Project report submitted in partial fulfillment for the Degree of B. Tech in Applied Electronics & Instrumentation Engineering under Maulana Abul Kalam Azad University of Technology

SMART IRRIGATION SYSTEM USING RASPBERRY Pi 3B+

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May, 2019

ACKNOWLEDGEMENT

It is a great privilege for us to express our profound gratitude to our respected teacher-**MR. DEBABRATA BHATTACHARYA** & **MS. NAIWRITA DEY** , Applied Electronics &Instrumentation Engineering, RCC Institute of Information Technology, for his/her constant guidance, valuable suggestions, supervision and inspiration throughout the course work without which it would have been difficult to complete the work within scheduled time.

We would like to express our gratitude towards other faculty members for his/her kind co- operation and encouragement which helped us in completion of this project.

We are also indebted to the Head of the Department, Applied Electronics & Instrumentation Engineering, RCC Institute of Information Technology for permitting us to pursue the project.

We would like to take this opportunity to thank all the respected teachers of this department for being a perennial source of inspiration and showing the right path at the time of necessity.

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CERTIFICATE OF APPROVAL

The project report titled “SMART IRRIGATION SYSTEM USING RASPBERRY Pi ” prepared by **SUBHASISH ROY** (11705515047), **MADHUSHREE DERE** (11705515024),**DIBYARUP DAS** (1170551015), **SAGNIK ROY(**11705515037); is hereby approved and certified as a creditable study in technological subjects performed in a way sufficient for its acceptance for partial fulfilment of the degree for which it is submitted.

It is to be understood that by this approval, the undersigned do not, necessarily endorse or approve any statement made, opinion expressed or conclusion drawn therein, but approve the project only for the purpose for which it is submitted.

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RECOMMENDATION

We hereby recommend that the project report titled be "SMART IRRIGATION SYSTEM USING RASPBERRY Pi " prepared by **SUBHASISH ROY** (11705515047), **MADHUSHREE DERE** (11705515024),**DIBYARUP DAS** (1170551015), **SAGNIK ROY(**11705515037); accepted in partial fulfillment of the requirement for the Degree of Bachelor of Technology in Applied Electronics & Instrumentation Engineering, RCC Institute of Information Technology.

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Abstract

The prominent target of this project is to propose an intelligent and smart irrigation system that would be used to control the watering and irrigation of plants. Human intervention reduction is the main purpose of this project. Water wastage would be reduced which is one of the major concern in today's world. Other aspects like cost, time conservation, effectiveness and low maintenance are also aided. Raspberry pi is used in this project to make the system compact. The system has soil moisture humidity and temperature sensors which measure the moisture of the soil, temperature of the environment and water level in the tank.

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Chapter 1: Introduction

India being the largest freshwater user in the world, and the country's total water use being greater than any other continent, the agricultural sector is the biggest user of water, followed by the domestic sector and the industrial sector. This project presents smart irrigation system for an agricultural farm with the use of devices like raspberry pi. Python programming language is used for automation purpose. Focus area will be parameters such as temperature and soil moisture. The system may prove to be a substitute to traditional farming method and adapting to an optimized irrigation is necessary nowadays due to the lack of world water resource. The system has a distributed wireless network of temperature and soil moisture sensor.The objectives of this project were to control the water supply to each plant automatically depending on values of temperature and soil moisture sensors. The commands from the user are processed at raspberry pi using python programming language. Internet or wifi module is interfaced with the system to provide data inspection. Agriculture is the spine of world's economy as well as the economy of a developing country like India. In this very moment of twenty-first century, the technology and its advancement has become so fluent in every sector of life that it is our duty to take it forward through the infrastructure for development of agriculture as well. Agriculture also contributes a significant role to gross domestic product (GDP).And as it is known; irrigation becomes the paramount part in agriculture. In existing system a farmer has to work physically to control the irrigation system and traditional instrumentation based on discrete and wired solutions presents difficulties in large geographical areas such as our country. As well as it goes against the development of long-term agricultural production and sustainable utilization of water resources. Conventional irrigation system leads to wastage of time and wastage of water. Whereas, automation helps reducing consumption of electricity, decreases the wastage of water, uses less manpower, and helps in energy saving. The increase in urbanization and rapid industrialization causes a large cavity in agricultural activities. This report has been arranged as followed by methodology followed by hardware prototyping and conclusion.

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agriculture as well[1]. Agriculture also contributes a significant role to gross domestic product (GDP).And as it is known, irrigation becomes the paramount part in agriculture [2]. In existing system a farmer has to work physically to control the irrigation system and traditional instrumentation based on discrete and wired solutions presents difficulties in large geographical areas such as our country. As well as it goes against the development of long-term agricultural production and sustainable utilization of water resources.Conventional irrigation system leads to wastage of time and wastage of water[3]. Whereas,automation helps reducing consumption of electricity, decreases the wastage of water, uses less manpower, and helps in energy saving. The increase in urbanization and rapid industrialization causes a large cavity in agricultural activities. So It can be concluded that, a matter of serious concern and to overcome this major problem, there have been a lot of works to automate the agricultural sector or to make irrigation smart, like uses of wireless networks, uses of RF module and using arduino to process the conventional irrigation into an
Automatedsmart one [4].

India is the largest freshwater user in the world, and the country's total water use is greater than any other continent. The agricultural sector is the biggest user of water, followed by the domestic sector and the industrial sector[5].This project presentsa smart irrigation system for an agriculture farm with the use of devices like raspberry pi. Python programming language is used for automation purpose. Focus area will beparameters such as temperature and soil moisture [6]. The system may prove to be a substitute to traditional farming method. And adopting an optimized irrigation is a necessity nowadays due to the lack of world water resource. The system has a distributed wireless network of temperature and soil moisture sensor.The objectives of this paper were to control the water supply to each plant automatically depending on values of temperature and soil moisture sensors.The commands from the user are processed at raspberry pi using python programming language and [7].Star Zigbee topology serves as backbone for thecommunication between raspberry pi and end devices. Soil moisture sensors, temperature sensors are placed in root zone of plant and gateway unit handles the sensor information and transmit data to a web application. Internet or wifi module is interfaced with the system to provide data inspection. Raspberry pi is the heart of the system[8]. But the raspberry pi cannot directly drive the Moisture Sensor to get its analog output. So an open source microcontroller, Arduino Uno is used. Resistive soil moisture sensor is connected to raspberry pi board through a node along with temperature and humidity sensor[9]. The raspberry pi board is connected to a power supply that directs the water pump to work along with the change in temperature, humidity, moisture and such environmental parameters. The use of resistive soil moisture sensor (FC-28) with soil hygrometer detection module, temperature and Humidity sensor (DHT11) provide us with a smart automated irrigation system.

Project Report Organization:

This report has been arranged in such a manner, Chapter 1descrobes the introduction about the system along with reported literature of recent developments. Chapter 2 describes Methodology, Chapter 3 describes about smart irrigation system, Chapter 4 describes about serial communication between arduino and raspberry pi, chapter 6 is about hardware prototyping, Chapter 7 is about experimental result followed by conclusion, reference and appendix.

