Design and Implementation of Automated Irrigation Control System using WSN: An overview

Ms. Tasneem Sanglikar
PG Student inE &TC Department
P. G. Moze College of Engineering,
Pune, India
tasneem.tamboli@gmail.com

Prof. Puranik V. G.
Assistant Professor
BhivarabaiSawant Institute of Technology
& Research, Wagholi, Pune, India
vishalpura@gmail.com

Abstract—Agriculture plays an important role in Indian economy. It is the biggest water user with the irrigation accounting for 70 percent of global water usage. It is assumed that without improved efficiency of water usage, the consumption of agriculture water can increase by 20 percent by 2050 at global level. In our country rainfall controls the agriculture; but the rainfall is non-uniform and irregular. This creates hassle in irrigation which badly affects the agriculture produce. This paper reviews different smart irrigation methods to achieve the efficiency in water use, higher production levels, low cost, decreased manpower requirements, higher reliability in water supply and certainly higher profits to farmers. The smart irrigation system should be cost effective so that the farmers can use it in the farm field.

Keywords— *Smart Irrigation, Nodes, Sensors, WSN*

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I. INTRODUCTION

Irrigation is the method of watering the soil. The soil water requirement depends on soil properties like moisture of soil and the temperature of the soil. It also depends on the crop which is grown in the soil. Lots of new technologies have been developed for irrigating the crop in order to efficient use of water. In India agricultural area receives very less power supply. The supply is usually given in nonpeak hours; also frequent power cuts and low voltage supply creates a big problem to farmers. The off-peak hours are usually night hours after 11 pm. It is risky for a farmer to go to the field for irrigation as there is threat to his life from wild animals and snake-bites. If water level dips, the water pumps may run dry, leading to pump damage. If farmer fails to attend the irrigation, there is chance of wastage of water and electricity. Also, excess watering leads to soil damage.

In order to control and monitor the irrigation process, smart and automated irrigation process is required.

II. LITERATURE REVIEW

Many studies and work have been carried out with a focus on smart irrigation. Following paragraphs takes a brief review of the work conducted in this regard.

SangmeshMalga et al [1] discussed issues like load shedding, pump related issues, environmental issues and risk to farmer's life. In his work he developed a small embedded system device (ESD) that takes care of overall irrigation process and makes farmer's work easier. The system makes use of SMS service. The farmer sends SMS as a command which is received by GSM module, decode it and forward the decoded commandto the microcontroller to take further actions. Farmer first verifies the status of parameters like water level of the supply, soil temperature, rainfall, three-phase supply, by sending an SMS to the ESD. ESD in return sends information regarding the status of above mentioned parameters. If farmer finds all the parameters in the limits, he sends another SMS to the ESD to start the irrigation. The ESD starts the pump and initiates the irrigation process.

In this system, the microcontroller (PIC18F4550) itself acts as the sensor for water level detection and rain detection, avoiding need of separate sensors for the same.

Microcontroller works as the water level detector and rain detector sensor. Two pins of microcontroller are used for sensing water level and another two pins are used for rain detector sensor, out of two pins one pin is used as input to microcontroller and other pin is used as output.

This system gives protection against power supply fluctuations, dry run state of motor, overheating of motor winding and prevention of wastage of water and electricity. Another advantage of this system is that the farmer need not visit the farms in late-night hours to start the pumps, which reduces threat to life.

BenahmedKhelifaet al [2] discussedsmart irrigation techniques using 'Internet of Things' (IoT). This paper proposes a technology for smart irrigation management through internet and smart phones. The system uses sensors which are placed in the agriculture field, measures the soil moisture value, water level in the tank and well-water level values. These values are sent through ZigBee mesh network to smart gateway. Then these values are sent to web service through mobile data communication network. The web servers use intelligent software to analyse the data and act according to the result obtained to perform desired action. This system which is based on 'ICT' and 'IoT' technologies ensures low cost and high accuracy in control of irrigation. This system encourages optimum use of water, reduces irrigation efforts and reduces the cost of working force.

ChandankumarSahu et al [3] proposed a low cost smart irrigation control system which includes sensor nodes and control nodes. This paper proposes to decrease number of moisture sensors and wireless network devices. The field is divided into small squares and the moisture sensors are placed at the corners of each square. The moisture sensors send the information of moisture content of the soil to ARDUINO-UNO development board through wireless network device, where an ATMEGA-328 microcontroller process the data and calculates the dryness level of soil. This information is sent to

RASPBERRY-Pi which is control node. The control node calculates the water requirement of the soil by comparing dryness level with predefined values and actuates electromagnetic valves to start/ stop irrigation.

