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Automatic Wireless Water Management System(AWWMS) for Smart Vineyard Irrigation using IoT Technology

J. Daniel Francis Selvaraj[1*], P.Mano Paul[2], I. Diana Jeba Jingle[3]

[1] Department of Information Technology, Sri Krishna College of Engineering and Technology, Coimbatore (An Autonomous Institution) Affiliated to Anna University, Chennai, India

[2]Department of Computer Science and Engineering, Presidency University, Bangalore, India.

[3]Department of Computer Science and Engineering, Christ University, Bangalore, India.

[*]Corresponding Author

Abstract

Vineyard Irrigation consumes large amount of water for sustainability and quality production of grapes. In order to meet the demand of grapes on the growing population across the world, vineyard irrigation has to be improved. Improper tracking of the growth of grapes in vineyard has led to serious problem in quality production of grapes. To address these problems on vineyard irrigation, this paper proposes an automatic wireless water management system (AWWMS) using Internet of Things for vineyard growth. The proposed system primarily focuses on optimal water usage and reduced manual labor on vineyard field so that wastage of time, cost and power on grape production can be saved. The system involves the coordination of wireless sensors deployed in the soil in gathering required real-time information such as soil moisture, air humidity and environmental temperature which is then passed to the cloud server through IoT gateway for making decisions on whether to water the soil or not. The proposed AWWMS system was developed and tested on a small scale environment. We developed test cases based on air humidity, soil moisture, environmental temperature and water pump status. We clearly state that deployment of this AWWMS system in large scale environment can yield better results.

Keywords: Water Management, Vineyard Irrigation, IoT, Arduino.

I INTRODUCTION

Wine culture has boomed and reached almost all around the world. Winemaking techniques involve traditional and innovative ones. Vineyard irrigation consumes large amount of water for sustainability and quality production of grapes. Vineyard consumes 300 to 700 mm of water every day and improving the water use for vineyards is a crucial task for sustainable winegrowing.In recent times, the grape ripening process failed to produce quality yield due to the variations in climatic conditions,which led to serious problem on improper tracking of the growth of grapes in vineyard.To meet the demand of grapes of the growing populationin India and across the world, the vineyard irrigation has to be improved and increased. IoT technologies can be developed to help the vineyard irrigation by monitoring and controlling the crop sustainability in an automatic way without manual labour.

IoT includes a number of smart concepts for future usage like Smart City, Smart Home, Smart Irrigation, and Smart Transportation. It can also be used for managing the amount of water intake by the crops to enhance yield and long-term sustainability. Smart irrigation can be used with the help of sensors. Tank water level, soil humidity level, temperature are some of the real-time parameters that can be used for improving the crop growth using IoT. The sensors can form a network and coordinate together in monitoring the water level of the crops in agriculture filed.

This paper proposes a smart vineyard irrigation system through water management. The system controls irrigation in vineyard filed by automatically monitoring the soil moisture, environmental temperature, and air humidity. The real-time data is passed to the cloud server through IoT gateway for making decisions and controlling actions.

The paper is structured as follows: section 2 presents the related work that has been surveyed on vineyard irrigation, while section 3 clearly states the problems in traditional irrigation system and section 4 focuses on the proposed automatic water management system for smart vineyard irrigation and section 5 presents the test case analysis carried out on the test data, the findings and observations with comparative results and finally we conclude in section 6.

II RELATED WORK

A number of research work has been carried out to improve the performance of irrigation. We surveyed the importance of vineyard irrigation as this is our primary focus. All these works discussed below, provided efficient monitoring of sensor data.

In [1], arduino technology was used to monitor the water level and roofing of green house. Decision making is done using real-time statistical data (i.e., humidity, moisture, temperature and light intensity sensors) collected from sensors.AgriSys [2] is an Agriculture System uses parameters like humidity sensors, pH, temperature from sensors and fuzzy interference to acquire the input data. The sensors are monitored through LCD or PC.In [3] a ANN based approach was proposed for the controlling the automatic irrigation control problem. This approach has resulted in a possibility of better efficient control and can save a lot of water and energy thereby providing optimized results to all forms of irrigation system.In [4], an advanced technique was proposed to monitor the soil moisture content using flow sensors and thereby controlling the motor pump automatically without any manual effort. This method uses parameters like temperature, eater level, etc. However, other parameters like pH, soil electrical conductivity are not considered for smart irrigation.

In [5], a ZigBee technology based wireless sensing network was proposed to support smart irrigation system by considering air humidity, soil moisture, temperature sensor as input parameters.In [6], the WSN and Zigbee technologyare integrated together so that the collected data can be transmitted to a GPRS connected web server through cellular network. Internet connected graphical applications are used to monitor the sensed data. In [7], an automatic wireless watering user friendly system was proposed and the user monitors the log file about the status and events carried out.In [8], a wireless sensor network with clustering is created for sensing the soil moisture, temperature and air humidity for automatic water management for smart irrigation. Power saving of sensor nodes is achieved through sleep-wake up plan. The sensed data are handled and implemented for decision making using MATLAB with Graphical user interface (GUI) support.

