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Field Irrigation Management System Using Wireless Sensor Network

Jignesh B Patel, Chetan B Bhatt, Bhargav Patel, Kunal Parwani and Chirag Sohaliya

Abstract – Increased demand of farm product due to population growth and limited resources of irrigation water has made the field irrigation management system as an important element of agricultural activity. Wireless Sensor Network (WSN) is the most preferred platform due to its low cost, small size, low power consumption, reduced maintenance, great flexibility, portability and scalability features. WSN based expert system is proposed to provide optimized water supply for various crops in the field. It uses on field soil moisture and temperature data to understand the actual need of water.

Index terms – Field Irrigation, Soil Moisture, Wireless Sensor Networks

I. INTRODUCTION

AGRICULTURE is one of the most important economic activity in the country. Although the total contribution of agriculture in country's GDP is about 16% which is third after industry and service sector but, it employs the largest (about 52%) workforce of the country. Apart from direct employment, it supports economical activities such as animal husbandry and agro based industries. Seed, water, fertilizers and pesticides are considered as important inputs in agriculture. Among these, water is the most important supply as majority part of the country is arid or semi arid and prone to draught. Major threat to the agriculture sector is insufficient water supply. This has demanded the need of effective water management system for farm irrigation.

The conventional method to decide the need of water supply is based on information like- type of crops, variety of crops and time duration etc. Scientific study reveals that these approaches are not a right practice to decide water supply to the farm. It is equally important to consider present weather and soil condition in the decision making process to determine frequency and quantity of the water supply. The present practice leads wastage of water resource and also reduces productivity. Modern practices in irrigation address the optimized used of water and higher water productivity [1].

The proposed system is intended to provide portable, scalable and affordable solution to achieve optimized usage of water supply.

It collects on field data like soil and atmosphere temperature and soil moisture with the help of Wireless Sensor Networks (WSN). The collected data stored in the centralized data server. On the basis of these data, an expert system generates a decision about the need of water irrigation in the field. Optimized usage of water reduces the wastage of water and also increases the production.

This paper next presents some of the applications of WSN in the area of agriculture in general. It is followed by discussion of development of sensor nodes for soil moisture and temperature, and field irrigation management system in section – III and section – IV respectively. Section - V presents the architecture of expert system to be developed in future work. Finally the paper is concluded in section – VI.

II. WIRELESS SENSOR NETWORK FOR AGRICULTURE APPLICATION

Wireless communication and distributed computational capabilities of WSN provides many advantages over wired data acquisition for agricultural applications. These advantages are like- low cost, small size, low power consumption, reduced maintenance, great flexibility, portability, scalability and distributed intelligence. WSN is a network of many smart sensors which can sense any physical variable and communicating with each other and transfer the data remotely without any wired connection. As many as 250 different successful applications of WSN are listed in [2]. Many researchers have made an effort to achieve high yield and low usages of water, fertilizers and pesticide with successful implementation of WSN in the field as well in greenhouses and vineyards [3],[4],[5]. WSN technology along with RFID technology provides solution for many application of agriculture as well food industries. A very good survey on these applications is presented in [6]. Another concept of *Precision Agriculture* was grown during the last decade. It is to incorporate site-specific crop management strategies along with the soil moisture content measurements. This involves large number of soil health monitoring smart sensors together [7].

It is proposed to develop a WSN based expert system which provides the support to the farmers to decide the right amount of water supply to the field. An intelligent system provides the required knowledge base in terms of optimum conditions of soil moisture and soil temperature for all popular crops. Following sections discuss the design and implementation of both in details.

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III. ON FIELD DATA ACQUISITION

An important part of the work is to decide the most suitable protocol for proposed WSN for agriculture application. Any wireless sensor is made up of blocks like-microcontroller, transceiver, signal conditioning circuit, power supply, and memory. Wireless sensor networks are networks of compact microsensors with wireless communication capability. A comprehensive comparative study of sensor nodes platforms, energy management techniques, off-the-shelf microcontrollers, battery types and radio devices are presented in [8]. Functional architecture and its related challenges are shown in Fig. 1.

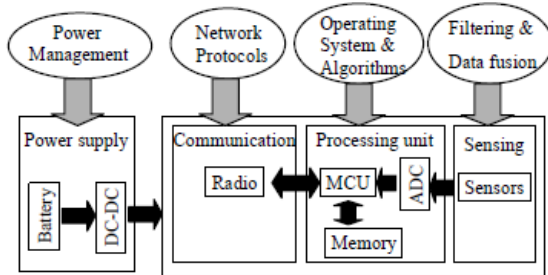


Fig. 1 Functional Block diagram of wireless sensor node

In case of agriculture application, long battery life, large distance and low complexity are desirable features of WSN. Bluetooth (over IEEE 802.15.1), ultra-wideband, (UWB, over IEEE 802.15.3), ZigBee (over IEEE 802.15.4), Wi-Fi (over IEEE 802.11) and Wireless Hart (over IEEE 802.15.4) are five protocol standards for short-range wireless communications. A very comprehensive study of above mentioned protocols in terms of nominal transmission power, nominal range, maximum signal rate, frequency band, encryption, maximum number of cell nodes, extension of the basic cell, coexistence mechanism, spreading techniques, modulation type, channel bandwidth, number of RF channels is presented by Lee and his colleague [9]. The comparative study reveals that the ZigBee would be the proffered protocol compare to others due to long battery life (in months), long range (10-100 m), moderate signal rate (250 kb/s) and easy availability of commercial hardware. commercial hardware modules available at lower cost. Conceptual diagram of the proposed system is presented in fig.2. The overall system comprises sensor node for soil moistures and temperature, base station and expert system.

