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Internet of Things Enabled Intelligent and Smart Irrigation System

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Abstract—Internet of Things (IoT) has made irrigation of agriculture fields more smart, convenient and comfortable. It has enhanced yield quality by providing intelligence feature in the soil condition monitoring using plethora of sensors and actuators. IoT has enabled farmers to become more knowledgeable and has simplified their decision making process for the irrigation of their agriculture land. By Using IoT, agriculture fields can now be irrigated remotely and status of soil parameters can be monitored more precisely even when farmer is away from their agriculture fields. In this paper smart irrigation system using IoT has been implemented which can monitor soil temperature, moisture content and amount of rain water using different sensors. These parameters can be monitored remotely using Wi-Fi module and brought under control by switching on water pump motor with the help of required accessories. Implementation of this smart irrigation system has improved the quality of product apart from enhancing the productivity of the farm while providing comfort, convenience and information to the farmer.

Keywords— Internet of Things, Smart Irrigation**,** Water Utilization, Soil Monitoring, Intelligent Decision

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I. INTRODUCTION

Internet of things is an interface in which computing and networking capabilities are embedded in any kind of conceivable object [1]. It is an interconnection between the physical world and the digital world, wherein the digital world interacts with the physical world using plethora of sensors and actuators [2]. It has the power of sensing, communicating and computing capabilities. The block diagram of IoT is shown in figure. 1.

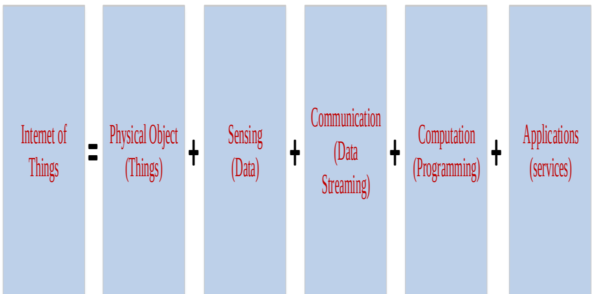

Figure 1. Definition of Internet of Things

In a country like India, where majority of the population resides in villages and are involved in agricultural work. Their economic and social status can get a major boost if the irrigation system is made intelligent and smart using latest technology such as IoT. In the present work, sensors have been used to measure soil moisture, soil temperature, and humidity level. In case of any of these parameters such as, soil moisture falls below 30 %, soil temperature rises above 45 degree Celsius and humidity falls below 30 %, corrective action are initiated by sending message to the farmer's mobile, displaying message in the LCD display, turning on LED light and switching on the water pump. Once the levels are brought back within normal limit, reverse actions are initiated.

II. DEVICES USED IN THE PRESENT WORK

The essential components for the present work consists of Arduino Uno board, smartphone, Wi-Fi Module, Temperature sensor, humidity sensor, rain sensor, relay, etc [3]. Arduino Uno board model R3 has been used as IoT development board that is depicted in figure 2. AVR ATmega328, 32 bit microprocessor at 16 MHz clock speed been used in this board that operates at 5 Volt DC power. It has 32 KB flash memory, 2 KB SRAM and 1 KB EEPROM, 14 digital input/output pins and 6 analog input pins. It has one onboard reset button, provision of a USB, power jack, and ICSP header. All the essential requirement for small IoT project requirements are embedded on the printed circuit board itself.

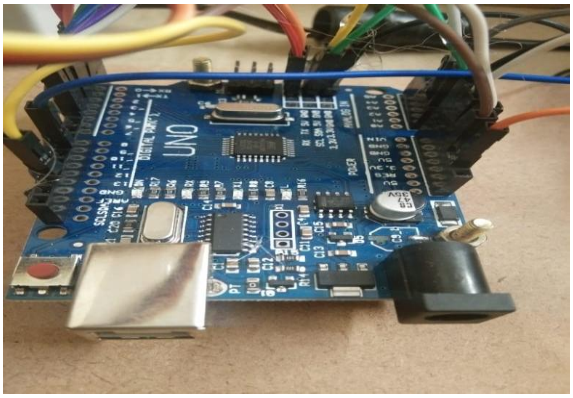

Figure 2. Arduino Uno Board

Liquid Crystal Display

The liquid crystal display (LCD) used in the present work and depicted in figure 3, operates with 5 volts DC voltage and is a 16 character by 2 line display module. It is having green back light with 4/8 bit MPU interface and a built-in HD44780 LCD driver. In this LCD each character is displayed in 5x7 pixel matrix. It has two registers, namely, Command and Data [4].

Command instructions are stored in the command register. A command is an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc. The data to be displayed on the LCD is stored in the register [5].

