A Hybrid System for Smart Agriculture Utilizing IoT and Machine Learning

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Abstract—**For generations, crop production has been the foundation of global development. Farmers will require water to irrigate the land to fulfill this need, nevertheless, as a result of the residents upsurge and rising consumption, farmers require a solution that alters their methods of operation due to the dearth of this resource.The idea of "Agriculture 4.0" has materialized as a result of the introduction of new technology in order to stay up with and sustain growth. Outcome has become easier with the incorporation of artificial intelligence and IoT with the gathering and analysis of agricultural data.This paper asserts a smart, adaptable irrigation strategy that uses little energy and costs little expense and can be used in a variety of situations.This strategy for smart agriculture is based on machine learning algorithms. In an atmosphere that promotes greater plant development for months, we employed a collection of sensors (soil humidity, temperature, and water level) for all of this. The system uses the Rasberry Pi series, by which the varying nature of the moisture content in the soil is sensed accordingly by the sensing system. The models based on Neural Networks are utilized to determine the result. Since the water gets wasted a lot of time due to ignorance this system can also help in reducing the wastage in near time.**

Keywords—Rasberry Pi;Soil Moisture Sensor; NOOBs; IoT; Ultrasonic sensor; pir sensor.

I. Introduction

Precision agriculture, often known as agriculture 4.0, is a method of agricultural management that analyses, analyzes, and responds to variations in the same environment and other environmental factors. The major goal of the research of agriculture 4.0 is to offer a judgment aid system for governing the entire field of agriculture in order to maximize input profit and resource preservation. The initial stages toward Agriculture 4.0 include predicting the delivery and impact of various fertilizers using remote sensing and crop health sensors.

The phrase used to analyst and determine crop yield is agribusiness. Animal husbandry, yield production, agrochemicals, agricultural equipment, seed procurement, and advertising and distribution tactics are all included in the agriculture business ecosystem. This agri-food structure composed of representatives and organizations that have an impact on the food and fiber chain[3,4].

Water should be organized for, produced, preserved, regulated, and most importantly utilized sustainably because water is a precious and rare natural resource that is also essential to life. Due to rising needs and finite resources, appropriate utilization of the existing water resources at the farm level is required. In order to produce crops at their best and fulfill future demands for food, crop yields must be increased in areas with scarce water supplies. Utilizing the limited water supply wisely can allow you to irrigate more land while using the same quantity of water.[1,2]

In recent times, some academics have employed internet of things and artificial intelligence technologies to accurately solve irrigation difficulties.

By applying the concept of real-time to identify moisture in the soil deficient in root zones , the authors of [7] conducted out an irrigation control framework. To do this, the researchers utilized a system of recognition of the ground water data to generate a linear time series model. In [8], the authors introduced a linear time series model called the Deep Length Short-Term Memory model, which employs functional process across time to forecast soil moisture for lychee plantation.

These models do, however, provide improved irrigation management, but when combined with data analysis methods, they result in very sluggish sampling that is only applicable to the calibration region.

In order to effectively manage autonomous intelligent irrigation, we intend to provide an irrigation prediction technique in this study. We took the following three steps:

i. Setting up the sensors (soil moisture, temperature, and water level).

ii. Connecting the collection of sensors to an acquisition system,

iii. Using the Rasberry Pi and an IoT platform to improve the irrigation system through monitoring, storage, and notification.

In the event of large-scale irrigation systems or home uses, this strategy will be very helpful. On the one end, this will make the difficult chore of crop irrigation simpler, and on the other, it will improve water conservation.[5,6]

A. Problems while watering the plants

Let's start by talking about the issues or crises that farmers are now facing. The majority of these issues are caused by water waste in agriculture as well as a lack of understanding of crop development and the amount of water required for its production. Three categories may be used to group the issues:

(i) Water

In many regions, there is an inadequate supply and an uneven distribution of water. Crop irrigation uses significantly more water than is necessary, making the supply for other uses insufficient. So many regions of our nation are going to have severe water shortages throughout the summer. Many of these places' administrative sectors are unable to implement different water conservation strategies.

