ISSN (ONLINE): 2454-9762
ISSN (PRINT): 2454-9762
Available online at www.ijarmate.com

International Journal of Advanced Research in Management, Architecture, Technology and Engineering (IJARMATE) Vol. 5, Issue 4, April 2019

IOT BASED SOLAR POWERED AGRIBOT FOR IRRIGATION AND FARM MONITORING

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ABSTRACT

Agriculture contributes to a major portion of India's GDP. Two major issues in modern agriculture are water scarcity and high labor costs. These issues can be resolved using agriculture task automation, which encourages precision agriculture.Considering abundance of sunlight in India, this paper discusses the design and development of an IoT based solar powered Agribot that automates irrigation task and enables remote farm monitoring. The Agribot is developed using an Arduino microcontroller. It harvests solar power when not performing irrigation. While executing the task of irrigation, it moves along a pre-determined path of a given farm, and senses soil moisture content and temperature at regular points. At each sensing point, data acquired from multiple sensors is processed locally to decide the necessity of irrigation and accordingly farm is watered. Further, Agribot acts as an IoT device and transmits the data collected from multiple sensors to a remote server using Wi-Fi link. At the remote server, raw data is processed using signal processing operations such asfiltering, compression and prediction. Accordingly, the analyzed data statistics are displayed using an interactive interface, as per user request.

I. INTRODUCTION

According to the recent statistics [1], the land used for crop cultivation in India is decreasing at an accelerating rate. Outdated irrigation techniques and availability of water resources are the primary reasonsfor incoherent production. Hence, technological solutions for agriculture task automation are the need of the hour. In particular, simplified irrigation mechanisms reducing water wastage are very essential, which encourage precision agriculture .Technological solutions for irrigation and agricultural task automation are driven by electric power. Throughout a year India receives solar radiation on an average 3000 hours of sunshine (i.e. 4-7kWh of solar radiation per sq. meters). Hence solar driven technological solutions for agriculture task automation can yield better benefits for Indian environmental conditions. Many such technological solutions have been addressed in the literature that achieve agriculture task automation and help in remote monitoring the farm land. Some of them are discussed as follows. Asmart irrigation controller is developed using microcontroller , which transmits the data using XBee link to a remote server. However, the developed system can monitor moisture only at a single point. Hence, to monitor a given farm area, large number of sensors have to be deployed which increases the cost of the system. XBee can communicate in a limited range of 50 m. The developed remote interface does not perform any signal processing operations to obtain useful statistics relevant for farm monitoring. A two cell overhead crane system [5] is proposed for agricultural task automation. Specifically, tasks such as spraying fertilizer, irrigation, planting seeds have been proposed for automation by a solar driven crane system. However development of such systemsrequire a large budget and in addition if such systems need to monitor the farm land, multiple sets of sensors need to be placed at various geographical points. An agricultural solution for the farmer based on Wireless Sensor Networks and GPRS technology is proposed [6], using multiple sensors that sense the health of the plant along with environmental parameters. Using ARM processor, a smart GSM controlled weather based irrigation system is developed , which senses the soil moisture at a given geographical position and irrigates the farm based on prediction of rain. However, the amount of hardware required for forming a sensor network in and is large, because multiple sets of all the sensors are to be placed over a geographically spread farm

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area that needs to be monitored. Other than farm land automated irrigation system, automation can also benefit green roof irrigation to save water resources. Based on the soil moisture, humidity, solar radiation and wind speed, a micro controller based irrigation system is developed. The sensing system is based on a single node rather than multiple points. Hence for a complete roof garden,several sensor nodes are required.On contrast to the systems discussed above, agricultural robotscan also be used for irrigation and agricultural task automation In this paper, we develop an Agribot, capable of irrigating the form, harvesting solar power while not irrigating and also monitoring the farm from a distant node. At the distant node, after proper analysis of raw data obtained from different data transmissions at the farm, useful data statistics are obtained and displayed according to user interest. The benefits of the developed Agribot are better efficiency in water usage compared to manual irrigation, achieved via direct soil moisture and humidity measurements at various geographical positions in the farm. It is worth noting that the developed Agribot irrigates the farm not based on a single point data like in the automated systems [4-8], but irrigates based on averaged data obtained at each point. As the Agribot can move around the farm, there is no necessity of installing multiple sensors at various geographical points in the given farm. The data collected at various geographical points at various times in a day are transmitted to the cloud. Hence historical data is available over the entire farm under supervision, which by appropriate analytics can be used for prediction of future data. To aid in prediction, we employ filtering of the raw data to remove noise in the measurements and also compression of the data to aid in large data storage. A single set of sensors can help in complete farm monitoring unlike the need for dedicated sensors at various positions in a fixed automation systems [4-8]. Further maintenance of sensors at many positions in the farm is not a convenient solution in agriculture. Hence Agribot has immense scope for