Figure 3. Liquid Crystal Display

Temperature Sensor (LM35)

The temperature sensor used for this project is LM35. This is a precision integrated-circuit temperature sensors, with an output voltage linearly proportional to the temperature in degree Celsius [6].

Figure 4 Temperature Sensor

Rain Sensor

For measuring rainfall intensity and detection of rain drop, rain sensor module has been used as reflected in figure 5. It has a rain board and control board, power indicator LED and an adjustable sensitivity potentiometer. It requires 5V DC power supply [7].

Figure 5 Rain Sensor

Soil Moisture Sensor

Fig 6 shows a simple and very low-cost circuit of a resistor-based soil sensor that has been used in the present work. It is considered to be a crude sensor that is used for inaccurate measurement such as to indicate that whether the soil being wet or not [8]. The sensor measures the soil resistance between the two electrodes. The resistance value depends upon the moisture content of the soil [9].

Figure 6 Soil Moisture Sensor

Relay

The relay used in the present project as shown in figure 7, is an electromechanical switch. It performs switching operations without any human interaction. It has been used to connect display device, LED indicator and water pump motor as per requirements [10-12].

Figure 7 Relay

Pump Motor

The pump motor used in the work is a submersible pump that is designed for reliability. It is of small size, has adjustable flow and convenient to clean. The motor is close-coupled to the body of the water booster pump, consumes less power, and is almost maintainace free [13-15]. It has been used to pour water in the filed in the case of less soil moisture content is detected form the soil moisture sensor [16-18].

Figure 8 Pump Motor

WIFI IoT Module

ESP8266 Wi-Fi IoT module has been used in this work that is shown in figure 9. It has 1 MB flash memory and is convenient to connect Arduino board to a Wi-Fi network. It has eight pin header that includes two GPIO pins used for direct connection of the module to sensors, peripherals, or host controller. It requires 3.3V power supply for its operation [21].

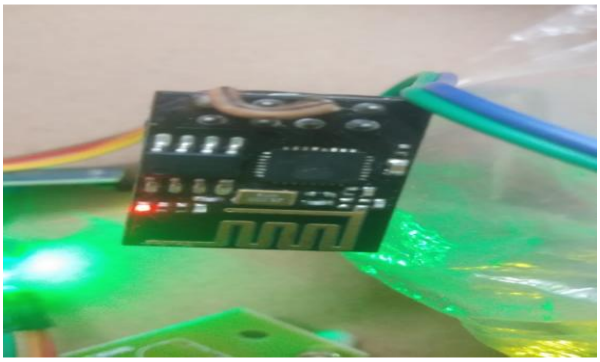

Figure 9 Wi-Fi IoT Module

III. ARCHITECTURE OF THE PROPOSED SYSTEM

The present work is based on a three layer IoT architecture as depicted in figure 10. All sensors have been connected to the physical layer for collection of data. Wi-Fi module has been used at the network layer for processing and transfer of information [20]. Application layer has been used for switching on water pump, information display in the LCD and sending message to the smart phone.

Figure 10. IoT Architecture

Interfacing of devices with Arduino board is shown in figure 11. Soil sensor, temperature sensor, rain sensor, relay, water pump, LCD display etc. has been connected through appropriate pins with Arduino board.

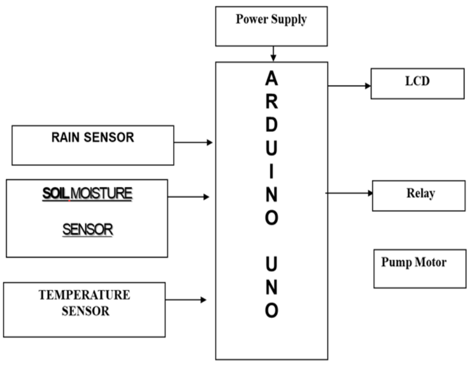

Figure 11. Interfacing of Devices

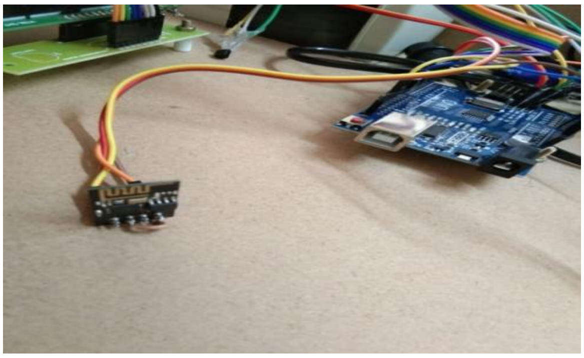

Figure 12 Interfacing of Wi- Fi IoT Module

Figure 12 depicts how Wi-Fi module has been interfaced with the Arduino board. This has been used to transmit information related various parameters of the agriculture in the smart phone of the user [19].