Chapter 2: Methodology

In this chapter, the objectives are to learn, develop andfurnish the project. To see, step-wise how things are implemented and put together to bring the project live. Our edible food items and everything is produced through a system which is called irrigation system. The main objective is to take the irrigation, a next step further. The major parameters to be measured, to make it smart is to monitor the temperature and humidity (presence of rain) and then control the watering system through the submersible pump. And, all these sensors and pump are connected through the Raspberry Pi. In simple words, on one side, the Pi monitors the Temperature and Humidity though the respective sensors. And, on the other hand Pi checks the condition and judges if the watering is necessary or not. The following steps guides through the procedure undertaken to make Irrigation Smart:

Step1: In this above proposal two different types of sensors (i.e. Temperature& moisture)are used to detect the required scarcity of water in the soil for proper undergoing of the process, that is, for proper irrigation.

Step2: Required action by the help of controller(i.e. Raspberry pi 3 model b+) is to be taken for the deficit of the physical parameters of the soil for a healthy process.

Step3: An autonomous system is implemented here for taking the action by supplying adequate amount of raw materials(i.e. water) through the pump which is indeed controlled by the Raspberry Pi itself.

Step4: For the exact amount of water in the soil to be measured is to read the analog output of the Moisture Sensor. But since, Raspberry Pi cannot read analog outputs, an external open source microcontroller, Arduino Uno is used.

Block Diagram of Proposed scheme:

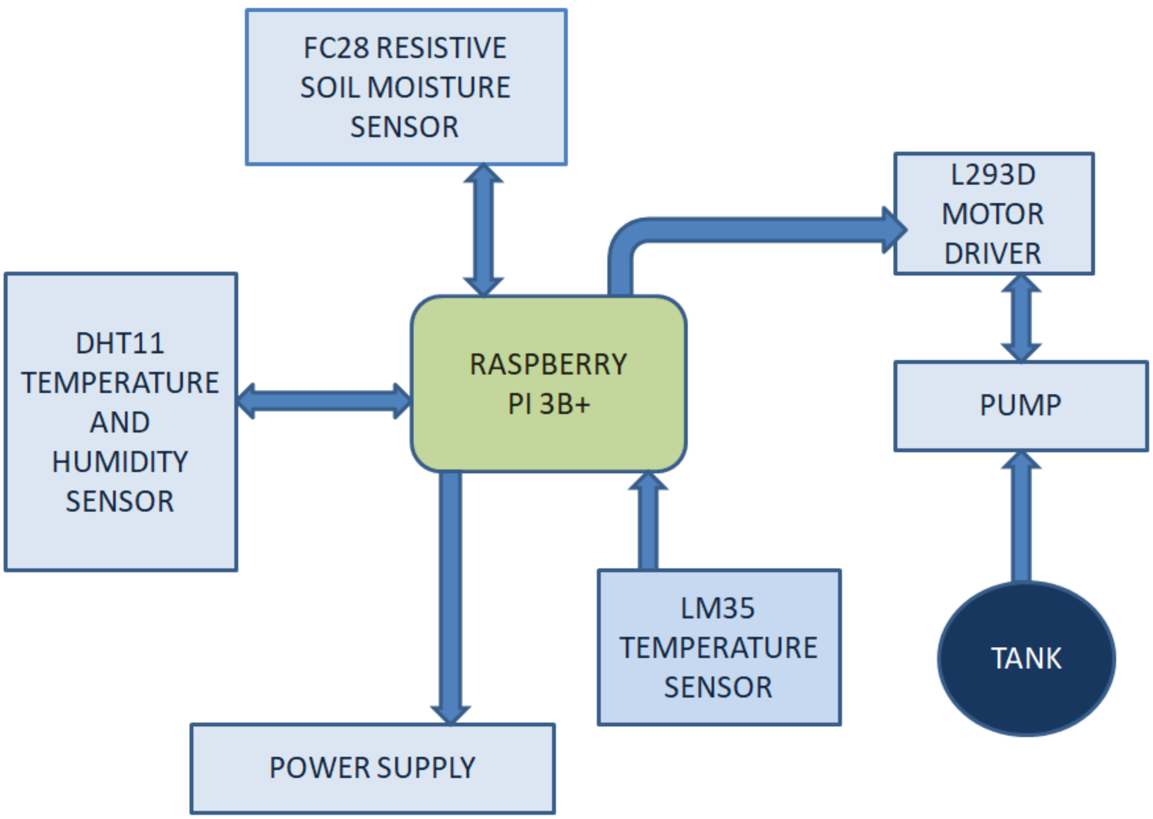


Fig 1:Block diagram of the proposed system

Chapter 3:Smart irrigation system

Since the dawn of civilization mankind have been involved in different methods to produce food and when trading came into business, mass scale crops were needed to be produced. So irrigation was a vital operation for this business to bloom. But the main problem arose when insufficient human labour decreased the crop growth. So, on engineering terms, when automation and IOT came to lifethis problem had its only solution. To make irrigation that would decrease human labour and make production way more rapidly and efficiently. Unlike traditional irrigation controllers that operate on a preset programmed schedule and timers, smart irrigation controllers monitor weather, soil conditions, evaporation and plant water use to automatically adjust the watering schedule to actual conditions of the site.

Monitored Parameters:

1. **Soil Moisture:**

   There are some sensors for the Raspberry Pi that can measure humidity, temperature and other values. Nevertheless, these modules are almost exclusively suitable for the air and not intended for use in the earth.
   For some projects, such as an automatic plant supply, the moisture of the soil must be measured, then, e.g. refilled with water.
   When resistive soil moisture sensor is used, the analog readings are considered and through ADC conversion got from the Arduino Uno to see how the raspberry pi can interpret it. The output i.e.; analog voltages are taken and for those values, a value in between 0 and 1023 is measured and then it is converted for the calculation of humidity percentage in the soil.
   A value between 0 and 1023 is output. In our test, the sensor has often returned a 0, which would mean total wetness (conductivity). But since only values around 100-200 appear, if the sensor is completely submerged in water, a value of 0 is obviously wrong, so it is needed to filter this value in the script. In addition, values come out around ~ 1000 if there is nothing conductive (air) between the sensor plates.
   Depending on the material (earth, water, sand, etc.), which is located between the plates,

other values come out in the dry/wet state. Therefore, it makes sense to take multiple measurements and adjust the analog threshold for application.

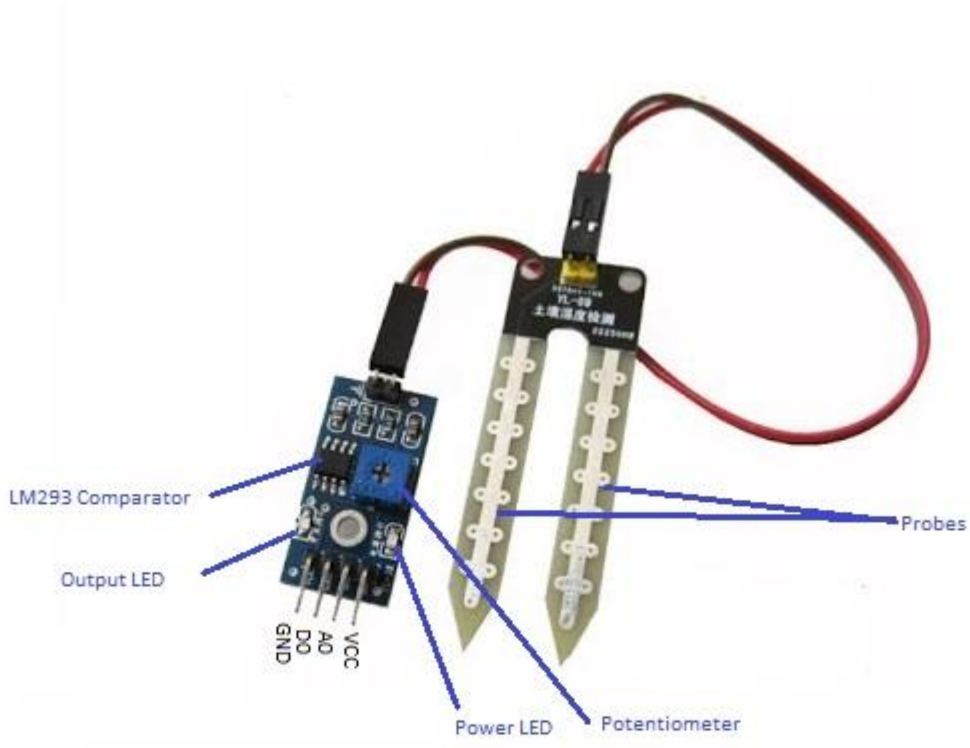


Fig 2: Resistive soil moisture sensor FC-28 and related module.

