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Internet of Things based Smart Agriculture

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Abstract: *Agriculture has been the most important practice in human civilization. In an advanced agriculture the consumption of water is very high. Internet of Things (IoT) plays a crucial role in smart agriculture. This proposed work describes the automated system to make effective utilization of water resources and fertilizers. And this system also includes detection of animals and prevention of trees. This paper suggests an economical and easy to use microcontroller based automated irrigation system that utilizes the android smart phone for remote control. This paper presents a new agriculture monitoring system based on WSNs (Wireless Sensor Networks) and the data's are transmitted through IoT. WSNs collect sensor data periodically to the controller, process and store historical data, which could facilitate clients and experts in agriculture to monitor the conditions in the field. The purpose of the experiment is to find better ways of automatic controlling and monitoring an irrigation system and manual control by smart phone. The system is proposed using embedded systems, MPLAB and PROTEUS software. The detailed monitoring and control strategy of a smart irrigation and smart controlling system are demonstrated in this paper.*

Keyword: *Embedded systems, Smart Irrigation system, Smart Controlling system, Wireless sensor networks, sensors.*

1. INTRODUCTION

The Agriculture is the backbone of Indian economy. Agriculture aims to provide good quality and high yield with less labor on required lands. Agriculture makes the good use of the soil, fertilizers, climate and biological potential of fields to provide a controllable and suitable environment for plants so as to increase the productivity. In India, around 70% of the population earns its livelihood from agriculture. Manual collection of data provides variations from incorrect measurement taking. Wireless distinct sensor nodes can reduce time and effort required for monitoring the environment. We can reduce a lot of manual work in the field of agriculture using automation [1-2].

IoT (Internet of things) is a shared network of objects and things which can interact each other provided with the internet connection and widely used in connecting devices and collecting data information. By using IoT we can expect the increase in production with low cost by monitoring and controlling the efficiency of the soil, fertilizer efficiency, monitoring storage capacity of water tanks and also theft detection and animal detection in agriculture areas. The most important things of smart farming are environmental measurements and water management. The combination of traditional methods with latest technology as Internet of Things and wireless Sensor

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Networks can lead to agricultural modernization. These sensors are small in size, low-cost, low-power, collaborative and allow random development, which ensures a large range of applications in agriculture monitoring system. The system design consists of soil moisture sensor, pH sensor, water flow sensor, PIR sensor and a microphone.

2. EXISTING SYSTEM

2.1 Experimental Investigation of Remote Control via Android Smart Phone of Arduino-Based Automated Irrigation System Using Moisture Sensor

The system goal of the system suggests an easy-to-use arduino based automated irrigation method that utilizes the android smart phone for remote control of agriculture. The system design consists of a soil moisture sensor that provides a voltage signal proportional to the moisture content in the soil which is compared with a threshold value of various soils and specific crops. Arduino is linked wirelessly via the HC-05 module to an android smart phone from the arduino the output is displayed on the user interface (UI).The UI in the android smart phone allows the user for easy remote control of the irrigation system that involves switching on and off of the drive motor by the arduino, wired to its controller, based on commands from the android smart phone [3].

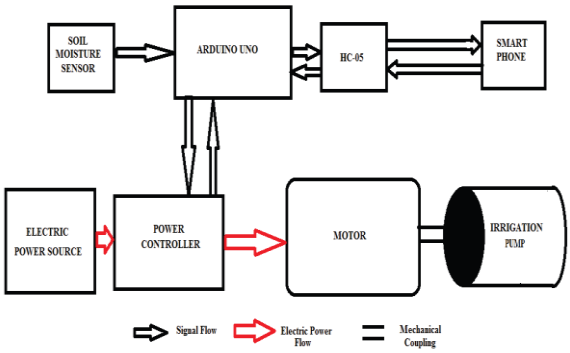

Figure 1 Arduino-based automated irrigation system using moisture sensor.

The contamination of air, water and other fundamental component elements of the earth's ecosystem have potential to alter the balance of nature in a negative manner. The objective is to provide an implementable design of a relatively economical, simple and easy-to-use automated irrigation system that also has remote control. An Arduino-based automated irrigation system that involves switching the irrigation drive as per the real time data provided by soil moisture sensor has been proposed. The automation and wireless communication controls that switch the drive have been successfully tested on a laboratory prototype. With some improvisations the proposed system can be used in the real time precision agriculture application.