In [9], an IoT multiplatform networking was developed using wireless sensors in a distributed environment for controlling wineries and vineyards. In [10], the authors made a review on how to improve the water usage efficiency for vineyard irrigation in semi-waterless regions. In [11], a study was done on the effect of water savings and cost on vineyard growth across multiple sites. In [12], an IoT monitoring architecture has been designed and deployed for precision viticulture (i.e., a digital technology on vineyard irrigation). In [13], SEnviro was presented for monitoring water management in vineyard irrigation.

All these systems discussed above are designed on a wireless sensor network to provide automatic irrigation through water management with different communication technologies and different modes of data storage. Generally the collected sensor data are stored on servers and larger number of nodes, the servers will need more space to store the sensed data which results in increased cost. In this case, cloud servers can be used to handle huge amount of data to provide a smart agriculture.

III PROBLEM STATEMENT

Agriculture in India is the basic necessity and major source of Indian’s livelihood. The Indian economy is mainly affected by agriculture. Due to the increased consumption of water usage every day, water scarcity problem is a serious concern not only for crops but also for indoor plants.

Traditional Vineyard Irrigation Methods used manual irrigation like Sprinklers, Drip or Trickle Irrigation and Flood Type Feeding Systems. The crops are watered directly in the soil and due to this, the crops undergo high stress and hence the yield is reduced. If automatic watering system is introduced, then improper water control can be controlled. Increase in population at a rapid rate (i.e., population will reach 8 billion by 2025 and 9.6 billion by 2050) is the major reason for such water scarcity problem [13]. This emerging global water crisis can be solved to a greater extent by deploying automatic irrigation system for vineyard growth. Therefore the limitations of the traditional vineyard irrigation system are stated as follows: 1) Irrigation is done manually to manage crop growth, 2) Water is wasted in large quantity, 3) Wastage of time and money, and 4) Crops undergo high stress.

Smart vineyard Irrigation System addresses the limitations of traditional vineyard irrigation. The Smart vineyard irrigation can reduce the water consumption by considering the parameters like soil moisture, temperature, weather condition etc. For this, wireless sensors are used that checks the soil condition on whether or not water is needed.The Smart Vineyard Irrigation System is anIoTTechnology that automates the irrigation process based on the above mentioned parameters like soil moisture, temperature, weather condition etc. The sensor data can be outputted using a graphical display device. The motor pump can be automated using ON/OFF valves controlled using controllers. Smart vineyard Irrigation System provides the following benefits: 1) Crops are free from stress because they are watered based on water level available in the soil, 2) Manual Watering Time, effort and money is saved, 3) Increases the vine production and sustainability, 4) preserve the water resources for future needs.

This paper proposes a smart vineyard irrigation system which uses IoT technology on the vineyard fields to monitor the soil moisture and a Cloud server to store the data and control the water usage. The proposed system collects real-time data such as air humidity, soil moisture, and environmental temperature through sensors and monitors and controls them automatically.

IV PROPOSED SYSTEM

The proposed system has 3 major phases: Data Collection phase, Control phase and Activation phase.The sensors play a major role in data collection phase. A reasonable number of sensors were deployed into the vineyard soil in order to sense the soil humidity. The Control phase functioned using ATMega328 Arduino Microcontroller and it controls the activation phase after analyzing the input data collected using sensors. The activation phase performs on/off mechanism on the water pump automatically based on the soil humidity levels without any manual intervention.

