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Interoperable Internet of Things platform for Smart Irrigation System using Solar Energy

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Abstract - *Agricultural zone is backbone of a country economy and agricultural depends upon population as population increases, uses of water and energy also increases. In automated Irrigation System continuous and real time monitoring of moisture content in the soil is very important. Now a day we know. It's very difficult to those farmers who is having wide cultivated areas, and do not have the proper mechanism of water Supply to the targeted areas of their fields due to lack of electricity or sometimes load-Shedding problem. Due to improper method of manually irrigation system, usually a lot of water, Time and power wastage occurs. To overcome the problem of load shedding or lack of electricity and water wastage in irrigation system. In this paper we proposed a solution which is Solar Power smart Irrigation system using Arduino Uno and a credit card size minicomputer known as Raspberry pi using multi_Sensor based on the internet of things. Solar power is the best choice in our country for use with irrigation systems. In our proposed system Solar Panel plays an important role, this solar panel converts the solar energy in to electrical energy, and a battery is used to save this energy for irrigation purposes. At daytime when the intensity of Sun light is maximum, the solar panel will absorb the energy of the sun and the energy will keep in the external DC battery. For the purpose of achieving maximum intensity of sun light, a light dependent resistor (LDR's) are insert on the solar panel. We have to maintain the face of solar panel perpendicular to sun to achieve maximum power. For tracking system LDR's and Servo motors are used. On the basis of the received signal from programed LDR's, the Servo motors rotates the panel accordingly. The Arduino Uno is programmed in such a way that detects the sunlight through the LDRs and then actuate the servo motors to rotate the solar panel to that area where it can receive maximum sunlight. For sensing the moisture condition of the soil, a Soil moisture sensor is used. On the Basis of sensors values, the required action will be taken automatically. When the sensor data is lower than or greater than the threshold value of the sensors, the flow of water will be started or stop automatically accordingly. We aim to save water from wastage, solve energy crisis, cutoff human intervention and improve utilization of resources.*

Key Words: *Arduino Uno, Raspberry pi, GUI, Light Dependent Resistors (LDR's), Soil moisture sensor, servo motors, Solar panel.*

1. INTRODUCTION

In Pakistan, agriculture plays a significant role to the country development and prosperity as our country economy depends upon agricultural. According to research due to rapid increase in population and also in food demands it uses 85% of fresh water all over the world. About 25% of the irrigated area of Pakistan is affected by water rises to surface level and acidity problems. The key factor for the agriculture is the supply of water on time and also in proper amount. But unfortunately, we do not have such an intelligent system to make efficient use of available agricultural resources due to uncertainty in rainfall, and also shortage of water in land or tank reservoirs.

In everyday life most of the physical's objects need to control over the web to perform their task. Smart irrigation system is an essential part of IOT's. IOT's is a grooming technology which has the capability to convert physical objects to smart one, using advanced technology such as Raspberry pi, sensors, GUI and actuators, and also perform the communication between the user and devices. Now a day's various irrigation systems [1] are used throughout the world to minimize dependency of rain. Due to the load-shedding or unavailability of electricity and poor management of water supply, in the manual irrigation system many times crops become damaged, due to over irrigation or under irrigation problems. The extraction of water from earth continuously, increase the ratio of un-Irrigated land. At present, farmer manually irrigates land at regular time, whether there is no need of watering the crops. Sometimes there comes a shortage of water resulting dried the crops. Similarly, this process sometimes requires more water and man power or sometimes the flow of water is much slow due to which water reaches late to the needed areas. Because of poor management of channels due to which the crops cannot give the desired results. So, to solve this problem solar power smart irrigation system is used. In this paper, we proposed a system which provides a graphical user interface (GUI) for controlling and monitoring the whole system. The farmer can access their field status through mobile phone or laptop from anywhere at any time resulting reducing the man power, and save time. Our system consists of mainly four nodes such as, aggregation node, actuator node, sensor node and user node. In the design system the sensor node senses the moisture content of the soil and sends the received data from Sensor node to Aggregation node via Bluetooth. The

Aggregation node will decide the action and send it to the actuator node and also update the user node as well as shown in figure (1). If the soil moisture sensor reading is less than the predefined value, the motor pump will be started automatically, and vice versa. The aim of implementing this system in fields is to observe accurate measurement, improve productivity, save water from wastage, reduce energy crisis and also cut down human intervention.

