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Automatic Irrigation System using Fuzzy Logic

***Jose Anand**
***J. Raja Paul Perinbam**

*Research Scholar, Anna University Chennai, & Associate Professor/ECE, KCG College of Technology, Chennai, Tamil Nadu,

**Professor (Retired)/ECE, Anna University & Professor/ECE, KCG College of Technology, Chennai, Tamil Nadu, India,

Abstract – Water is an essential element for growth of the plants. The amount of water given to the plants depends on its size, and moisture control of soil. The moisture of soil is affected by temperature of environment, evaporation due to wind velocity and the water budget. Saving water is vital for all irrigation projects. For water saving in the irrigation system, we need to monitor the parameters like atmospheric temperature, humidity, wind speed and direction, water radiation, soil temperature, sunshine and rain fall, etc., Based on these parameters, needed water should to given for the plants, based on its growth. This paper presents a low cost Fuzzy Logic Controller (FLC) based automatic irrigation system to irrigate the crop efficiently with water savings. This system will save the use of water and other nutrients efficiently to improve the yield of the crop.

Index – Fuzzy Logic, Irrigation System, Water, Wireless Sensor Networks

1. Introduction

Water is essential to all life on Earth. Water as a result is a precious natural resource that must not be wasted. The usage of water is increasing globally and the irrigation cost is also subsequently rising. Irrigation system is an old one, since agriculture is the foremost occupation of civilized humanity. To irrigate large areas of fields is an onerous job, and various irrigation scheduling techniques are developed based on monitoring the soil, field, and weather conditions.

Agriculture uses 85% of available freshwater resources worldwide, and this percentage will continue to be dominant in water consumption because of population growth and increased food demand. There is an urgent need to create strategies based on science and technology for sustainable use of water, including technical, agronomic, managerial, and institutional improvements [10].

The advancement in technology and decrease in size, the sensors are becoming involved in almost every field of life. Sensors for soil moisture monitoring have been used in a variety of natural resource management practices, such as research on crop yield, watershed management, environmental monitoring, precision agriculture and irrigation scheduling. In advanced agriculture, many instruments and methods have been used to monitor and measure soil moisture. These irrigation management techniques and instruments vary with respect to their accuracy, labor intensity, cost and simplicity of use.

Earlier, many studies have been conducted to assess the soil water with devices both qualitatively and quantitatively in respect to setup requirements, maintenance, initial cost, accuracy and data interpretation. At the same time, the sensor industry coupled with rapidly advancing computer technology has resulted in a variety of new sensors for irrigation scheduling. The newly-designed sensors monitor soil moisture content continuously and on a real-time basis.

In particular, the timing and amount of irrigation are important factors for well-organized on-farm water management. Scientific Irrigation Scheduling (SIS) is distinct in using crop evaporation and transpiration data, as well as soil moisture-based sensor technologies to precisely calculate when and how much to irrigate. In recent years, agriculture faces many challenges, while humanity depends on agriculture and water for survival, so precision agriculture monitoring is critical and the demand for environmental monitoring and remote controlling in agriculture is rapidly growing.

Wireless sensor networks (WSNs) are being used in a wide variety of serious applications such as military and healthcare applications, agriculture and industrial process monitoring. WSN is an intelligent private network made by a large number of sensor nodes which do specific function. Wireless transmission allows deploy the sensors at remote, dangerous, and hazardous location. WSN has several advantages including easy installation, cost-effectiveness, small size and low power consumption.

Solar energy is the most abundant source of energy in the world. Solar power is not only an answer to today's energy crisis but also an environmental friendly form of energy. Photovoltaic generation is an efficient approach for using the solar energy. Solar panels are now-a-days widely used for running street lights, for powering water heaters and to congregate domestic loads. The cost of solar panels has been constantly decreasing which encourages its usage in various sectors.

One of the applications of solar energy technology is used in irrigation systems for farming. Solar powered irrigation system is a suitable substitute for farmers in the present state of energy crisis in India. This green way for energy production which provides free energy once an initial investment is made. In this paper we propose an automatic irrigation system using solar power which drives water pumps to pump water from bore well to a tank and the outlet valve of tank is automatically regulated using controller and moisture sensor to control the flow rate of water from the tank to the irrigation field which optimizes the use of water.

