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Smart Rooftop Irrigation System

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***Abstract*: Agriculture, being one of the most fundamental resources of food has faced several issues in its traditional methods of agriculture such as excessive wastage of water during irrigation of field, dependency on non- renewable power source, time, money, human resource etc. This can be overcome using today's technologies like IoT.**

The proposed research work aims at successfully developing a Smart Rooftop Irrigation System using Single board computer raspberry pie, sensors, cloud and intelligent applications with an objective of automating the total irrigation system which provides adequate water required by crop by monitoring the moisture of soil and the temperature of the surroundings. This is achieved with the help of dht11, bh1750 sensors and a raspberry pi model b+ for interfacing these values. Using mandami's rule, a fuzzy inference system is created and is used to monitor the amount of water required by a plant, by limiting the sensor values to the predefined threshold value set that contains the required light, temperature and moisture values. These values are displayed on a mobile application in real time using Google's Cloud Firebase. A drip irrigation system which is connected to a main water tank is used in order to ensure that all the plants are being watered adequately.

Irrigation using IoT is a key component of precision agriculture. Replacing manual irrigation with automatic valves and systems reduces the human error. It also helps farmers to avoid water wastage and improve the quality of crop growth in their fields by irrigating at the correct times, minimizing runoffs and other wastages, and determining the soil moisture levels accurately, thereby, finding the irrigation requirements at any place.

***Keywords*: Realtime database, raspberry pi, IoT, Fuzzy logic, automatic irrigation**

I. INTRODUCTION

According to the UN projections, world population will rise from 6.8 billion today to 9.1 billion in 2050 that signifies food production has to be raised to feed the one third more mouths. And, the agriculture industry is accountable for fulfilling humans' need for food, energy, and shelter to a great extent. The only solution to all these problems is Agriculture Modernization that has already started by some of the tech savvy farmers. For the next generation agriculture fields, data collected from sensors would become the fertilizer to grow crops. IOT would uncover the new ways that tap the full potential of agriculture yield and alleviate all the challenges that hinders the growth of the crop.

The Internet of Things (IoT) is the "network of interconnected sensor-equipped electronic devices that collect data, communicate with each other, and can be monitored or controlled remotely over the Internet". The main goal of the IoT's development is extends the limit of internet connectivity from digital devices to physical objects. It enables the communication between digital devices, objects and other systems. The data collected can be shared between person to person, machines to person (M2P) or machine to machine (M2M) and data is stored and managed at cloud. The Smart Irrigation System is an IoT based device which is capable of automating the irrigation process by analyzing the moisture of soil and the climate condition (like rain). It provide water supply at the right time, in the right quantity and at the right place in field which plays a vital role in the plant's growth. Water management remotely is also challenging task, especially the management becomes more difficult during the shortage of water, which may otherwise damage the crop. By using sensors like moisture, temperature, etc. water supply for irrigation can be managed easily by analyzing the condition of soil and climate. Soil moisture sensors smartly measure the soil moisture and based on that data, field irrigated automatically with less human interventions.

II. LITERATURE SURVEY

By using technology in the field of agriculture, an important role in played in increasing the production and reducing man power.

Bennis, H. Fouchal, O. Zytoune, D. Aboutajdine, "Drip Irrigation System using Wireless Sensor Networks", in this model, a soil moisture,pressure and temperature sensor is used to monitor the irrigation. To achieve QoS performance, a priority based routing protocol is used. [1]

Sangamesh Malge, Kalyani Bhole, "Novel, Low cost Remotely operated smart Irrigation system",in this paper a ESD is used. Sensors like temperature,rain and level are integrated to it. The PIC18F4550 starts irrigation process by starting the irrigation pump.An SMS is sent to the farmer about the action of the PIC18F4550.[2]

Nikhil Agrawal, Smita Singhal, "Smart Drip Irrigation System using Raspberry pi and Arduino" ,python is used to process the commands from the user. The arduino is used to receive the on/off controls from the raspi. The central co-ordinator is the raspi. [3]

Bhagyashree K.Chate , Prof.J.G.Rana ,"Smart irrigation system using Raspberry pi", using parameters like temperature and moisture, a smart irrigation system is built using raspi. Here the water motor is controlled automatically, and using a webcam, the field can be monitored continuously.[4]

III. SCOPE AND INNOVATION

Smart Irrigation system makes use of IoT. The main objective of this project is to build an automated system where the levels of moisture and temperature are being continuously monitored. Depending on the values, an automated pump using fuzzy system is used to switch on and off. This project is executed using raspberry pi and various sensors.