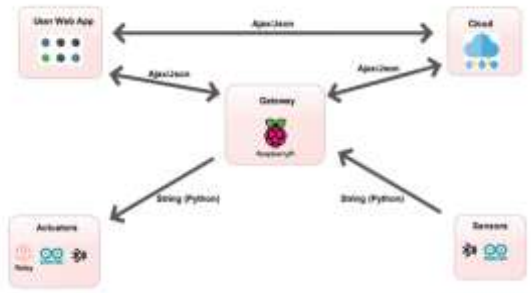

Fig (1.1)

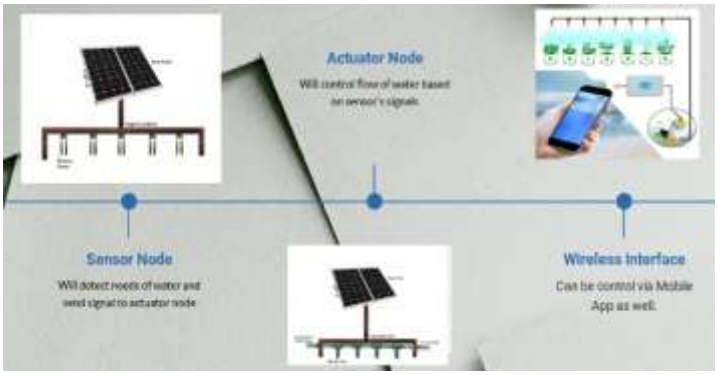

Fig (1.2)

For operation of the proposed system. The motor pump require energy for irrigation purposes. At present situation, due to lack of electricity we cannot achieve such smart irrigation system. The only solution to this problem is solar power. As we know that the sun is the major source of all forms of energy. In this model we use solar panel for converting solar energy in to electrical energy. We use light dependent resistors (LDR's) on the solar panel to achieve greater amount of energy. The rotation of solar panel in order to make the face of solar panel perpendicular to sun can be achieved via servo motors and LDR's. According to research the tracking system of solar panel increases power output of solar panel 30% to 60% than the ordinary system. In this paper, we propose an automated irrigation system based on solar energy. This solar energy is used to turn ON/OFF the motor pump for filling the water tank as shown in figure (1). A solenoid valve is used to start and stop the flow of water to the targeted areas of fields. The whole architecture of this system consists of Arduino Uno, Raspberry pi, Bluetooth module, Relays, solenoid valve and moisture sensor to monitor the rate of water supply from the water tank reservoir to the needed areas in the irrigation field which reduces the wastage of water and improve the quality and productivity of crops.

Fig (1.3)

2. Problem Definition

The distribution of water to those areas of field where water is needed is known as irrigation system. In today life, irrigation system is used in an agricultural field is to minimize dependency of rain. Agricultural plays very important role in a country economy. Our country economy is totally based on agricultural. There are many types of irrigation system which is used all over the world. Most of these systems are manual system or time-based irrigation systems. Such types of irrigation system sometime create many difficulties for farmers. In these types of systems water are applied for fixed interval, the fixed interval or time-based watering system leads to over or less irrigation than desired or requirements, and also it requires man power for monitoring which reduces the field efficiency. In manual Irrigation system Human interaction occurs for monitoring and controlling of water supply and also to check the productivity and quality of crop, so a lot of time and efforts is required. The main problem caused due to water shortage is [2] slowing down crop growth rate, late flowering and decreasing of the yield. Moreover, over irrigation to crops leads to damage the roots and also the plants, extra cost for farmer, wastage of time and water, and also increase the salinity of the soil. Electricity is required for the functioning of the designed irrigation system, to tackle the current energy crisis solar panel is essential for power generation. The main problem of fixed solar panel is that due to the rotation of the sun we cannot achieve maximum power from the sun as shown in figure (2).

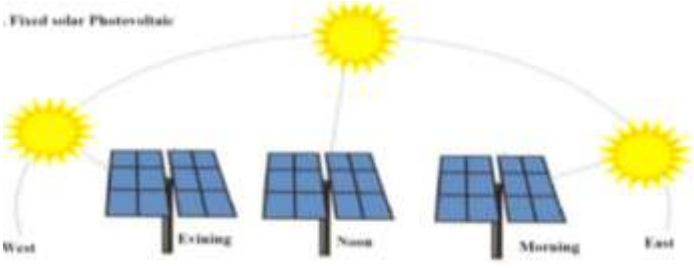

Fig (2.1) Fixed solar photovoltaic.