2. **Temperature:**

As it is known, there are no ADC channels provided internally in Raspberry Pi. So if interfacing is needed for any analog sensors an ADC conversion unit is required. ADC0804 is a chip designed to convert analog signal in to 8 bit digital data. This chip is one of the popular series of ADC. It's an 8bit conversion unit, so having values of 0 to 255. The resolution of this chip changes based on the reference voltage that is chosen. The **ADC0804 operates at 5V** and so it provides output in 5V logic signal. In 8 pin output (representing 8bits), every pin provides +5V output to represent logic'1'. So the problem is the PI logic is of +3.3v, so one cannot give +5V logic to the +3.3V GPIO pin of PI. If +5V is given to any GPIO pin of PI, the board gets damaged. So to step-down logic level from +5V, voltage divider circuit is highly recommended. The usage two resistors to divide +5V logic into 2*2.5V logics. So after division it will give +2.5V logic to PI. So, whenever logic ‘1’ is presented by ADC0804 it is seen +2.5V at the PI GPIO Pin, instead of +5V. Temperature is usually measured in “Centigrade” or “Fahrenheit”. “LM35” sensor provides output in degree Centigrade. LM35 is a three pin transistor like device. The pins are numbered as,

PIN1= VCC - Power (Connected to +5V)

PIN2= Signal or Output (connected to ADC chip)

PIN3 = Ground (Connected to ground)

This sensor provides variable voltage at the output, based on temperature. For every +1 centigrade rise in temperature there will be +10mV higher voltage at the output pin. So if the temperature is 0◦ centigrade the output of sensor will be 0V, if the temperature is 10◦ centigrade the output of sensor will be +100mV, if the temperature is 25◦ centigrade the output of sensor will be +250mV. The LM35 output has lot of voltage fluctuations; so a **100uF capacitor** is used to smooth out the output.

The ADC always have lots of noise, this noise can greatly affect the performance, so a **0.1uF capacitor is used for Noise Filtration**. Without this there will be lot of fluctuations at output.

The chip works on RC (Resistor-Capacitor) oscillator clock. As shown in circuit diagram**, C2 and R20 form a Clock.** The important thing to remember here is the capacitor C2 can be changed to a lower value for higher rate of ADC conversion. However with higher speed there will be decrease in accuracy. So if the application requires higher accuracy, choose the capacitor with higher value and for higher speed choose the capacitor with lower value. The LM35 provides +10mV for every centigrade. The maximum temperature that can be measured by the LM35 is 150º centigrade. So it will have a maximum of 1.5V at the LM35 output terminal. But the default reference voltage of ADC0804 is +5V. So if the given reference value, the resolution of the output will be low because it would be using a maximum of (5/1.5) 34% of digital output range.

The ADC0804 has an adjustable Vref pin (PIN9).So it will be **set to the Vref of the chip to +2V**. To set Vref +2V, it is needed to provide a voltage of +1V (VREF/2) at PIN9. Here a 10K pot is used to adjust the voltage at PIN9 to +1V. Use the voltmeter to get the accurate voltage.

3. **Humidity:**

The percentage of water present in the air is termed as humidity. Humidity is of basically two types- relative humidity and absolute humidity.

Relative humidity= (density of water vapor / density of water vapor at saturation)*100%

Absolute humidity= Mass(vapor) / volume. Unit-grams/m3

Specific humidity= Mass(vapor) / total mass.

Dew Point: Temperature(above 0°C) at which the water vapor in a gas condenses to liquid water)

Frost Point: Temperature(below 0°C) at which the water vapor in a gas condenses to ice.

This type of measurement relies on two electrical conductors with a non-conductive polymer film laying between them to create an electrical field between them. Moisture from the air collects on the film and causes changes in the voltage levels between the two plates. This change is then converted into a digital measurement of the air's relative humidity after taking the air temperature into account.

The DHT11 calculates relative humidity by measuring the electrical resistance between two electrodes. The humidity sensing component of the DHT11 is a moisture holding substrate with the electrodes applied to the surface. When water vapor is absorbed by the substrate, ions are released by the substrate which increases the conductivity between the electrodes. The change in resistance between the two electrodes is proportional to the relative humidity. Higher relative humidity decreases the resistance between the electrodes while lower relative humidity increases the resistance between the electrodes.

The DHT11 converts the resistance measurement to relative humidity on a chip mounted to the back of the unit and transmits the humidity and temperature readings directly to the Raspberry Pi.

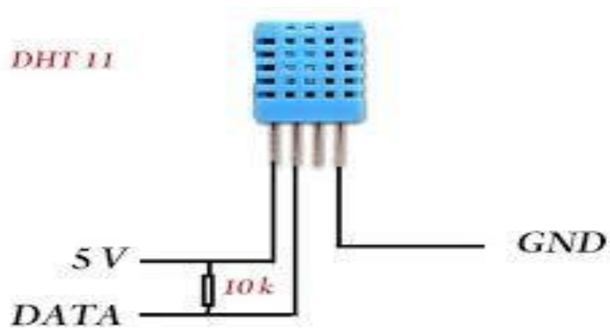


Fig 3: Temperature and humidity sensor DHT11.

Chapter 4: Interfacing of Raspberry pi and Arduino through Serial Connection

PI has only 26 GPIO pins and zero ADC channels, so when projects with analog outputs are being furnished, PI cannot do all the interactions alone. So more output pins are needed with additional functions, for adding more functions to PI, a communication between PI and UNO is established. With that all the function of UNO can be used as they were PI functions.

Although there are many boards on Arduino platform, but Arduino Uno got many Appreciations, for its ease of doing projects.

Arduino Uno setup:

Connect the UNO to the PC first and then write the program in the Arduino IDE software and upload the program to the UNO. Then disconnect the UNO from PC. Attach the UNO to the PI after programming.

