Review on Agricultural Environment Monitoring by Using Wireless Sensor Networks

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***Abstract*— The advancement in technologies made sensors involved in several field of life. Agriculture is one of these domains which use sensors to get many benefits such as irrigation and pest control. Wireless Sensor Networks (WSN) is formed by many networked sensing nodes. The goal of a WSN is to deliver a meaningful information from raw local data collected by sensors. The flexibility, fault tolerance, low cost and high sensing fidelity of the WSN created many new and exciting application areas for remote sensing. The aim of this paper is to review the application of WSN and their architecture in agriculture. This review also highlights on the different communication technologies and sensors applied in agriculture.**

***Index Terms*— WSN, irrigation, fault tolerance ,communication technologies**

I. INTRODUCTION

The utilization of WSN in agriculture made a great research interest in the farming domain. Agricultural is the most investigated realm for the WSN. The WSN will provide a precision in agriculture, which would provide a solution in profit optimization and crop production. Farmers now can gather vital agricultural information by using WSN to monitor their fields. This information can be used to maximize and cultivate the agriculture harvest [1]. Technologies like grid computing, satellite navigation, the context-aware computing and ubiquitous computing are supporting the said domain for improved monitoring and decision-making capabilities [2]. The use of WSN in supporting agriculture practices in a very good direction [3, 4]. The advancements in technologies helped in reding the size of sensors which enabled them to be used in many domains of human life. Due to the importance of sensor technology, several issues related applications are in research. Small memory, energy constraint, limited computing power and data security are some of the substantial issues of WSN for which researchers proposed several solutions [5-7]. This paper aims to review the application of WSN and highlights the different communication technologies and sensors applied in agriculture field.

II. WSN IN AGRICULTURE

1-Reducing Water Consumption in Turfgrass

50- 75% of residential water is utilized for irrigation. The used systems are exceptionally poor at adapting irrigation to meet the demands. This is attributed to the incomplete information for system operators who rely either on periodic irrigation programs or visual inspection. This results in fertilizer and soil leaching and over-watering. The work in [7] demonstrated a irrigation control system based on WSN that reduced water consumption for residential turfgrass irrigation. They used a wireless soil moisture sensors node with an adaptive irrigation controller that waters on demand without user input. The result is a system that requires less user intervention, lowers water consumption, and adapts to changing climatic conditions. The authors used an easy-to deploy and low-cost system for residential users. The system is made of three components: a soil moisture sensor, a sensing node that is responsible for scheduling and reporting soil moisture readings, and a controller node responsible for controlling and scheduling irrigation events. The system delivered 54% less water with no noticeable effect on visual appearance within and between the test plots. Additionally, the system operated in an efficient fashion and had no interruptions in service.

2-Agricultural Environment Monitoring

An agricultural environment monitoring system maintains the crop growing environment in an optimal status. However, the existing agricultural monitoring systems are mostly used and applied in closed agricultural environments such as cattle sheds, greenhouses. The authors in [8] proposes an agricultural monitoring system for monitoring information in outdoors agricultural production environment by using WSN technology. The system collects soil and environmental information through WSN system, collects location information by utilizing GPS receivers and collects image information through CCTVs. The authors claimed that the system could even monitor the environmental information on the outdoors remotely, and they expected that the system could contribute to increasing the crop yields and improve the quality in the agricultural field through supporting the decision making of production by analyzing the collected information.

3-Automation of Drip Irrigation

Irrigation from freshwater resources is of crucial importance. Due to the raising demand for freshwater, optimal usage of water resources has been provided with greater extent by automation technology and its apparatus such as sensors, drip irrigation, remote control and solar power. The traditional instrumentation solutions suffer from many difficulties on controlling and measuring systems. The work in [9] demonstrated an application of a WSN for real time monitoring of water content in soil by using a low-cost wireless controlled irrigation system. The proposed system has 3 units namely: sensor unit, valve unit and base station unit, see Fig (1). The system provides an efficient use of freshwater resource. Additionally, the developed irrigation system removes the need for workmanship for flooding irrigation. The authors claimed that the system can be utilized in many commercial agricultural productions. Additionally, the system has the advantages of ensuring of rapid growing weeds, diminishing of excessive water usage and preventing moisture stress of trees.