At the same time, precision agriculture refers to the use of information and control technologies in agriculture. Agricultural inputs such as irrigation and fertilizers can be applied in accurate quantities as determined by modeling of crop growth patterns to maximize the crop yield and to minimize the impact on the environment. Fertilizer uptake and irrigation needs within a field depend on factors that vary in space and time. A WSN with sensor nodes spread throughout the field can periodically collect and relay soil data to the information processing center. This data is used as inputs to the modeling software to determine the optimal quantities of the agricultural inputs like fertilizers, irrigation, pesticides, etc., which are required in different locations at different times in the field [11].

The rest of the paper is organized as follows. Section 2 reviews about the related literature on diverse irrigation system applied for various applications. Section 3 describes about the automatic irrigation system and section 4 details the fuzzy logic based automatic irrigation system. Finally conclusion is given in section 5.

2. Related Works

In this section, we review the prior work on the various irrigation system implemented in different applications using diverse algorithms. Javadi et al [1] proposed a system for irrigation based on Fuzzy Logic Controller (FLC) methodology. The FLC is based on a Mamedani controller and is build on MATLAB software. The FLC model estimates effectively the amount of water uptake for plants in distinct depth using the reliable irrigation model, evapotranspiration functions, environmental conditions of greenhouse, soil type, type of plant and another factor affecting the irrigation of greenhouse.

Khriji et al [2] presented a complete irrigation solution for the farmers based on WSN. The automated irrigation system using low-cost sensor nodes having reduced power consumption can reduce the water waste and is cost effective. A node is deployed using TelosB mote and adequate sensors/actuators. Field nodes are used to detect the level of moisture and temperature in the soil. Weather nodes monitor the climatic changes, and the nodes connected to actuators are used to control the opening of the irrigation valve when needed.

Mahir et al [3] proposed an efficient water usage system by pump power reduction using solar-powered drip irrigation system in an orchard. Soil moisture content is analyzed by Artificial Neural Networks (ANN) to provide even distribution of water for the required location. This will prevent the unnecessary irrigation and reduce the water demand. This system reduces the orchard's daily water usage and energy consumption by 38 percentages.

Farid et al [4] presented a practical solution based on intelligent and effective system for a field of hyper aridity. The system consists of a feedback FLC that logs key field parameters through specific sensors and a Zigbee-GPRS remote monitoring and database platform. The system is deployed in existing drip irrigation systems without any physical modification. FLC acquires data from these sensors and fuzzy rules are applied to produce appropriate time and duration for irrigation.

Christos et al [5] described an adaptable decision support system and its integration with a wireless sensor/actuator network to implement autonomous closed-loop zone-specific irrigation. Ontology is used for defining the application logic emphasizes system flexibility and adaptability and supports the application of automatic inferential and validation mechanisms. Machine learning is applied with rules by analyzing logged datasets for extracting new knowledge and extending the system.

Singh et al [6] presents a solution for an irrigation controller for cultivation of vegetable plants based on the fuzzy logic methodology. In this system the amount of water given to the plants depends on its size, moisture control of soil, which is affected by temperature of environment, evaporation due to wind velocity and water budget. The system feed water to plants in a controlled and optimal way. Solar energy conversion technology is used to feed power to the pump controller.

Xin et al [7] described an autonomous precision irrigation system through the integration of a center pivot irrigation system with wireless underground sensor networks. The wireless underground sensor aided center pivot system will provide autonomous irrigation management capabilities by monitoring the soil conditions in real time using wireless underground sensors. Experiments were conducted with a hydraulic drive and continuous-move center pivot irrigation system.

Robert et al [8] promoted a commercial wireless sensing and control networks using valve control hardware and software. The valve actuation system included development of custom node firmware, actuator hardware and firmware, an internet gateway with control, and communication and web interface software. The system uses single hop radio range using a mesh network with 34 valve actuators for controlling the valves and water meters.

Nolz et al [9] studied two types of soil water potential sensors. One is the Watermark sensor by Irrometer Co., and the other is MPS-1 by Decagon Devices, Inc. The system was integrated with sensors into a wireless monitoring network to determine and evaluate calibration functions for the integrated sensors. The system compares the measuring range and the reaction time of both sensor types in a soil layer during drying. Data were transmitted over several kilometers and made available via Internet access.

Nolz et al [14] integrated the sensors into a wireless monitoring network to determine and evaluate calibration functions for the integrated sensors, and compare the measuring range and the reaction time of both sensor types in a soil layer during drying. The integration of the sensors into the telemetry network worked well. Data were transmitted over several kilometers and made available via Internet access.