Ayman M. Hussain et al [4] in his paper represent irrigation management system for open canals using WSN and water pumps. This system uses two sensors, water level sensor and flow sensor. Water level sensor is connected to main irrigation canals, which monitors the water level of the canal. Flow sensor is connected to water pump which keeps track of the amount of water pumped for irrigation. These sensors are connected to microcontroller which has serial interface to Zigbee module .The wireless gateway which uses Zigbee, collects sensor data periodically and then sends it to web server via GPRS. The web server is connected to the database which monitors irrigation water level at all main and auxiliary canals .The web based IMS analyse the data stored in database and compares with specified values. Then it (IMS) sends SMS to farmers and engineers to make aware of water requirement.

Jaypal J. Baviskar et al [5] proposes an automated irrigation system which uses IVRS (interactive voice response system) for remote controlling and monitoring the irrigation. This system consists of two main units - pump control unit (PCU) and farm control unit (FCU). The PCU is installed near the water source which controls the working of the pump to supply water to particular area of field. The FCU is installed near the field that must be monitored and controlled. The FCU observes the moisture level of the soil and controls the valve.
When the user gives a call to the system from his mobile, the system first verifies the caller's mobile number and starts its operation only if the number is verified. System first checks the availability of water and electricity and informs the same to the user on his mobile. Various messages are pre-recorded and stored in voice IC to guide the user. The user interacts with the system through IVRS and selects the control command/s to be executed. When system receives the command, it simply executes the program to carry out desired operation. This helps the farmer to perform his job efficiently from remote location. This system is password protected. Whenever the GSM modem receives any call, the system verifies and allows only authenticated user to access the system. GSM technology provides complete accessibility, simplicity, smallest amount of signal deterioration and large coverage area. The proposed system is cost effective and involves minimum latency.

An automatic mist irrigation system is proposed for cardamom field [6], which consists of wireless sensor network for continuously monitoring and controlling irrigation system. The cardamom field has plain and slope areas, this system support these two areas. Over watering to the cardamom field causes diseases to cardamom and damage it. This system provides uniform distribution of water to both plain and slope areas and thus it prevents the water overflow at the slope areas which protect the plant and save water.

The sensors are distributed in the field. They are used to monitor the condition of the field like soil temperature, moisture content etc. This information is transmitted by the sensors by using Wi-Fi technology. The solenoid valves are used to start/stop the water supply. The system processes the information received from the sensors and if water is required by the soil, the solenoids are actuated. The solenoids starts mist emitters to supply water to the field in accordance with defined limits of soil properties like soil moisture, temperature and humidity. This system is used to monitor the tank water level also. If it is below the specified level, pump is started automatically; by providing the sound alarms at the same time. As soon as water level reaches 90 % the motor is automatically switched off. Xbee-PRO is used to establish communication between the field station and irrigation controller at the base station. The advantage of this system is that it is a low cost and low power consuming technology, using a wireless sensor network.

A. Kumar et al [7] proposes low cost moisture sensor and XBee based data acquisition system required for automated irrigation system. Moisture sensor measures the relative moisture of any environment. The authors have developed an impedance based moisture sensor. Impedance based sensors works on the change of impedance between two electrodes due to varying moisture content in the surrounding medium. When the electrodes are kept in soil, its moisture level changes can be measured in a relative manner.

XBee technology is a low cost and low power wireless technology. It works over a larger distance as compared to Bluetooth and with lower power requirements than the Wi-Fi technology. Also it can be connected to 25400 node which in much higher number than Bluetooth and Wi-Fi. XBee technology exhibits a high three-tire security, using protocol such as ACL or advanced encryption standard in (AES-128) for security. In this paper only moisture sensor was tested. More sensors can be added to record other parameters like temperature, rainfall, air humidity etc.

