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Smart Agricultural Services Using Deep Learning, Big Data, and IoT

Amit Kumar Gupta, Dinesh Goyal,
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Smart Agricultural Services Using Deep Learning, Big Data, and IoT

The agricultural sector can benefit immensely from developments in the field of smart farming. However, this research area focuses on providing specific fixes to particular situations and falls short on implementing data-driven frameworks that provide large-scale benefits to the industry as a whole. Using deep learning can bring immense data and improve our understanding of various earth sciences and improve farm services to yield better crop production and profit.

Smart Agricultural Services Using Deep Learning, Big Data, and IoT is an essential publication that focuses on the application of deep learning to agriculture. While highlighting a broad range of topics including crop models, cybersecurity, and sustainable agriculture, this book is ideally designed for engineers, programmers, software developers, agriculturalists, farmers, policymakers, researchers, academicians, and students.

Topics Covered

- Anomaly Detection
- Big Data Integration
- Big Data Management
- Cloud-Based Systems
- Crop Models
- Cybersecurity
- Data Privacy
- Decision Support Systems
- Deep Packet Inspection
- Man-Machine Dialogue Systems
- Sustainable Agriculture

ISBN 978-1-7998-5485-2
90000
9 781799 854852

IGI Global
PUBLISHER of TIMELY KNOWLEDGE
701 E. Chocolate Avenue
Hershey, PA 17033, USA
www.igi-global.com

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Chapter 1
A Neural Network-Based Approach for Pest Detection and Control in Modern Agriculture Using Internet of Things

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ABSTRACT

The networks acquire an altered move towards the difficulty solving skills rather than that of conventional computers. Artificial neural networks are comparatively crude electronic designs based on the neural structure of the brain. The chapter describes

DOI: 10.4018/978-1-7998-5003-8.ch001

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two different types of approaches to training, supervised and unsupervised, as well as the real-time applications of artificial neural networks. Based on the character of the application and the power of the internal data patterns we can normally foresee a network to train quite well. ANNs offers an analytical solution to conventional techniques that are often restricted by severe presumptions of normality, linearity, variable independence, etc. The chapter describes the necessities of items required for pest management through pheromones such as different types of pest are explained and also focused on use of pest control pheromones.

1. INTRODUCTION

A system is required for farmers to foresee the crop requirements, so that they may enhance the crop quality and its quantity. Farmers have lack knowledge about current technologies that may help them enhance quality of seeds, irrigation facilities and good management of the crops. The delivery of crops in market gets delayed due to the lack of proper road connectivity between the rural and urban areas (Rashid, 2015). Also, climatic situations can become unpredictable hence resulting in wrong decisions by farmers. In mountain areas irrigation water is not easily available and cost much to farmers. Sensor networks are a solution to all these problems which may be utilised to determine the approximate values of field information. They also help in determining the simulation models of the crop, insects, diseases, and other data. Thus, farmers can monitor in real time the field conditions. How it is carried out will be discussed in next sections.

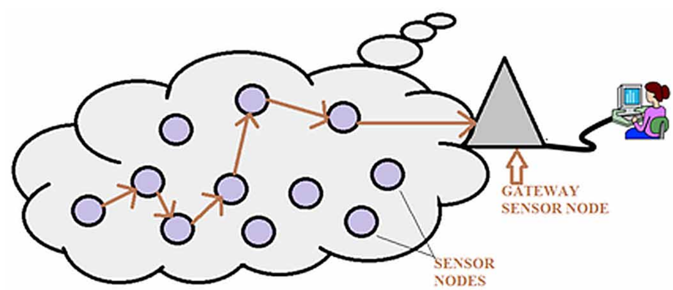
Integration of different geographical and temporal figure of the farm-land are easily achieved with the help of wireless sensor networks, also the variations in climate, pressure, soil humidity, motion, temperature, pest and suggesting best solution for management to the farmers are also possible with Wireless sensor networks.

The increment in wireless sensor network deployment in industrial, agricultural and habitat monitoring applications is due to the fact that this technology consumes low power and requires low data rates for transmission or reception of data, hence it proved to be an energy efficient technology. In addition to this it also provides mobility and flexibility in connection which enhance network expansion when required. The main objective of agriculture through WSN is to make crop production better by managing and monitoring the growth duration.

1.1 Introduction to Wireless Sensor Network

Each node equipped in a wireless sensor network includes a sensor module, a processing data storage module, a power supply module and a wireless transmission unit (Rashid, 2015; Navin, 2013). Every node is provided with the capacity that they are easily able to collect and process physical information so that the gathered data can be further sent to the monitoring station (base station) or to the sink node. Wireless sensor network consists of implementation of more than one sink nodes and several sensor nodes in a physical environment. The topology arrangement of Wireless sensor network nodes may differ from a star network to a multi-hop wireless mesh network. The processing technique between the hops of the WSN can be done by using either flooding or routing. One of the best features of these sensor nodes is that they can switch between various modes when required; the modes are sleep, active and idle. When not in use they switch to sleep mode to save energy, this increases the lifetime of the nodes and they can be used for a long period without replacement.