3. Related Work

We have concluded that Different systems have been designed for smart irrigation including sprinkle irrigation system, Drip irrigation system.

3.1) manual irrigation system: in manual irrigation system, water is supplied to crop using paths, and sand barriers by the farmers manually. Through this irrigation system the wastage of water and time occurs, along with human interaction.

3.2) Sprinkle irrigation system: in sprinkle irrigation system sprinklers is used for spraying the water in the form of small drops. Due to which the water cannot reach to the roots of the plant. This type of irrigation needs a lot of powers.

3.3) Drip irrigation system: This method consumes a lot of time, because water is supplied in a very low amount to the targeted areas.

In [3] designed a smart irrigation system using soil moisture sensor for detection of moisture content present in the soil. The flow of water to the needed areas is based on the received value from the sensor. This system does not provide the updates to farmers about the current status of the field.

In [4] proposed a system to measure the soil parameters such as Temperature, Humidity, moisture content and PH for getting high quality crop from soil. In this system, the turning of motor pump automatically was based on the received signal from the sensor. In this system the farmers have no access to check their fields and crops status.

In [5] proposed a smart irrigation system using DHT22 (Temperature and humidity) sensor to sense the moisture content of the soil. On the basis of the received data the Micro controller will start the flow of water to the targeted area. In this system the update is sent to farmer via GSM. This system has no capability to monitor the other parameters in the cultivated areas.

In [6] proposed a solution which monitor sensors data, control actuators, and sends data to web application. The whole system is based on solar energy. The operation of irrigation system is carried out through the solar panel. But in this model, there is no tracking system.

In [7] describe a solution which is based on solar energy. In this system action is taken on the received data from soil moisture sensor using PIC microcontroller to turn ON/OFF motor pump. But the limitation of this system is that farmers cannot check the status of their fields or crops.

In [8] proposed a solution for controlling and monitoring environmental parameters using wireless sensors network along with Zigbee. But in this proposed solution, it is difficult for farmers to check the status of their fields, but in our system, farmers can access their fields status from anywhere at any time using GUI.

S. Hari Shankar [9] proposed an irrigation system based on solar energy. But in this system, there is solar tracking through which we can achieve more energy throughout the daytime.

In 2010 khan [10] proposed a system for automatic solar tracking based on sensors. The tracking system in Khan proposed model is single axis, our system is better than this because, our proposed system is dual axis.

In 2014 Binoy seal [11] present an automatic irrigation system based on solar energy. The impediment of this system is that, first there is no tracking system of solar panel to get maximum energy throughout the day, and secondly this system is based on GSM so the framers cannot check the status of their field.

Agrawal in 2015 [12] proposed a drip irrigation system including Arduino Micro controllers, raspberry pi, xbee modules and relay boards. The moisture sensor is interfaced with Arduino Micro controller. A credit card sized minicomputer known as raspberry pi is used to process the commands received from the user. The action is taken on the basis of the received data from raspberry pi to Arduino Micro controllers using ZigBee protocol.

Mahesh in 2017 [13] Design wireless sensors network for monitoring temperature, humidity and other soil parameters.

In 2016 Prof. Rashmi Jain [14] designed a drip irrigation system based on Data mining algorithm using different types of sensors like soil moisture sensor, wind direction, wind speed and temperature Sensors. In this system waters are supplied in a low amount to the deep roots of the plant. This consumes a lot of time.

Our designed system is totally different from the existence systems. Our system is based on Internet of Things, we provide a service to the farmers to check their fields status and also check the status of water in the water tank from anywhere at any time via mobile or personal computer.

4. Proposed System

Nowadays agricultural field is facing lot of problems due to unavailability of electricity and also shortage of water resources. To reduce these difficulties Engineers and researchers have focused to develop a system to solve the current rising problems of farmers. The proposed system is divided into two portions.

1) Solar tracking system
2) smart irrigation system.