(ii) Power Usage

When the motor pump is running, about 6 Horse Power per acre of power is consumed. The motor does not need to run for such a lengthy period of time. In actuality, 1-2 Horse Power are sufficient to water crops per hectare. Throughout the remaining time, the motor is needlessly left ON. 70% of the electricity may be used for other things if we design and effectively install an automated watering feature.

B. Related Work

(i) Agriculture 4.0

The phrase "agricultural 4.0" refers to all forms of agriculture, but this time with greater attention to detail across the whole food supply chain, beginning with the kind of soil, climate, irrigation techniques, water usage, and crop recovery. We will require the many instruments available for agricultural 4.0 or agriculture of the future to ensure this[9].

The manufacturing ecosphere has recently made investments in technical advancement, focusing primarily on low-cost and highly effective production actions with knowledge-based development acquired through years of visualization and information gathering that have paid off in creating an IoT system based on intelligent irrigation and water reuse that has saved 5.5 billion m3 annually as well as an IoT system based on smart lighting that has ended up saving 5.5 billion m3 annually and also saving of energy upto 44% of the total disengagement of water

(ii) Artificial Intelligence for Agriculture

A novel idea called Artificial Intelligence for Agricultural Innovation (AI4AI) is starting to gain acceptance among scientists. Artificial intelligence (AI) and machine learning (ML) are being quickly incorporated into agriculture in terms of both field-based agricultural practices and agricultural goods[15]. Cognitive Computing is quickly overtaking other technologies in agricultural services due to its capacity to comprehend, learn, and adapt to various conditions with greater precision.

Table 1 lists other earlier research that utilised machine learning models and included features, experiments, and simulations:

Reference	Supervised Model	Features
13	Linear Regression	This study uses a database that was compiled using data from several detecting sensors to forecast the amount of irrigation water that will be needed.
11	KNN	Here, the system is utilised to analyse and keep track of drone-shot agricultural photos.
12	SVM	In a household plant setting, this approach enables automated watering quantity modification.

Neural Network

Any arbitrary mapping from one vector space to another vector space may be carried out using the neural network

[10]. These neural networks are able to access undiscovered information that was previously concealed in the data but cannot extract it. It should be highlighted that learning in mathematical formalism [14] entails changing the weighting factors to ensure that particular requirements are satisfied.

II. METHODOLOGY

A. Context

We outline every step we took to implement the irrigation system in this article. Many processes used to realize this smart irrigation system as depicted in Fig. 1. To achieve this, we began by selecting the sensors required for the model's realization, commencing with the soil moisture sensor, which is used to display the amount of soil moisture, and moving on to the temperature/humidity and rain sensors. Once the sensors are wired up to the Rasberry Pi Arduino board, we can begin programming the board to control the sensors in a way that will allow the various pieces of data to be combined and delivered in real time.

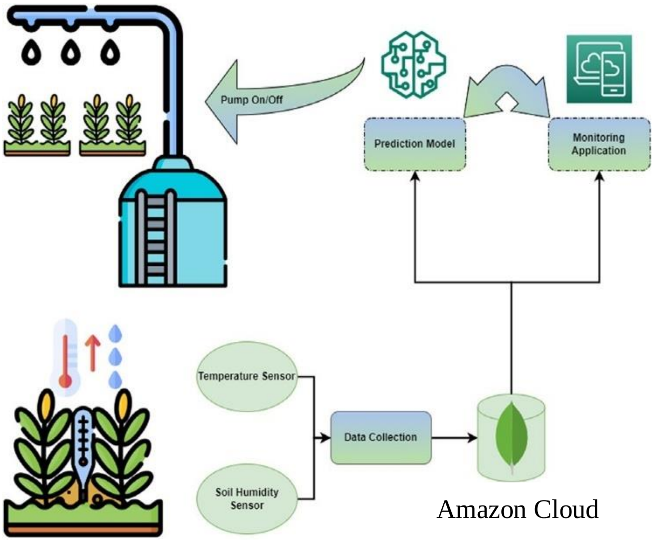

Fig 1: Irrigation System

B. Context

With the aid of specialists in the field of agriculture and among the information recorded by a number of algorithms, we were able to gather several sorts of data, including:

Temperature, air humidity, soil humidity, and rainfall data were all gathered by the sensors.