2.2 A new agriculture monitoring system based on WSNs

This paper presents a new agriculture monitoring system based on WSN (Wireless sensor networks) with IP camera. By using IP cameras the system can be controlled remotely to have close vision of crops in the field. It collects sensor data periodically to the control center (microcontroller), process the data and store historical data for future use. An agriculture environment monitoring system includes control, transmission, data processing and management. Remote sensors should be able to self-organized and sends data stably and periodically to the controller. Traditional WSNs monitoring system only focused on environmental parameters, such as temperature and humility, we integrated video information and environmental data. An agricultural environment monitoring system includes data acquisition, transmission and management. Sensors technologies provide convince opportunities to data acquisition.

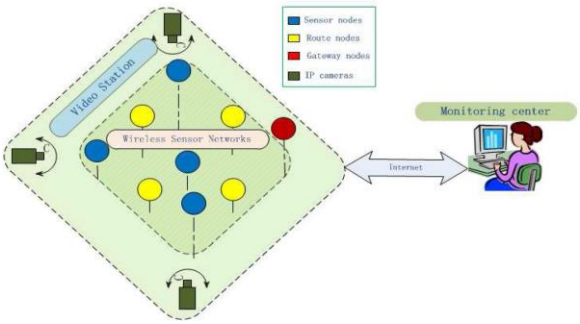

Figure 2 Agriculture monitoring system based on WSNs.

Large amount of sensor can be deployed in the environment to collect environmental parameters and send them to the users through wireless data communication. Sensors are small in size, low-cost, low power, collaborative and allow random deployment, which ensure a large range of application in environment monitoring systems. In this system a new agriculture monitoring system based on WSNs is designed consisting of three layers: the top layer is the monitoring section, it collects all data and displays the output to the screen [4]. The middle layer consists of several spatial stations, which includes IP cameras and gateway nodes. And the lower layer is the wireless sensor network layer made up of sensor nodes and routing nodes. The system is designed not only to monitor the agriculture field, but also to integrate video monitoring technologies.

2.3 Sustainable Agriculture Using Eco-Friendly and Energy Efficient Sensor Technology

Climate change will have a huge impact on agriculture which includes floods, extreme weather conditions, intense storms and heat waves, water shortage

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in certain parts of the world. The sustainable agriculture supports careful management and cultivation of crops involving less use of fertilizers, pesticides, calculated use of precious natural resources like energy, water through controlled irrigation practices with the help of sensor technology and electronic control systems. An algorithm formulated with the threshold values of sensor outputs is used to code the microcontroller which performs the required actions. Agricultural progress is important not just to feed the increasing population but also to provide raw materials to industries and back the development of other sectors. Hence it must be understood that industrial and agricultural developments are not alternatives, but complementary to each other in the path to achieve food security.

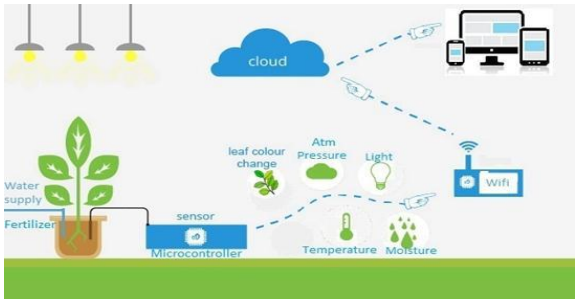

Figure 3 Sustainable agriculture using sensor technology

This system aims at conserving energy and water by using drip irrigation method and to monitor and control the plants by maintaining the optimum temperature and light intensity. Different sensors like soil moisture, temperature, pressure, humidity, light sensors are used in this system. The input and output devices includes the light, soil moisture, pressure, temperature and color sensors, led grow lights, relays to control valves and sprinklers, Wi-Fi module to send required data to web server via internet. A safety threshold value is maintained to protect the plants. The cloud based user friendly interface facilitate real time data logging of environment parameters which also supporting analysis of past statistics for future growth by means of a web based customized application. The sensor senses the change and microcontroller reads this from the data at its input port. The system will lessen labor, conserve water, and increase crop yield produce maximum automation.