For solving the current rising issue of electricity, where there in no access of power for irrigation system, we proposed a dual axis solar tracking module. Our proposed system mainly consists of Arduino Uno, Raspberry pi, soil moisture sensor, LDR sensor, water pump, solenoid valve, servo motors, Solar panel and Bluetooth. For communication between sensor node, Actuator node and aggregation node a low cost and low power consumption communication module known as Bluetooth is used. The light dependent resistors (LDR's) sensors are insert on solar panel for the purpose to achieve maximum sunlight which helps to collect more electricity, through which we can operate the motor pump for irrigation. For controlling and monitoring of moisture content of soil a sensor known as soil moisture sensor is used. An ultrasonic sensor known as range finder is used to monitor the water level in the water tank reservoirs. All the sensors, actuators and Bluetooth are interfaced with Arduino Uno. The received value from the sensors are provided to Arduino Uno as input. On the basis of these inputs the action will be taken. A Bluetooth is used to send the received data from sensor node to Aggregation node. A Raspberry pi an aggregation node is used for taking action based on the received data from sensor node as shown in figure (4).

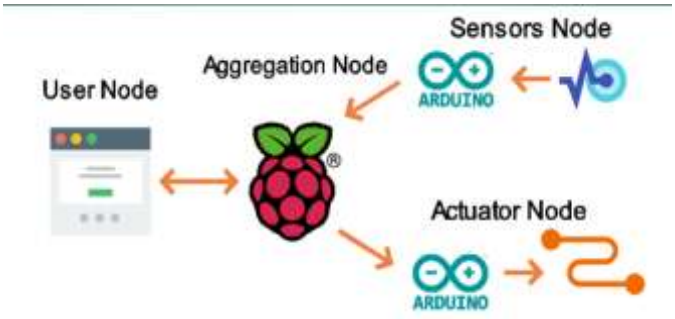

Fig (4.1)

The turning ON/OFF of a solenoid valve and motor pump is carried out through Actuator node. When the interfaced sensor data is less than or greater than the pre-defined value of the sensor, the flow of water will be started/stop automatically. At the same time, a user can get the information on his laptop, personal computer or mobile using web technologies.

4.1) Solar Tracking System:

Sun is the main source of energy and available in very huge amount all over the world. Solar energy is environmentally friendly form of energy and also reduces the current energy crisis up to some extent. During hot summer days Farmers are facing many problems in irrigation in order to keep their crops healthy in those areas where there is no availability of electricity.

The aim of designing this project is to detect the sun light to get maximum energy during day time by tracking the solar panel, to remove the present rising energy crisis up to some extent by tracking the circular motion of the sun via LDR's. In our proposed system we design dual axis solar tracking system. According to [15] Single axis is cheaper but not efficient to solve the current problem of energy, while two axis tracking is more efficient, up to 45-50%. The change in the position of solar panel is based on the maximum intensity of sun, to get maximum power. Now the energy obtained from sun using solar panel will be stored in DC battery for operating the motor pump to fill the water tank and also used for irrigation system. The rotation of solar panel throughout the day is based on servo motors and LDR's.

Now for detection of sunlight we interfaced LDR's and Servo motors with Arduino in such a way to get maximum sun light during daytime by rotating the Solar panel via Servo motors in the direction of Sun. The LDR's detects sun light and sends the received data to Arduino. Here we use five LDR's. Four of them are insert on each corner of the solar panel and one on the center of the panel. In this way the panel will be rotating from zero degree to 180 degree during day time. As a result, the solar panel will be rotating in that direction where the intensity of sun light is maximum and it will produce maximum power as shown in figure (4.1).

Fig (4.1.1)

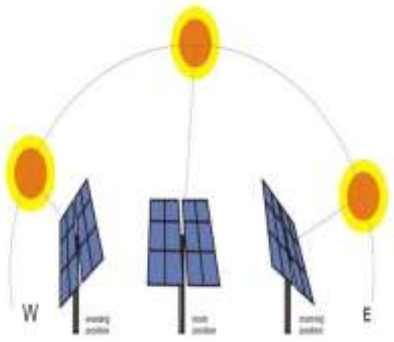

Fig (4.1.2)

When the LDR's is not sensing the sun light, it will not be sending the data to Arduino, therefore the panel will be stationary. The tracking system is based on maximum intensity of light. When light falls with maximum intensity on one of the inserted sensors, the Arduino sends commands to Servo motor to move the panel in the direction of LDR's accordingly. After some time when the sun light become out

of the magnitude of that LDR's, but at the same time the next inserted LDR's will sense the sun light with maximum intensity, So the servo motor rotates the panel in the corresponding direction of sensor. This process continuous during day time. This is the method of tracking of solar panel using LDR's and servo motors to get maximum power. In [16] M. P. a. T. Tudorache show that in summer the efficiency of solar energy rises up to 100% while in winter this efficiency is 40%, due to cloudy weather or rain, the overall power is 50% maximum.