Data gathered with water pumps: Pumping (On/Off) details

Node for Rasberry Pi: This node enables communication between our Arduino card and the node-red server.

Preprocessing node: This node is used to enable data that sensors output from being split up.

The extraction of particular data from the preprocessing node is done using the nodes for soil humidity, air humidity, temperature, and rain.

The Notify and Mail nodes enable the emailing of a series of notifications to enable effective sensor monitoring.

Local data node: Enables the storing of local data.

Dashboard nodes: Enables the viewing of data in real-time.

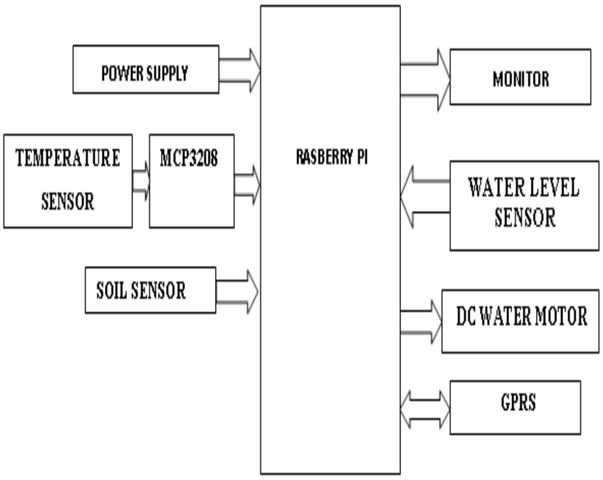

Fig 2: System Block Diagram

C. Data Set

We started implementing these devices in various environments with multiple domestic crops in the widespread data gathering for the absolute need of details with the aid of IoT technologies, which are made up of a wide range of automated equipment in the form of detectors capable of self-organization and working to gather information. This was a nearly complete implementation of our Dataset implemented to deploy the data using an algorithm to generate a very important data set of our system. We locate the time stamping data, digital data, and incoming data from the centralized sensors at the intersection. Accompanying this growth, we find: soil moisture data, temperature data and water level data.

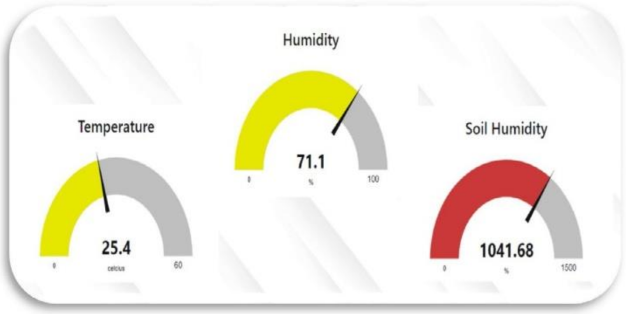

Fig 3: Supervision System

III. SYSTEM OVERVIEW

1. HARDWARE REQUIREMENTS

A. RASPBERRY PI3 MODEL B+:

Fig 4: Rasberry Pi

The computing power of the Raspberry Pi 2 is six times greater than that of earlier versions. This second-generation Raspberry Pi is equipped with an upgraded BroadcomBCM2836 processor, a potent quad-core ARM Cortex-A7 processor that operates at 900MHz. Additionally, the board has increased storage size to 1Gbyte.

