AUTOMATED IRRIGATION SYSTEM WITH PUMP HEALTH DETECTION

Punit Gupta[1], Neha Shivhare[2]

[1]B.E.(IT) (Final year), Aarupadai Veedu Institute of Technology, Kanchipuram, Tamil Nadu (India)

[2]B.Tech (IT) (Third year), SRM University Kanchipuram, Tamil Nadu (India)

ABSTRACT

This paper deals with efficiently automating the irrigation process, which is the most important agricultural activity. This is achieved by determining two factors – availability of rain and moisture content of soil. There is a base station that fetches weather forecast to determine availability of rain and the pump node checks for soil moisture content to determine when to start pump. The communication between the base station and pump nodes are achieved using Zigbee protocol. When the soil moisture content goes below a certain percent, the pump node sends trigger to base station and return status of rain in the next 2 hours. Based on that response, if there is no upcoming rain, then the pump is started else it puts the pump on standby for next 2 hours. If rain does not occur during that duration, the pump is started. The pump remains active till a required moisture level is reached. This process saves a lot of ground water by smartly analyzing the conditions and deciding when to irrigate, without affecting plant health.

Keywords: Arduino, Irrigation, Moisture, Soil, Sensors, Wireless Sensor Networks, Zigbee

I. INTRODUCTION

India faces a major problem regarding water availability for irrigation of crops in the field. The management of irrigation in India is not fully developed and the irrigation facilities are inadequate. Under-irrigation of plants increases the salt content in the soil which is harmful for the growth of plants and second major problem is over-irrigation, which is mainly caused because of distribution of excess quantity of water to different varieties of plants. One of the basic and generic requirement for plants to grow is sufficient amount of water. This system provides a smart environment for plants to grow. It involves soil hygrometer sensors placed along with the crops on the field. These sensors measure the water content in the soil. The pump motors will also be constantly monitored and a plumber will be notified in case of mal-functioning. Systems using Weather forecast data (from Meteorological Department) can be effectively used in Smart Plant Watering System, weather forecasts provides the details of the weather conditions that help the farmers to decide whether to irrigate the field or not.

II.MICROCONTROLLER BASED IRRIGATION SYSTEM

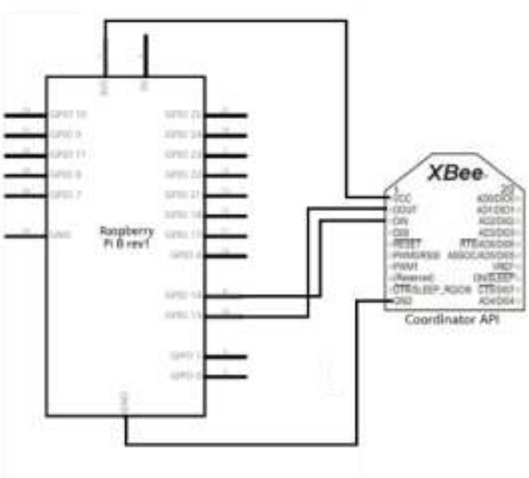
The setup comprises of two nodes: 1)The Base station and 2) The Pump Node

1) The Base station - It uses a Raspberry Pi with Xbee and GSM Module [Fig. 1]. The GSM Module is used to fetch Weather forecast data (from Meteorological Department) and send SMS. The data received will be used to determine whether the pumps should be started, or wait if rain is expected within 2 hours. The communication

between pump nodes and base station will take place using Zigbee protocol [1] in a star topology. The Base station acts as centralized management center. Solar cells are used to charge lithium ion batteries to power the whole system [2]. The base station can handle pump nodes within a range of 100 metres. The power requirements are very low and can be easily handled by solar cells.

2) The Pump node - It uses an Arduino UNO microcontroller [Fig. 2] to read and process data from soil sensors and start/stop the pump motor. The microcontroller will constantly monitor the soil moisture content using sensor and will trigger a request to Base station if moisture content goes below 15%. On successful response from the Base station, the pump motor will start and will continue irrigating till the threshold is reached. If rain is expected then the pump motors will stay on standby. If rain does not occur within the expected time period then the pump motors will start. The motors will keep running till the sensors detect the required amount of water in the soil. In case, the motor stops working or fails to start, a trigger is made to the base station module to notify the plumber via SMS.