IV. METHODOLOGY

1. Architecture:

The proposed research work successfully used Single board computer RasPberry Pi, Sensors, Cloud and intelligent applications to derive useful output in the form of effective-economical solution to agrarian crisis in the country.

The project consists of several components listed as follows:

i) Raspberry Pi model 3b+ as the main mcu.
ii) Sensors such as DHT11, BH1750, soil moisture sensor for temperature, humidity, light and moisture content values.
iii) Google Firebase for data storage on cloud.
iv) Mobile Application to host the values in a user- friendly manner

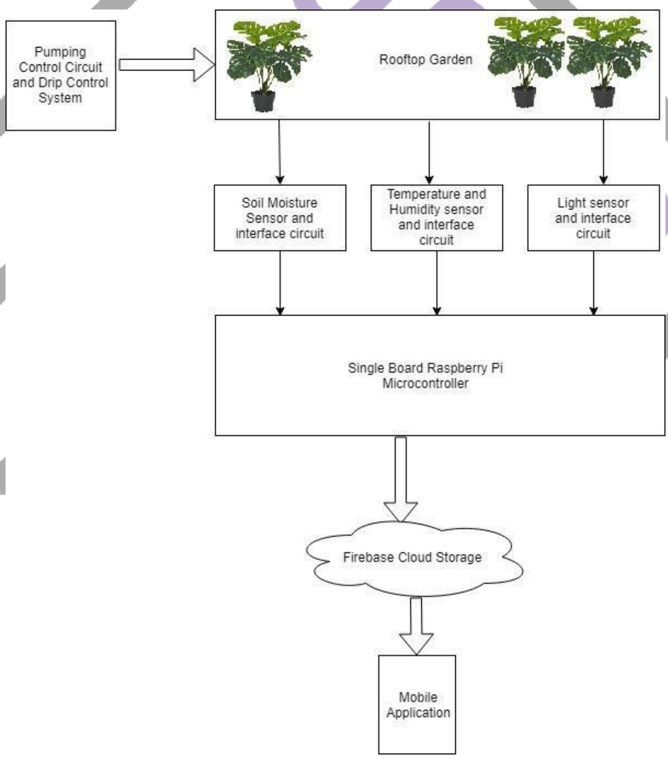

Figure 1 – System Architecture

2. System Design

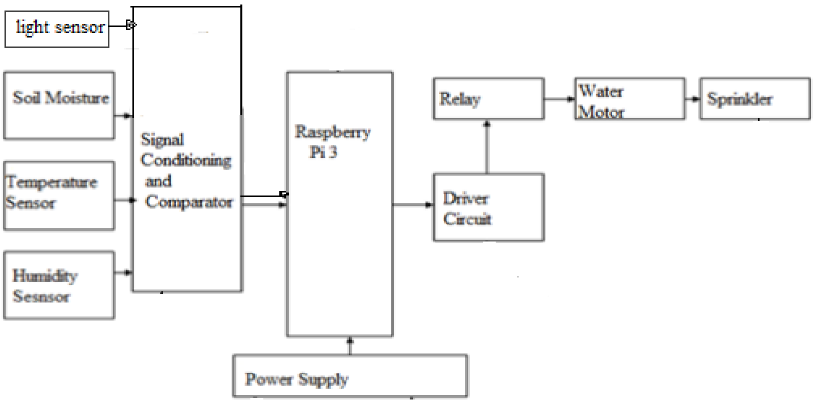

Figure 2 – System Circuit

RaspberryPi

It is a small, powerful and lightweight ARM based computer capable of high computation. Raspberry Pi 3 Model B + has a

CPU: 4× ARM Cortex-A53, 1.2GHz, **GPU:** Broadcom VideoCore IV, **RAM:** 1GB LPDDR2 (900 MHz), **Storage:** microSD and **Ports:** HDMI, 3.5mm analogue audio-video jack, 4× USB 2.0, Ethernet, Camera Serial Interface (CSI), Display Serial Interface (DSI). It supports I2C, SPI and UART Communications protocol.