2.4 Wireless sensor based control system in agriculture field

This system describes the automated system to make effective utilization of water resources for agriculture and crop growth monitoring using GSM. The effective utilization of drip irrigation process is improved by using the signals obtained from soil moisture sensor [5]. The output signals of the sensors are coordinate by the microcontroller and transmitted to the user with the help of GSM modem. Irrigation is the process of artificially supplying water to land where crops are cultivated. The optimized water use for an agriculture crops has been achieved successfully by this system. In Conventional water irrigation system the wastage of water is very high. Therefore, the conventional method can be replaced by drip irrigation technology. This technology advancement is possible to design systems eradicate the direct involvement of the cultivator with respect to irrigation of their fields. The GSM facility servers as an important part for controlling the drip irrigation which sending the information to the cultivator using SMS to a mobile device.

Figure 4 Hardware circuit set up of system and message to the cultivator to turn on the system.

In this system ARM core processor is act as a central processing unit. Moisture condition of this soil is measured by using sensors. ON and OFF status of the pump used in this system is controlled by the system depending upon the requirements of crops. This paper proposes the design of the innovative GSM based remote controlled embedded system for irrigation. The system is a low cost system where information is exchange via SMS on GSM network. The ZigBee device can future be attached with the camera module that can be placed in different locations of fields to take the snapshots of the plant at predefined intervals of time [6]. The snapshots can be used by the farmer to monitor the growth of the plant and also can control

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the population of the pests that may be growing symbiotically with the crop by applying proper pesticides. The fertilizers and pesticides can also be stirred and send through the pipe or sprayer.

2.5Mobile integrated smart irrigation management and monitoring system using IoT

Tradition methods that are used for irrigation, such as overhead sprinkler and flood type, is not that much efficient. An automated irrigation system is essential for conservation of the water and indirectly viability of the farm since it is an important commodity. In automation system water availability to crop is monitoring through sensors and as per the need watering is done through the controlled irrigation. The idea is to focus on parameters such as temperature and soil moisture .This is a system based on application controlled monitoring system. The main objective of this project is to control the water supply and monitor the plants through a Smartphone.

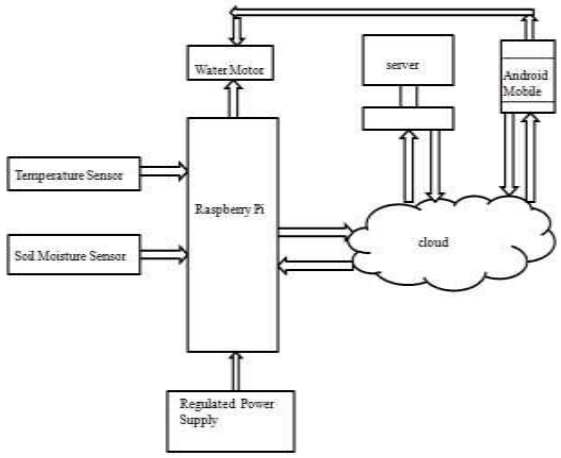

Figure 5 Smart Irrigation management using IOT.

Irrigation requirements depend on soil properties like moisture and temperature and type of crop which is grown in the soil. Technologies have been developed for efficient use of water for irrigation purpose. To control and monitor the irrigation process, smart and automated irrigation system is developed, implemented and tested [7]. There is a need for automated irrigation system because it is simple and easy to install. This system uses values ON and OFF to control water motor. This proposed automated irrigation and monitoring system consists of the raspberry pi, water pump, and moisture and temperature sensors. The crops or plant are irrigated with respect to the water requirements at different stages of their growth. The smart phone is connected to raspberry pi through Bluetooth. The motor is controlled by the smart phone by the values ON and OFF. The primary application for should be done and would develop the system to more mature state [10].

3. PROPOSED SYSTEM

The design of agriculture automation is designed with PIC16F877A microcontroller which has to be built along with specifying requirements. The resource necessary to produce crops is reducing rapidly. The people who are disabled cannot work properly; found it difficult to cope with production of crops. Even people far from their field are unable to monitor their crops. So, in the proposed work an automated agriculture system is designed which is able to:

- Monitor and control the irrigation system.
- Damage caused by predators can be reduced.
- Water conservation can be maintained.
- Increased productivity and high yield.
- Animal detection and theft (i.e., cutting of trees without the farmer's knowledge) can be prevented.

