OPTIMIZATION OF CROP PRODUCTION

Project report submitted in partial fulfillment of the requirement for the degree of Bachelor of Technology

In

Computer Science and Engineering

By

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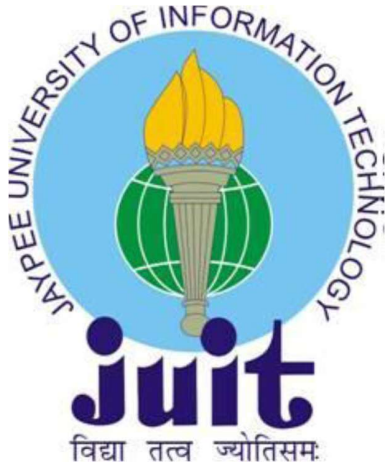

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Candidate's Declaration

I hereby declare that the work presented in this report entitled OPTIMIZATION OF CROP PRODUCTION in partial fulfillment of the requirements for the award of the degree of Bachelor of Technology in Computer Science and Engineering/Information Technology submitted in the department of Computer Science & Engineering and Information Technology, Jaypee University of Information Technology Waknaghat is an authentic record of my own work carried out over a period from August 2018 to December 2018 under the supervision of Dr. Hemraj Saini Associate Professor (Senior Grade), Computer Science & Engineering and Information Technology.
The matter embodied in the report has not been submitted for the award of any other degree or diploma.

Satyam Aggarwal (151385)

Shubham Aggarwal (151430)

This is to certify that the above statement made by the candidate is true to the best of my knowledge.

Dr. Hemraj Saini
Associate Professor (Senior Grade)
Computer Science and Engineering/Information
Dated:

ACKNOWLEDGEMENT

We have taken efforts in this project. However, it would not have been possible without the kind support and help of many individuals and organizations. We would like to extend our sincere thanks to all of them.

We are highly indebted to Dr. Hemraj Saini for their guidance and constant supervision as well as for providing necessary information regarding the project and also for their support in completing the project. We would like to express our gratitude towards our parents and Jaypee University of Information Technology for their kind co-operation and encouragement which helped us in completion of this project.

Our thanks and appreciations also go to our colleague in developing the project and people who have willingly helped us out with their abilities.

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LIST OF ACRONYMS & ABBREVIATIONS

GDP	Gross Domestic Product
IoT	Internet of Things
ML	Machine Learning
ANN	Artificial Neural Network
FL	Fuzzy Logic
ANFIS	Artificial Neuro Fuzzy Inference System
PIR	Passive Infrared Sensor
LDR	Light Dependent Resistor
DHT	Di-hydro testosterone
pH	Potential Of Hydrogen
SQL	Standardized Query Language

ABSTRACT

Agriculture plays a crucial role in the development of agricultural country. Most of the population of India depends upon farming and one third of the nation's capital comes from farming. Issues concerning agriculture have always been hindering the development of the country. The only solution to this problem is smart agriculture, by helping the farmers to decide which crop to grow according to the soil and climatic conditions. These conditions play very important role in crop production. Without having the knowledge of the current condition of the field it will be difficult to get the expected output from the fields the only solution a farmer has left with is to monitor the fields by physically going in fields to check whether the soil and climatic conditions are favorable according to crop requirement or not. In this project we are attempting to build a system which will sense different important elements like soil moisture, temperature and humidity of the fields and will provide us with the most optimized decision using NEURO FUZZY technique. The data will be collected using various smart sensors and will be sent to remote server where data will be analyzed and appropriate output will be given. Ultimately this will result in greater yields and hence the farmer's income.

CHAPTER – 1
INTRODUCTION

1.1 Introduction:

Agriculture plays very important role in our daily life from providing food to the clothes we need. Agriculture is the art of growing crops, nurturing them and finally getting the food to fulfill the needs of the humans. It is most important activity in the world. Population is increasing day by day and the current world population is expected to reach 10.5 billion by 2050 further adding concern to global food security. In order to meet this increasing food demand, food accessibility and availability has to be increased by increasing the production and reducing the losses. In order to handle this situation farmers have to face the challenge of producing sufficient to meet the demands by maintaining the quality and quantity of resources for future generation.

Figure 1.1 Farms in different stages[21]

In Agriculture different crops are grown on different types of land, different crops require different type of soils, different types and amounts of nutrients, and different types and

amounts of water and require different climatic conditions to grow. The amount of water required by the plant is also dependent on the growing season and the climate in which it is grown. If we select the right crop for the given soil conditions and climate, one can optimize yields and save water requirements for irrigation, minimizing the use of fertilizers which are used to boost the production. But the excessive use of fertilizers has damaged the soil adversely and nutrient factor of the crop. We are attempting to solve this problem by reading different parameters of soil like soil moisture, pH etc. and various climatic parameters like temperature, humidity etc. and by taking these parameters into the account we can help the farmer to decide which crop is most suitable for conditions recorded from his farm. We have recorded various parameters using smart sensors this includes soil moisture sensor(YL-69) to get moisture content of the soil, Temperature and humidity sensors(DHT11) to get temperature and humidity of the field. For instance, if we record soil moisture which is suitable for rice and temperature and humidity which is suitable for rice then we will recommend farmer to grow rice on that particular field for better yields.

1.1.1 Introduction to IOT:

"The Internet of Things is the network of physical objects that contain embedded technology to communicate and sense or interact with their internal states or the external environment." -Gartner

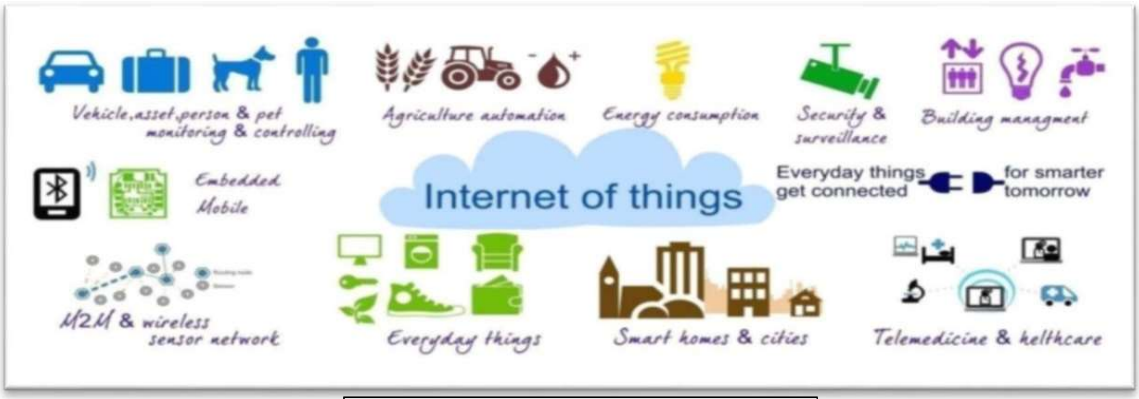

Figure 1.2 IoT and its application[13]

The Internet of Things (IoT) can be a system of reticulate computing devices, mechanical and digital machines, objects, animals or of us that ar furnished distinctive identifiers and conjointly the power to transfer information over a network whereas not requiring human-to- human or human-to- computer interaction. A thing, inside the net of Things, is somebody with a monitor implant, a placental mammal with a micro chip device, associate automobile that has intrinsic sensors to alert the actuation once tire pressure is low or the opposite natural or artificial object that will be allotted associate scientific discipline or branch of information address and furnished the ability to transfer knowledge over a network.

The term Internet of Things generally refers to areas where network connectivity among various devices and computing capability of the microcontroller extends to objects, sensors (like PIR sensor, LDR sensor etc.) and everyday items (like switch boards, bulbs, fans etc.) not normally considered computers, allowing these smart devices to sense or create, interchange and consume data with minimal human efforts. There is, however, no single, universal definition.

1.1.2 Introduction to Neuro-Fuzzy System:

Neuro fuzzy system is a hybrid system of neural networks and Fuzzy logics. An Artificial Neural Network (ANN) is a system that performs operations on the data as the natural sensory systems, for example, the mind, process data. The uniqueness of this system is that it has a very new kind of structure for processing the information. This system has large network of interconnected elements for processing called neurons which work together in co-ordination to find solution of a problem. These artificial neurons are the imitation of the biological neuron which strives to simulate the information processing capabilities of its biological exemplar. ANNs are typically composed of a great number of interconnected artificial neurons. As people learn from experiences this system also learns from the training dataset which have input along with desired output so our system analyses the input and builds algorithm to map input to the output and in this way system learns and provide output to the user given input.

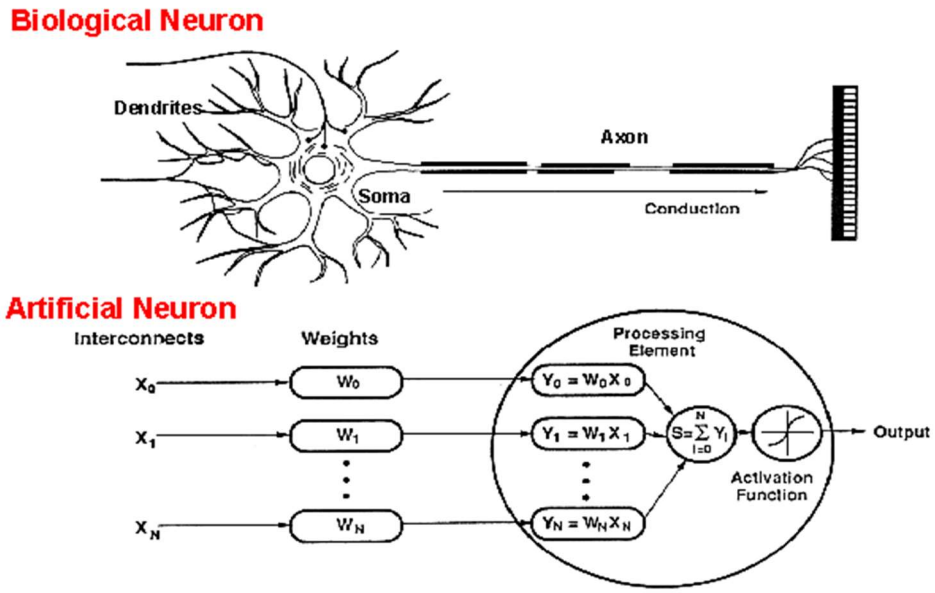

Fig 1.3 Artificial and Biological neuron[4]

Neurons are the basic building blocks of a neural network. Basically each neuron is connected to many other neurons and receives input from them. Then this input is fed to the activation function which alters its internal state. After processing , output is sent to many other neurons.