Flowchart:

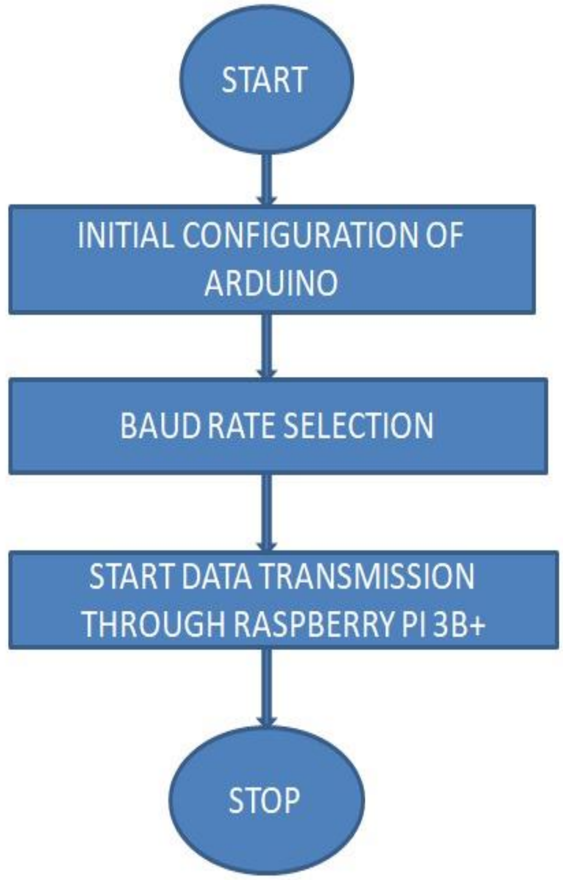


Fig 4: Flowchart for setting up Arduino to read analog data.

Now the program here initializes the Serial Communication of UNO. When the button attached to the UNO is pressed, the UNO sends few characters to the PI serially through USB port.

Raspberry Pi setup:

After that a program for PI is written to receive this data being sent by UNO serially.

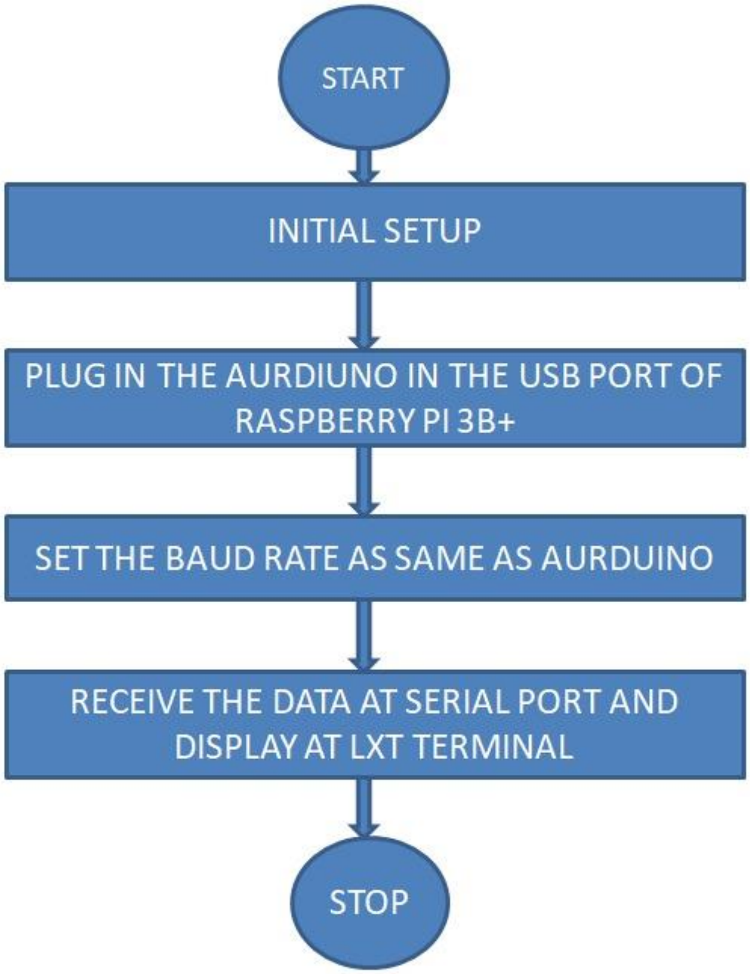


Fig 5: Flowchart for setting up Raspberry Pi to read data from Arduino.

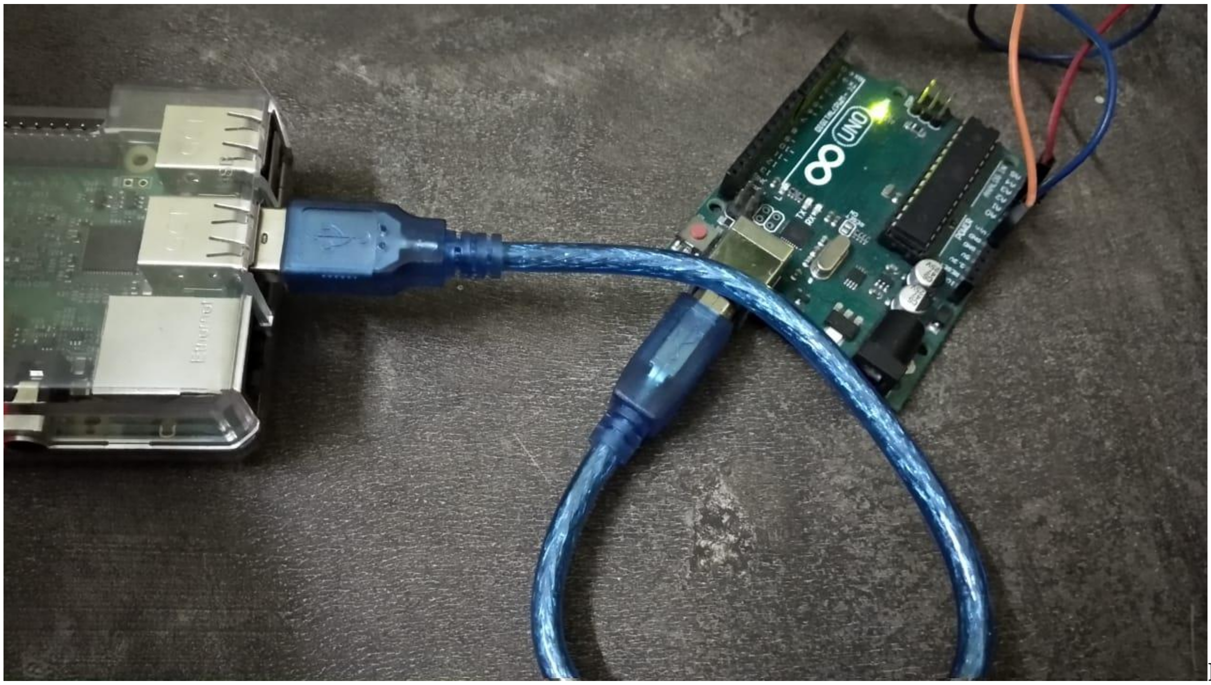


Fig 6: Raspberry and Arduino Interfacing.

The above picture shows the real time interfacing between Raspberry Pi and Arduino Uno. The interfacing was done through the open source Arduino software (IDE).