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ISSN (PRINT): 2454-9762
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utilization in farm monitoring systems.The developed prototype of the Agribot in this paper forms a low cost system due to the incorporation of a screw rod methodology and only a single set of sensors, which can virtually sense and transmit data from multiple locations in a given farm. The model developed is based upon Arduino Mega AT2560 processor. The battery incorporated can be recharged using renewable solar energy using two solar panels. Hence while not irrigating the farm land, the Agribot is capable of harvesting the solar power. The rest of the paper is organized as follows. In section II, the design details of the Agribot and the method of implementation are provided along with the details of various sensors used in the developed Agribot. Section III discusses the working details of the Agribot in a given farm. Section IV provides the details of analysis of the raw data and corresponding signal processing tasks. Section V provides the results of testing the Agribot and Section VI concludes the paper.

II. DESIGN AND IMPLEMENTATION OF AGRIBOT

The Agribot based automated irrigation system is controlled using ATmega2560 micro controller programmed on Arduino platform. The Agribot is intended to move on the contour of the rectangular field. Two principle factors required to choose the measure of water required to irrigate the field are soil moisture content and temperature of surrounding environment. Hence, two sensors soil moisture (YL-69) and temperature sensor (LM-35) are utilized to assess the required water for irrigation. These sensors collect the data on the contour of the rectangular field with the help of screw rod mechanism. The data is processed in Arduino micro controller. The Agribot processes and evaluates the data according to which it irrigates the soil near the sensing point uniformly. Furthermore the data collected from Arduino was transferred to cloud (Thing-Speak) by use of ESP8266 module. This raw data includes the information of soil moisture sensor and temperature sensor. These data represent the state of the soil.Thus any analysis on this will help

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to take a decision on future action of irrigation. The primary analysis that this work deals with is the filtering, prediction and compression aspects of the raw data collected. The system has three major parts; sensing, control section and the output section. The soil humidity was detected using YL- 69 soil sensor (a resistance type sensor) and LM35 temperature sensor. The control unit was achieved using ATMega2560 microcontroller based on Arduino platform. The output of the control unit was used to control the irrigation system by switching it on and off depending on the soil moisture content and surrounding environment temperature. The hardware connected to the Agribot comprises of various components required to drive the Agribot. Two H bridges are used to drive the DC motor of the wheels of Agribot, another H bridge is used to run the screw rod mechanism to sense the soil moisture.Relay is used to drive the pump. Solar panels are used to convert solar energy into usable electrical energy using boost convertor. A LM7805 IC regulator is used to convert 12 V DC supply into 5V DC supply which is used to drive the relay. The block diagram of the developed Agribot

The details of various sensors and associated components used in the developed Agribot are discussed as follows:

A) YL 69 Soil moisture sensor:YL-69 sensoris made of two electrodes, which enable the sensor to read the moisture content around it. A current is passed across the electrodes through the soil and the resistance to the current in the soil determines the soil moisture. If the soil has more water, resistance will be low and thus more current will pass through. The sensor has both digital and analogoutputs and is available with a small PCB board fitted with LM393 comparator and a digital potentiometer.

