢ Diode
- ➢ Relay
- ➢ Resistors
- ➢ Capacitor
- ➢ Transistor(Voltage regulator)
- ➢ Wemos D1 mini(ESP8266EX)
- ➢ Soil PH sensor
- ➢ Soil moisture sensor
- ➢ Soil temperature sensor
- ➢ 24Volts DC pump
- ➢ Sprinkler

DESCRIPTION OF COMPONENTS

RELAY

A relay is a device that is operated electrically. Most relays use an electromagnet to control a switch mechanically, but other operating concepts, such as solid-state relays, are also used. Relays are used when a circuit must be controlled by a separate low-power signal or multiple circuits must be controlled by a single signal.

Fig. 3.5: Relay

Wemos D1 mini (ESP8266EX)

This is a microcontroller and Wi-Fi module integrated device for processing of data and wireless connectivity.

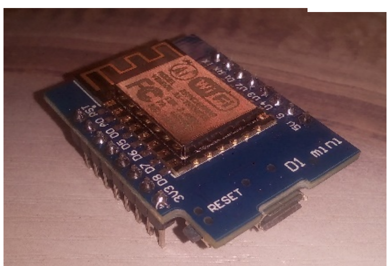
This is a miniature wireless 802.11 (Wifi) microcontroller development board that turns ESP8266 wireless microcontroller module into a full-fledged development board. This can be said to be a little Arduino with wifi, it's based around the ESP8266. It has 11 digital ports and 1 analogue port with a built in microUSB interface allowing it to be programmed directly from the Arduino IDE. It runs on voltages from 5V or 3.3V with Logic levels of 3.3V for all ports.

Microcontroller	**ESP-8266EX**
Operating Voltage	3.3V
Digital I/O Pins	11
Analog Input Pins	1(Max input: 3.2V)

Microcontroller	**ESP-8266EX**
Clock Speed	80MHz/160MHz
Flash	4M bytes
Length	34.2mm
Width	25.6mm
Weight	10g

Table 1.1: Wemos D1 mini (ESP 8266EX) Specification

Source: (RasPiO, 2018)

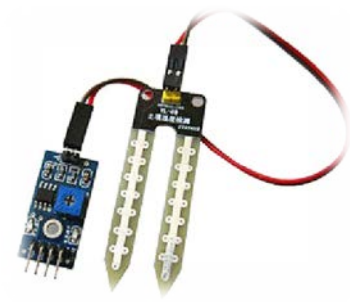


Arduino ESP 8266

Fig. 3.6:Wemos D1 mini (ESP8266EX)

SOIL MOISTURE SENSOR

Sensor for soil moisture tests the volumetric water content in soil. It is used to measure the soil's moisture content. If the sensor reads the soil moisture value above the threshold value, the digital output will be low level (0V), and if it is below the threshold level, the digital output will be high level (5V). The digital pin is used to read the current value of soil moisture directly to see whether or not it is above the threshold. Using a potentiometer, the threshold voltage can be regulated.



Soil Moisture Sensor ***Fig. 3.7: Soil Moisture Sensor***

DS18B20 SOIL TEMPERATURE SENSOR

This is a temperature sensor that is waterproof and usable when testing in wet conditions. The sensor is up to 125 ° C digital, the cable is wrapped in PVC, so it is recommended to be held below 100 ° C. It is digital, so even over long distances, signal loss does not occur. The DS18B20 offers temperature readings of up to 12-bit (configurable) over a single-wire interface, so that only one wire and ground must be attached from a central microcontroller. It can be used with up to 3.0-5.5V devices.

Fig. 3.8: Soil Temperature Sensor

DC PUMP

This is for the pumping of the irrigation water from its the source. A pump is a device or a system that by transfer fluids (liquids or gases). Pumps run and consume energy by some mechanism to do mechanical work in order to transfer the fluid. Pumps function in many sizes, from microscopic to large industrial pumps, through many sources of energy, including manual operation, electricity, generators or wind power.

Fig. 3.9: DC Pump

SPRINKLER

This is for the distribution of the irrigation water. This is a method for irrigating fields, lawns, parks, golf courses and so on. This is also used for refrigeration and to control dust in the air. Sprinkler irrigation is the mechanism by which water is distributed to look like actual rainfall in a monitored way. The water is pumped through an array of pumps, controlled by valves and sprinklers.

Fig. 3.10: Sprinkler

SOFTWAREDESIGN

ARDUINO IDE

This is Arduino Integrated Development Environment used for the programming of the microcontroller on the operation of the system.