Table of RPi Serial Communications Methods via GPIO*

Name	Description	Function
I^2C	Inter-Integrated Circuit	Half duplex, serial data transmission used for short-distance between boards, modules and peripherals. Uses 2 pins.
SPI	Serial Peripheral Interface bus	Full-duplex, serial data transmission used for short-distance between devices. Uses 4 pins.
UART	Universal Asynchronous Receiver-Transmitter	Asynchronous, serial data transmission between devices. Uses 2 pins.

Table 1 – Serial Communication methods

An SSH connection with laptop also helps to track the sensor values on screen.

Figure 3 – RaspberryPi Model 3 B+

Soil Moisture sensor

Soil moisture sensor includes comparator (LM393) which converts the analog data to discrete. Two soil probes consist of two thin copper wires each of 5 cm length which can be immersed into the soil under test. The circuit gives a voltage output corresponding to the conductivity of soil. The soil in between the probes acts as a variable resistance whose value depends upon moisture content in soil. Pins used are:

SENSOR	**RASPI**
VCC	**5V**
GND	**GND**
SIG	**GPIO21**

Table 2 – Soil and Moisture Sensor

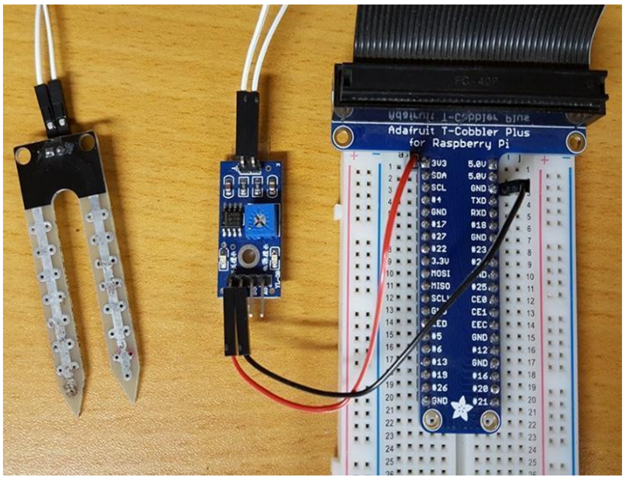

Figure 4 – Soil and Moisture Sensor

CODE SNIPPET:

```
import time

#GPIO SETUP
channel = 21
GPIO.setmode(GPIO.BCM)
GPIO.setup(channel, GPIO.IN)

def callback(channel):
        if GPIO.input(channel):
            print("no water detected")
        else:
            print("water detected")
```

DHT11 sensor:

The DHT11 is a basic, ultra low-cost digital temperature and humidity sensor. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air, and displays a digital signal on the data pin (no analog input pins needed). It is fairly simple to use, but requires careful timing to grab data. According to the pin diagram the 1-wire data bus is pulled up with a resistor to VCC. So if nothing occurs the voltage on the bus is equal to VCC. Communication Format used in the protocol can be separated into Request, Response and Data Reading.

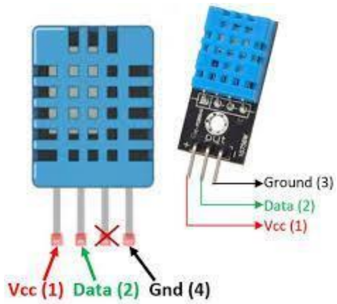

Figure 5 – DHT11 Sensor

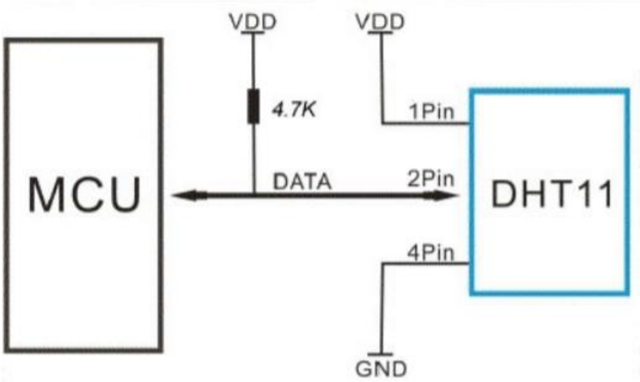

Figure 6 – DHT11 Pin Communication

CODE SNIPPET:

```
import sys

import Adafruit_DHT

while True:

humidity, temperature = Adafruit_DHT.read_retry(11, 4)

print 'Temp: {0:0.1f} C  Humidity: {1:0.1f} %'.format(temperature, humidity)
```