We are using neural networks because of its ability to identify the different trends, sequences and patterns in a large dataset which otherwise is very complex to detect by the human mind and traditional computers. This system acts as an expert when trained with proper training dataset of a particular category of data to be analyzed.

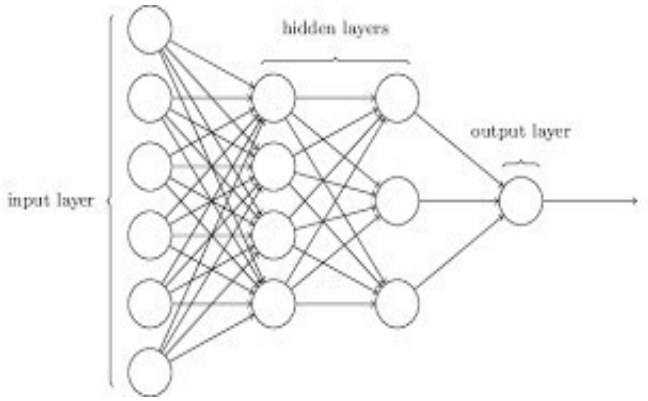

Figure 1.4 Neural network[9]

In real world we come across various scenarios where we cannot answer or judge whether it is true or false that is in binary logic. But the fuzzy logic provide us the varied flexibility to choose true , false or intermediate value that is it provide us range from 0 to 1 to answer any situation. It also provide us opportunity to consider uncertainties and inaccuracies in any scenario. Fuzzy logic is different from Boolean logic as it permits or allows the use of natural language to write the queries and is similar to human thinking. We can apply fuzzy logics in various fields like Artificial intelligence, neural networks, control systems like cruise control, air conditioning, ship boilers etc. Fuzzy system consist of fuzzy sets which are defined by membership function and fuzzy rules according to which the fuzzy system works.

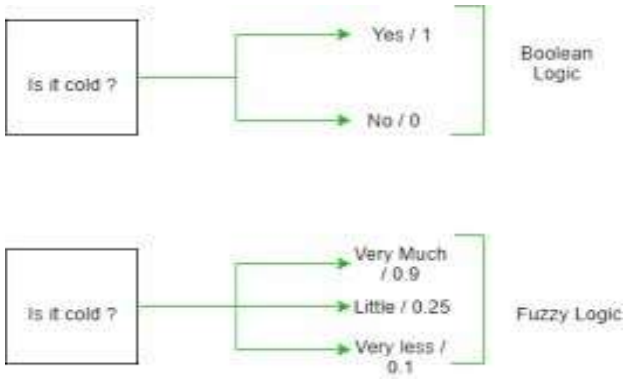

Figure 1.5 Fuzzy Logic[22]

ANN uses backpropagation technique to learn from given input mapped to particular output and uses gradient descent as optimization strategy to reach to an optimal solution. These both algorithms work hand in hand to help system learn in better and efficient way.

The main advantage of neural network is that it learns from the examples but we can't use the prior knowledge to initialize the network and also can't interpret the final states through rules. On the other hand fuzzy systems uses the prior knowledge in the form of linguistic rules to interpret the results but the system cannot learn. So here we come with the hybrid system which uses the advantages and suppresses the disadvantages of each other to get good results.

1.2 Problem statement:

Agriculture suffers a lot due to lack of correct knowledge of best agricultural practices, which once enforced will increase the yields at minimal prices and resource utilization. Many farmers are leaving or going away from farm practices (mainly agriculture) and related The problem statement represents the necessity for the projected system because activities because they are not getting good return on their investments that is, they are taking up huge loans to buy the resources to grow crops (like seeds, fertilizers, pest control and tools etc.) but the produce is not sufficient enough to pay off their loans and as a result they end up in having huge losses and debts on their heads. Hence, this is a huge blow to the Indian economy as large proportions of the fertile land of our country are becoming wasted, that were otherwise the foremost supply of the nation's gross domestic product (GDP) once. So through this project we want to provide very trivial solution to this huge problem by introducing a smart crop farming scheme in which we are helping farmers to do farming in optimized manner that is, helping them to decide which crop is most suitable to the current soil and climatic parameters of the farm ,so that farmer can witness the higher yield.

1.3 Objectives:

The objective of the projected system is to extend the quality of agricultural economy in India. Agriculture plays a vital role in the development of agricultural country. Most of the population of India depends upon farming and connected activities and one third of the nation's capital comes from it. Issues concerning agriculture have always been hindering the expansion of the country. We can solve this problem by combining the present traditional agricultural techniques with modern agriculture.

Primary objective of this project is to help the farmers to decide which crop to grow according to the soil and climatic conditions. These conditions play very important role in crop production. Without having the knowledge of the current condition of the field it will be difficult to get the expected output from the fields the only solution a farmer has

left with is to monitor the fields by physically going in fields to check whether the soil and climatic conditions are favorable according to crop requirement or not.
Secondly, through this project we are attempting to build a system which will sense different important elements like soil moisture, temperature and humidity of the fields and will provide us with the most optimized decision using NEURO FUZZY technique. The data will be collected using various smart sensors and will be sent to remote server where data will be analyzed and appropriate output will be given.
Ultimate objective of this will result in

- Greater yields.
- Increase in GDP.
- Saves resources by smart selection of crop.
- Quality life of farmer.

1.4 Methodology:

The methodology used in the projected system consist of a microcontroller board Arduino. This microcontroller chip is further connected to single centralized server where server acts as interface or junction where data is processed and the output or information is shared with the farmer (USER). The data is collected using various sensors like soil moisture sensor, temperature and humidity sensor.

Our system has two main operations to perform, firstly to use smart device which include soil moisture sensor (YL-69) to measure the moisture content of the soil, temperature and humidity sensor (DHT-11) to measure temperature and humidity respectively of the farm. Secondly, after collecting this data, data is sent to the server where various operations are performed on the data that is, an optimization technique called Neuro-fuzzy which is a hybrid system of neural networks and fuzzy logic. This optimized result is sent to the farmer (USER) that is, the best suitable crop that can be grown on that farm conditions. This system would be of great help to the farmers as now they can use this system to

make decision over which crop should they cultivate and which crop would give them higher yields in current scenario.

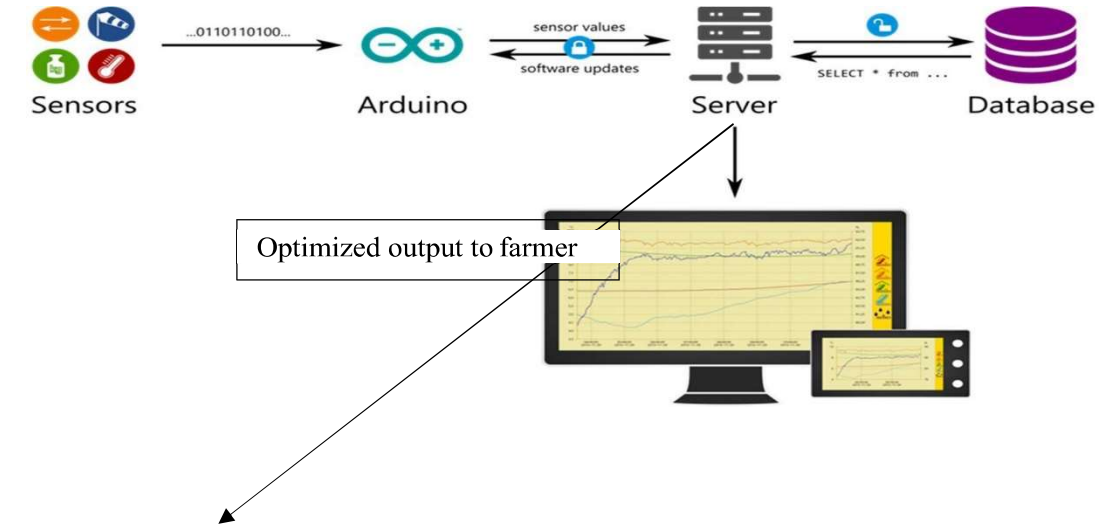

Figure 1.6 Methodology of proposed system

1.5 Motivation:

The main aim of this project is to introduce a low cost system which will help the farmer to take up the decision on which crop to grow. In agriculture the people are still using traditional methods but with the changing environmental conditions and increasing food demand these methods need to be collaborated with the modern agriculture techniques that is, using smart devices (sensors) to collect the data from the fields and then giving optimized results to the farmer.

In order to increase the GDP of the country and to improve the life of the farmers who work very hard day and night to feed the nation. These farmers now days are ending up their lives due to less production which results in increasing debts. Information and Communication Technology can be used to help these farmers

in agriculture to increase their produce and profits and hence making their life better.

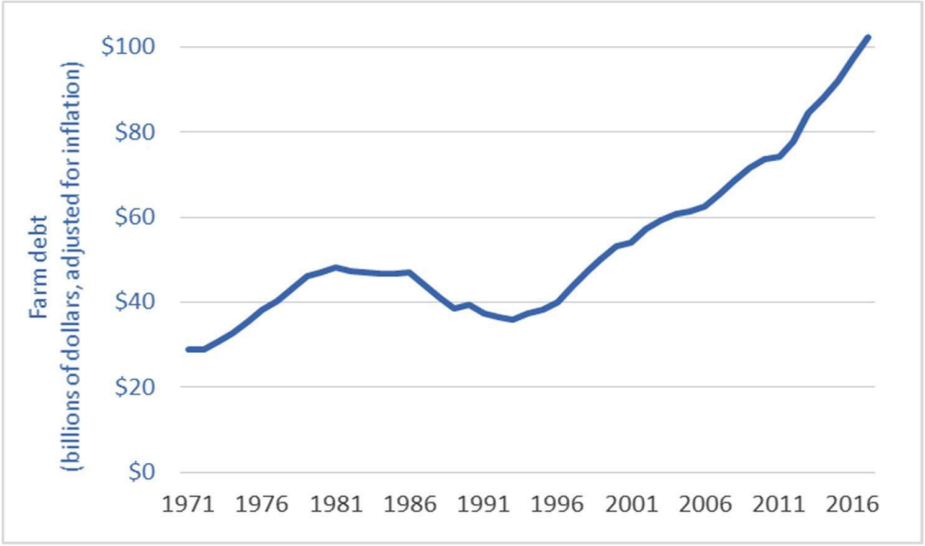

Figure 1.7 depicting debts of farmer[17]

1.6 Organization:

In this chapter we have discussed about the current scenario of the agriculture in our country. Then, we have discussed how various crops are dependent on various factors.