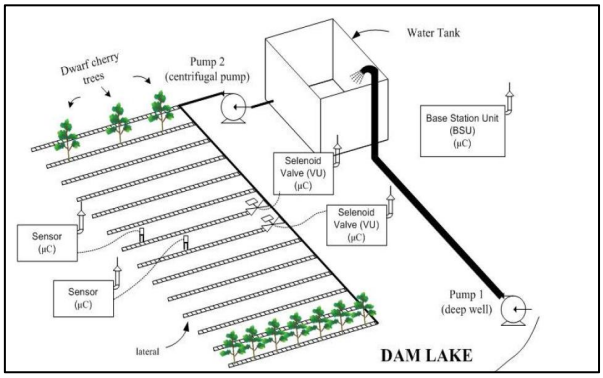

Fig. 1. the proposed system used in Ref [9]

4- Intelligent Water-saving Irrigation System

To improve the utilization rate of irrigation water it is necessary to implement precise controlled information based on water crops demand data. However, if there is no cable network in the irrigation field, the cost of crop will be higher, and the farming will be unfavorable. WSN could be an appropriate technique for a precise irrigation. The work in [10] proposed a system based on WSN and Fuzzy Control for water saving irrigation, see Fig. 2. The WSN is consisting of irrigation controller node, sensor node and coordinator node. The irrigation controller node controls the automatic watering. While the sensor node is used to be for gathering information such as air temperature and soil humidity regularly and send it to the coordinator node. A fuzzy controller is embedded in the coordinator node in order to take air temperature and soil humidity as its input and determine water demand by fuzzy inference and fuzzy judge and output it to irrigation controller node. The intelligent water-saving irrigation system includes two primary functions. The first one is to control intelligent water-saving irrigation. The second one is to finish collection of soil humidity information. The authors showed that the system can accurately determine the water demand, which is a scientific basis for water-saving irrigation. The wireless design made irrigation more convenient intelligent

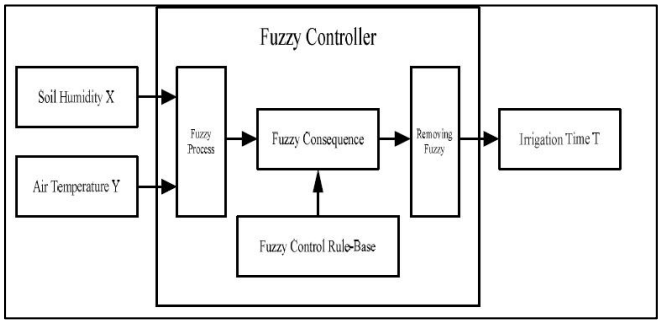

Fig. 2. the structure of the proposed fuzzy controller system, Ref. [10]

5- *An Intelligent Irrigation System by Using Fuzzy Control*

The implementations of water-saving irrigation are receiving much of the research interest [11]. As excessive soil moisture could cause the rot of crops' roots, took away a lot of fertilizer and cause water pollution. Controlling and monitoring and of soil moisture content had made great progress along the development of computer and WSN technology [12]. However, there remained two main problems: First, it is difficult to establish a precise mathematical model. Second, it had a complex wiring, maintenance and installation costs. The author in [13] developed an intelligent irrigation system based on fuzzy control and WSNs. As the fuzzy system is suitable in irrigation systems and does not depend on accurate mathematical model, additionally, it has a dynamic and good robustness response. The proposed system consists of WSNs and the monitoring center. In which all the nodes collect information of soil moisture, then the soil moisture content deviation and the rate of change of deviation are taken as input variables of fuzzy controller. The authors showed that the system has a reliable and stable data transmission, which give a right amount of irrigation based on crops growth information and deliver a real-time monitoring of soil on crop growth.