B) **LM 35 Temperature Sensor:**

The LM35 are precision ICbased temperature sensing devices with an output voltage linearly proportional to the Centigrade temperature.LM35 sensor has 3 pins namely Vcc which is given to supply, ground which is given to ground of the controller and output pin given to one of the analog pins of controller. The LM35 device does not require any external calibration or trimming to provide typical accuracies of ±¼°C at room temperature and ±¾°C, over a full −55°C to 150°C temperature range. The device is used with single power supply, or with dual supply.

C) **DC Motors and IC drivers:**

DC motors are used by the Agribot to move and also help the on board sensors to reach the soil while sensing measurements are being collected. A DC motor in simple words is a device that converts direct current (electrical energy) into mechanical energy. The DC motors are driven by L293D, which is a dual H-bridge motor driver IC. Motor drivers act as current amplifiers since they take a low-current control signal and provide a higher-current signal. This higher current signal is used to drive the motors. L293D contains two inbuilt H-bridge driver circuits. In its common mode of operation, two DC motors can be driven simultaneously, both in forward and reverse direction.

D) **RELAY**:

A relay is used by the Agribot to carry out the task of irrigation. The relay module is an electrically operated switch that allows you to turn on or off a circuit using voltage and/or current much higher than a microcontroller could handle.

III. **WORKING OF AGRIBOT**

The Agribot is programmed to move forward for 10 seconds.It stops at the first plant position. With the help of the screw rod the soil moisture sensor is placed in the soil for 5 seconds and the values from both sensors are stored in two different arrays in the micro controller and then the soil moisture sensor is returned to its initial position. The Arduino micro controller takes the average of the sensor readings and transmits these values to the cloud using WiFi module ESP8266 that is interfaced with the Arduino. Thus the Agribot acts as an IoT device. The Agribot moves to its next sensing point and the above procedure repeats. The agribot was programmed to move along the contour of a rectangular area, with each side of the rectangle having two sensing points. After completing a revolution around the rectangular field,the values from each sensing point are compared with the threshold value that is set based upon on the season and crop that is being cultivated and the duration for which the Agribot has to irrigate the plant is calculated.Once the values are being calculated the Agribot starts its second revolution around the considered rectangular path. If the soil moisture value is greater than 750 and less than 1023 and temp is greater than 30, water will be supplied for 5 seconds. If the soil moisture value is less than 750 and greater than 500 and temp is less than 30, water will be supplied for 3seconds. If the soil moisture value is less than 450, no water supply takes place along one side of the rectangle, the robotmoves further for 5 seconds and the same process repeats for remaining sides. In short if the value of sensors is less than threshold .The motor are directed to move in forward direction and water the area near sensing point. If the sensor value is above the threshold the pump does not water that area and just passes that area. The flow chart representing the above mentioned working of the Agribot is shown in Figure 2. In the developed model of the Agribot, there are 5 DC motors.Four are used to propel the Agribot and one is used for driving the screw rod mechanism. The screw rod mechanism helps the on board sensors of the Agribot to reach very near to the soil,while sensing measurements are done and helps them return back to their initial positions while not sensing.

RESULTS

The Agribot prototype is tested for its working on a small rectangular area for its operation described in the flow chart of Figure 2. The Agribot prototype is shown in Figure 4. The irrigation set up and the solar panel based harvesting system are also shown in Figure 5 and Figure 6 respectively The raw data is sent to the cloud and the related graphs on think speak server are shown in Figure 7. On the humidity, soil moisture and temperature data available in the cloud server,

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CONCLUSION

In this paper, an Agribot, which acts as an IoT device is developed for remote farm monitoring and also irrigating the farm land. The developed Agribot is solar powered and hence it harvests solar energy when not irrigating. Agribot is a better choice compared to fixed automation devices that help in farm monitoring and irrigation as it requires less hardware compared to a fixed system. The developed Agribot in this paper can irrigate the farm land and transmit the data acquired at various geographical positions to the cloud. Further at the cloud end, the data is processed and analysed for useful information and prediction. Development of prediction driven irrigation activities of the Agribot form the future scope of this paper.

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International Journal of Advanced Research in Management, Architecture, Technology and Engineering (IJARMATE) Vol. 5, Issue 4, April 2019

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