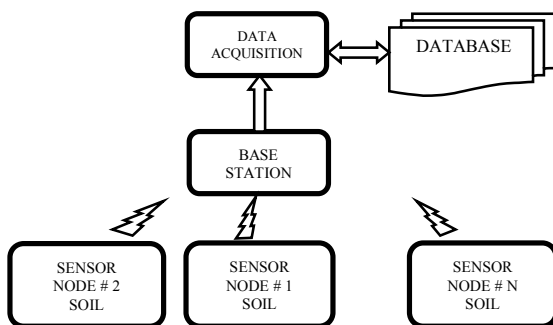


Fig. 2 Concept diagram of proposed system

The sensor nodes are developed on the microcontroller PIC 16f877A based platform. XBee Series 2 based on ZigBee/802.15.4 silicon from Ember™ is used as transceiver module. Local display for soil moisture and temperature is available on each node through LCD LM016L. Each node is powered by Li-ion battery.

1) Soil Moisture Node

Most important parameter for on field measurement is soil moisture. Soil moisture is the water that held in the spaces between soil particles. There are two different levels of soil moisture viz. surface moisture of upper 10 cm of soil and root zone soil moisture from 20-40 cm. Soil moisture is key parameter to determine when to irrigate and how much water to supply. It has been observed that most of the time the fields are over irrigated. More water than the required prevents the nitrogen to be used by roots, and lack of oxygen in the root zone. Subsequently it reduces the productivity. Different crops need different level of moisture for optimum growth. It is known as Maximum Allowable Depletion (MAD). In depth understanding of permanent wilting point and field capacity for various types of soils i.e. sand, slits and clay is presented in [10]. Over irrigation leads to wastage of energy and natural resources. A serious threat on sustainable agriculture in North Gujarat due to water wastage is presented in a white paper. [11].

Various options of solid state moisture sensors were explored. Among these, Decagon's EC-5 and Watermark's 200 SS-V are popular and suitable sensors for soil moisture measurement. These sensors are costly and not easily available in local market. As an intermediate solution, Honeywell's HIH 4000-002 was considered to approximately measurement of soil moisture.

2) Temperature Sensor Node

Soil and surrounding atmosphere temperature play a vital role in irrigation scheduling. Abnormal variation in atmospheric temperature leads towards the change in the predefined irrigation scheduling. Normally the temperature near the plant is less due to evaporation process. If the plant receives enough water from the soil than the about 2-4° C less temperature is maintained near the plant. A stress condition of the plant can detect by closely monitoring the temperature near the plant.

LM-35 is the most suitable sensor to measure the temperature on the field due to limited range of measurement and small size.

IV. FIELD IRRIGATION MANAGEMENT SYSTEM

An important part of the system is the management system. One of the sensor nodes is configured as receiver or base station. It is connected with the host PC via serial port. The data received by the receiver node further transmits the data in its serial buffer to the microcontroller. The microcontroller transmits the data serially via MAX 232 to the computer. Data received by host PC is then stored in the data base and most recent value is shown on the screen by the GUI (Graphical User Interface) developed in Visual Basic 6. A few snapshot of the system is shown in fig. 3.



Fig 3a Main GUI panel



Fig 3b Expert comment on the screen

It is possible to generate charts and graph of the on field temperature and soil moisture values since the sawing of the seed. This feature is helpful for analysis. History button provides facility to view the previous readings of the parameters directly stored in the database. The user can directly check the previous readings without opening the Microsoft Access file. An attempt is made to develop expert system which guides the farmer about the perfect irrigation schedule according to the selected crop. The expert system shows the values of minimum soil moisture and maximum allowable temperature to be maintained for that particular crop at different time zone i.e. from sawing to cultivation. It helps farmer to provide optimum water supply in the field. The system helps to prevent wastage of water and energy used in irrigation due to over irrigation.

V. FUTURE WORK

The proposed system is in the pilot scale. The future work is planned in two directions. The first is to expand the sensor network to cover larger size actual field. The factors like battery life, optimum number of nodes and quality of service are going to be very important in actual implementation. Simulation study using open platform *ns2* is being planned. Better interoperability between nodes and gateway will be the prime objective. It will make the system scalable and flexible enough to implement for different conditions. It is also planned to develop low cost and easy to use soil moisture sensor. This is very much important to reduce the overall cost.

Inclusion of pH measurement of soil is also planned.

The proposed expert system is very primitive. It is planned to develop an expert system which take the actual field data from the sensor network and integrate them with the knowledge base to generate suggestive action for better agriculture activities like – irrigation schedule, crop pattern, preventive care for pathogenic conditions, close monitoring of quality of farm product, etc. Proposed structure for such system is shown in fig. 4.

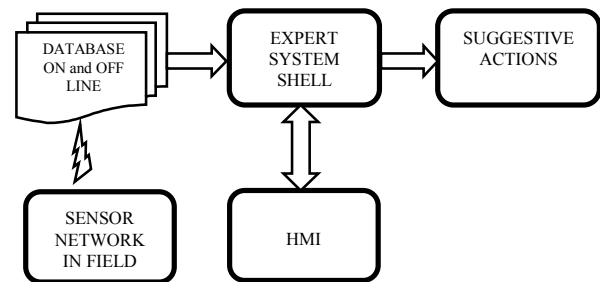


Fig 4 Block diagram of Proposed Expert System

VI. CONCLUSION

Increase in the productivity and overall profitability in agriculture is a need of the day. An efficient usage of water in the field is the key to achieve these. Proposed irrigation management system will help to achieve the optimum supply to various crops. Wireless Sensor Network works can be used as backbone to the proposed system.

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