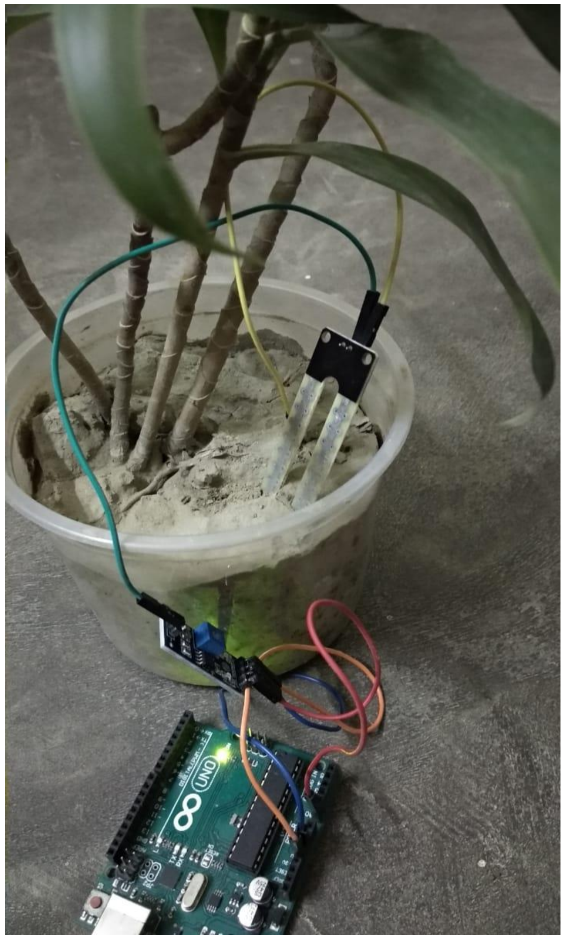


Fig 7: Arduino and Plant moisture sensing

The above diagram shows the real time analysis of soil moisture using Arduino Uno .

Chapter 5: Hardware Prototype Set up of raspberry pi

Here, in this project, Raspberry Pi 3 Model B+ which is the newest, fastest and easiest to use. To connect a power socket, the Raspberry Pi has a micro USB port. It will be needing a power supply which at least provides 2.5 amps. Raspberry Pi needs an SD card to store all its files and the Raspbian operating system. It will also need a micro SD card with a capacity of at least 8 GB as an external hard drive. To view the Raspbian desktop environment, a screen is required and a cable to link the screen and Pi. The screen can be a TV or serial monitor. Even if the screen has built in speakers, the Pi will be able to use these to play sound. The Raspberry Pi has a HDMI output port that is compatible with the HDMI port of most modern TVs and computer monitors. If the screen has a DVI port,connection of the Pi to the screen can be done using a HDMI to DVI cable. The large Raspberry Pi models have a standard Ethernet port to connect them to the internet. The Raspberry Pi 3 and Pi zero W can also be wirelessly connected to the web.

List of components(with specification):

1.Resistive soil moisture sensor	Operating Voltage:3.3 ~ 5.5 VDC Output Voltage: 0 ~ 3.0VDC Operating Current: 5mA Interface: PH2.0-3P, Dimensions: 3.86 x 0.905 inches (L x W), Weight: 15g
2. Raspberry Pi 3 Model B+	SoC: Broadcom BCM2837 (roughly 50% faster than the **Pi**2) CPU: 1.2 GHZ quad-core ARM Cortex A53 (ARMv8 Instruction Set) GPU: Broadcom Video Core IV @ 400 MHz.

3. Temperature and humidity sensor – DHT11	Supply Voltage: +5 V, Temperature range :0-50 °C error of ± 2 °C, Humidity :20-90% RH ± 5% RH error, Interface: Digital
4. **Arduino UNO**	• Microcontroller: ATmega328 • Operating Voltage: 5V • Input Voltage (recommended): 7-12V • Input Voltage (limits): 6-20V • Digital I/O Pins: 14 (of which 6 provide PWM output) • Analog Input Pins: 6 • DC Current per I/O Pin: 40 mA • DC Current for 3.3V Pin: 50 mA • Flash Memory: 32 KB of which 0.5 KB used by bootloader • SRAM: 2 KB (ATmega328) • EEPROM: 1 KB (ATmega328) • Clock Speed: 16 MHz
5. LM35	• Calibrated Directly in Celsius (Centigrade) • Linear + 10-mV/°C Scale Factor • 0.5°C Ensured Accuracy (at 25°C) • Rated for Full −55°C to 150°C

Range

- Suitable for Remote Applications
- Low-Cost Due to Wafer-Level Trimming
- Operates From 4 V to 30 V
- Less Than 60-µA Current Drain
- Low Self-Heating, 0.08°C in Still Air
- Non-Linearity Only ±¼°C Typical
- Low-Impedance Output, 0.1 Ω for 1-mA Load

Configuration of Raspberry Pi 3 B+ with VNC client:

1. Before connecting the Raspberry Pi board to laptop display, it need an SD card with the OS preinstalled, or install Raspbian on a blank SD card. After setting up the SD Card, insert it into the Raspberry Pi. Next, connect themicro USB cable to the Raspberry Pi to power it. Also, connect the display (the HDMI is only required to run the Pi for the first time) and power on the Pi.

2. Sharing Internet Over Ethernet
3. Setting Up the VNC Server to Connect Your Raspberry Pi to a Laptop Display
4. Starting VNC Server on Pi

5. Setting up the Client Side (Laptop)

6.Running VNC Server during Startup in the Raspberry Pi GUI. These are the following steps to run VNC:

Step1: went to command prompt

Step2: type- sudonano<filename>.py

Step3: wrote the python code and saved the code by pressing control X then press y.

Step4: again went to command format

Step5: type- python <filename>.py

Circuit diagram:

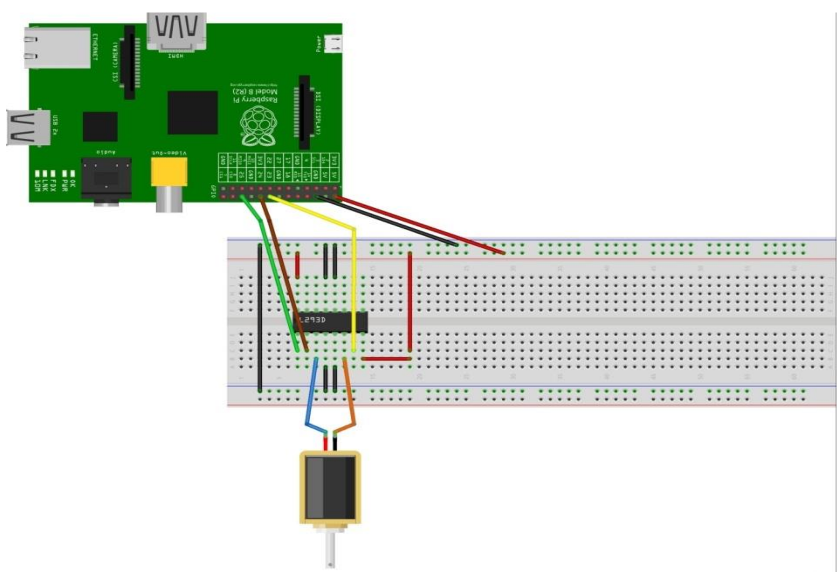


Fig 8: Circuit Diagram of connection between L293D motor driver and Raspberry Pi

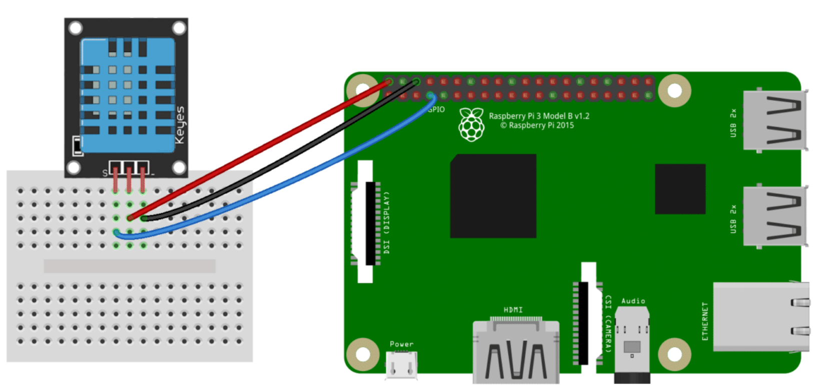


Fig 9: Circuit Diagram of the connection between DHT11 and Raspberry Pi

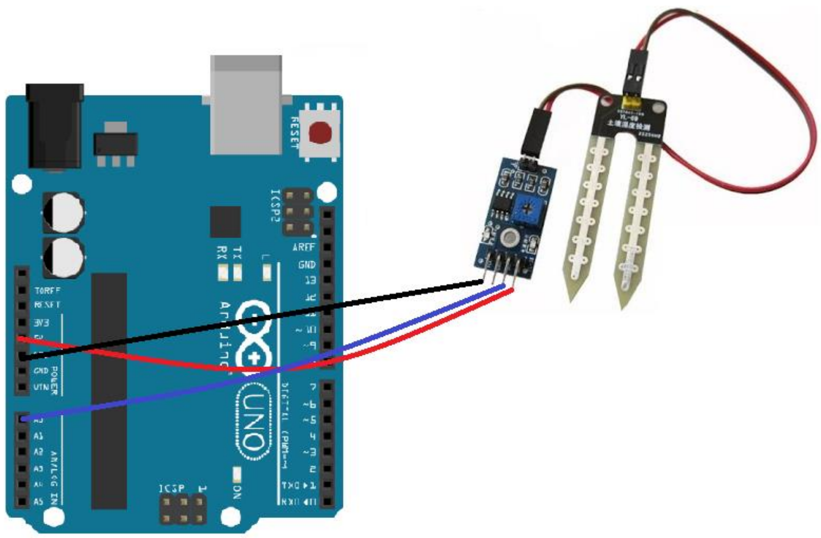


Fig 10: Circuit Diagram of connection between Arduino UNO and FC-28

Flowchart:

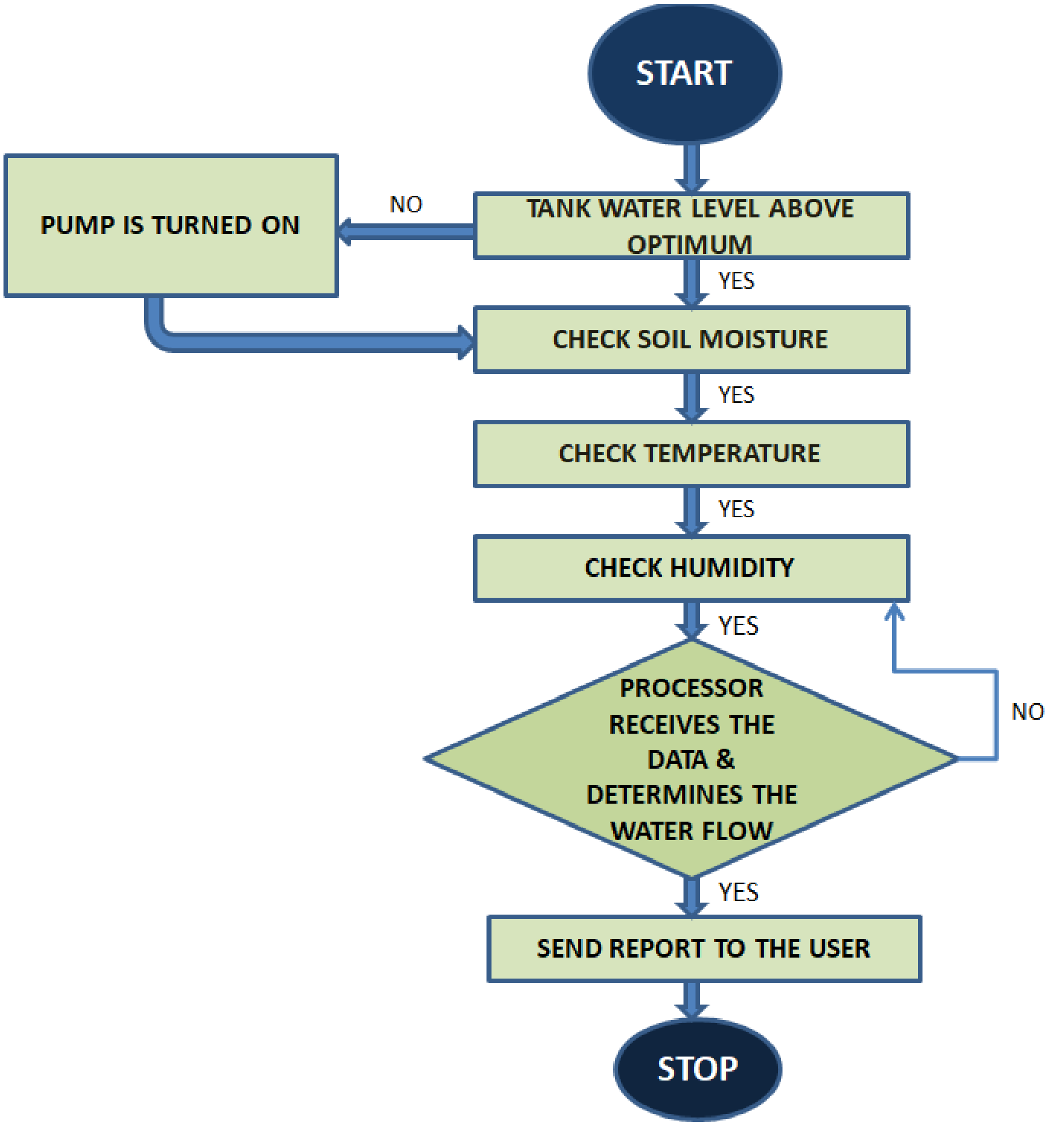


Fig 11: Flowchart of the full System

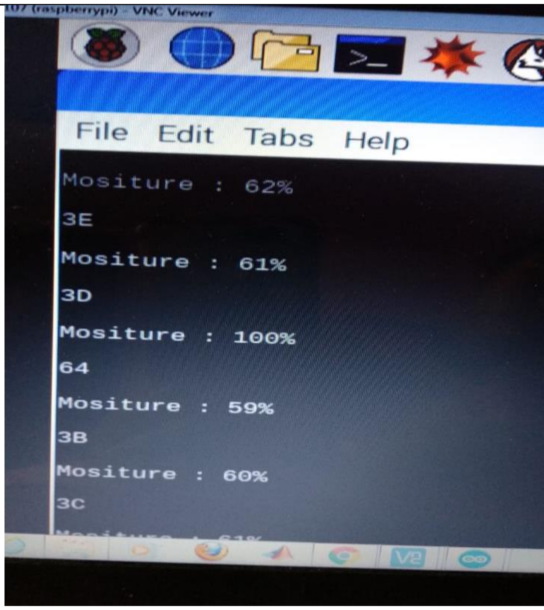
Chapter 6: Experimental results and observation tables

Experimental Results:

As a part of this project, the python code was compiled and run for the motor (water pump), which showed that after a specific interval of time the motor would stop pumping water. The time interval was given as 10 seconds, which showed "Motor is On" at the beginning and exactly after 10 seconds it showed "Motor is Off".