BH1750 sensor

This sensor detects light intensity falling on the sensor and directly gives a digital signal as an output. It is interfaced to the Raspberry Pi using i2c bus addresses.

Power Supply: 3.3V - 5V

Light Range：0 - 65535 lx (Lux)

Module PCB	Desc	GPIO Header Pins
GND	Ground	P1-14
ADD	Address select	P1-14
SDA	I2C SDA	P1-03
SCL	I2C SCL	P1-05
VCC	3.3V	P1-01

Table 3 – Light intensity Sensor pins

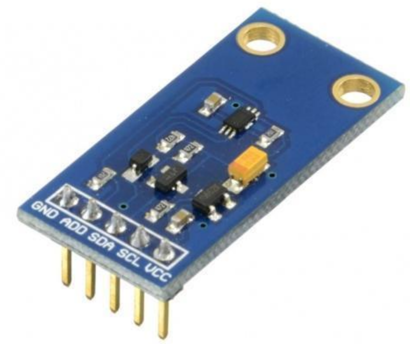

Figure 7 –BH1750 Sensor

CODE SNIPPET:

```
import smbus
import time
def readLight(addr=DEVICE):
  # Read data from I2C interface
  data = bus.read_i2c_block_data(addr,ONE_TIME_HIGH_RES_MODE_1)
  return convertToNumber(data)

def main():

  while True:
    lightLevel=readLight()
    print("Light Level : " + format(lightLevel,'.2f') + " lx")
    time.sleep(0.5)
```

Water Pump

A device that moves fluids such as liquid and gas as well as slurries is popularly known as pump. In this case, a water pump is used to water the plants based on the soil moisture and temperature level.

VCC -> 5V GND -> GND SIG -> GPIO 4

PUMP	RASPI
VCC	5V
GND	GND
SIGNAL	GPIO4

Table 4 – Water Pump

Figure 8 – Personalized Water Pump

Water Storage Tank and Ultrasound Distance Sensor-HC-SR04

The main water pipe is fed back to the water tank to avoid any water wastage. Water tank has ultrasonic distance sensor which keeps a track of water depth in the tank. As soon as the water level falls below a threshold level, a signal is sent to microcontroller to open solenoid valve which is attached to the water tap and thus the water can be refilled into the water tank.The on/off signal is continuously sent to the solenoid valve and thus the water level in the tank does not drop below or above a threshold to avoid damage in the water pump or overflow of water from the tank.

Figure 9 –Terminal Displaying the values every 5 seconds

3.Software Design Components

MobaXterm

MobaXterm is an enhanced terminal emulator program for Windows, similar to Putty, that establishes an SSH connection between the Raspberry PI and the monitor, which in this case is a laptop.

This terminal serves as a platform to write python modules that can be loaded onto the Raspberry Pi.

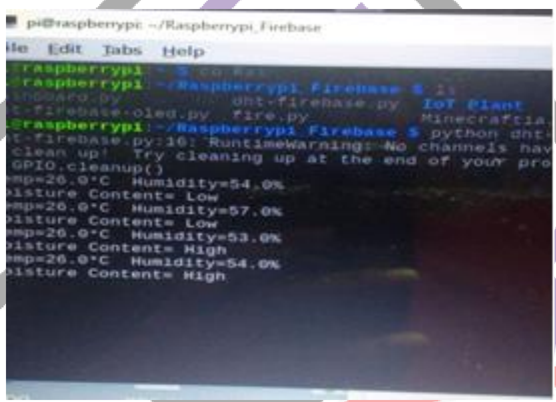

Figure 10 –Terminal Displaying the values every 5 seconds

Firebase- Realtime Database on Cloud:

The Firebase Realtime Database is Google's database that is hosted on the cloud. The data is stored in JSON format (NoSQL) and is synchronized in realtime to the connected client, which automatically ensures that the client receives any updates on the database's values. Real Time syncing makes it easy for your users to access their data from any device: web or mobile, and it helps your users collaborate with one another. When your users go offline, the Realtime Database SDKs use local cache on the device to serve and store changes. When the device comes online, the local data is automatically synchronized.