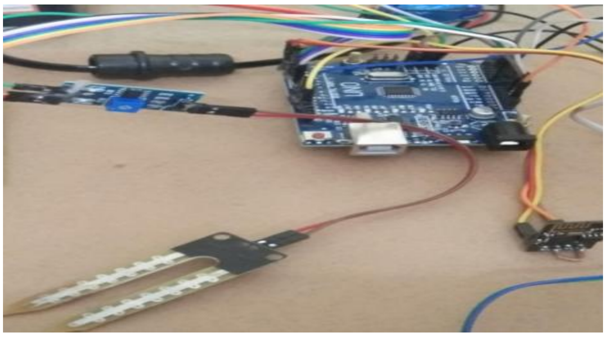

Figure 13 Interfacing of Soil Moisture Sensor

Interfacing of soil moisture sensor with Arduino board has been shown in figure 13. Whenever soil moisture content is less than 30 % warning message will be given to the farmer.

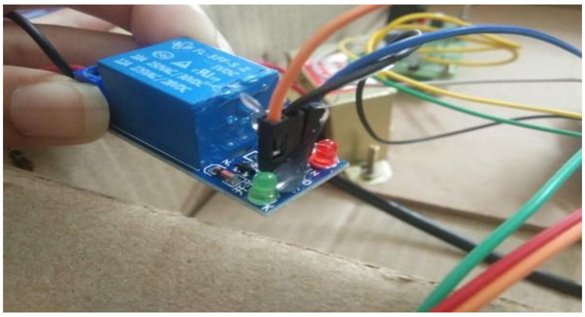

Figure 14 Interfacing of Relay

Figure 14 depicts the interfacing of the relay unit. Relay unit will switch on the water pump motor whenever any of the parameters falls below the normal value. It also connects the LCD display unit and LED for visual display.

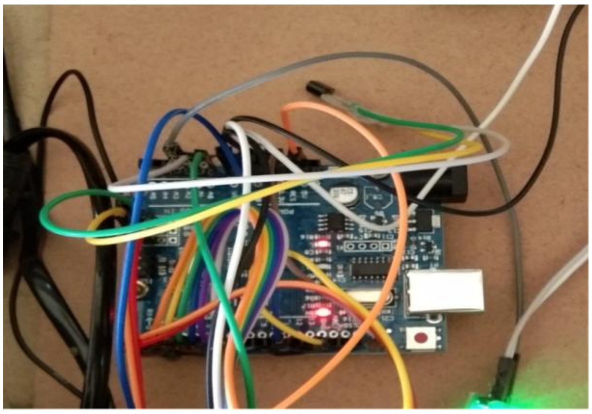

Figure 15 Interfacing of Temperature Sensor

Temperature sensor will sense the soil temperature and activate the pump through relay unit in case of temperature rises above 45 degree Celsius. Its interfacing with arduino board is reflected through figure 15.

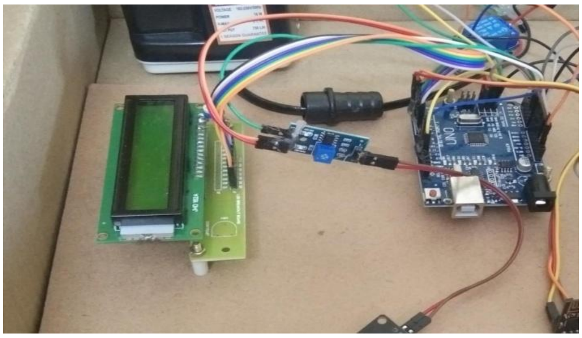

Figure 16 Interfacing of Arduino with LCD

The observed parameters of soil is displayed through 16 X 2 LCD display unit. Its interfacing with the Arduino board is depicted in figure 16.

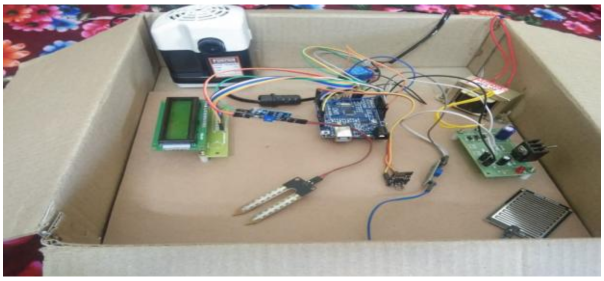

Figure 17 Interfacing of all Sensors with Arduino Board

The fully integrated work with all sensors interfaced is shown in figure 17. In case any of the soil parameter is not within the range LED light will glow, information will be dispayed in the LCD and message will be delivered in the users mobile phone.