Christos et al [15] described the design of an adaptable decision support system and its integration with a wireless sensor/actuator network to implement autonomous closed-loop zone-specific irrigation. Using ontology for defining the application logic emphasizes system flexibility and adaptability and supports the application of automatic inferential and validation mechanisms. A machine learning process is applied for inducing new rules by analyzing logged datasets for extracting new knowledge and extending the system ontology in order to cope.

3. Automatic Irrigation System

The physical and chemical properties of field soil play a vital role in water and nutrients movement and storage. The type of soil is very important considering the variable factor in agriculture. Soil particles attract water due to chemical bonding and texture. Different types of soil have different capacity to hold up water. Water from soil is released through parts of the plant and soil surface. When soil moisture depleted to an extreme level, the plants are not able to take further water from soil [12]. The various types of soil and its contaminants are shown in figure 1.

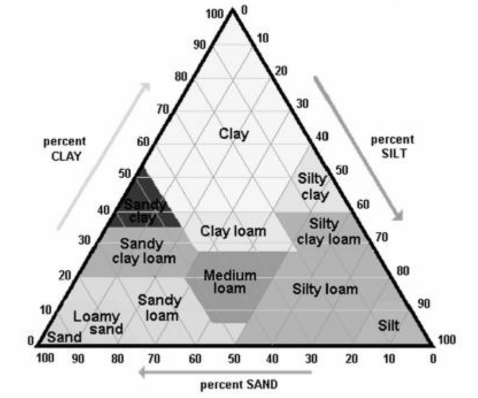

Figure 1 Soil Classification Triangle

The system is classified into four important sections namely wireless sensor nodes in cluster, Cluster head node for coordination, irrigation controller using fuzzy logic, and irrigation pipe network using drip irrigation. The WSN consists of sensor node cluster, coordinator node and controller node. Irrigation pipes networks are laid over the irrigated areas. The deployment of humidity sensor node is to form a sensor node cluster according to the plant conditions and watering status [13]. Each node is responsible for monitoring a small area of soil moisture conditions, and sends the information to coordinate the node within certain time interval. This information is sent to FLC section for proper irrigation to soil moisture information in order to decide whether or not to conduct water and how long the irrigation time is. The system principle is shown in figure 2.

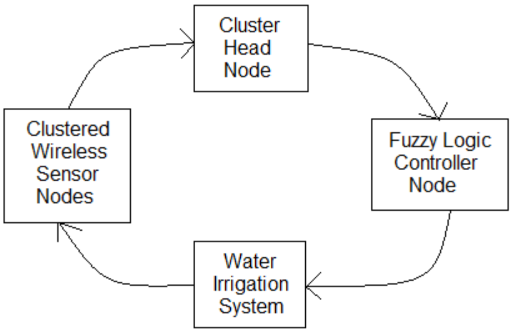

Figure 2 System Architecture

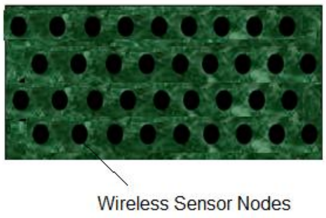

Figure 3 Clustered Wireless Sensor Node in the Field

Figure 3 shows the clustered wireless sensor node named motes connected in the field. The nodes are connected in a hexagonal cell based structure to get maximum coverage. Each node is also connected with a drip irrigation valve to supply water to the respective area in the field, and is shown in figure 4. Figure 5 shows the various sensors used in the field node to measure the parameters like soil humidity, and temperature. In figure 5, (a) shows PCB requirements for the wireless sensor node, (b) shows the ZigBee radio modem, (c) shows the temperature sensor, (d) shows the moisture sensor, (e) shows the battery arrangements for the node, (f) shows the solar panel, and (g) shows the supports made with polyvinyl chloride.