We have also taken the brief introduction to Internet of things (IOT) and Neural networks, fuzzy logic and Neuro-Fuzzy system. We have also taken what are the main objectives and methodology of the projected system and what is the motivation for this project.

In chapter 2, we shared the information which we have gather after surveying various research papers, websites, journals and other projects of this domain.

In chapter 3, we have described the system architecture that is the model of the system. We have also described what are the various hardware tools and software tools we have used in our project.

In chapter 4, we have described how the different module works and what algorithm we are using in our project.

In chapter 5, we have discussed how we are going to test our system and what, are the different plans to implement the testing of our system.

In chapter 6, we will try to show the results till now we have achieved by implementing our project,

In chapter 7, we have concluded in brief what we have done in this project and what is the future scope of this project.

CHAPTER -2
LITERATURE SURVEY

In this section of report, all the information collected from various research papers journals and websites are illustrated.

1. Crop growth environment[7.211]:

This paper discusses how various environmental factors are necessary for the growth of crop. Some factors may be suitable for a crop to grow in anti-season but many other factors will affect the development of the crop. These all factors can be monitored using sensors which collect data from the field and other embedded technology.
Analyzing the various factors which effect the growth of crops:

Effect of temperature:
Temperature has two main aspects first, it effects the metabolic process of the crop which includes photosynthesis, transpiration etc. Secondly, it effects the temperature of the soil and mainly absorption of water in plants and enzyme activity.

Effect of humidity:
Crops need enough water for their proper development and growth. Mainly, water is needed for cell expansion but lack of water effects the growth of plant that is crops will be short. But excess of humidity is also main reason of crop diseases. So suitable humidity is required by the specific crop.

Effect of Soil type:
Soil contain various vital nutrients which are necessary for the crop growth. Different types of crop at different stages require different types of nutrients. So we should take care about different mineral intake of crop during growth process. But excess of nutrients will affect the growth.

2. Optimizing crop management[7.26]:

This paper mainly focuses on using various analytical tools to analyze the soil and climatic conditions to enhance the crop yields. Data analytics and optimization techniques are being widely used in agriculture and thus helping the farms to produce higher yields, contributing to global food security and sustainable use of the depleting natural resources.

In order to achieve optimization, there is need of better measurement of the field conditions like soil type, soil moisture, pH of soil, temperature and humidity etc. Initially, famers have to invest in these smart devices which would return better results in future. Here , the major analysis was made on the data collected through sensors about the nitrogen used by the crops then took the appropriate decisions that improved the production in the future.

3. Neuro fuzzy as a decision maker[7.215][17]:

In this paper neuro fuzzy algorithm was used to make decision to switch among various processes efficiently so that resource allocation of an operating system become more efficient. When scheduling algorithm like Shortest job first, round robin were compared with the new scheduling algorithm implemented using neuro fuzzy the results were much faster than that of traditional scheduling algorithms.

Here neural networks which attempted to show the learning capabilities as same as that of biological species were used with the fuzzy logics.

4. Application of ANFIS for better yields of strawberry[2]:

In this investigation, a versatile neuro-fuzzy induction framework (ANFIS) was utilized to estimate nursery strawberry yield based on the various blend of vitality inputs. Additionally, neural systems (ANNs) structure was produced and summed up to contrast their outcomes and proposed ANFIS demonstrate. Information for the present examination was arbitrarily gathered from 33 nurseries from Guilan territory, Iran. Vitality inputs utilized in strawberry development included work, substance manures,

diesel fuel, apparatus, biocides, power, flammable gas and water for the water system which was altogether chosen as information parameters of the models and correspondingly strawberry yield was considered as yield variable. The coefficient of assurance (R2), root mean square blunder (RMSE), mean total mistake (MAE) and mean supreme rate blunder (MAPE) were determined as 0.9121, 0.0667, 0.0388 and 0.0084 for ANN model and they were determined as 0.963, 0.017, 0.014 and 0.003 for ANFIS demonstrate. At long last, an examination between created ANN and proposed ANFIS was made and the results revealed that ANFIS model can anticipate strawberry yield generally superior to does ANN demonstrate.

5. Product development using decision making approach based on fuzzy logic[3]:

In this paper it is stated that now days a lot of time is spent by the managers to take critical decision in the organization at every level. The decision is based on various factors which must be taken into account and all the alternatives of that decision must be weighted before reaching the final decision. We will first identify the uncertainty factors that are affecting the decision points. Finally, a system is proposed which uses fuzzy logic approach to take decisions efficiently and reducing the risk.

Initially rules were identified which highly disturb the decision making process like budget allocation to the correct new product, risk on the investment, targeting the right product for the different classes of customer. On the basis of these rules different projects pitched are weighted and the project which is best suitable according to the declared rules and with highest weight is selected.

6. IoT based approach to agriculture monitoring[13]:

Rundown: The framework was produced utilizing Wi-Fi Gateway and sensors and whole framework is structured by making a control focus and give data to the server utilizing web administrations. This framework is intended to for Soil properties - electrical conductivity, temperature, dampness, and Soil supplements -

Phosphorous (P), Nitrogen (N), Potassium (K), and Spectral reflectance for plant

supplements.

Advantages:

- Soil supplements and properties are legitimately told on the web application.
- Support for remote field organizations and observing.
- Appropriate order and control focus is there to check all parameter legitimately.

Disadvantages:

- This idea was to complex for traditional farmers
- This was complex framework which is not a decent alternative for agriculturists or farmers.
- The downsides of the framework were its staggering expense innovation utilized.

7. Character recognition using neural network[19]:

This paper gives us the idea of how neural networks work as learning algorithm. Here we have multiple layers forming a intense network of interconnected nodes.

These networks are inspired by the brains. Neural networks there are nodes known as neurons which hold a number between 0 and 1. In a 28X28 pixel image there are 784 neurons which contain the value depending on the degree of pixel activation and of these acts as input in the first layer of the neural networks. Neural network contains many layers out of which some are hidden that is the only input and output layer is known. Neurons of the previous layer use to activate the neurons of the next layer. The activation of the neurons of the next layer depends upon the weighted sum. But this weighted sum must fit in the range of 0 to 1 which can be done using sigmoid function. Main challenge here was to find the appropriate weights. Here these weights were allocated by the machine automatically by learning from the training data.

8. DESIGNING NEURO-FUZZY SYSTEMS THROUGH BACKPROPAGATION[19]

This paper gives us idea how hybrid neuro fuzzy system is better than individual neural network system and Fuzzy system. This hybrid system is adaptive in nature i.e. it learns from prior knowledge and the results can be interpreted by the linguistic rules. The main

goal of this adaptive system is to overcome the disadvantages of individual system and retain their advantages to create an efficient system which could use neural network to determine the parameters of the fuzzy system and neural network can use the fuzzy system to generate rules which could justify the final state.

9. During our survey we came across various apps:

• IFFCO Kisan App:

This app was offered by Indian Farmers Fertilizer Cooperative Limited (IFFCO), the app is dedicated to farmers of India. They can seek advice from agriculture experts and scientists and explore its library to know about crops, agriculture cycle, agriculture field preparation, water management, disease control and agriculture proactive actions.

Limitation: But farmer can't convey the exact conditions of his farm to the experts along with the samples and sometimes it is difficult for farmer to understand what experts are advising them.

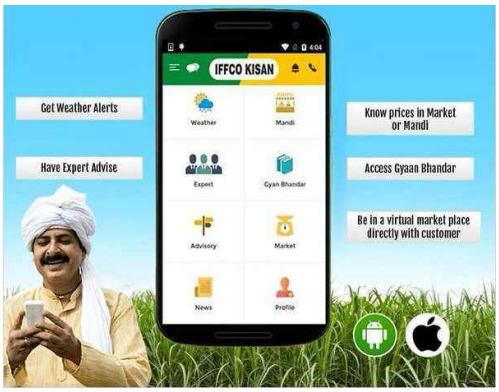

Figure 2.1 Iffco kissan app

• CCMobile App:

The users can read the environment metrics like temperature, humidity, wind velocity and moisture remotely. They can also compare those metrics over a period of time, say

weekly, fortnightly or monthly to assess the status of their crop. The sensor readings are available through SMS / email alerts, graphing and historical data.

Limitation: This app use to help the farmer by protecting his crop or ways he could monitor them remotely without physically monitoring by going in the fields.

Figure 2.2 cc mobile app

But our system consider all the parameters simultaneously and advice the farmer to grow the crop which is suitable according to the current conditions of the farm.