IV. RESULTS AND DISCUSSIONS

Sensors have been used to measure soil moisture, soil temperature, and humidity level. It has been connected to the physical layer by properly interfacing with the Arduino board. In case of any of these parameters such as, soil moisture falls below 30 %, soil temperature rises above 45 degree Celsius and humidity falls below 30 %, the data is communicated to the network layer for processing and imitating desired action.

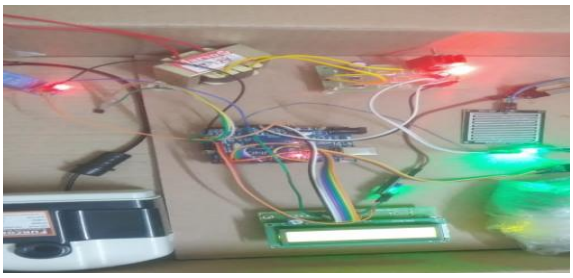

Figure 18. Alarm under low moisture level observed

All communication related devices such as Wi-Fi IoT module have been connected to the network layer. Figure 5 depicts activation of the system under abnormal soil parameters.Water pump has been interfaced with arduino board at application layer. Figure 19 shows message being received in the farmer's mobile phone.

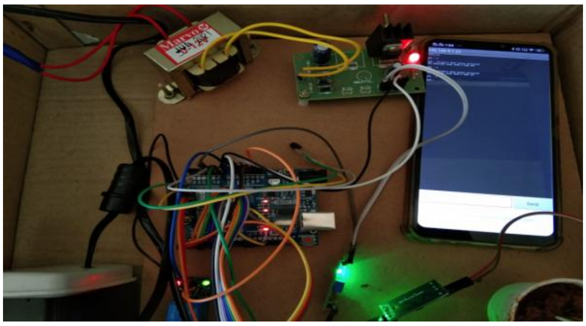

Figure 19 Message displayed in Smart Phone

Schedule for watering field, their supervision, and other informations are provided to the farmer based on the processing of the data collected through sensors. The data is stored and analysed using Fog / Edge computing, and also accumulate for futute analysis purpose.
A portion of the program code of the present system ia appended below.

```
include <LiquidCrystal.h>
#include <SoftwareSerial.h>
// initialize the library with the numbers of the
interface pins
LiquidCrystal lcd(7, 6, 5, 4, 3, 2);
const int analog1InPin = A0;//SOIL
const int analog2InPin = A1; //TEMP
const int analog3InPin = A2;//RAIN
const int pumpPin = 11;
int sensor1Value = 0;
int sensor2Value = 0;
int sensor3Value = 0;
void sendwifi(String chr, unsigned int len)
{
 String temp[20];
 Serial.print("AT+CIPSEND=0,");
 Serial.println(len);
 delay(1000);
 Serial.println(chr);
 delay(2000);
}
void setup()
{
 pinMode(analog1InPin, INPUT);//SOIL
 pinMode(analog2InPin, INPUT); //TEMP
 pinMode(analog3InPin, INPUT); //RAIN
 pinMode(pumpPin, OUTPUT);
  lcd.begin(16, 2);
 lcd.clear(); lcd.setCursor(0, 0);
lcd.print("WELCOME");
 Serial.begin(9600);
 delay(1000);
 lcd.clear(); lcd.setCursor(0, 0); lcd.print("WIFI
INIT");
 Serial.print("AT\r\n");
 delay(1000);
 Serial.print("ATE0\r\n");
 delay(1000);
 Serial.print("AT+CIPMUX=1\r\n");
 delay(1000);
 Serial.print("AT+CIPSERVER=1,23\r\n");
 delay(1000);
 lcd.clear(); lcd.setCursor(0, 0);
lcd.print("192.168.4.1");
 lcd.setCursor(0, 1); lcd.print("Port: 23");
```

V. CONCLUSION AND FUTURE WORK

The economic and social status of farmers can get a major boost if the irrigation system is made intelligent and smart using latest technology such as IoT. The present work is based on three layer IoT architecture wherein sensors have been connected to the physical layer. Communication devises (Wi-Fi module) at the network layer for processing and transferring of information. Switching of water pump, information display in the LCD and transmitting message to the smart phone have been achieved through application layer.

In the present work, sensors have been used to measure soil moisture, soil temperature, and humidity level. In case of any of these parameters such as, soil moisture falls below 30 %, soil temperature rises above 45 degree Celsius and humidity falls below 30 %, corrective action are initiated by sending message to the farmer's mobile, displaying message in the LCD display, turning on LED light and switching on the water pump. Once the levels are brought back within normal limit, reverse actions are initiated. In a country like India, where majority of the population resides in villages and are involved in agricultural work, the present system if implemented in larger scale can prove to be a boon for farmers. Implementation of this smart irrigation system will not only improve the quality of product but also enhance productivity of the farm while providing comfort, convenience and information to the farmer.

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