These values are displayed on the android or web application. In android, the firebase sdk is installed and configured, which using the valueListener() and onDataChange(), reads the changes in the database and displays them accordingly.

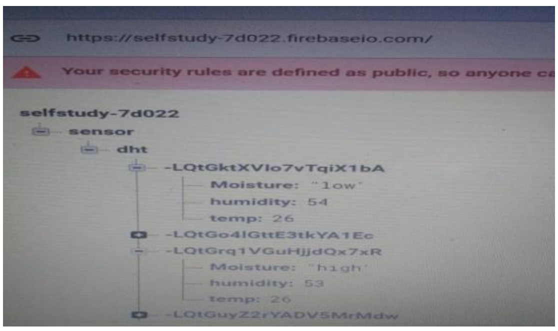

Figure 11 –Real Time database stores the values every 5 seconds

Fuzzy inference system

The input parameters will be described by three regions: 'COLD', 'NORMAL' & 'HOT' for temperature sensor, 'DRY', 'MODERATE' & 'MOIST' for humidity sensor and 'DARK', 'NORMAL' & 'BRIGHT' for Sunshine.

Sensor	Name of MF	Membership function	Range	Standard Deviation	Mean value
Temperature sensor	Cold	Gaussian	[-20, 40]	15	-20
Temperature sensor	Normal	Gaussian	[-20, 40]	15	10
Temperature sensor	Hot	Gaussian	[-20, 40]	15	40

Table 5: Fuzzified values for temperature

Sunshine Illumination	Threshold (cd)
Dark	[0 5]
Normal	[0 5 10]
Bright	[5 10]

Table 6: Fuzzified values for solar radiation

The values are fuzzified using mamdhani's rule. These results using if-then rules and fuzzy logic operators such as 'AND' and 'OR' are used to obtain an inference. The aggregation of the inference is achieved, and a crisp output is defined. These values are compared with the given plant's required temperature, light and moisture values, through which, the motor is switched on or off accordingly.

S.No	Irrigation Motor State	Description	Output value
1	ON	Motor will pump the water to the corresponding field	1
2	OFF	Motor will not pump the water	0