CHAPTER – 3

SYSTEM DESIGN AND ARCHITECTURE

3.1 Architecture of the system:

The architecture design of our system:

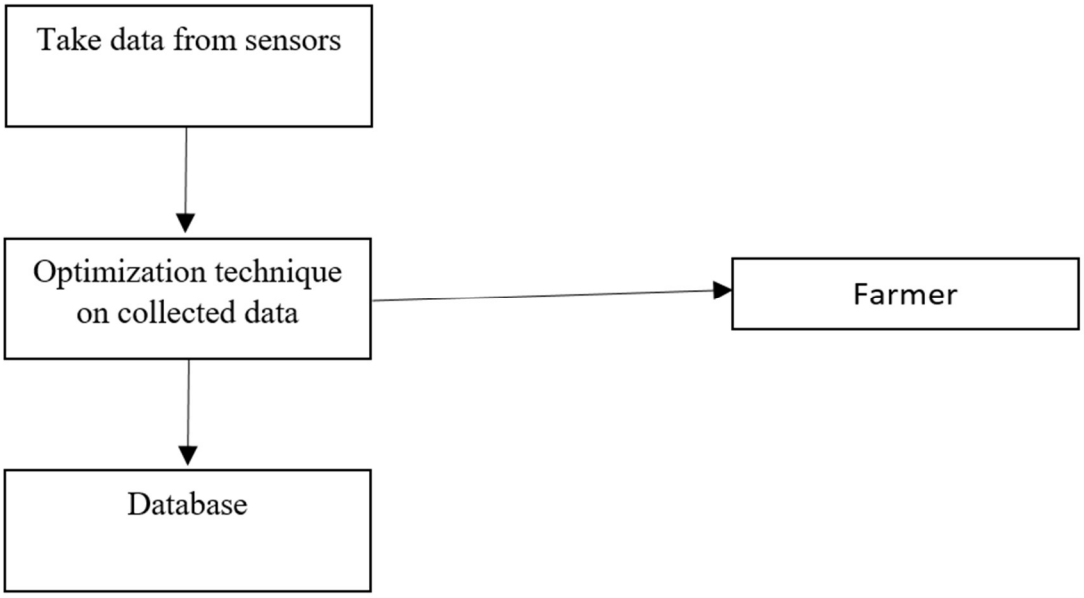

Figure 3.1 Architecture of system

This model tend to depict the most important modules of our system that we have designed as in figure 6.

The architecture of the system is sculptured as follows:

MODULE-1: This module consists of Arduino (microcontroller) and sensors. Sensors are collecting the data and sending it to the microcontroller.

MODULE-2: This module consists of centralized server where Arduino will post

the data. Further this data will be analyzed and optimized using Neuro-fuzzy system.

MODULE-3: The data posted on the centralized server is then stored in a database for future analysis.

MODULE-4: The optimized result generated from module 2 will be conveyed or shared with the farmer. The farmer will use this optimized result in his fields and will get the better results.

3.2 Analytical:

The system consist of a microcontroller board Arduino. This microcontroller chip is further connected to single centralized server where server acts as interface or junction where data is processed and the output or information is shared with the farmer (USER). The data is collected using various sensors like soil moisture sensor, temperature and humidity sensor. All these sensors are connected to the Arduino which send their readings to this microcontroller for processing.

Our system has two main operations to perform, firstly to use smart device which include soil moisture sensor (YL-69) to measure the moisture content of the soil, temperature and humidity sensor (DHT-11) to measure temperature and humidity respectively of the farm. Secondly, after collecting this data, data is sent to the server where various operations are performed on the data that is, an optimization technique called Neuro-fuzzy which is a hybrid system of neural networks and fuzzy logic. This optimized result is sent to the farmer (USER) that is, the best suitable crop that can be grown on that farm conditions. This system would be of great help to the farmers as now they can use this system to make decision over which crop should they cultivate and which crop would give them higher yields in current scenario.

HARDWARE TOOLS:

- Arduino :

  It is a board which includes microcontroller chip which can be programmed using any Arduino programming language and in Arduino development environment.

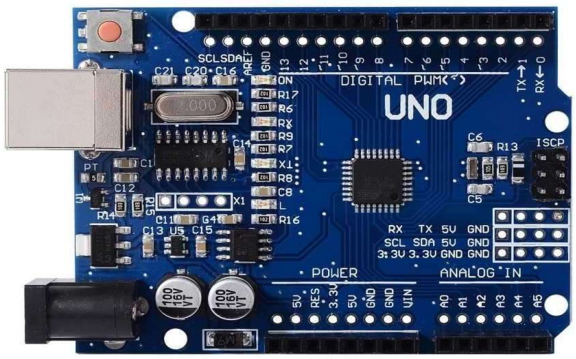

Figure 3.2 Arduino Uno

- Soil-Moisture Sensor:

  The soil moisture sensor is used to measure the wetness level in (volume%) that is set by the assistance of the two probes that successively measure the live insulator permittivity, therefore lower the content of H2O within the soil higher the output and the other way around. Insert the two probes into the soil to be examined and the water content of the soil will be recorded.

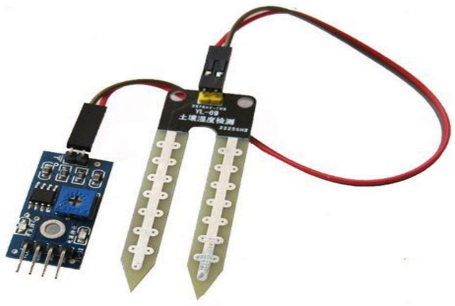

Figure 3.3 Soil moisture sensor

- pH Sensor :

The pH sensor is also called Hydrogen ion concentration detector which calculates the distinction in potential difference between the sample or substance and electrode which is taken as reference. This potential is said to the hydrogen ion concentration of the sample which can be controlled by providing nutrients to the soil.

Figure 3.4 pH sensor

- Temperature and Humidity Sensor:

This sensor is used to measure humidity as well as temperature. The temperature is sensed using thermistor, it consist of variable resistor that changes its resistance according to the temperature.

Humidity is measured by figuring the conductivity of fluid substrate which changes on change in humidity.

Figure 3.5 DHT

SOFTWARE TOOLS:

- Arduino IDE:

It is a software which provides us a text editor where we can write the code so that it could be uploaded in Arduino. An Arduino C/C++ sketch, as seen by the Arduino IDE programmer, consist of two functions.

a) Setup: This function is called only once when a program starts after power- up or reset. It is mainly used to initialize variables, input and output pin modes, and other libraries needed in the sketch.

b) Loop: After setup function has been called, function loop is executed again and again in the main program. This function controls the board until the board is switched off or is reset.

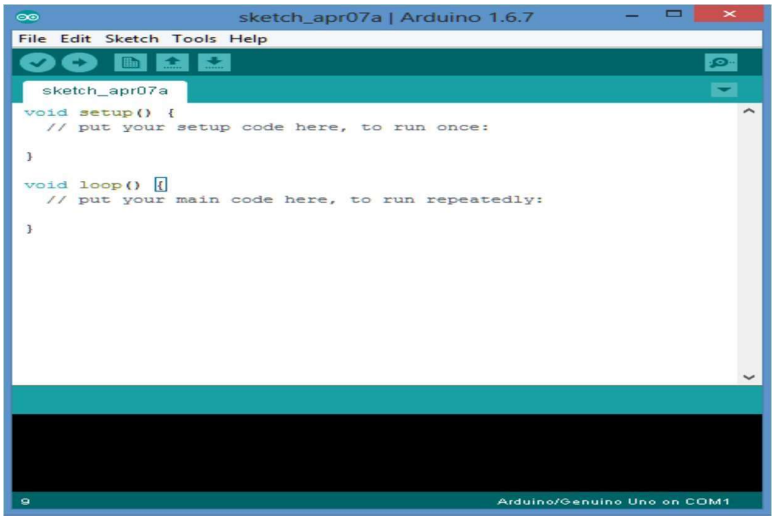

Figure 3.6 Arduino IDE opening window

- MATLAB:

Matlab is a multi-paradigm numerical computing environment and is a programming language developed by mathworks. This software is used for big data, machine learning (ML) and analytics. MATLAB provides us Neuro-fuzzy designer tool and fuzzy logic toolbox which will help us to design, train and test

(ANFIS) using input/output training data.

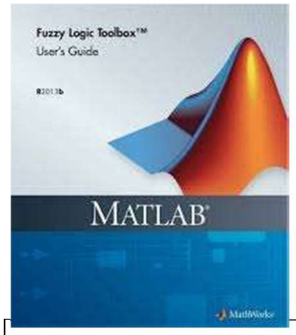

Figure 3.7 Matlab

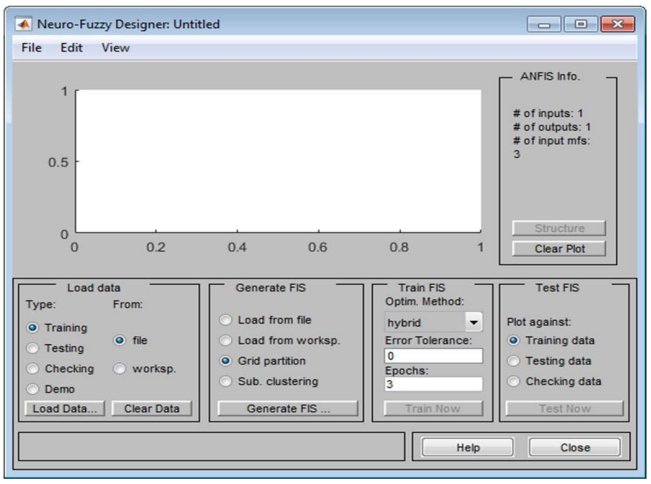

Figure 3.8 Neuro fuzzy designer

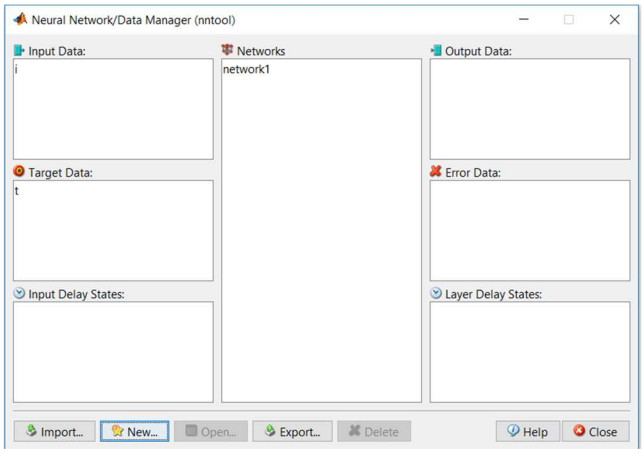

Figure 3.9 Neural network tool

- MY SQL:

  My SQL is the one of the most popular databases which is used to store data from various application here we are storing data coming from the sensors to Arduino then to server and finally to the SQL database.