The coding consists of:

- Reading Soil parameters from the sensors
- Defining threshold for the parameters

- Comparing the parameters to control the pump switch
- Opening connection to internet network
- Connecting to the IoT platform (Blynk) through authentication code generated from the IoT platform server.
- Pushing data to the IoT platform (Blynk) in real time

BLYNK ANDROID APPLICATION

This is the IoT platform used for the wireless control, management and monitoring of the system. It has a dashboard created and buttons and other widgets needed for the control of the system, arranged onto the screen. Pins turned on and displays data from sensors using the widgets. A user account was set up on the application and authentication code was generated to be able to connect the system hardware and the Blynk IoT platform. On the account, the system application interfaces were set up with the Blynk built-in widgets, the widgets present on the system interface are:

- Soil Temperature gauge to get data from the sensor pin
- Pump switch button to get data from the pump pin
- Soil moisture display to get data from the sensor pin
- Pump switch LED from the pump pin
- System power LED from the microcontroller voltage source
- System Operational graph (Soil temperature, Soil moisture, Pump on)

Preambles

Variations in ecological factors can affect average crop yield. Plants need some provisions for optimum healthy growth and development. It is particularly crucial to monitor the crop field condition so sensors are used. Temperature sensor-TMP007 is utilized; It measures the soil temperature values in real time, and the humidity sensor monitors the average water moisture in the agricultural field. IOT in Agriculture reveals the benefits of providing ICT in the agricultural sector, which reveals how local folk can replace part of traditional strategies. Experimenter modules are shown using different sensors for which field-sourced information is fed into. A sample of the system is made using Microcontroller Wemos D1 mini (ESP8266Ex)

Inside the integrated smart network, the controller is connected to all peripheral units (sensors and mechanical systems). Measurements are made from the sensors, analysis and operation of the electrical devices is thus provided. Appropriate soil moisture, optimum soil temperature and perfect humidity information are needed for proper operation of the device. Based on the plant property which grows in the field this knowledge will be entered into the system. For growing plant the soil humidity and soil temperature are determined separately. Drip irrigation system is used to regulate soil and surface temperature. As each plant uses different sensors, each plant's data on soil moisture and soil temperature can vary. To monitor irrigation the device requires a consistent temperature and humidity value. It's for this reason that the irrigation scheme is regulated by the average soil temperatures and the average soil moisture of all the plants concerned. The irrigation system works if the average soil humidity drops below the ideal soil humidity or if the average soil temperature reaches the ideal soil temperature. The pumping system is turned off when any of the soil moisture and soil temperature reaches the ideal value. When any of the soil humidity and soil temperature reaches the ideal value, the pumping system is turned off. Soil moisture and soil temperature are therefore best holding in place. Soil-related measurements are set between (6:00 a.m. to 8:00 a.m. and (5:00 a.m. to 7:00 a.m.) p.m which are appropriate time interval for watering the field. In this time cycle, measurements from soil temperature and sensors of soil moisture are taken into account at intervals of 2 minutes in order to reduce unnecessary rainfall.

Algorithm

The pseudo code provided in Algorithm 1 flips the pump on / off according to the soil moisture min and max value.

Algorithm 1 pumping algorithm

```
procedure PUMPING (time, mh, ml)
    read soil moisture sensors
    if (time between 06:00 and 08:00) or (time between 17:00 and 19:00) then
        for Every two minutes do
            avg ← the average of soil moisture
            if avg < ml then
                pumping system on
            else if avg>=mh then
            pumping system off
    else
break
```

The soil temperature information is collected every 30 minutes to avoid unexpected changes in temperature during the day between 8:00-20:00 and an average is produced, the soil temperature requirement for each crop varies accordingly; the average crop temperature used to track and enable the pumping system.

The pseudo code given in Algorithm 2 flips on/off the pump according to min and max soil temperature value. Where tx max. Soil temperature value, tm minimum soil temperature

Algorithm 2 pumping algorithm

```
procedure PUMPING (time, tx, tm)
    read soil temperature sensors
    if (time between 06:00 and 08:00) or (time between 17:00 and 19:00) then
        for Every thirty minutes do
            avg ← the average of soil temperature
            if avg > tx then
                pumping system on
            else if avg<= tm then
            pumping system off
    else
break
```


The precision Monitoring System is a mixture of hardware and software components. The hardware part includes embedded systems, IC, measuring instruments and the software program is the Arduino IDE, while C++ was also used to program the microcontroller to interface with the arduino. Temperature sensor, PIR sensor, and soil moisture sensor are the main instruments that are used. The data gathered with the aid of the sensors are sent to the UNO microcontroller at Arduino . The gathered information may be displayed in an Arduino screen. A GSM module is embedded in the Arduino this May be activated or not but when deployed it helps to facilitate passing information across to farm owners wherever they are.