B. LCD Display

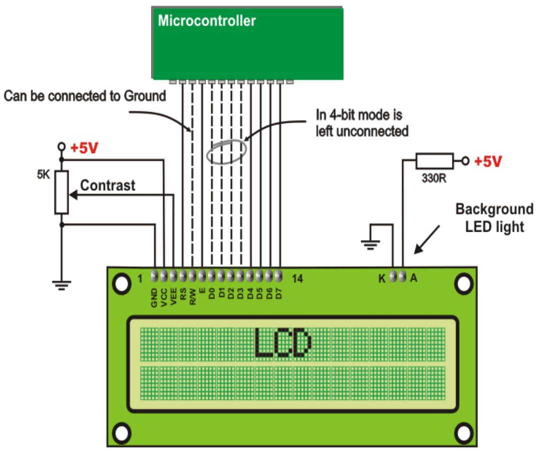

Fig 5:Interfacing of LCD to micro controller

Make pin RS=0 to transmit any instruction from table 2 to the LCD, and make RS=1 to deliver data. After that, activate the LCD's internal latch by sending a high to low pulse to the E pin.

POWER SUPPLY: The power supplies are made to transform high-voltage AC mains electricity into a suitable short inventory for electronic devices and circuits. A power supply can be divided into a number of blocks, each of which serves a specific purpose. Regulated D.C Power Supply is a type of d.c. power supply that keeps the output voltage constant despite changes in the load or the a.c. mains voltage.

C. Regulator

The output voltages of voltage regulator ICs can be fixed (usually 5, 12 and 15V) or variable. They are rated based on the highest current they can carry. There exist negative voltage regulators, primarily for use with multiple supply. Most regulators include some level of automated overcurrent (also known as "overload protection") and thermal (also known as "heat shields") security.

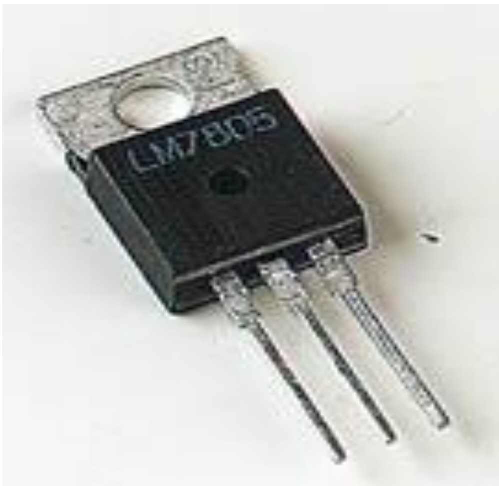

Fig 6:A three terminal Voltage Regulator

(i) 78XX:

The Bay Linear LM78XX is a three-terminal integrated linear positive regulator. The LM78XX is helpful in a variety of applications since it offers a number of fixed voltage levels. The LM78XX typically produces reduced quiescent current and an effective output impedance improvement of two orders of magnitude when used as a zener diode/resistor combo replacement. Possible packages for the LM78XX include TO-252, TO-220, and TO-263.

D. Soil Moisture Sensor

This is a straightforward moisture sensor that may be used to measure soil moisture. When there is a scarcity of soil moisture, the module outputs a high level, whereas the output is low. By using the sensor, a watering device is created automatically, saving you from having to select and hire garden plant managers. The sensitivity may be adjusted using a digital potentiometer (blue). operational voltage range of 3.3 to 5 volts. Simple digital output from a single-chip microprocessor using g and v. easy installation, fixed bolt hole. control board Size of PCB: 3 cm by 1.6 cm; size of soil probe: 6 cm by 2 cm. The red power indication light and the green output indicator light for the digital switch (green) The LM393 chips used by the comparator provide stable operation.

Fig 7:Soil Moisture Sensor

E. Water Pump

Fig 8:Water Pump

A little water pump, this is submerged one. It can hold up to 120 litres of water in an hour and uses just 220 mA of current. It has a power supply range of 2.5 to 6 v and is a tiny, inexpensive water submersible pump. Its operation requires only that you attach a pipe to the motor outlets, submerge it under water, and supply electricity.