Figure 3.9 SQL

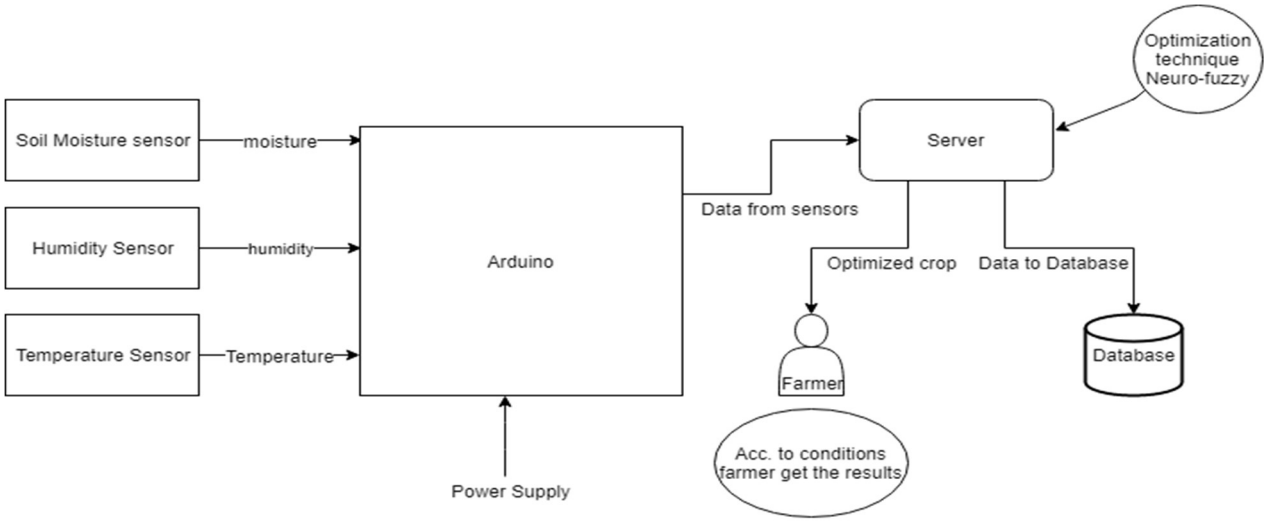

Figure 3.10 Detailed architecture

CHAPTER – 4
ALGORITHMS

Before the algorithm there are some basic terms which need to be defined first that are: Fuzzification, inference engine, Defuzzification, membership function, Back propagation and Gradient descent.

Basic terms of neuro fuzzy system:

- Fuzzification: In this layer the inputs which we received from sensor that is temperature, moisture etc. are processed and converted into fuzzy values which further form fuzzy sets using membership function.
- Membership function: This function is a mathematical function defines how much a input is a part of the fuzzy set.
- Inference Engine: This engine evaluates all the if-then rules and determines the truth value. If the given input value does not fully satisfy the if-then rule then some partial value is given. From these values it is decided which rule to be fired according to the values assigned corresponding to each rule.
- Defuzzification: Here the fuzzy sets which we obtained from the inference engine are converted into crisp values. This process is very complex and important.
- Back propagation: It is a very important learning algorithm that helps the system to learn efficiently. Initially random weights are assigned to the network and the result is calculated and is compared with the expected output. Then accordingly the system is tuned by adjusting the weights and these weights are updated in the backward direction. This process of feedback, calculation and modification of weights finally leads us to well trained model.

- Gradient Descent: This is an optimization algorithm which is used to find the value of parameters which will minimize the cost function. This is an iterative method where we start with some initial parameters and calculate the cost function with these initial weights. We try to move in the direction to minimize the cost function. Initially when we are far from the optimal point we take large steps but when we are near to the optimal point we take small steps so that we don't miss the optimal point. Here step size plays very crucial role which is determined through learning rate. At the optimal point the gradient tends to zero i.e. cost function is not reducing anymore and that means model stops learning.

Rules:

- if soil moisture is between 90-120 then grow rice
  if soil moisture is between 70-100 then grow wheat
  if soil moisture is between 50-70 then grow potato
- if humidity is between 60-80 then grow rice
  if humidity is between 50-60 then grow wheat
  if humidity is between 85-95 then grow potato
- if temperature is between 25-35 then grow rice
  if temperature is between 12-26 then grow wheat
  if temperature is between 15-25 then grow potato

Arduino Pseudo Code for receiving data from the sensors

//Read Sensors Data

//Dht

//YL-69

• Step1: Assigning data pins of Arduino to sensors

.const int soilpin=A0;

.int ledsoil=12;

.int dht_apin=A1;

• Step 2: this setup fxn is used to setup the board to receive data

```
void setup()
{
.Serial.begin(9600); htdelay(500);//Delay to let system boot
.Serial.println("DHT11 Humidity & temperature Sensor YL-69 Moisture sensor\n");
htdelay(1000);//Wait before accessing Sensor
htpinMode(ledsoil,OUTPUT);

}//end "setup()"
```

• Step 3: this function runs infinitely that is run the block of code again and again until termination condition

```
void loop(){
//Start of Program
DHT.read11(dht_apin);//using DHT library to read data from sensors
//to print humidity//Serial.print(" humidity = ");
Serial.print(DHT.humidity);
Serial.print("% ");
//to print temperature//Serial.print("temperature= ");
Serial.print(DHT.temperature); Serial.println("C ");
//to print moisture//Serial.print("Current Moisture =");
int moisture=analogRead(soilpin);
Serial.print(moisture);
// end}
delay(5000);//Wait 5 seconds before accessing sensor again.}// end loop()
```

Step 4: Read data again and again after given interval of time.

Step 5: Displaying the received data on serial com port of Arduino IDE

Step 6: The data collected by these sensors fed as input to the neuro fuzzy system.

Step 7: This system is earlier trained by some training data. When the system is fed with training data it develops some inference rules to map input to the output and when we retrain this system the performance keeps on improving.

Step 8: After training the system, the data from the field is directly fed to the system as input and in return system gives us the output (in the form of numeric values which represent some specific crop)

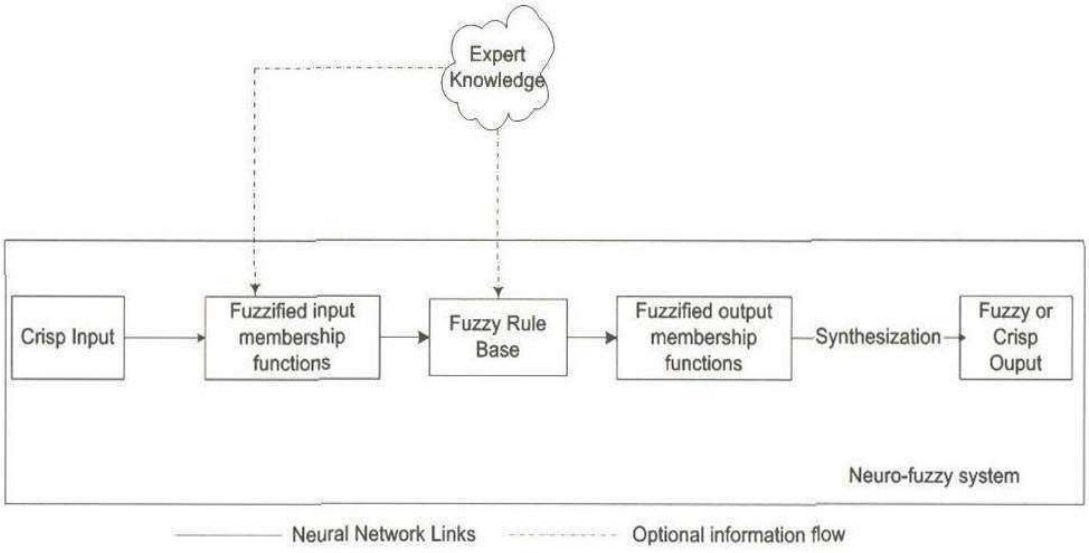

Figure 4.1 flow chart of neuro fuzzy system.

Chapter -5

TEST PLANS

In this section, we have taken a testing dataset and explained the testing plans

5.1 Dataset:

Here, we have testing dataset of 200 samples collected from various fields on the basis of some factors. The output of these samples would be name of crop which will be according to the values of different parameters.

Table 5.1 Testing dataset

Samples/Parameters	Temperature(.C)	Moisture Tension(cb)	Humidity(%)
1	25	54	82
2	21	96	73
3	33	101	56
4	27	72	55
5	23	63	85
6	38	90	81
7	11	89	59
8	21	73	59
9	25	52	94
10	17	87	62
11	15	69	83
12	23	54	92
13	16	92	60
14	19	66	88
15	34	97	74
16	13	71	58
17	20	50	84
18	30	91	70
19	13	69	58
20	35	110	81
21	19	57	88
22	35	91	65
23	26	113	64

Figure (above) shows the dataset having various samples from different farms. The output for the testing dataset will come when this data is passed through the optimization technique which on the basis of some rules make decision which crop to grow by comparing these values to the ideal required values for a particular crop. The above dataset is based on the parameters:

1.	Soil Moisture(in centibars)
2.	Humidity(%)
3.	Temperature(C)

Table 5.2 Parameters

Ideal conditions of various crops like Wheat, Rice, Potato are build the rules which were further used to take the decision depicted in the following tables:

Parameters	Ideal Values
Temperature(°C)	25-35
Moisture Tension(cb)	90-120
Humidity(%)	60-80
Rainfall(mm)	140-180
Soil Type	Clay-silt loam
pH Range	5.5-6.5
Season(to sow)	June-July
Season(to harvest)	Nov-Dec

Table 5.3 Ideal conditions for RICE

Parameters	Ideal Values
Temperature(°C)	12-26
Moisture Tension(cb)	70-100
Humidity(%)	50-60
Rainfall(mm)	60-87
Soil Type	Clay loam

pH Range	5.8-7
Season(to sow)	Oct-Dec
Season(to harvest)	March

Table 5.4 Ideal conditions for WHEAT

Parameters	Ideal Values
Temperature(°C)	15-25
Moisture Tension(cb)	50-70
Humidity(%)	85-95
Rainfall(mm)	600-700
Soil Type	Loam-Sandy loam
pH Range	5.2-6.4
Season(to sow)	March
Season(to harvest)	June

Table 5.5 Ideal conditions for POTATO

5.2 Test Setup:

Testing is very crucial step that helps to detect errors. Testing is a way or procedure of finding errors which might occur during the implementation phase. We may also take it a way to check if the system is able to fulfill the objective and to check the functionality of various components. But the only testing that we are doing is acceptance testing.