Figure 4.1 ***Hardware Implementation***

RESULTS

The various sensors are incorporated and used to collate temperature measurement, moisture measurement and PH measurement. The hardware is interfaced with all the sensors in the module. The hardware components are the microcontroller, buzzer, relay, ADC converter, GSM module and all the interfaced sensors.. The output shown below denotes the temperature and soil moisture condition.

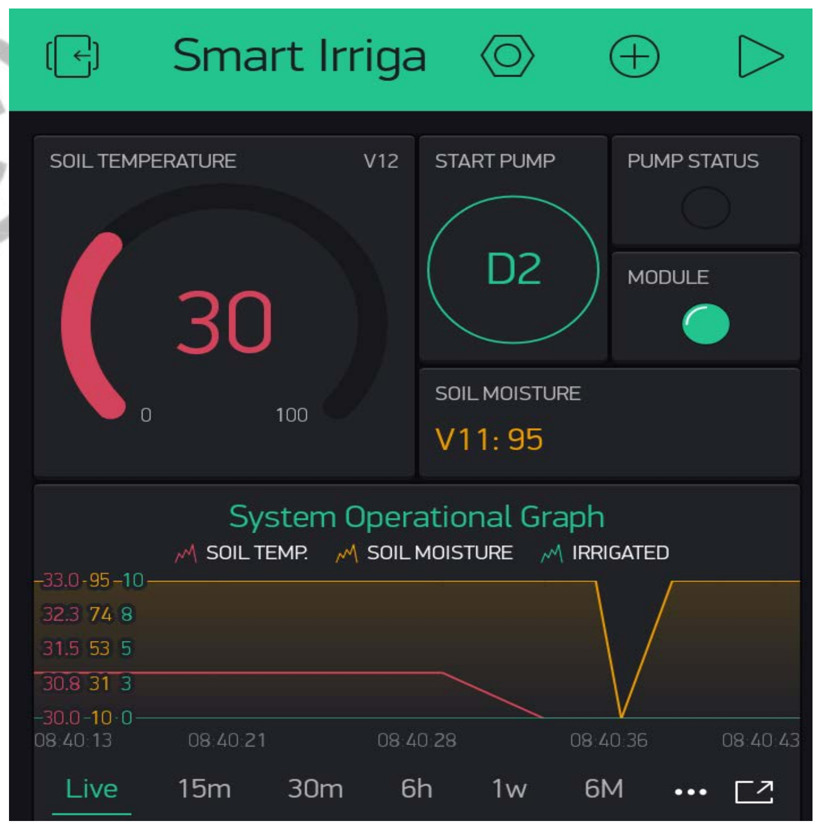


Figure 4.3 IoT Application Interface when System is off

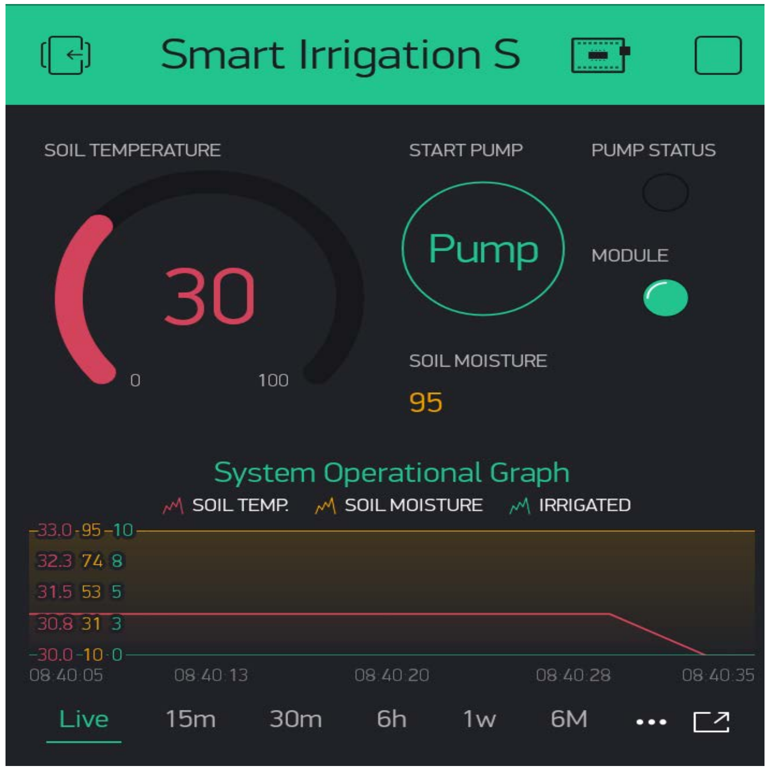


Figure 4.4 System's IoT Application Interface when soil moisture is high

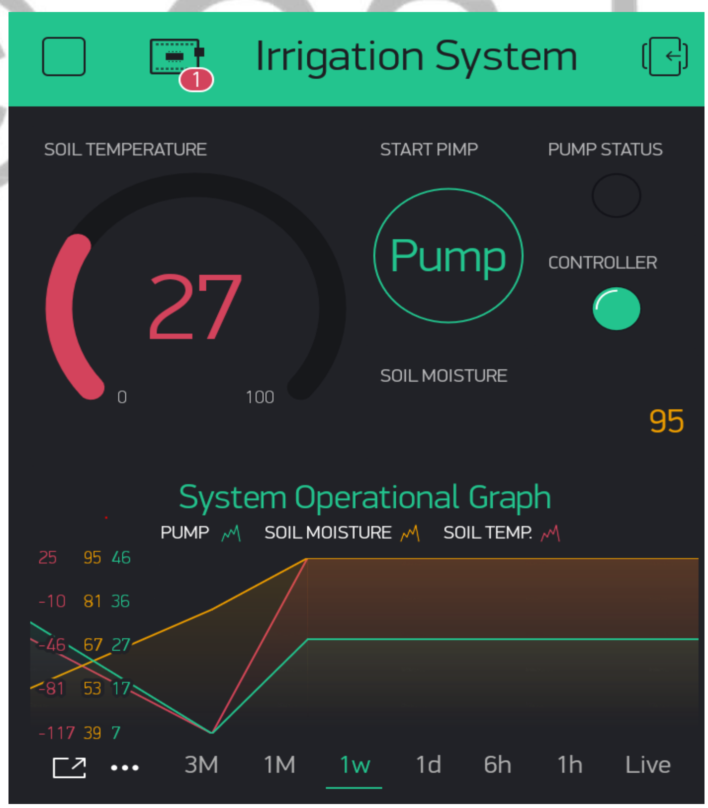


Figure 4.5 IoT platform interface of system when soil moisture is low and pump is On

The graphs in the Blynk IoT application above demonstrate the system's operation in real time and its data are derived from the system's sensors and microcontrollers. The left hands side (Vertical axis) showing the parameters (Soil temperature, Soil moisture, Pump status) values and the horizontal axis (base axis) showing the time of the system operation.

CONCLUSION AND RECOMMENDATIONS

The whole system will serve as a crop rapid intervention scheme for the farmer, because it will safeguard the crops by protecting them from very severe temperatures, excess water in the soil and too little or too much nutrient in the soil, thereby allowing the farmers to get optimum crop yield. This will also ultimately allow good use of water, as the amount of soil moisture varies from crop to crop and the soil moisture sensor will indeed be responsible for this.

Summary

The basic concept of the combination of the soil moisture sensor system, soil temperature sensor system and the PH sensor system is to place sensors in a representative part of the planting field and allowing the sensors to “sense” if there is sufficient moisture and nutrient in the soil for the plant and if the temperature of the soil will suite any particular crop. If there is enough water in the soil, the sensor will prevent the sprinkler