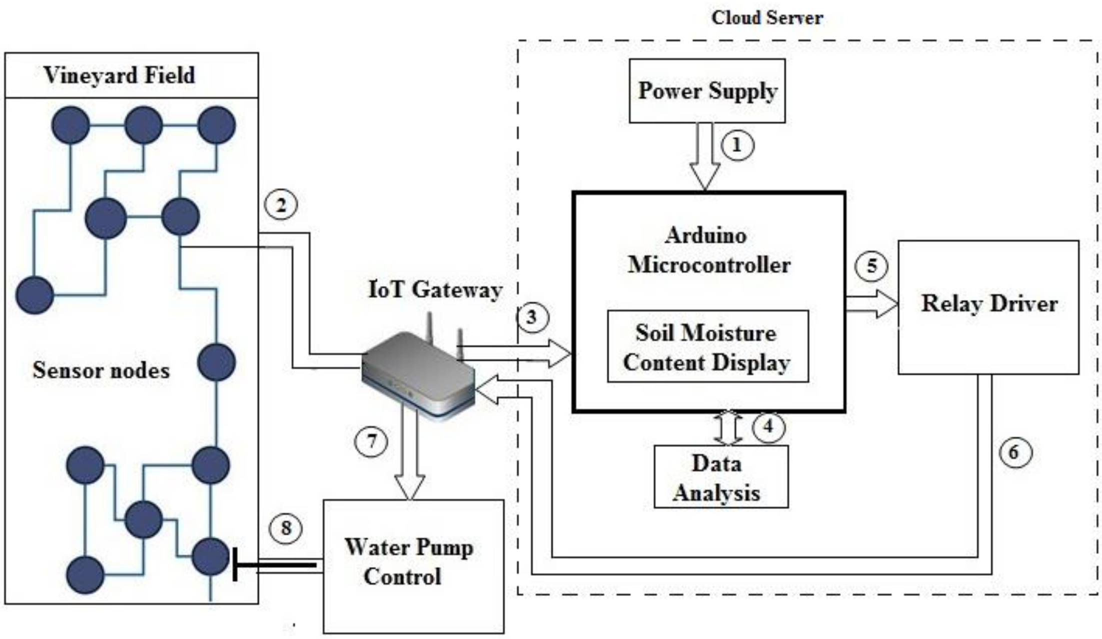

Figure 1. The Proposed Architecture for Smart Vineyard Irrigation

Every sensor node is a hardware device that collects measurements on environmental parameters. A low-power and low-cost ESP8266 System on Chip (SoC) controller records the sensor data and controls each node. Power saving of sensor nodes is achieved through sleep-wake up plan. The sensor nodes wake up from sleep mode each hour and tries for a successful Wi-Fi network connection. REST API is used to provide an interface between sensor nodes and arduino. In wakeup mode, the sensor nodes send sensed information and in sleep mode node stay idle. Each SoC controller contains a IPv4 protocol stack with WPA/WPA2 authentication. The sensor nodes are programmed through Arduino community which includes sensor libraries and Arduino Integrated Development Environment (AIDE).

The IoT gateway is a powerful hardware that is used to provide long-term water management in a large environment. The gateway gathers all the information simultaneously from all sensors. Dedicated servers like laptops or desktop computers or a Single-board computer can be used as an IoT gateway. The IoT gateway integrates a RAM, SoC and a number of ports. The ports can reduce the cost, power consumption and increase battery usage and heat dissipation.

The Wi-Fi standard selected for communication is IEEE 802.11b/g/n because it provides sufficient data rate (11 to 300 Mb/s) and can provide a good range of connectivity (between 20-100 m) with rechargeable batteries to save power.

The working of the proposed system is as follows: The sensors measure the moisture content levels available in the soil and forwards the data and parameters to the IoT Gateway. We used IoT gateway so that the proposed system can provide long-term water management for large environment. The IoT gateway, collects information from individual sensors and forwards the collected information to the microcontroller.

The microcontroller performs analysis on the collected sensor data based on the soil humidity level and brings up a decision on whether to water the soil or not. If the soil moisture level is found to be below the threshold level, then the microcontroller passes an triggering message to the relay driver which then forwards the message to the Water Pump Control (that is run by a 12V motor IC) through the IoT Gateway. The water pump waters the soil until sufficient water is distributed. The Relay Driver is controlled by the microcontroller and it consists of a relay circuit with several resistors and diodes and a transistor. The sensors have an amplifier circuit and probes embedded within. A potentiometer has been used to set the threshold levels on the microcontroller. The microcontroller needs input power supply in the range from 7V to 12V for efficient functioning. Figure 1 depicts the architecture of the proposed AWWMS system.

V TEST CASE ANALYSIS

The proposed AWWMS system has been developed and tested on a small scale environment. We developed test cases based on air humidity, soil moisture, environmental temperature and water pump status.TABLE I shows the test case analysis on tested data and we obtained success results for each cases. We observed that smart vineyard irrigation consumed only less quantity of water when compared to traditional irrigation. We clearly state that deployment of this AWWMS system in large scale environment can yield better results.

Table 1. Test Case Analysis on Test Data

Temperature	**Soil moisture content**	**Relay condition**	**Water pump status**	**Test case**
High	<1000 and >500	ON	ON	SUCCESS
Medium	<500 and >300	OFF	ON	SUCCESS
Low	<300	OFF	OFF	SUCCESS

VI CONCLUSION

Thus the Automatic Wireless Water Management System (AWWMS) provides a better proposal to save water usage in Vineyard Irrigation. The system has been designed in small scale environment and tested successfully. The system provides integrated support of the hardware used and has been tested to function automatically. The sensors play a major role in measuring the water content of the crops. The sensors measure the moisture content levels available in the soil and send a signal to Arduino if the moisture content is below the required level. The arduino then triggers the water pump to switch ON whereby plants are watered. When the soil obtains the required moisture content, the arduino board triggers the water pump to switch OFF. Thus the entire system is made to function automatically. Deployment of this AWWMS system in large scale environment can yield better results.

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