The block diagram of the proposed system is shown in the fig:

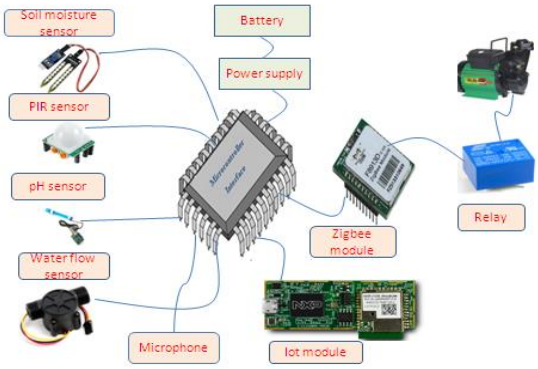

Figure 6 Block diagram of the proposed system

In the proposed system monitoring and controlling are done through sensors such as soil moisture sensor, PIR sensor, pH sensor, water flow sensor. To prevent tress, a microphone is used to record the sound of axe or other tools used for cutting of trees. Here the data is transmitted to the farmer's smart phone through IoT. In this system the data is being processed by PIC16F877A microcontroller. The Internet of Things is regarded as the third way of information technology after Internet and mobile communication network, which is characterized more through sense and measure.

The working of this proposed technique is illustrated as follows:

- The soil moisture sensor senses and measures the moisture level in the soil.
- The PIR sensor detects the animals and a high frequency sound signal is provided.
- The pH sensor and water flow sensor is used to optimize the fertilizer usage.

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- These data are processed and the optimum water level will be supplied to the field by automatically switching on the power supply to the water pump.
- These data will be transmitted to the user's mobile phone through Iot using a separate IP address for the given microcontroller which is programmed to send the data given by the sensor to the user through a web page showing the live condition of the field.

The proposed system uses internet of Things to automate the irrigation process. Soil moisture sensors are used to sense and measure the moisture content in the soil for optimize use of water. Moisture sensors are designed to estimate soil volumetric water content based on the dielectric constant of the soil.it uses a capacitance to measure the water content of the soil.

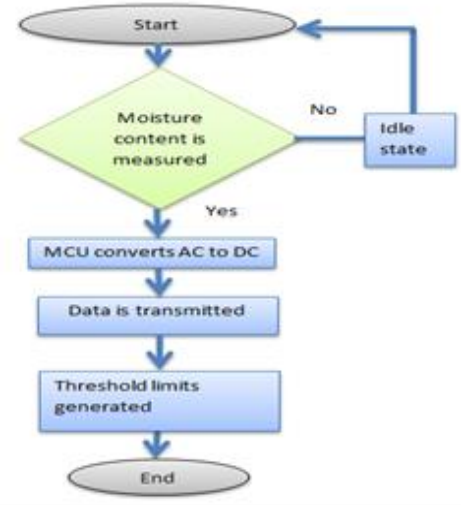

Figure 7 Flow diagram of soil moisture sensor

Simply inserting the sensor into the soil in which the moisture level to be tested and the volumetric water content of the soil will be shown. The data will be collected in microcontroller and it is sent to the database using Zigbee technology and is stored in the data base. These data's are used to analyze the water requirement for all kinds of crops grown in different climatic conditions. These data's are stored in the data base. After a period of time the system starts to irrigate the field on its own based on data collected. The moisture level in the soil every time will be compared with the data collected in the database. If there is any water requirement the system itself commands the pump to be turned ON to irrigate the part of the field. After the process is done, the pump will be turned OFF automatically. This helps the system to decide on whether to open or close the water valve and to decide the quantity to water to be supplied to the crops. In case of rain the automated irrigation system would be stopped in order to avoid over watering to crops and resumes after the rain stops. Sprinklers can be used to avoid wastage of water, but this is possible only for certain crops.

On the other hand excess use of fertilizers damages the crops. In the proposed system a flow sensor and pH sensors are used to control the usage of fertilizers in crops. Generally fertilizers like urea are mixed with water and fed to crops and plants. The fertilizers are mixed with water in assumption basis; this can cause damage to crops by not knowing the exact amount of fertilizers required for the crops. By using water flow sensor we can calculate the amount of water and amount to fertilizer's mixed with it in the flow. When the required amount of fertilizers fed to soil then the flow will be automatically kept OFF. Working flow of water flow sensor is shown in the fig 8.