system from activating and applying water. However, if the sensor senses that the soil is very low or the temperature of the soil is high, it allows pumping to take place. The Microcontroller based system monitors and controls all the activities of the sensors efficiently. The soil moisture and ambient temperature will be determined and the crop will be supplied with water accordingly which prevents water from being clogged in the soil. This system conserves water and energy because the water is fed directly to the root of the crop and it improves the crop quality. This also aims to save money, reduce human error in applying the available levels of soil moisture and increase their net income.

Conclusion

The IoT soil monitoring system was successfully designed and tested. It was developed through the integrated features of all the components used for the hardware. The location of each element was thought out and strategically positioned, thereby leading to the unit's better functionality. The humidity sensors measure the level of moisture (water content) of the soil. If the level of humidity is found to be below the target amount, the moisture sensor sends the signal to the IC (Microcontroller) to flip ON the Water Pump to supply water to the soil. When the desired moisture level is reached, the system is flip OFF on its own and the Water Pump is turned OFF Therefore, the whole system's performance has been carefully tested, and it is said to be operating effectively.

Recommendations

Development of this system for large acres of land can improve it for future developments. The system can also be integrated to check soil quality and crop growth in each soil. The sensors and microcontroller are interfaced successfully, and connectivity between different nodes was achieved. Both results and preliminary experiments show that this initiative is a complete solution to field operations and problems of irrigation. Implementing such a device in the field will certainly help increase crop yields and total production.

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