Initially, we have trained the machine through training dataset. Here, testing will be done using testing dataset and we will check the results or outputs whether they are same as required or we come across some deviations. If so we will test it with much larger dataset and compare the output with desired results

CHAPTER -6

RESULTS AND PERFORMANCE ANALYSIS

After implementing the projected system which includes use of smart sensors and Neuro fuzzy system we expect the following results:

Expected result from the system after successful implementation.

Table 6.1 Expected Results

Samples/Parameters	Temperature(.C)	Moisture Tension(cb)	Humidity(%)	Output
1	25	54	82	Potato
2	21	96	73	Rice
3	33	101	56	Rice
4	27	72	55	Wheat
5	23	63	85	Potato
6	38	90	81	Rice
7	11	89	59	Wheat
8	21	73	59	Wheat
9	25	52	94	Potato
10	17	87	62	Wheat
11	15	69	83	Potato
12	23	54	92	Potato
13	16	92	60	Wheat
14	19	66	88	Potato
15	34	97	74	Rice
16	13	71	58	Wheat
17	20	50	84	Potato
18	30	91	70	Rice
19	13	69	58	Wheat
20	35	110	81	Rice
21	19	57	88	Potato
22	35	91	65	Rice
23	26	113	64	Rice
24	30	107	66	Rice
25	18	71	82	Potato

Data received on serial port of the Arduino by DHT 11 sensor.

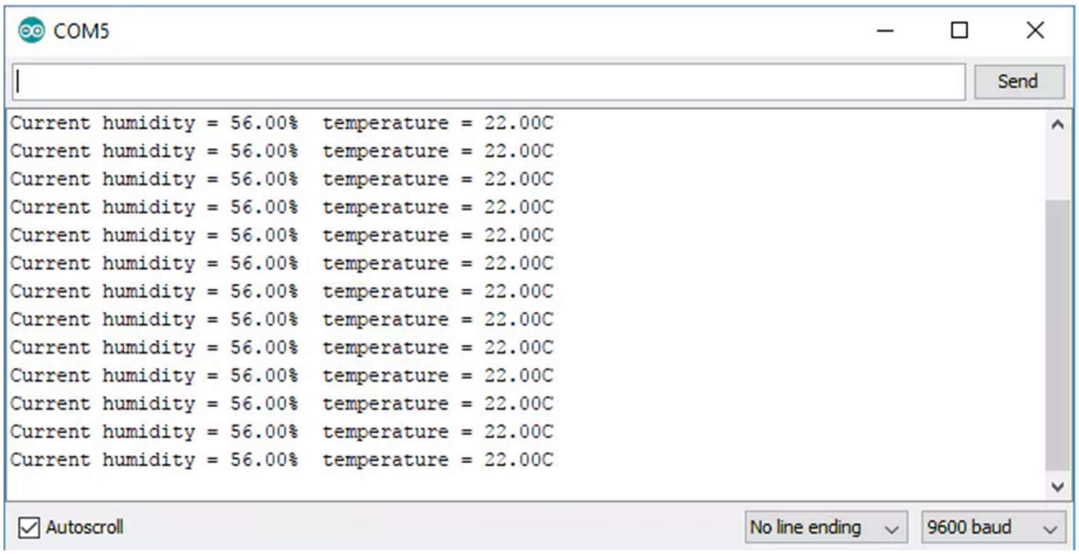

Figure 6.1 data received on serial port.

Performance analysis of sensors:

Sensors are very important aspect of this proposed system as the whole system depends upon the quality of data collected by these sensors.

Soil moisture sensor:

Table 6.2 Performance parameters of soil moisture sensor:

Model Name	YL -38
Sensing Range	0 to 45% volumetric water content of soil
Operating Temperature	-40 °C to +60 °C
Power Consumption	3mA
Operating Voltage	5V DC

Temperature and humidity sensor:

Table 6.3 Performance analysis of DHT-11 sensor:

Sensing Range	20-90% RH
Accuracy	±5% RH
Temperature Range	0-50 °C
Temperature Accuracy	±2% °C
Operating Voltage	3V to 5.5V

The soil moisture sensor measures the moisture and returns value in range of 0-100 which is mapped from values of range 0-550 by the sensor, humidity and temperature are measured by the DHT sensor and returns value in percentage and temperature is returned in Celsius, all these values are sent to the Arduino and from Arduino these are sent to the server where neuro fuzzy is implemented over this data to give the output that is gives the decision that which crop is most suitable for these conditions.

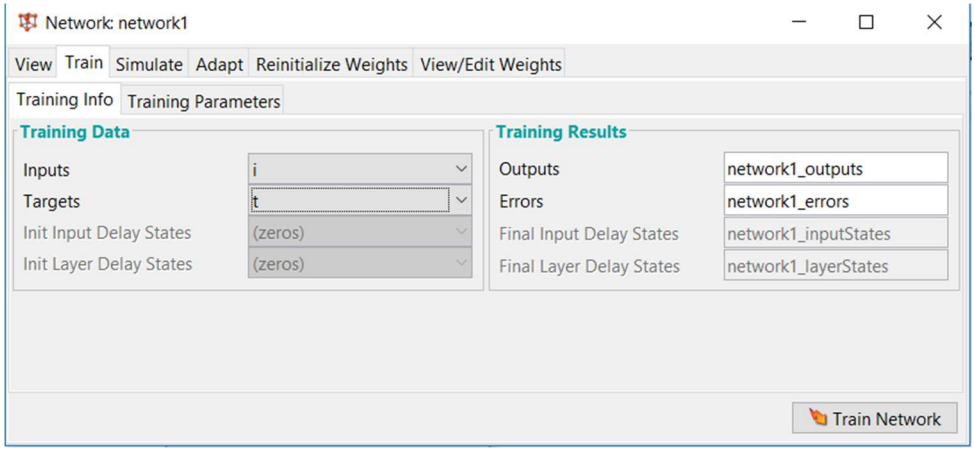

Figure 6.2 Setting inputs and target data for training the neural network (nntool)

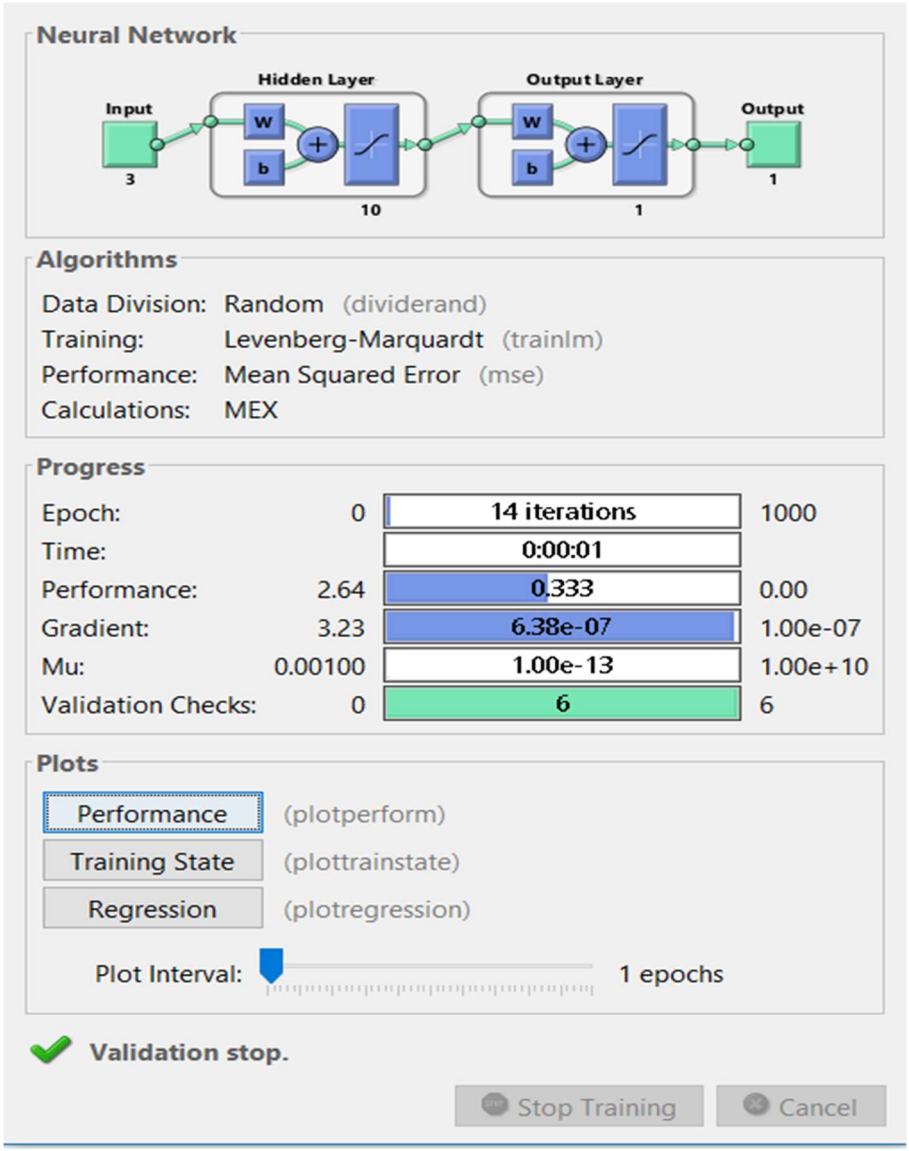

Figure 6.3 Training the neural network.

Fig 6.2 is showing how we have imported training data i.e i as inputs and t as target data and have trained the system using nntool. Fig 6.3 shows progress while training the data how much iterations are completed till that point.