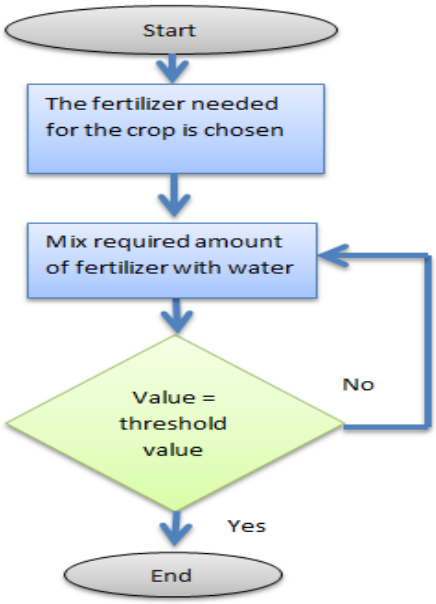

Figure 8 Flow diagram of water flow sensor

Fertilizing soil is very important to get the best crop yields. Because pH will affect the nutrients available in crops.it is important to check soil pH before and after adding any type of fertilizer pH sensor is used in the propped system to identify the three states: Acidic state, Basic state and the neutral state. Values below 7 are considered to be acidic, values above 7 are alkaline (the opposite of acidic that is basic), it contains more negatively charged hydroxide ions and 7 is neutral. pH is important for growing plants because we break down exactly what we need to know for nutrient rich soil and it influences how easily plants can take up nutrients from the soil. The data will be collected in the microcontroller and sent using Zigbee technology to the database and stored. Collected data will be compared every time with the stored data in the database. Flow of pH sensor is shown in the fig 9.

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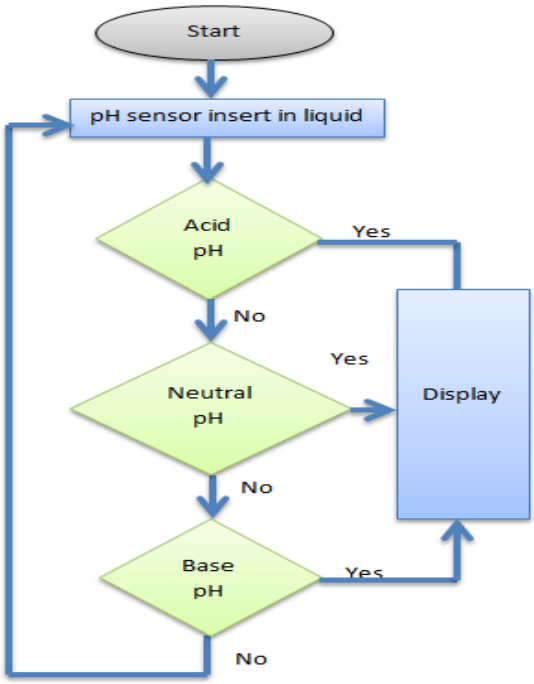

Figure 9 Flow diagram of pH sensor

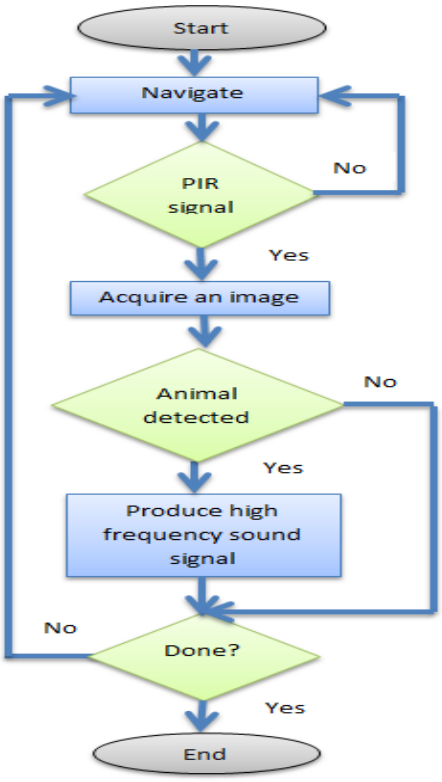

Figure 10 Flow diagram of PIR sensor

A PIR sensor abbreviated as "Passive Infrared" or sometimes called as PID (passive Infrared Detector).A PIR sensor is used to sense the movement of people, animal, or other objects. They emit infrared energy when there is any sudden increase in infrared energy; an alarm is sounded.in the proposed system PIR sensor is used for the detection of animals. When the animals are detected, the data will be programmed as PIR=1 and a high frequency sound signal will be generated to threaten the animal not to get into the field. If detected the message will be sent to the farmer's smart phone through Internet of Things technology. When the animal is detected the data will be collected in the controller unit and to the database using Zigbee technology. Working of PIR sensor is shown in the fig.10