NattapolKaewmard et al [8] presented the process of how microcontroller (MCU) gathers the environment information about humidity, temperature, soil moisture, and groundwater level. The sensor devices collect environment data which communicates between Atmel AVR microcontroller (Arduino) and sensors. The data transmission between microcontroller and wireless sensor network is achieved via XBee (wireless module ZigBee - XBee Series 2). The purpose is to build the WSN system. This system can work either indoors (like greenhouses), outdoors (field) and various environments as well. The XBee transmits the signal as the characters through small Chip. It can transfer the data as point-to-multipoint or point-to- point until the destination node has received the data.

A wireless sensor network (WSN) is used for temperature measurement system [9]. In this system, digital multipoint thermometers are used to measure temperature data. This data is transmitted to the advanced RISC microprocessor (ARM) by using Wireless Fidelity (Wi-Fi) technology. WSNs can be easily established without using cables. they helps to cover a wider area.

A number of studies show that WSNs are cost effective solution to collect, receive and transmit data. An RF based weather monitoring system is proposed in [10]. It explains different methods of measuring pressure, temperature and humidity in the atmosphere in order to real time weather monitoring. Weather is checked at different levels of the atmosphere with the help of a hydrogen balloons in which pressure, temperature and humidity sensors are embedded.

Tao chi et al [11] explained that, in recent year, the advanced large-scale greenhouse has been widely used in farming. They (large-scale greenhouses) always occupy several hundred square meters of land. Also they must be able to adapt different plant species in different seasons. Frequent use of greenhouse needs the sensor location to be moved repeatedly. This makes traditional wire layout costly. Also a great deal of time and energy is required in order to resolve the wiring problems. This system introduces a newest WSN. This WSN depends on the sensor nodes distributed closely in order to collect the environmental information. This information is sent to clustering nodes by using wireless data link. The WSN behaves as self-organisation which takes the data to the centre. The node in network is intensive; it can handle huge quantity of data and capable of covering a large area. Energy efficiency play a decisive role in designing a wireless sensor node. The new technology intends to reduce the cost and effort of the integrated wiring. It also plans tries to enhance the flexibility and mobility of the surveillance point set.

III. Proposed Methodology

All the systems discussed above are worked for single a crop only. In the proposed work, different crops are considered along with their water requirement at different stages. The crops are irrigated with respect to the water requirement at different stages of their growth.

The block diagram of proposed system is shown in figure 1. The system consists of two parts: a) field station; and b) base station. The field station which operates in the farm at different locations, consists of soil moisture sensor (YL-69), temperature sensor(LM35), humidity sensor (SY-HS-220), ARM Cortex M3 (LPC1769), AC motor (HG410-EU), Relay (RW-SH-112D), Driver (BC547) and Zigbee. The base station consists of Zigbee and Matlab program.

The field station communicates with remote PC via Zigbee module. Soil moisture sensor, Humidity sensor and Temperature sensor can be interfaced with ARM Cortex M3 which has inbuilt ADC, and the data can be sent to PC serially via Zigbee module.

A. Field station

a) Temperature sensor

The temperature sensors in LM35 series are precision sensors. They are integrated-circuit temperature sensors whose output voltage is directly proportional to Celsius (Centigrade) temperature. LM32 doesn’t need to subtract large constant voltage from its output to calculate convenient centigrade scale values. Hence the LM32 is more advantageous as compared to linear temperature sensors. The LM35 is calibrated to operate over a temperature range of −55° to +150°C. It has Low impedance output of 0.1 Ω for 1 mA load.

b) Soil moisture sensor

This moisture sensor is simple sensor. It is used to measure moisture level of soil. It has dual output mode and its analog output is accurate. It operates in the range 3.3V-5V.

c) Humidity sensor

To measure amount of water molecules dissolved in air humidity sensor SY HS220 is used. It is precise and reliable. It work at 5 v sup land and operates at ≤ 0.3mA, operating temperature range is 0-60℃.

d) ARM Cortex M3(LPC1769)

LPC1769 is a 32bit ARM Cortex M3 microcontroller, operates at CPU frequencies of up to 120 MHz. The ARM Cortex-M3 CPU makes use of a 3-stage pipeline. It uses Harvard architecture along with separate local instruction and data buses. In addition, a third bus is used for peripherals.The advantage of the LPC1769 is that it includes up to 512 kB of flash memory with 64 kB of data memory. It has ethernet MAC, USB connectivity for Host / OTG interface. An 8-channel general purpose DMA controller and 2 SSP controllers are used to carry out processing operations. Four UARTs, 2 CAN channels, an SPI interface, three I2C-bus interfaces, 2-input plus 2-output I2S-bus interface are used for interfacing other components. An 8-channel 12-bit ADC and a 10-bit DAC are used for signal conversion. It also includes up to 70 general purpose I/O pins.