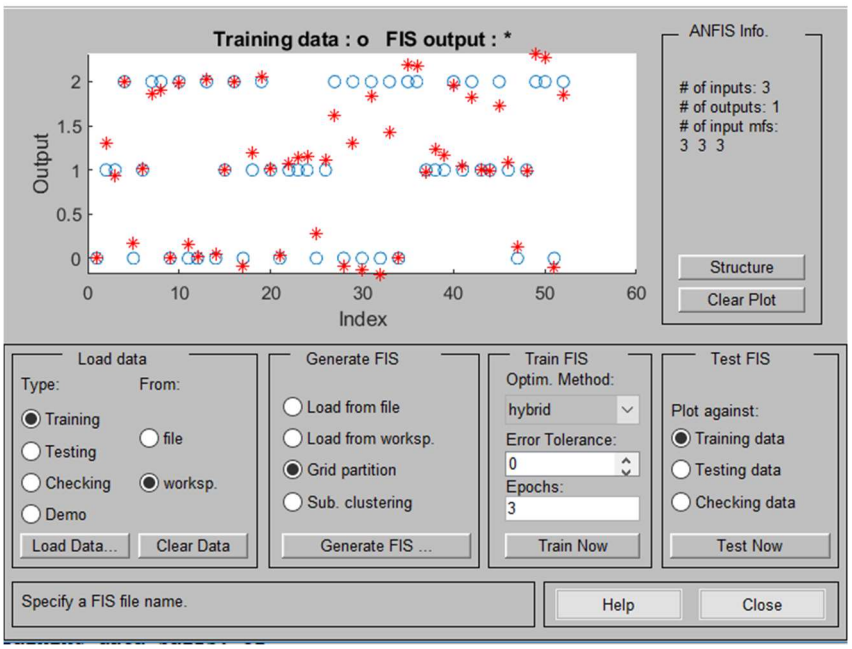

Figure 6.4 Training the neuro-fuzzy system

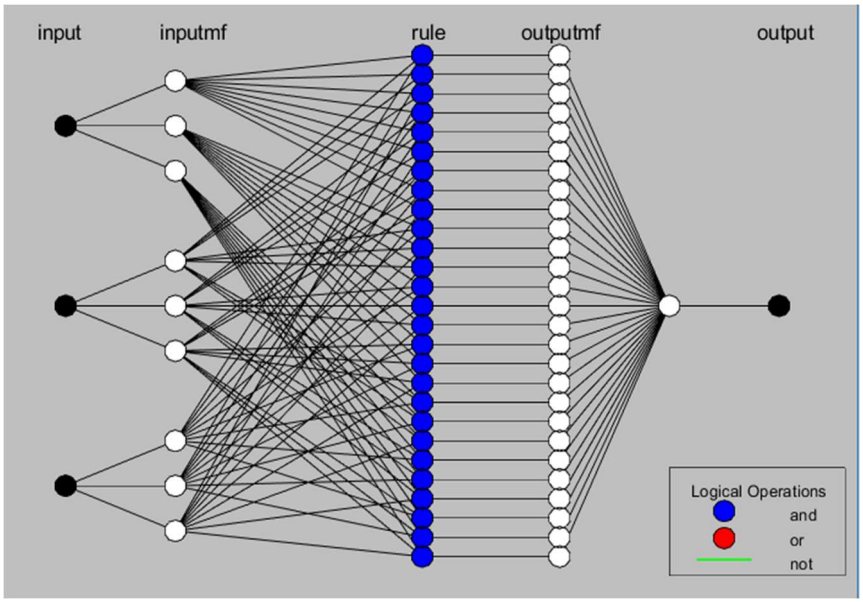

Figure 6.5 Neuro-fuzzy structure after training

Fig 6.4 shows the output through the training in Neuro-fuzzy system where blue circles show the expected output and the stars show the output of system after

training. Fig 6.5 shows the structure of our neuro-fuzzy model designed after training.

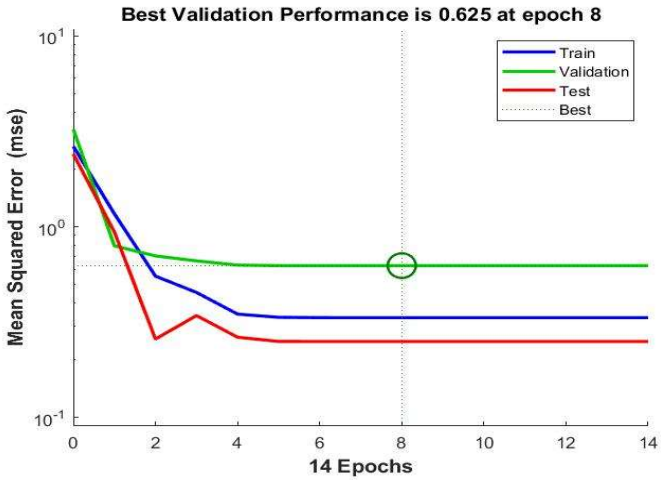

Figure 6.6 Graph depicting MSE after 1st training

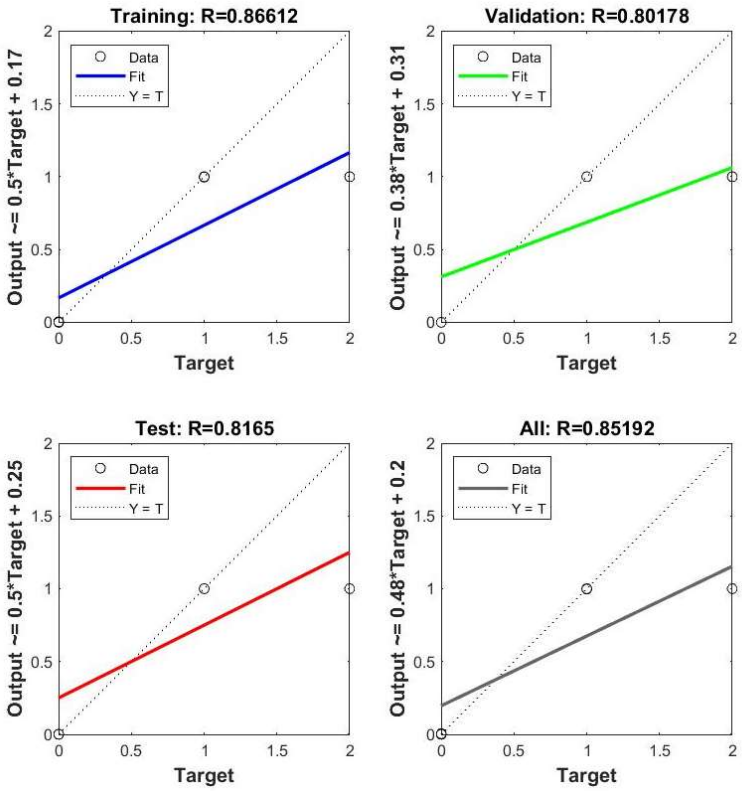

Figure 6.7 Performance graph after 1st training (where R values measure the co-relation between the outputs and targets)

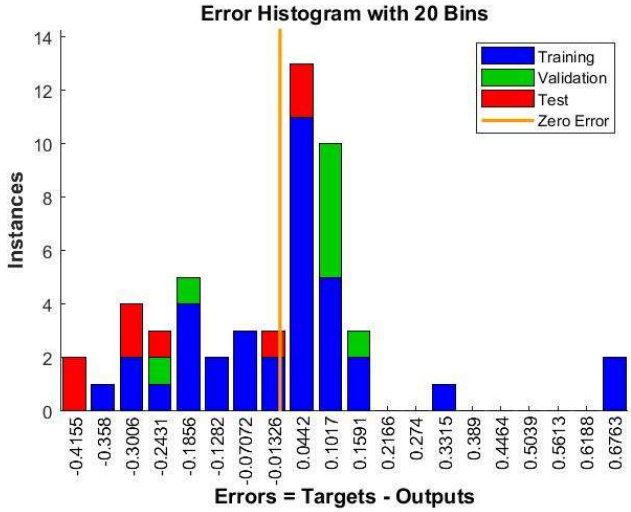

Figure 6.8 Histogram depicting the errors at different instances after 1st training.

Fig 6.6 is showing the graph after first training where it is showing the point at which we get minimum MSE i.e. the point where error is not decreasing further. Fig 6.7 shows the regression plots representing the co-relation between the output data and target data. Fig 6.8 is showing the histogram for errors at different instances.

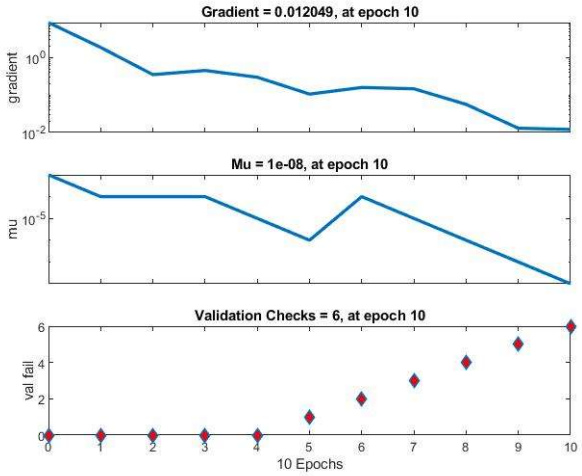

Figure 6.9 Graph depicting the minimum gradient with learning rate and validation checks