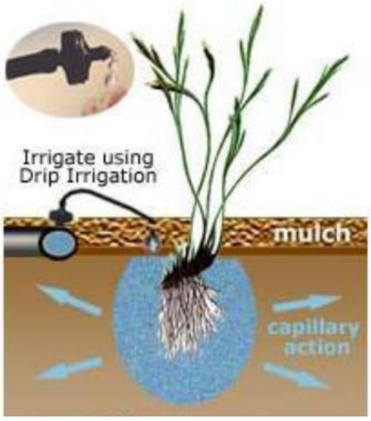

Figure 4 Drip Irrigation System

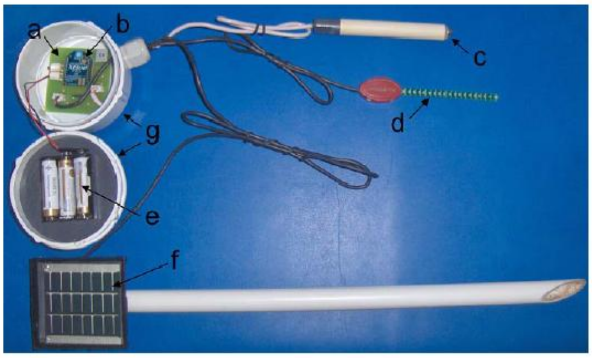

Figure 5 Wireless Sensor Node Unit

4. Fuzzy Logic based Irrigation System

Figure 6 shows the structure of the wireless sensor node deployed at the field using sensors. These wireless sensor nodes collects the parameters like humidity, temperature from the soil using sensors, process it, and communicate to the cluster head when the measured values are not in the expected range. Also based on the instruction received from the FLC based remote node, the controller will open the valve to irrigate the plants through the drip mechanism. The amount of water will be decided by the FLC based remote node, and based on this amount of valve is opened.

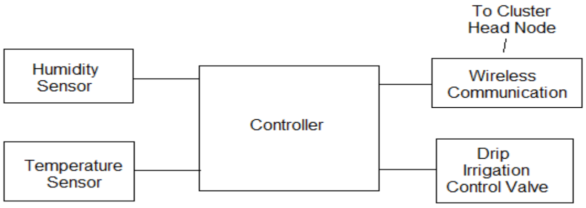

Figure 6 Field Node

Figure 7 shows the structure of the watering pipe layout in the field. The flush value is operated by the FLC controller, which operates on the conditions of the field. From the central pipe, polytube pipes are connected to which the drip system is connected to irrigate the plant in the field.

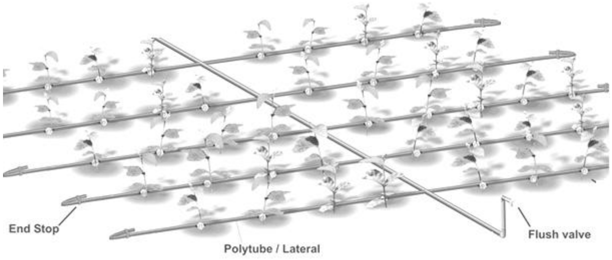

Figure 7 Structure of Watering Pipe Layout

Figure 8 shows the structure of the remote fuzzy based central controller node. The power required for the system is generated from the solar panel and is stored in the battery. The level of water in the water tank is sensed by water level sensor and is connected to the FLC. When the level of the water in the tank is low, the FLC triggers the motor through the relay. The motor is connected to the battery through a converter. FLC also monitors the amount of rainfall, wind speed, and atmospheric temperature using sensors.

Based on the various conditions, the FLC will control the opening and closing of valves from the water tank to the various fields in the irrigation system. The information of the condition of the field and the system is send to the farmer when required using the GSM module. The FLC is connected to the cluster head node through Zigbee protocol.

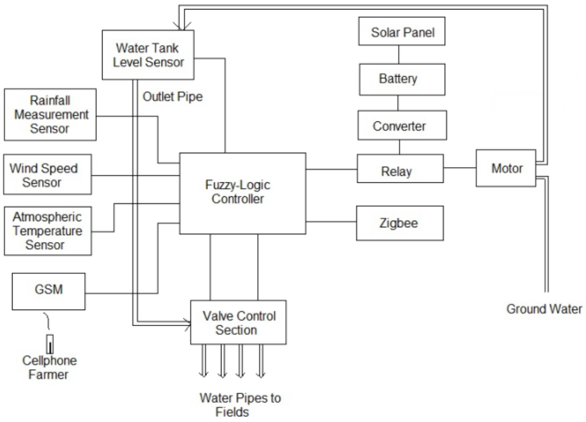

Figure 8 Remote Control Section

5. Conclusion

In this paper, WSN and FLC technology are introduced to design an automatic water-saving irrigation system. Based on the measured parameters the required amount of water is identified using the FLC, and is poured to the plants at regular intervals. When the system is used for large plantation areas, instead of drip irrigation, sprinkler systems can be used. The system will have great saving of irrigation water, better and healthier plants to provide a stable high yields.