PARAMETERS	TIMING	STATUS
Input Motor timing =	10 seconds	Pump will be on for 10 sec
Time interval =	10 seconds	Pump will be off after 10 sec
Result on display =	Motor is On (at 0 second)	Motor is Off (at 10^{th} second)

As the next part of the project, the analog readings of the soil moisture were noted from the Raspberry Pi, which was first interfaced serially with Arduino Uno and according to the reading of the sensors the pump was turned 'ON' or kept 'OFF'.


(raspberrypi) - VNC Viewer
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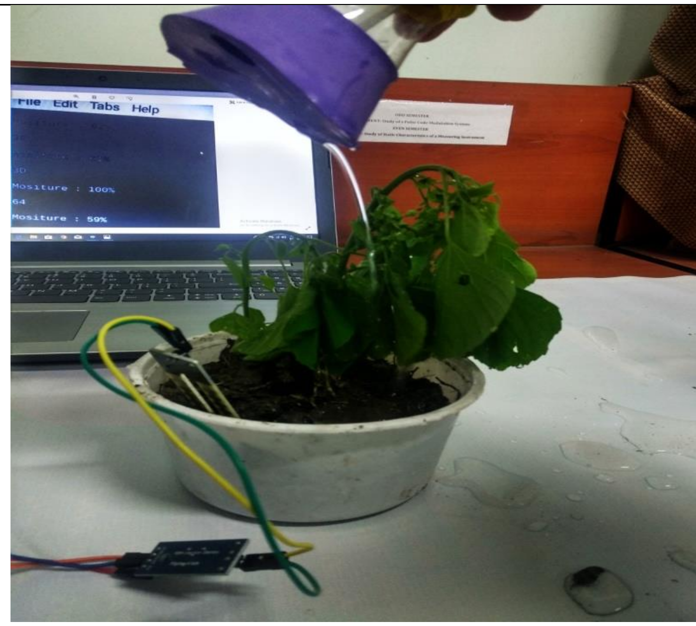
(A)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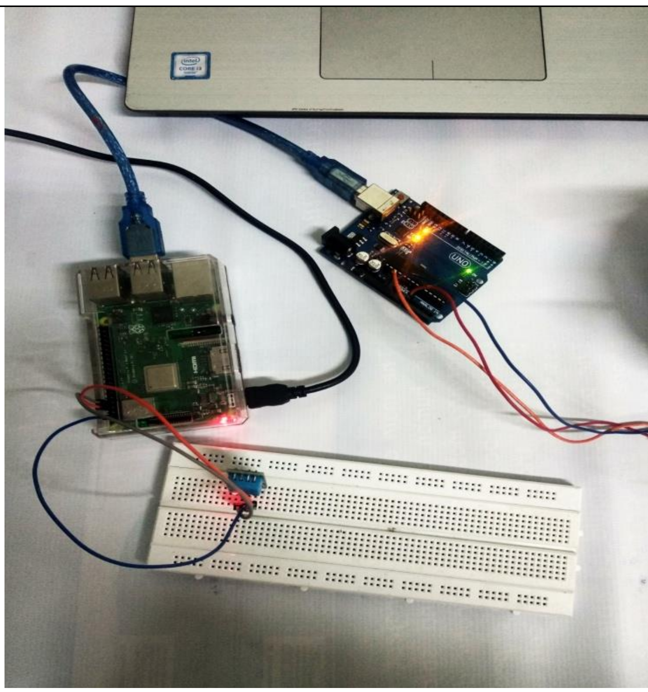

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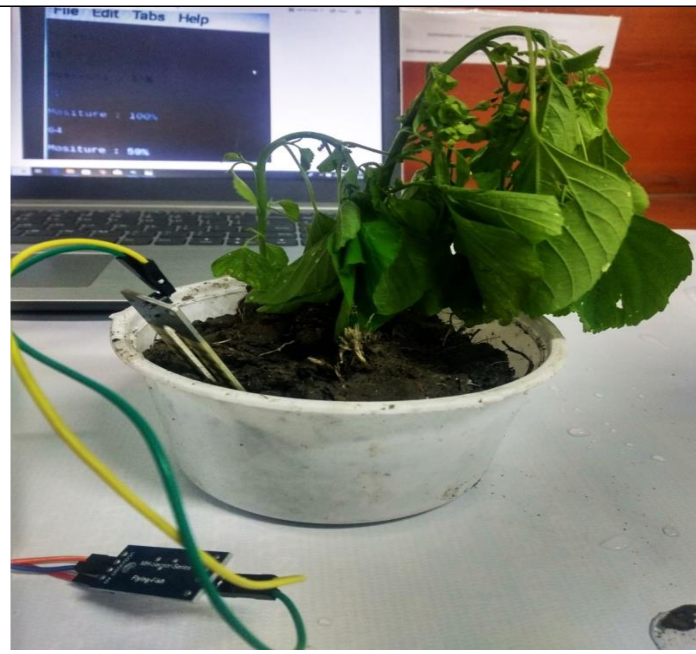
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Fig 12: (A) - Display of Sensor Output; (B)- Watering of plant calculating the moisture; (C)- Raspberry and Arduino Interfacing; (D)- Sensing Moisture from soil.