2.1 The Schematic Diagrams



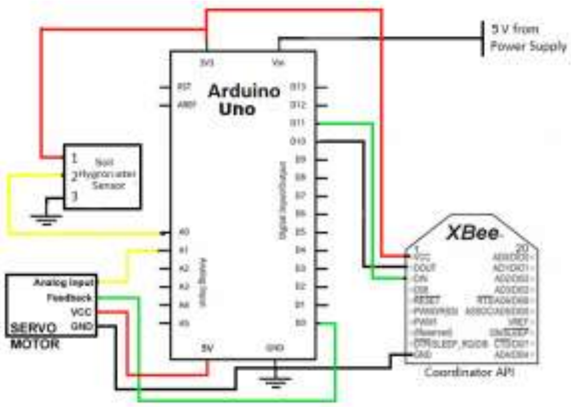


Fig 1 The Base Station **Fig 2. The Pump Node**

2.2 Hardware components

1. Raspberry Pi (Model B) – Raspberry Pi is a credit-card sized computer with a 700 Mhz ARM v6 processor and 512 MB RAM. It has USB, HDMI, Audio out and LAN ports to allow a variety of input and output devices to connect to it. It has a very low power requirement of 5V and 700ma. It is used as base station to store information regarding different crops and, fetch and process weather forecast data from the Internet [4].

2. Arduino UNO – It is a microcontroller board based on the ATmega328. It has 14 digital input/output pins, 6 analog inputs, a 16MHz ceramic resonator and a USB port. It can be programmed easily using a computer. It is used to control the start and stop of motors based on data received from the soil moisture sensors.

3. XBee Module – The communication between the 2 nodes is accomplished wirelessly using the ZigBee protocol. XBee supports frequencies including 2.4 GHz, 902 - 928 MHz and 865 - 868 MHz [5][7].

4. GSM Module – The GSM module connects to the Internet using GPRS from the SIM card. It includes the SIM900 communication module.

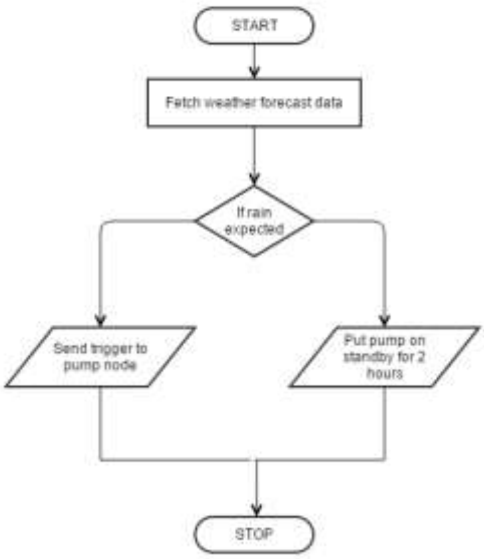
5. Soil Hygrometer – This is a simple water sensor which can be used to detect soil moisture. When the soil moisture deficit module detects excess of water, it outputs a high level, and vice versa [3]. It has an operating voltage of 3.3V-5V. It has dual output mode, digital output and analog output, to be precise.

6. Pump Motor – The pump motor is controlled by digital pins of Arduino. It has 5V power supply. [6]

III. SOFTWARE IMPLEMENTATION

The software code for handling the request and responses on the Base Station is written in Python on Raspberry Pi and in Arduino C for the Pump node on Arduino UNO. The figures belowdemostrate the working logic.