References

[1]. P. Javadi Kia, A. Tabatabaee Far, M. Omid, R. Alimardani, and L. Naderloo, "Intelligent Control based Fuzzy Logic for Automation of Greenhouse Irrigation System and Evaluation in Relation to Conventional Systems", World Applied Sciences Journal, Vol. 6, Issue 1, pp. 16-23, 2009.

[2]. Khriji S., Houssaini D. E., Jmal M. W., Viehweger C., Abid M., and Kanoun O., "Precision Irrigation based on Wireless Sensor Network", IET Journal on Science, Measurement and Technology, Vol. 8, Issue 3, pp. 98-106, 2014.

[3]. Mahir Dursun, and Semih Ozden, "An Efficient Improved Photovoltaic Irrigation System with Artificial Neural Network based Modeling of Soil Moisture Distribution – A Case Study in Turkey", Journal on Computers and Electronics in Agriculture, Vol. 102, pp. 120-126, March 2014.

[4]. Farid Touati, Mohammed Al-Hitmi, Kamel Benhmed, and Rohan Tabish, "A Fuzzy Logic based Irrigation System Enhanced with Wireless Data Logging Applied to the State of Qatar", Computers and Electronics in Agriculture, Vol. 98, pp. 233-241, Oct 2013.

[5]. Christos Goumopolulos, Brendan O'Flynn, and Archilles Kameas, "Automated Zone-specific Irrigation with Wireless Sensor/Actuator Network and Adaptable Decision Support", Journal on Computers and Electronics in Agriculture, Vol. 105, pp. 20-33, July 2014.

[6]. S. N. Singh, R. Jha, and M. K. Nandwana, "Optimal Design of Solar Powered Fuzzy Control Irrigation System for Cultivation of Green Vegetable Plants in Rural India", 1st International Conference on Recent Advances in Information Technology (RAIT), pp. 877-882, 2012.

[7]. Xin Dong, Mehmet C. Vuran, and Suat Irmak, "Autonomous Precision Agriculture through Integration of Wireless underground Sensor Networks with Center Pivot Irrigation Systems", Journal on Ad hoc Networks, Vol. 11, Issue 7, pp. 1975-1987, Sep 2013.

[8]. Robert W. Coates, Michael J. Delwiche, Alan Broad, and Mark Holler, "Wireless Sensor Network with Irrigation Valve Control", Journal on Computers and Electronics in Agriculture, Vol. 96, pp. 13-22, August 2013.

[9]. R. Nolz, G. Kammerer, and P. Cepuder, "Calibrating Soil Water Potential Sensors Integrated into a Wireless Monitoring Network", Journal on Agricultural Water Management, Vol. 116, pp. 12-20, Jan 2013.

[10]. W. A. Jury and H. J. Vaux, "The emerging global water crisis: Managing scarcity and conflict between water users," Advanced Agronomy, Vol. 95, pp. 1–76, Sep 2007.

[11]. Herman Sahota, Ratnesh Kumar, and Ahmed Kamal, "A Wireless Sensor Network for Precision Agriculture and its Performance", Wireless Communications and Mobile Computing, Vol. 11, pp. 1628-1645, 2011.

[12]. Jignesh Patel, Himanshu Patel, and Chetan Bhatt, “Fuzzy Logic based Decision Support System Framework for Irrigation Scheduling”, 2012 Nirma University International Conference on Engineering, (NUiCONE-2012), pp. 1-4, 06-08 Dec 2012.

[13]. Peng Xiaohong, Mo Zhi, Xiao Laisheng, and Liu Guodong, “ A Water-saving Irrigation System based on Fuzzy Controller Technology and Wireless Sensor Network”, 5th International Conference on Wireless Communications, Networking and Mobile Computing (WiCom ’09), pp. 1-4, 24-26 Sep 2009.

[14]. R. Nolz, G. Kammerer, and P. Cepuder, “Calibrating Soil Water Potential Sensors Integrated into a Wireless Monitoring Network”, Agricultural Water Management, Elsevier, 116, pp. 12-20, 2013.

[15]. Christos Goumopoulos, Brendan O’Flynn, and Achilles Kameas, “Automated Zone-specific Irrigagion with Wireless Sensor/actuator Network and Adaptable Decision Support”, Computers and Electronics in Agriculture, Elsevier, 105, pp. 20-33, 2014.