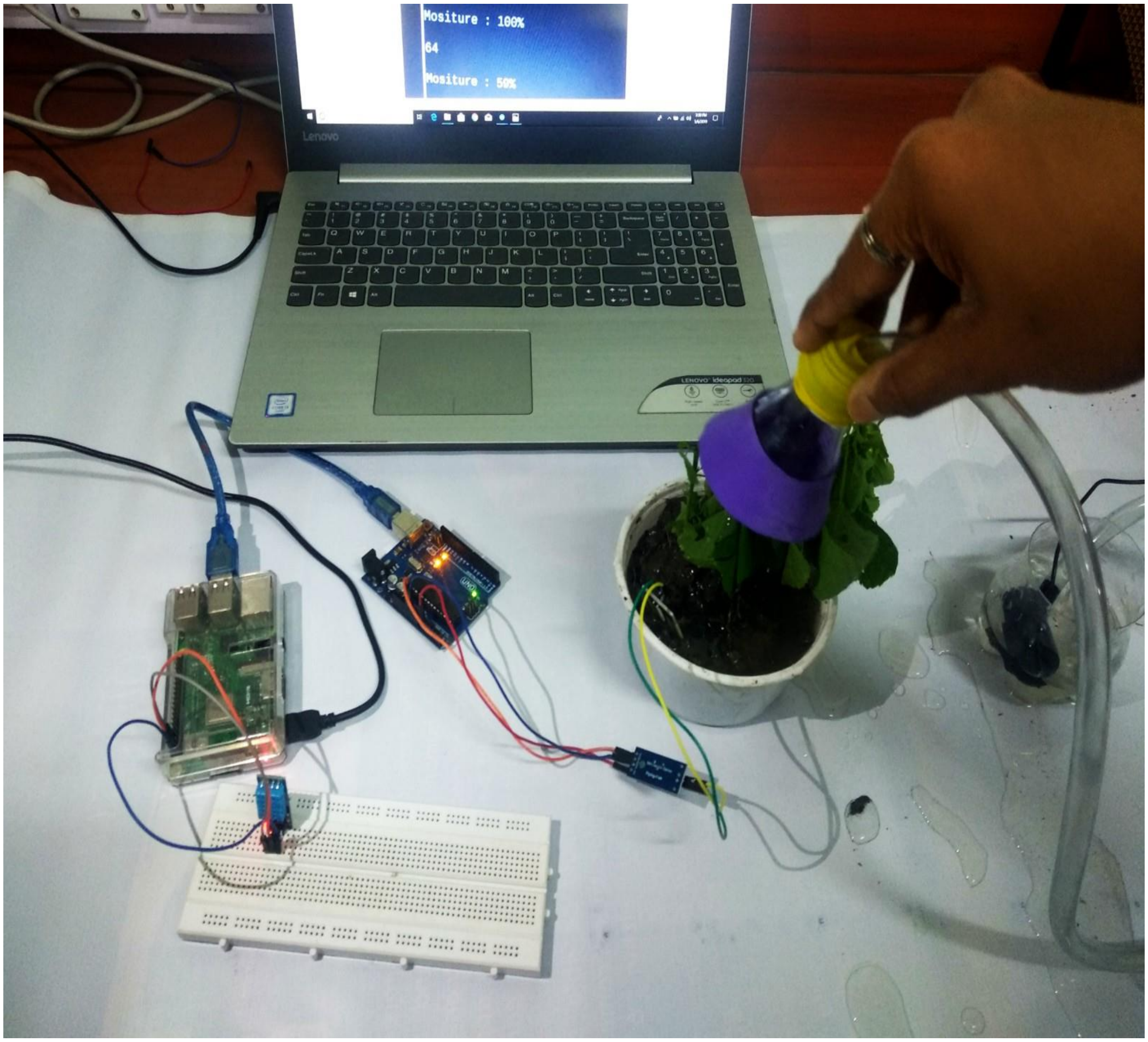

Fig 13: Test Run of the full System

Different soil samples were taken and for each soil sample different voltage readings were observed. A particular voltage denoted a particular amount of moisture in the soil. The maximum operating voltage of the moisture sensor was between 1V and 5V, where 1V denoted maximum moisture and 5V denoted minimum moisture.

Fig 14: Measuring Moisture as analog voltages from different soil samples.

The temperature and humidity of the surrounding area was analysed using the DHT11 sensor and according to that the water was supplied to the plant. When a certain level of humidity was there the pump was kept ‘OFF’ while with less humidity the pump was turned ‘ON’.

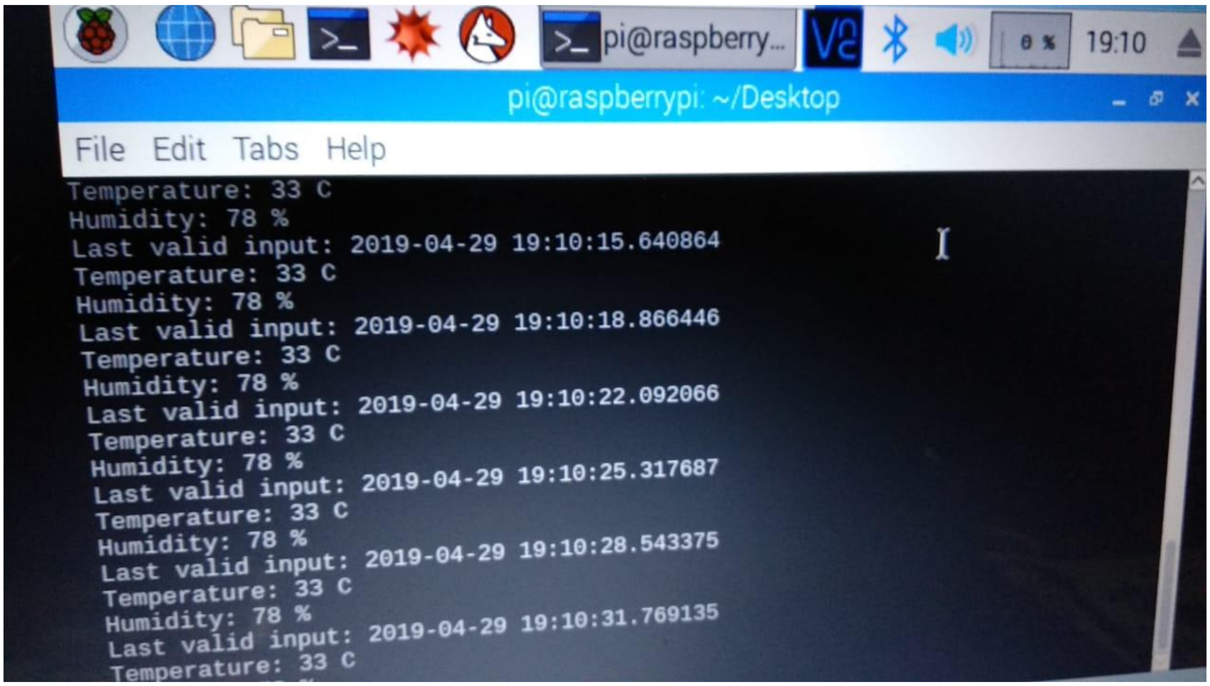

Fig 15: Temperature and humidity readings.

Observation Table of the Sensor Output:-

Conditions	Voltage	Statement
Open Air	5.2mV	Resistance between the probes is LEAST.
Sand	5.15 mV	Resistance is first observed between probes in this condition.
Dry Soil	4.74 mV	Resistance rises and voltage drop is noted.
Medium Wet Soil	2.91 mV	Resistance is duly noted as voltage drop is very high from the above conditions measured.
Wet Sand	2.22 mV	Voltage drop still occurs as there is high amount of water present in this condition.
Wet Soil(Moist)	1.63 mV	Maximum Water a soil sample can absord, so resistance between the probes is very high, as seen by the voltage reading. Maximum Water a soil sample can absord, so resistance between the probes is very high, as seen by the voltage reading.
Water	1.275 mV	Voltage reading noted in this condition is is the least, which implies that resistance is HIGHEST.

Chapter 7: Conclusion and Future scope

Conclusion:

By completing this project a smart irrigation system has been implemented using raspberry pi 3B+ module.It is an automated system and beneficial for mankind. This project proposes a design for smart home garden irrigation system that implements ready-to-use, energy-efficient, and cost effective devices.

1. The implemented system is integrated with multi-sensors such as soil moisture sensors, humidity and temperature sensors.
2. This proposed system managed to reduce cost, minimize waste water, and reduce physical human interface.
3. The entire system is monitored and controlled by the power full credit card sized microcomputer called Raspberry Pi.
4. The system is capable of automatic watering of plnats depending upon certain parameters.

Future Scope:

The future scope of this project can be comprehended in many aspects such as to add camera module to detect whether the plants are getting enough resources and whether they are growing without any resistances. Camera module clicks picture and send it through mail. Our project can be improvised by using a sensor to note the soil ph value such that usage of unnecessary Fertilizers can be reduced. A water meter can be installed to estimate the amount of water used for irrigation and thus giving a cost estimation. Further, it also reduces the investment of farmers. In addition to the excess cost of water, labour is becoming more and more expensive. The proposed irrigation system will be very efficient in areas like house gardens, office premises, buildings etc. where watering plants at regular interval matters. This system also presents a smart drip irrigation system to water plants using devices like raspberry pi, Arduino microcontrollers. This type of agriculture application of Internet of things in the real world environment is necessary to know the effect of the environment on such system. So is always better to know the risks beforehand.

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Appendix: Datasheet of sensors