e) Relay

RW series relays are used on the field station to carry out switching operation. It has contact capacity of 10 A at 120 VAC or 10A at 24 VDC. It has a contact resistance of 100mΩ at 1A, 6VDC. Its operation time is very short, 10 ms to contact and 5 ms to release.

f) AC Motor

AC motor (HG410-EU) operates at 220V-240V 50 Hz voltage and has power consumption of 25W. It has a flow rate of 1200LPH (315GPH). Dry operation damages the pump.

g) Zigbee module

Zigbee module uses IEEE 802.15.4 protocol for fast peer to peer, point to point networking and it cover distance range for communication can be 10 m at indoor and 100 m at outdoor.

B. Base station

The base station consist of Matlab® code on a personal computer and a Zigbee receiver to receiver to communicate with field station

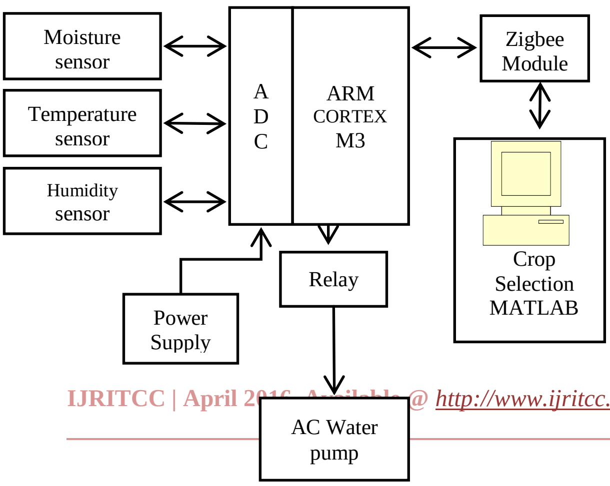

Figure 1: Block Diagram of the proposed work

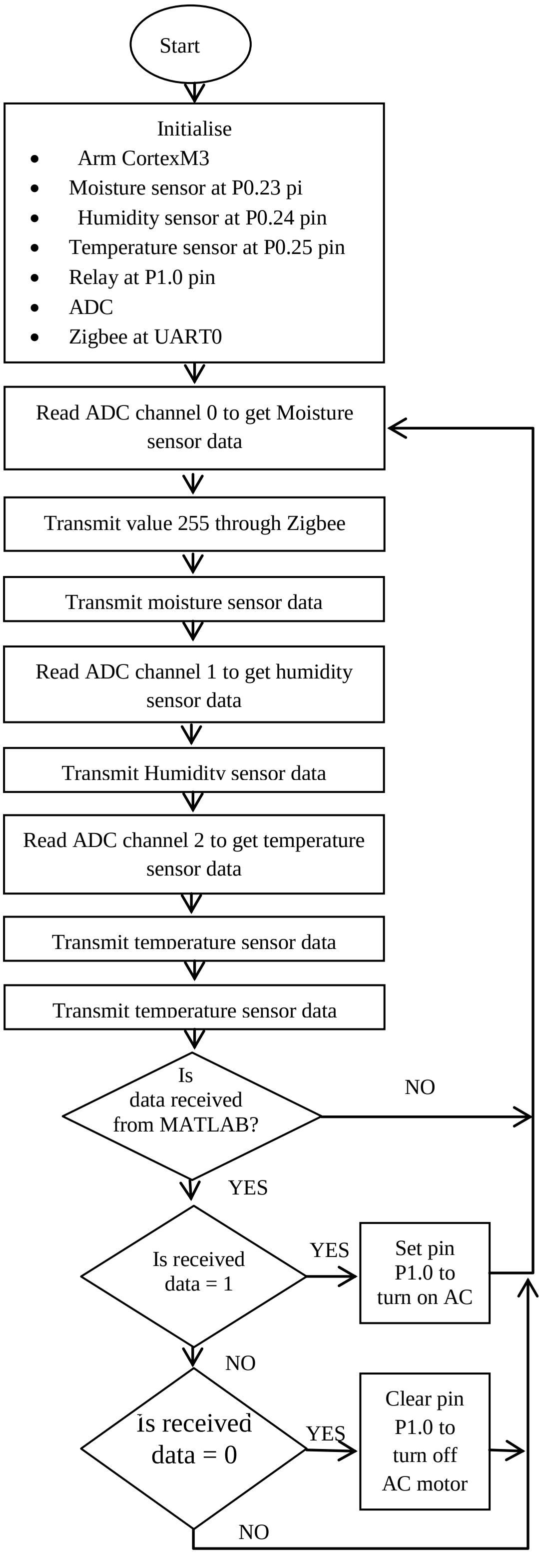

Figure 3: Algorithm for ARM Cortex M3

The ARM Cortex M3 can be programmed for different types of crops with respect to their watering requirements as perFAO standards. ARM Cortex monitors all the required things like soil water content, humidity and temperature as per crop growth stages indicated by FOA. It will control the watering valves as and when required via driver circuits. The project aims to reduce the wastage by automating the entire irrigation system. The water or moisture sensor, temperature sensor and humidity sensor is placed in the field which continuously senses the moisture, temperature and humidity content respectively in the field. The output of the sensors is transmitted wirelessly using a wireless module. Another wireless module at the receiving end receives the signals that are transmitted from wireless module. Those signals are given as an input to the main micro-controller which is the control unit (ARM Cortex M3). Lastly, the controller performs the motoring action.