4.2. Smart irrigation system:

The energy obtained from solar panel is transferred to DC battery. This energy is stored in the battery for motor pump and solenoid valve ON/OFF operation. The water pump is connected to the DC battery so that we could operate the motor pump on the energy produced from sun through solar panel. The motor pump will supply the water without human intervention to the tank reservoir and also directly to those areas where the land needs. For this purpose, we use soil moisture sensors. The sensors are interfaced with Arduino and will be insert inside the field. The sensor node senses the surrounding data continuously, and sends it to Aggregation node via Bluetooth. The ON and OFF operation of motor pump and solenoid valve is based on the data received from the interfaced sensors. When the moisture content of soil is less than/greater than the pre-defined value of the sensor, the flow of water will be started/stop automatically from the tank reservoir through solenoid valve as shown in figure (4.2). At the same time, the user will be updated via cloud. This is how the whole system operates automatically and based on solar power.

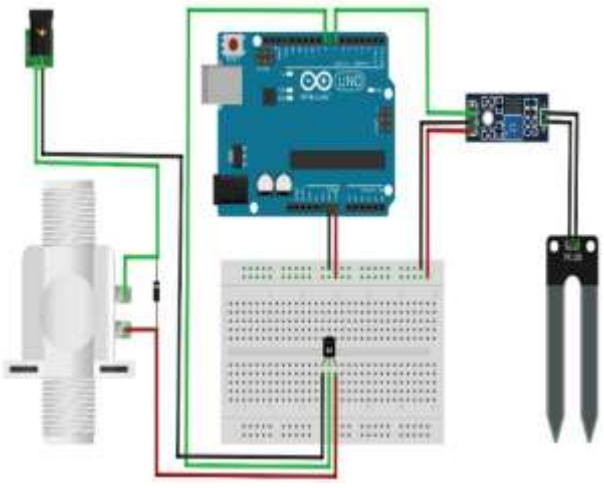

Fig (4.2.1)

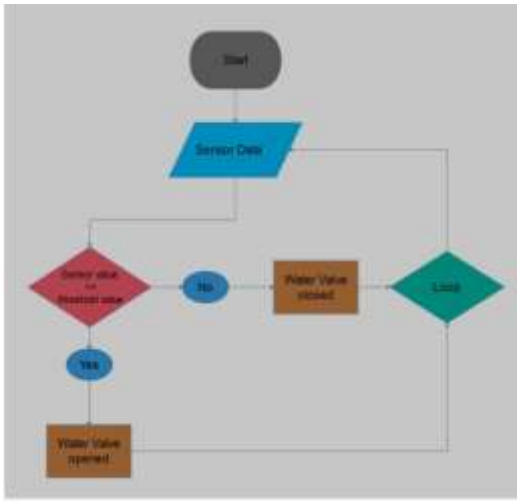

Fig (4.2.2)

5. CONCLUSION

In this paper we proposed Automated irrigation system based on Internet of Things (IOT's) using solar energy. Which provide cheap and reliable source of electricity and also provide automated control of irrigation system. The proposed system is beneficial for farmers as well as for government, because we proposed a solution to reduce current energy crises. The proposed system provides interconnection between different devices, using wireless, and web technologies (GUI) to check the moisture content, motor pump ON/OFF status, farm condition and sensors data graphically on Mobile or PC. Moreover, the system is based on solar energy which reduces the current energy crisis, avoids over irrigation, under irrigation, save water from wastage, cut down the human interaction, save time, provide proper management for irrigation and water supply to the needed areas in order to raise the productivity of agricultural activities. To solve the rising problem of load-shedding, and provide fully automated system for irrigation system to farmers. Our design model is the best Solution.

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