2. SOFTWARE REQUIREMENTS

A. Rasberry Pi OS System

An operating system is not included with the Raspberry Pi. New Out of the Box Software, sometimes known as NOOBS (NOOBS stands for **N**ew **O**ut **O**f **B**ox **S**oftware), is required for that. It is a system manager that makes downloading, installing, and configuring your Raspberry Pi simple. You may choose from a number of OSes when NOOBS first starts up. The operating systems that are offered depend on the Raspberry Pi model you are running. For the sake of this article, we'll adhere to the most prevalent Oses operating systems that are accessible on the most recent Raspberry Pi models. Currently, those include Windows IoT Core, OSMC, Open ELEC, Raspbian, and RISC OS.

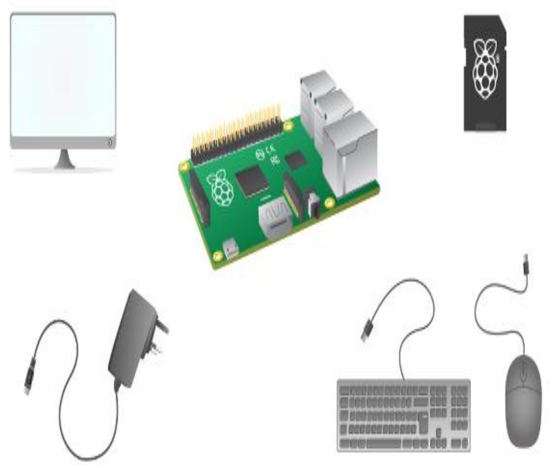

Fig 9:Rasberry Pi System

IV. RESULTS

The following is the flow chart of the system:

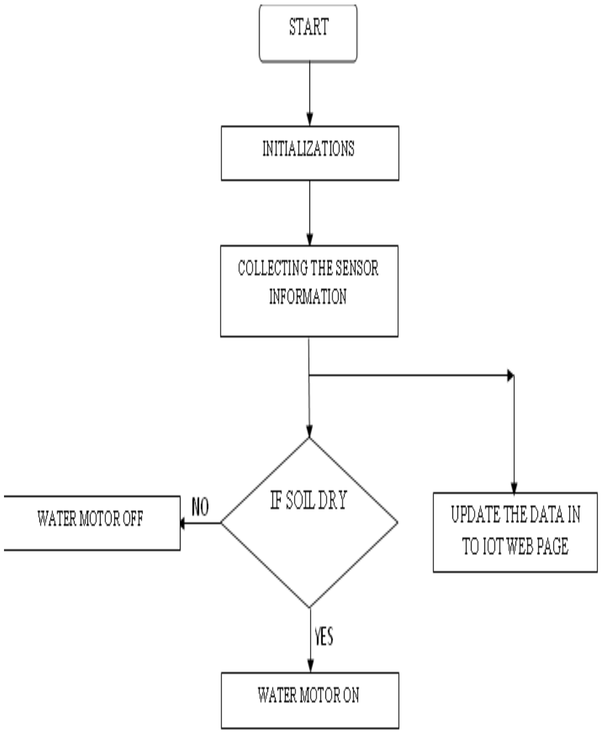

Fig 10 :Flow Chart Of the System

We discover the empirical observations that are consistently summarised by peer-to-peer identification, which classifies two distinct colours. The first is the colour red as a generic term for knowledge at category "0," as evaluated by the pouring, which depends on a temperature versus and with a humidity deviated towards deactivation. The colour green, on the other hand, represents category "1," which is based on temperature pumping vs being controlled at the same time by active humidity.