3.1 Flowcharts for the Software



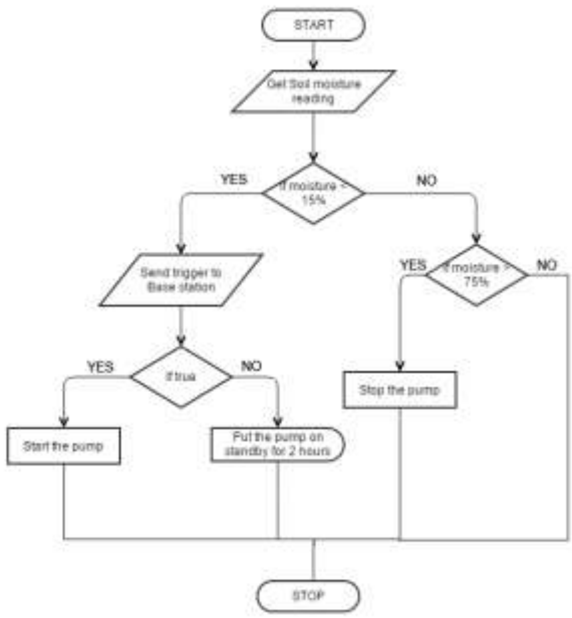


Fig. 3 Workflow of the Base Station **Fig. 4Motor Control on Pump Node**

3.2 Software Code

Different Operational States Exchanged Between Both Nodes

S.No.	Operational States	Action Denoted
1	State 0	Request to Base Station
2	State 1	Response to start the motor
3	State 2	Response to delay for 2 hours
4	State 3	Notify plumber

3.2.1 The Base station

```
#Import required libraries
defrainStatus():
plumber = "+919500000005"
city = "Chennai"
current_date = time.strftime("%Y%m%d")
url =
'http://api.dataweave.in/v1/indian_weather/findByCity/?api_key=b20a79e582ee4953ceccf41ac28aa08d&city='+
city+'&date='+current_date
```

```
response = urllib2.urlopen(url)
data = json.loads(response.read())
result = str(data["data"][0]["24 Hours Rainfall"][0])
if (result != 'NIL' and result != 'TRACE'):
        return 1
else:
        return 2
ser = Serial('/dev/ttyAMA0', 9600)
zb = ZigBee(ser)
while True:
try:
data = zb.wait_read_frame()
if data == '1':
        rain = rainStatus()
        zb.tx(dest_addr='\x00\x01', data=rain)
else if data == '3':
        sendSms(plumber);
exceptKeyboardInterrupt:
        break
ser.close()
```

3.2.2 The Pump node

```
#include <NewSoftSerial.h>
#include <Servo.h>
uint8_tpinRx = 10, pinTx = 11; // the pin on Arduino
longBaudRate = 9600;
char data;
intsoilSensor;
// Control and feedback pins
intservoPin = 0;
int feedback;
int state = 0;
// Initialize NewSoftSerial
NewSoftSerialmySerial(pinRx, pinTx );
Servo myservo;
void setup()
{
Serial.begin(BaudRate);
// This part is the NewSoftSerial for talking to XBee
mySerial.begin(BaudRate);
        myservo.attach(servoPin);
```

```
        }
voidmotorState(){
             while(state == 1){
myservo.write(0);
delay(100);
myservo.write(360);
}
        }
void loop()
{
soilSensor = analogRead(A0);

if(soilSensor< 445){ //Moisture level below 15%
Serial.print("Moisture level below 15%");
data = '0';
mySerial.print(data);
}
else if(soilSensor> 850){ //Moisture level above 75%
Serial.print("Moisture level above 75%");
state = 0;
motorState(); //Stop the motor
}
// Monitor data from XBee.
if ( mySerial.available() ) {
data = mySerial.read();
if(data == '1'){
state = 1;
motorState(); //Start the motor
if(analogRead(A1) == 0){
                         data = '3';
                         mySerial.print(data);
                   }
}else if(data == '2'){
delay(7200000); //Wait for 2 hours
    }
}
```

IV. CONCLUSION

The system optimizes irrigation procedures by eliminating human errors and providing optimum water requirement to the crops. It provides water at any time of the day based on the moisture content of the soil, which in turn reflects on plant health. Thus, by involvement of rain availability check, water conservation takes place and also helps to maintain the moisture to soil ratio at the root zone constant to some extent. This system is scalable and can be easily deployed to fields of any size. The pump motors give feedbacks so whenever a motor fails to start, a notification message is sent from the base station to respective number via SMS.

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