6-Agricultural System Monitoring

Traditional technique is farming is unable to cope with environmental changes condition (such as the increasing in the global temperature and pollution). Good control of the environmental parameter can increase the yield of crops. Environmental parameters like humidity, moisture and temperature plays important role in growth of the plant. A sustainable method is required in order to maintain the balance between the environment and these parameters. The authors in [14] developed WSN based system for agriculture monitoring. Moisture, temperature, and humidity measurements were considered in the study. For moisture measurement self-developed sensor was developed and calibrated, while for temperature and humidity integrated

sensor was used for user interface GSM service was utilized as it is easy to reach for most of the people, while a ZigBee protocol was used for wireless communication in order to collect the field data at center node. The proposed system can provide a real time monitoring for agricultural management. Additionally, the system combined the low power and low cost with modern age small size sensors.

7-Precision Agriculture by using IoT

Internet of Things (IOT) is considered as one of the most popular subjects recently, in which smart devices and sensors facilitate the communication and provision of information. In IoT, one of the main concepts is utilizing WSN, as WSN collect data from all the sensors in a network and it characterized by wide range of communication and a low power consumption. The authors in [15] proposed an architecture to monitor soil humidity, temperature, and moisture on small farms. The authors goal was to increase productivity on small agricultural farms and decrease water consumption. The proposed system sends a report to the end user, in which the report contains a 10-day weather forecast. The authors claimed that the proposed work can be of a great benefit to its users. As the users will enjoy saving in their time and water by directly dividing the land into as many regions as desired.

8- Agricultural Environment using Raspberry Pi based Sensor Nodes

The faming domain poses some difficulties in the collection of crop, soil and weather information, and fertilizer and water requirement. As a solution, WSN is applied in farming services such as fertilization, irrigation, pest control, animals monitoring, viticulture and greenhouse [16]. The authors in [17] developed a WSN for agricultural environment monitoring. Three important factors were addressed such as humidity, temperature and light. The sensor node developed was based from a microcomputer Raspberry Pi capable of sending data through Wi-Fi. The WSN is composed of 3 sensor nodes in which each sensor node is equipped with humidity, temperature and light sensors for the data collection of the environment status, see Fig. 3. This data was sent through Wi-Fi in the base station. The authors showed that the proposed systems can help in the characterization of the environmental condition of the agricultural environment.

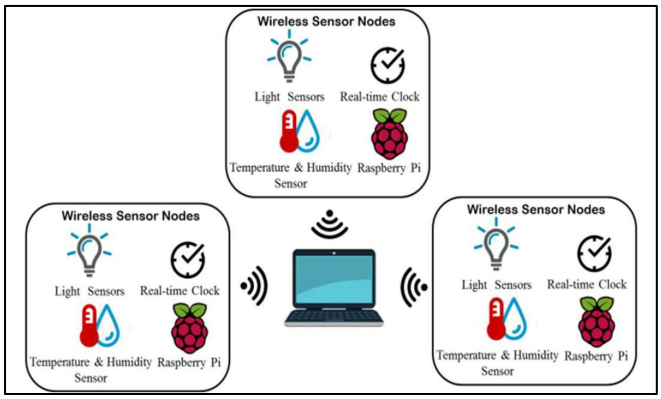

Fig. 3. Block diagram of the raspberry Pi based sensor nodes system, Ref. [17]

III. CONCLUSION

In this work, a survey on Wireless Sensor Networks (WSN) and their platform in agriculture was carried out. This survey paper focused on the application of WSN in agriculture in terms of irrigation, monitoring and water saving. Additionally, this paper reviewed the recent technologies and the underlying platforms used in developing these systems.

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