Table 7: Defuzzified values for output

3. Structure and Flow of the Project:

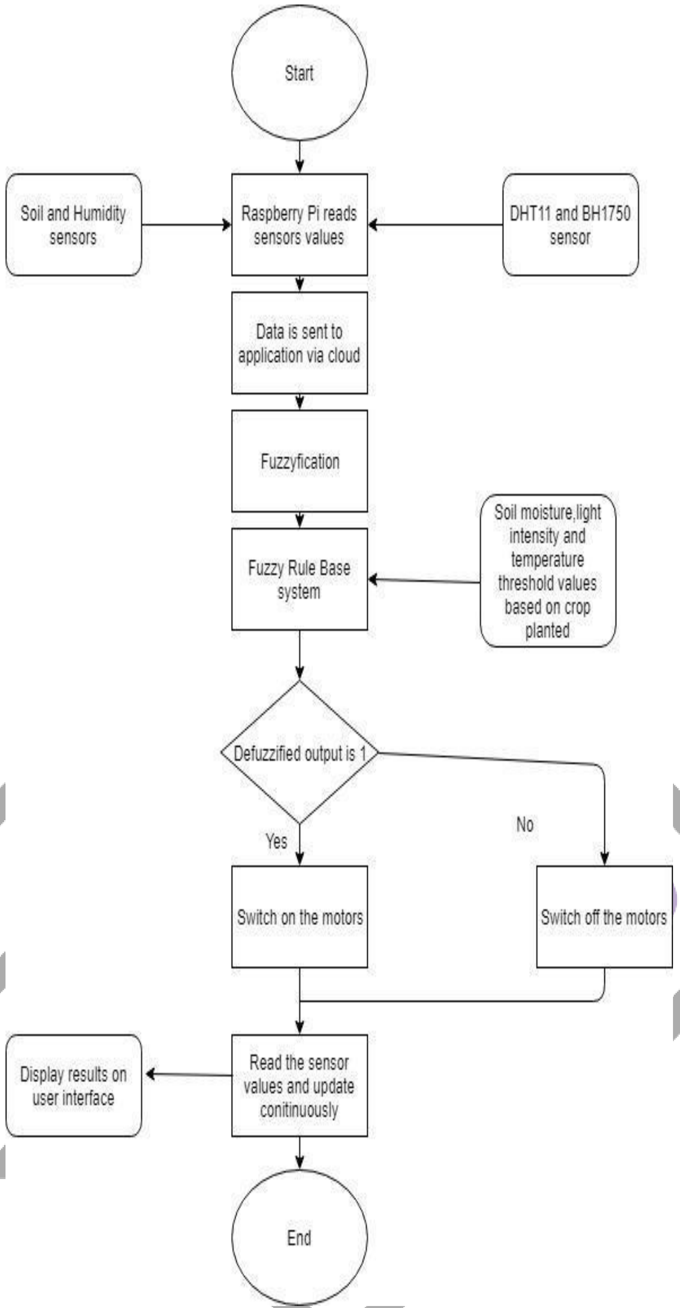

Figure 12: Flow

The following is a detailed analysis of how the project works:

1) The DHT11, BH1750 and the soil moisture sensor sense the soil it is present in and send the humidity, moisture content and temperature values at present to the Raspberry Pi. The module, using Adafruit_DHT reads these values and using the firebase module, they are stored in the firebase database.

2) The values are fuzzified using mamdhani's rule. These results are compared with the given plant's required temperature, light and moisture values, hence using if-then rules using the rule based fuzzy inference system, a crisp output is defined. In accordance, a signal is sent to switch on the motor, else the motor remains switched off.

3) These values are also displayed on the MobaXterm terminal's command prompt, as well as using the firebase database, on the real time application as well.

4) In the water tank, there is an Ultrasound Distance sensor that is used to measure the water level in the tank. Depending on the water level, the drip irrigation system is switched on.

Figure 13: Set Up

V. RESULTS

This installation makes use of raspberry pi,,relays, sensors and a water pump. A drip kit is used in this project, that consists of a main pipe with 16mm diameter, feeder pipes with 4mm diameter, drip hole punch and emitter valves.

The experiment is run on plants in a rooftop garden. It is found that the system works accurately and water is passed to the plants, as and when required. And the sensor values are continuously updated on firebase also.

VI. CONCLUSION AND FUTUTRE WORK

The project concludes that automation of irrigation system will become easy and comfortable for farmers to operate the irrigation at remote location i.e. from home. The microcontroller and sensors are successfully interfaced and the readings from the sensors and continuously updated in the firebase**.**This will save time and avoid problem of continuous vigilance. Not only this, it will also control the consumption of water for irrigation of the field, thus preventing the water wastage and would help sustain the productivity, increasing the yield.

The Rooftop irrigation system can not only be used in a garden but can be used to solve other problems where continuous monitoring of water supply is required like in fields used by the farmers, or in the watering of a stadium when necessary etc. This project can be made further more innovative by adding - controlling and monitoring the sprinkles of the drip irrigation system, checking the faults in the irrigation network and correcting them remotely and visualization the live working of integrated system in field area by pc/mobile. Also the future aspect of this model can be made into a much more intelligent system, wherein the system predicts user actions, rainfall pattern, time to harvest and many more features which will make the system independent of human operation..

This project can be incorporated to make sure the value of the soil and the expansion of harvest in each soil. Also, further this proposed system can be enhanced by adding up machine learning algorithms, which are capable to study and recognize other necessities of the crop, this would aid the agriculture field to be an automatic system. The inspections and outcomes tell us that this result can be executed for a lessening of water loss and decrease the manpower necessary for a field.

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