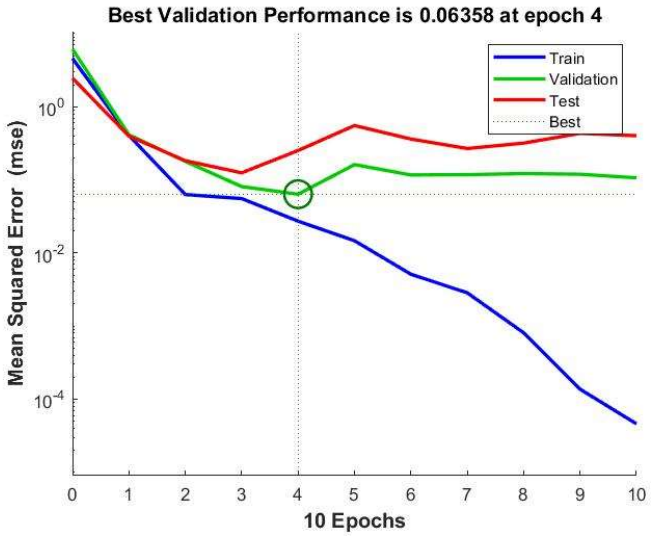

Figure 6.10 Graph depicting minimum MSE after training

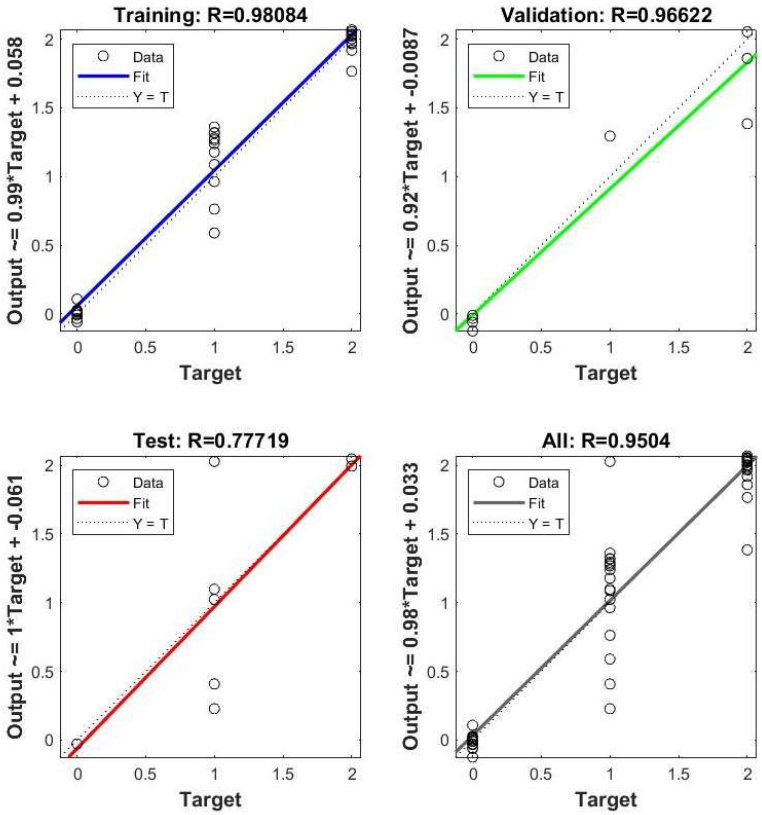

Figure 6.11 Best performance graph after training (where R values measure the co-relation between the outputs and targets)

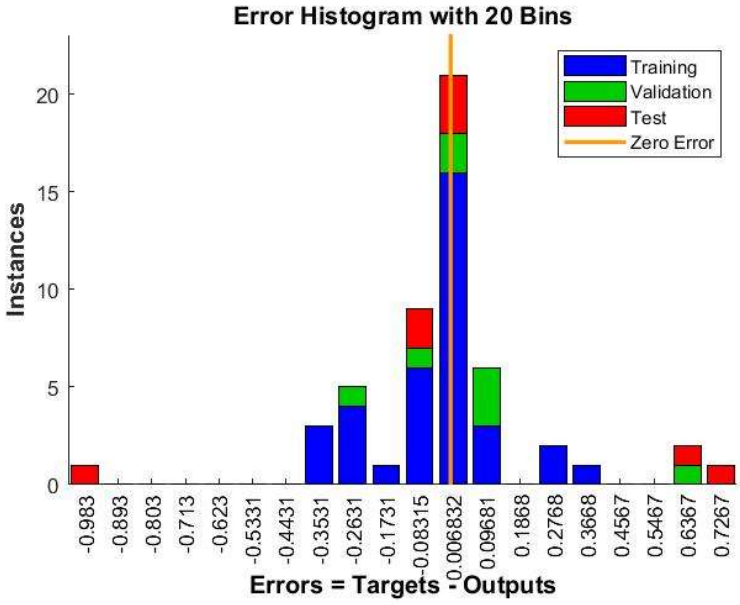

Figure 6.12 Histogram depicting the errors at different instances after some training.

Fig 6.10 is showing the graph after some training where it is showing the point at which we get minimum MSE i.e. the point where error is not decreasing further. Fig 6.11 shows the regression plots representing the co-relation between the output data and target data. Fig 6.12 is showing the histogram for errors at different instances. Above mentioned three pics are our best performance graph)

Table 6.1 depicting output for testing data

Temperature(.C)	25	21	33	27	23	38	11	21	25
Moisture Tension(cb)	54	96	101	72	63	90	89	73	52
Humidity(%)	82	73	56	55	85	81	59	59	94
Output	-2.27E-05	1	1	1	4.32E-05	1	1	1	5.29E-07

Table 6.1 shows the output we are getting against the inputs we have entered that are temperature, moisture and humidity and hence we are getting some outputs which quite close to actual outputs.

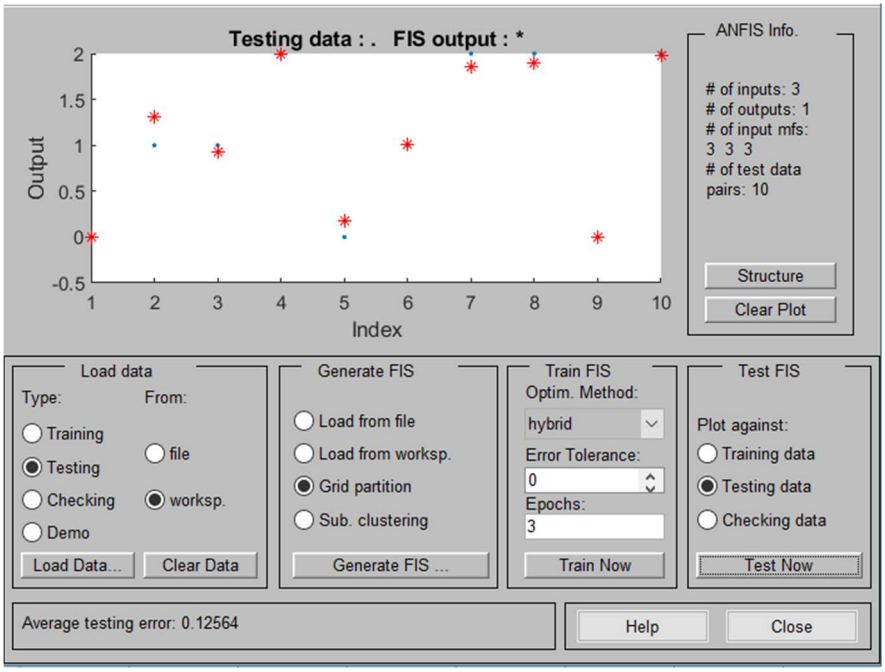

Figure 6.14 Depicting output for testing data (Neuro-fuzzy) with average error of 0.126.

Fig 6.14 shows the output through our trained model, where dot(.) represent the expected output of our testing data and star(*) represent the output we are getting.

Chapter -7
CONCLUSION

7.1 Conclusion:

In the proposed system we have use IOT to sense the data from the fields using some Sensors like soil moisture sensor (YL-69), Temperature and humidity sensor (DHT-11) which would tell us the actual conditions of the farm. Then this data will be sent to the server for further processing and will be analyzed. Then we have applied the optimization technique or say decision making technique using Neuro-fuzzy system. This technique will give us the most optimal result for the particular field whose data we have received and this output will be sent to the farmer.

Mainly the action of the system can be changed according to the situation that is according to the changing conditions. When farmer install this smart device on his/her farm he/she will get help to decide which crop will be the best according to the current scenario of the field. Hence this will increase the yields, use minimal resources and finally increase the profit of the farmer which will ultimately increase the GDP of our country and farmer happy.

The main and basic conclusion of our project, which we will be targeting in our further work are:

- To create simple and efficient system which, will truly help the farmer.
- The cost of our system should be less.
- To get the most optimized decision.

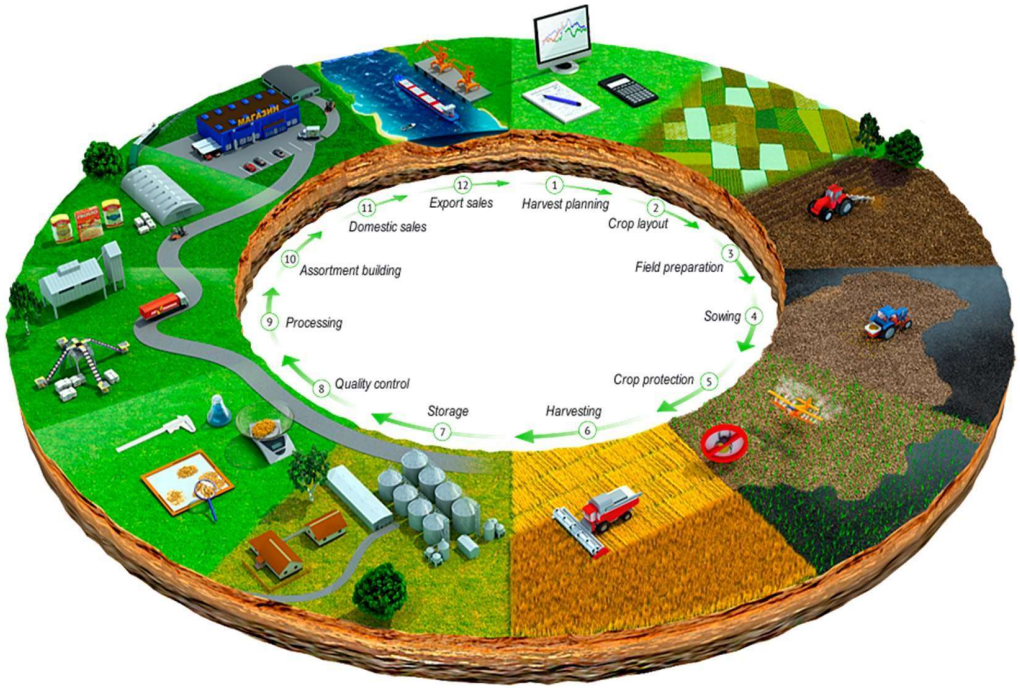

Figure 7.1 Crop production cycle

7.2 Future Scope:

The future of this projected system can be that it can be used in various farms taking readings of different parameters. Also we have used only some factors but in future we can include more number of parameters which will give us more broad view of the system.

Our proposed system has mainly three modules which are:

MODULE1: This module focuses on taking the data from the field through sensors and feeding the data to our next module.

MODULE2: This module focuses on processing the data i.e. applying various techniques like neural networks and neuro-fuzzy to take optimized decisions.

MODULE3: The main aim of this module is to supply back the optimized results to the farmer.

But till now we have mainly focused on module 2 which is processing part and module 1 i.e. gathering the information from the fields.

In future we can use more optimized technique or can try to improve the decision making technique which will give us much better results. We can also join this project with other smart IOT projects like smart agriculture to make totally automated and efficient system for farmer that is crop decision along with automated system to monitor the crop and some vital activities required for better crop yield.

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