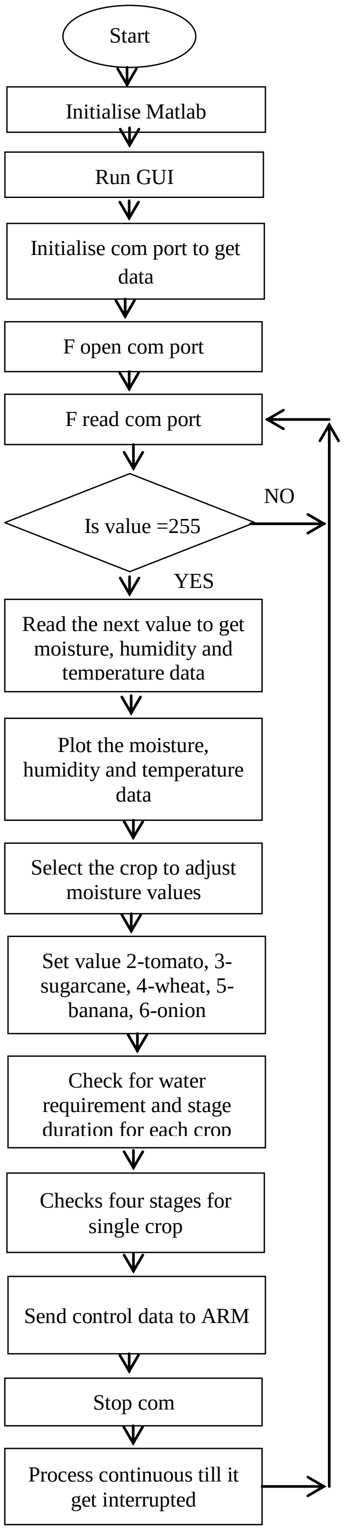

Figure 2: Algorithm for Matlab

The analog signals received from each sensor are converted by microcontroller in to digital one. These digital values are then compared with values representing the minimum allowable content of the soil. If the values recorded by the sensors are below minimum values, microcontroller sends signals to corresponding solenoid valves to start water supply. The controller carries an event driven program that operates its ports to control the pins according to the soil condition. If the compared value is below a set point the controller can take the action according to the set point.

At the base station we can select a different crops using MATLAB. It defines different crop's water requirement based on the crops growing stages required for proper irrigation. MATLAB receives data sent from field station via Zigbee interface. After selecting a crops, sensor shows the moisture content present in soil. At the same time temperature and humidity are observed. The received signal is compared with the threshold value of different crops of their crop stages. If any of these values is less than threshold value the base station send control signal to the field station to switch on the motor.

IV. Conclusion

This system will provide automated irrigation for different crops based on their water requirement and those crops growing stages using MATLAB. By using wireless module we can reduce the complication of wiring. We can monitor different parameters like temperature, humidity, moisture by using different sensor. By using this system we can reduce the labour cost and human intervention. Implementation of smart irrigation system helps farmers to initiate irrigation from remote locations, without visiting the farms in late nights.

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