The agriculture field includes samplings, plants, and trees. People far from field are unable to prevent their trees from theft .And for prevention of trees from cutting or theft without the farmer's knowledge, a microphone is kept in the field to record the sound of axe and other tree cutting tools. The sound will be programmed in the microcontroller and the data will be stored in the database. When the sound equivalent to the stored data is generated an alert will be sent to the farmer's smart phone and alarm will be set in the field to indicate theft or illegal act. The working flow of theft detection is shown in the fig 11.

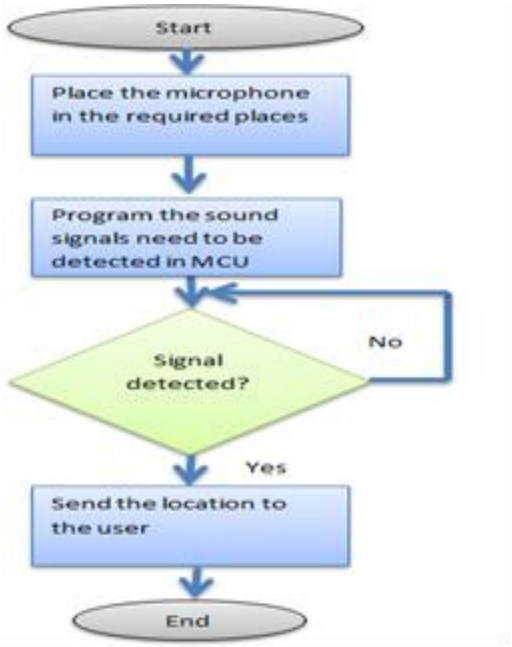

Figure 11 Flow diagram of Theft detection

4. MATERIALS AND METHODS

4.1 PIC Microcontroller

PIC is a family of microcontrollers made by Microchip technology and the microcontroller used in the proposed system is from PIC series. The acronym PIC stands for "Peripheral Interface Controller" or "Programmable Interface Controller".PIC microcontroller is the first RISC based microcontroller fabricated in

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CMOS (Complementary Metal Oxide Semiconductor) that uses separate bus for instruction and data allowing simultaneous access of program and data memory. A typical microcontroller includes a processor, memory and peripherals. It is a type of microcontroller component that is used in the development of electronics, computers, robotics and similar devices.

PIC16F877A consists of five ports such as Port A, Port B, Port C, Port D, Port E and the inputs are connected to the required ports. It has an inbuilt analog to digital converter. Technology that is used in PIC16F877 is flash technology, so that data is retained even when the power is switched off.

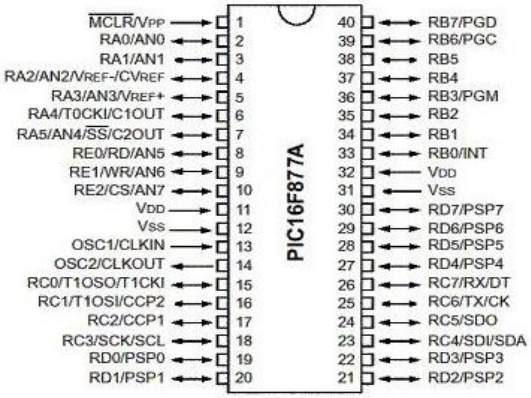

Figure 12 PIC Microcontroller

4.2 Soil moisture sensor

Soil moisture plays an important role in the development of weather patterns and agricultural applications. A soil moisture sensor measures the quantity of water contained in a material, such as soil on a volumetric basis. The soil moisture sensor is used to detect the data for requirement of water to the soil. It is used for automatic watering to the land. There are three pins: they are power supply, analog reading, ground connection. It has two pins to dip and check the moisture level [8-9].

In this proposed research soil moisture sensor is used to know the exact soil moisture conditions on their fields. This helps farmers to generally use less water to grow a crop; they are able to increase yields and the quality of the crop by improved management of soil moisture during critical plant growth stages.