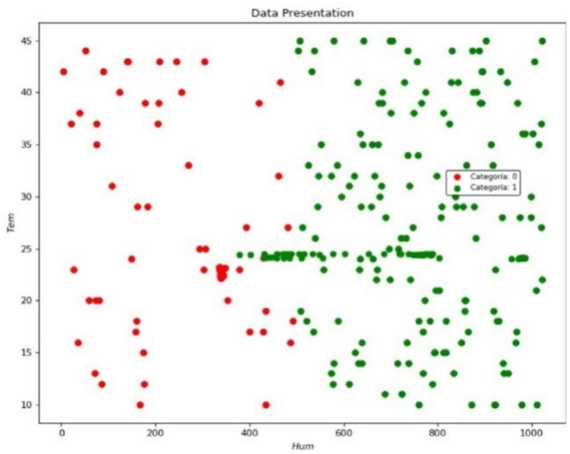

Fig 11:Data Presentation

A large amount of data is used to present the predefined plant sections, and this data is trained using a variety of methods and algorithms so that it can be extrapolated from past events to better predict future events, determine irrigation system forecasts, and support future trends that will unavoidably manifest.The usage of the neural network algorithm is justified since the likelihood of the output data really occurring depends on the methods used.

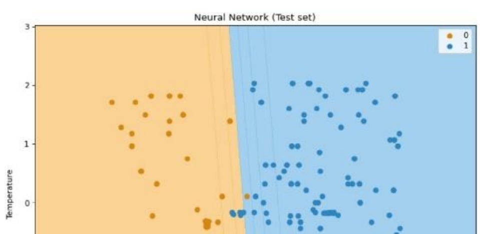

Fig 12 :Result of Neural Network Model

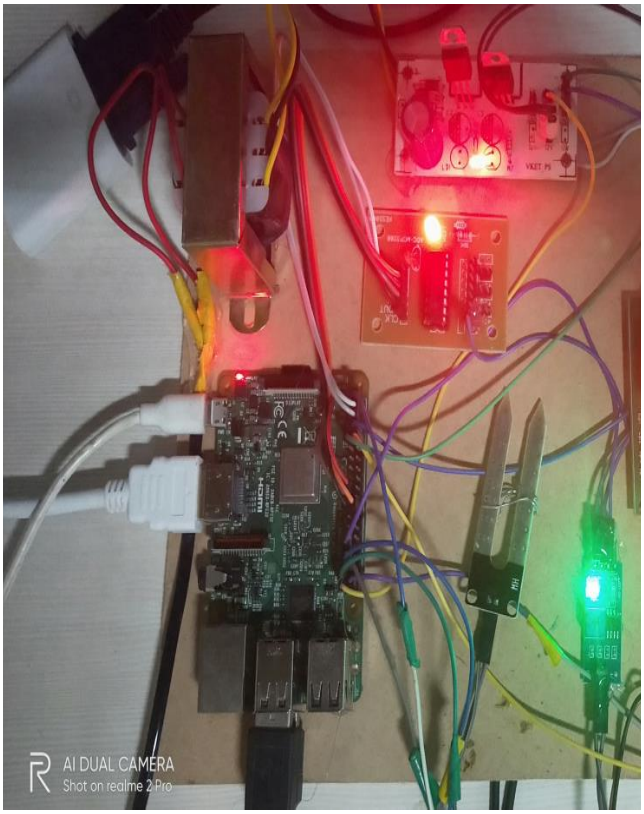

Fig 13:Complete hardware setup of the system

Figure 13 is showing the complete hardware setup of the system. The figure 14 depicts the output values of GUI.