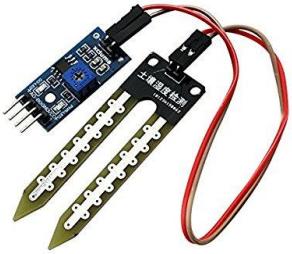

Figure 13 Soil moisture sensor.

4.3 PIR sensor

A passive infrared sensor measures infrared light radiating around objects in front of the sensor. The PIR sensor is an electronic sensor converts the resulting change in the incoming infrared radiation into the change in the output voltage, and this output voltage triggers the detection. In this proposed system Passive Infrared (PIR) sensors are used for the purpose of human and animal detection in the field. This is a type most commonly encountered in motion sensing.

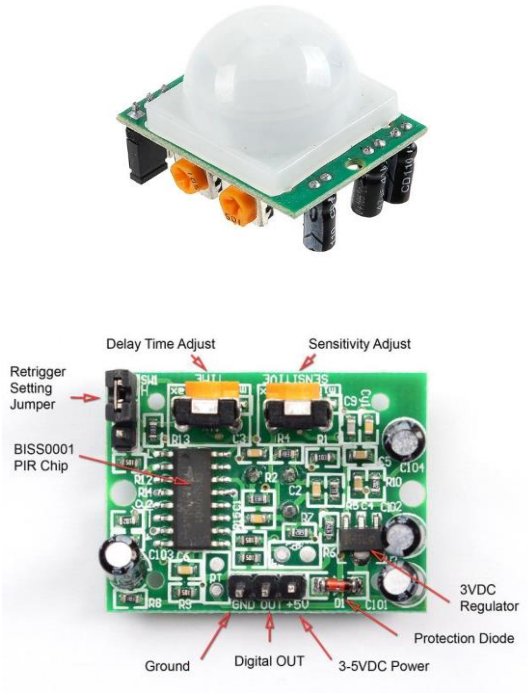

Figure 14 PIR sensor

They are commonly used in automatic door opening system, security alarm systems .PIR sensors are used as motion detectors in many applications such as Hospitals, grocery stores and libraries.

4.4pH sensor

pH is a measurement of acidic and basic in the substance. The higher the concentration of hydrogen ion, the more acidic the sample is and lowers the concentration of hydrogen ion, the more basic the sample is. Substance falls between pH0 and pH7. pH7 is completely neutral; neither it is acidic nor basic. Correct pH measurement is essential to ensure optimal plant growth and crop yield, because it allows nutrients to be freely available for plants to take in. Testing of pH of soil helps to determine what plants are best suited for that area. The pH meter is used in
many applications ranging from laboratory experimentation to quality control.

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Figure 15 pH sensor

In this proposed system pH sensors are used for soil, crop, and water testing in agriculture to achieve high quality produce from farming operation. The output can be digital or analog, and the device can be battery-powered or rely on line power. With pH sensor we can improve both the health and yield from our crops.

4.5 Water flow sensor

A water flow sensor consists of a plastic valve body, a water rotor, and a hall-effect sensor. When water flows through the rotor, rotor rolls. The speed of the flow sensor changes with different rate of flow. The hall-effect sensor outputs the corresponding pulse signal.

Figure 16 Water flow sensor

In the proposed system the water flow sensor is used to measure the amount of fertilizer mixed with water. Through this the farmers can get the exact scenario of fertilizers mixed with water and the usage of fertilizers can be optimized. There are different types of applications such as gas meter, chemicals, process auto-control, medical, food and beverages.

5. SIMULATION RESULT

Simulation results showing monitoring and controlling of moisture level and animal detection is shown below:

When soil moisture sensor value is less than the threshold value the water pump gets automatically ON and when the moisture level is greater then the threshold value the water pump gets automatically OFF. Fig 17 shows the automatic water pump ON output and Fig 18 shows the automatic water pump OFF output.

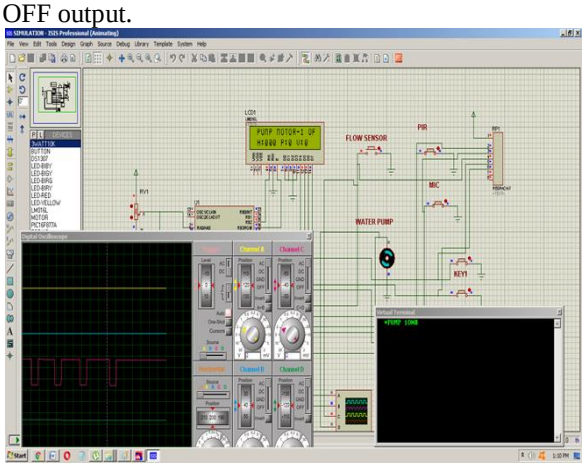

Figure 17 Simulation of automatic water pump ON.

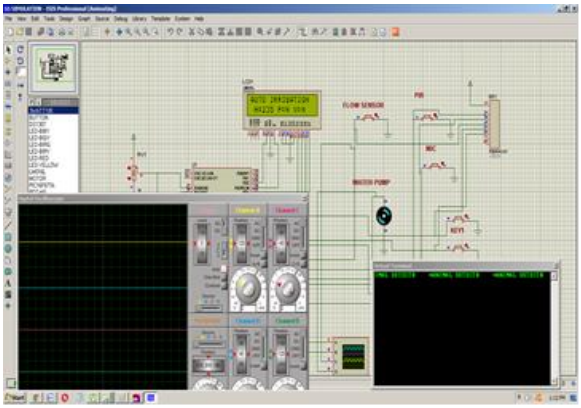

Figure 18 Simulation of automatic water pump OFF

The PIR sensor siganl is generated when the animal gets detected in the field and a high frequency sound signal is generated in the field.An alert message will be sent to the farmers smart phone.The simulation of animal detection is shown in the fig 18.

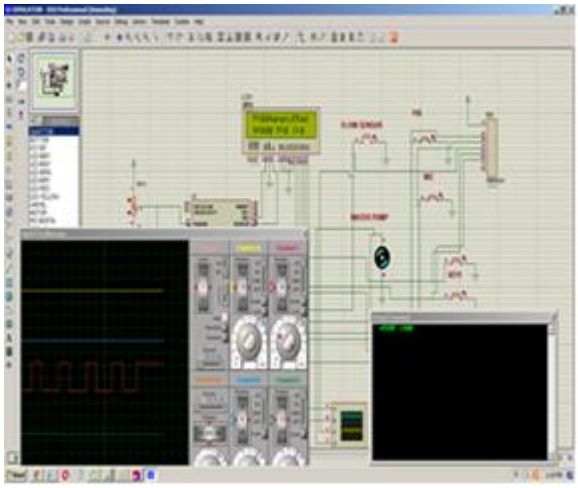

Figure 19 Simulation of animal detection.

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Data are transmitted to microcontroller through Zigbee. The farmer get the live condition of the field information through Internet of Things. The simulation of the message transmission is shown in the fig20.

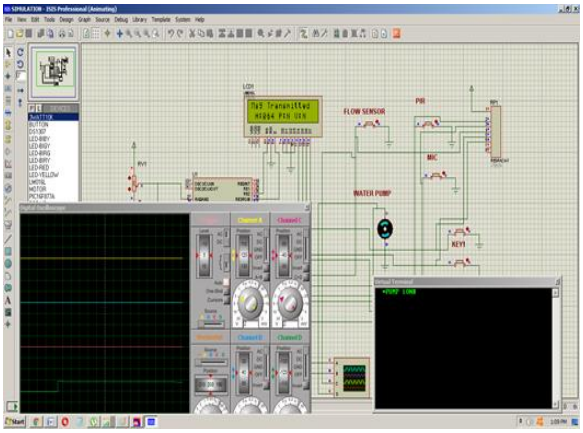

Figure 20 Simulation of message transmission.

6. CONCLUSION

After examining the survey papers on experimental investigation of remote control via android smart phone of arduino-based automated irrigation system using moisture sensor, A new agriculture monitoring system based on WSNs, Sustainable agriculture using eco-friendly and energy efficient sensor technology, wireless sensor based control system in agriculture field, Mobile integrated smart irrigation management and monitoring system using IoT is proposed. This system will alert the user by provides the information about the land. The future enhancements are given below:

- ❖ Irrigation system can be monitored and controlled.
- ❖ Damage in plants caused by fertilizers is reduced. Increased productivity.
- ❖ Water conservation.
- ❖ Detection of animal and prevention of trees.
- ❖ Both fully automatic and manual operations are possible.

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