Fig 14:Output Values of GUI

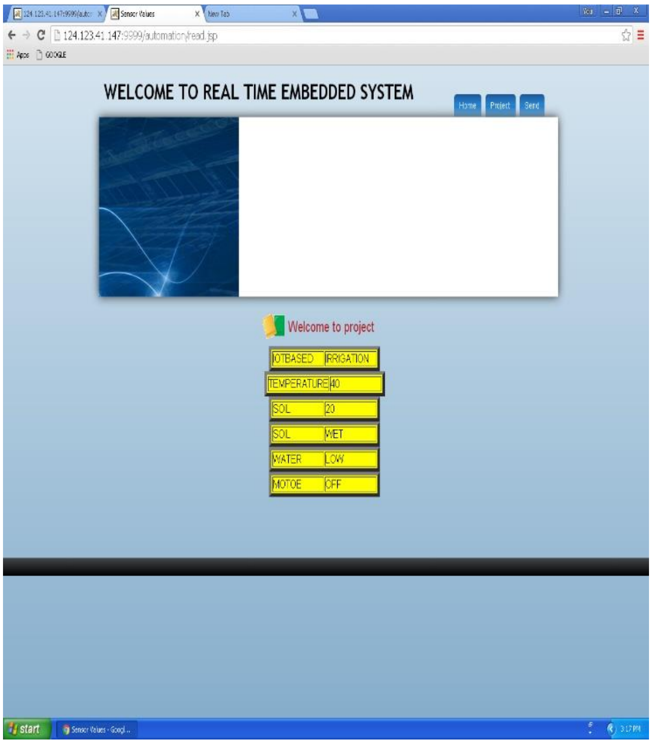

Fig 15:Updated Results on IOT Web Page

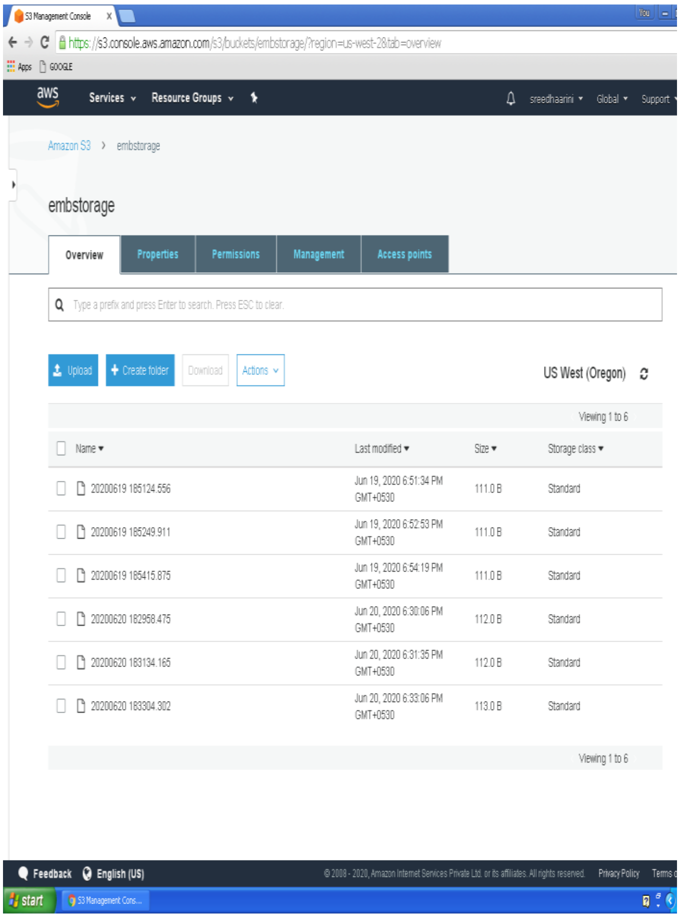

Fig 16:The figure is showing the data is stored on the Amazon cloud services

CONCLUSION

The world's food demand is expected to increase by more than 70% by the year 2050, making increased production to meet this demand a critical first step. It also involves controlling how much water is used for irrigation. The establishment of a database utilizing a data collecting card equipped with several sensors (soil humidity sensor, temperature and humidity sensor, water level sensors) is the first step in the irrigation prediction that we suggest in this work. This made it possible for us to gather a variety of data for use in our machine learning-based decision support models.

The findings indicated that Neural Network Recognition and, ultimately, the presentation of a web application to group all of the tasks completed throughout this course to make it easier to visualize and monitor the environment using a basic phone or laptop. In terms of the future, we want to increase the database's capacity by including additional data on the one hand, and apply additional algorithms—particularly semi-supervised learning—to assure decision-making accuracy on the other.

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