Figure 1. Deployment of Sensor Nodes and their communication with the Base Station



Environmental information plays a very crucial role in the field of agriculture. This is because the crop production is mainly bank on the environmental situations and the feedback of the plant development to varying environmental situations is highly problematic (Holt, 2007; William, 2005). Farmers and researchers should collect the information at their areas on their own but the traditional climate stations are very expensive and much big in size. Till now, data loggers were used for this task but with a condition that the users should have to go at these stations frequently to gather the related data. Hence to solve all such related problems sensor networks are desirable.

1.2 Precision Agriculture

Precision agriculture needs concentrated field data acquisition. One of the most auspicious application spheres in which wireless sensor network give a beneficial or even an optimal solution. In precision agriculture several parameters such as soli texture, temperature changes dramatically from, one area to other. So precision agriculture is the capability to tackle changes in productivity inside a field and increase financial return, lessen waste, make farming environment friendly with the help of automatic collection of data, documentation and utilisation of this data for strategic farm management decisions by using sensing and the communication methods (Lee, 2010; Singh, 2006).

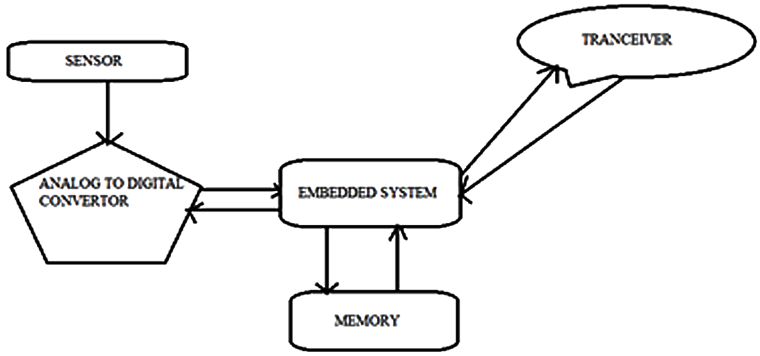
Various technologies are used in precision agriculture like remote sensing, global positioning system (GPS), and the geographic information system (GIS). One of the major parts of precision farming is the production of soil maps mentioning its properties. All these maps include crop scouting, soil sampling, yield monitoring. Remote sensing equipped with global positioning system coordinates generates accurate maps and the models of the complete farm. The sampling part is generally carried out by using some sort of electronic sensor like soil probes and remote optical scanners from satellite. The gathering of this information on a computer database gave birth to GIS software. These technologies proved very much expensive and needed large labour work. Hence precision farming using such technologies was not beneficial to farmers.

So, by using wireless sensor networks for precision farming it became easy for farmers to monitor the field with a high accuracy at a lower cost. Since WSN is made up of many sensor nodes including sensing, processing, transmission, mobiliser, position finding system and power supply.

In precision agriculture several methods are present to monitor and handle the needed environmental parameters for a specific crop. It is very necessary to analyse the techniques that can accurately handle the proper environment. With the help of wireless sensor network large areas can be covered and this is becoming famous for in green house technology of precision agriculture. Several types of sensors can be integrated in a sensor node hence the conditions of the crop and the soil, including temperature, crop illness, humidity, illumination, insects etc. can be monitored remotely in real-time. This helps in reducing the production cost by properly determining the soil conditions and plant growth, this is done by fine tuning seeding, fertilisers, chemical and water use, in addition this increase crop yield.

The above figure represents the architecture of a wireless sensor node. The analog to digital convertor converts the analog waves into digital waves so that they can be used for further processing. The function of embedded system is to drive the converted signal from the ADC device and does its further processing. The

Figure 2. Architecture of a Sensor Node



memory device is used to store data in its buffer and transmits it to the transceiver for uploading. The same process in opposite direction is done while receiving the data. There are many factors which need to be considered while implementing the system. The major parameters which requires attention while its implementation are quality of soil, soil temperature, the moisture available also some other parameters like temperature of air, humidity of air, speed of wind and direction, precipitation are considered when the system is being implemented in a farm (Suchita, 2016).

1.3 Various Sensors Employed in an Intelligent Farm

An intelligent farm accomplishes the complete utilization of the application of current information technology to assimilate the application of network & computer technology, and also the technology of IoT (Internet of things), wireless communication technology, video monitoring machinery, 3S technology, assimilate the decision support mechanism of knowledge and intelligence of agriculture deft, recognize the creative administration of remote monitoring of farm judgement, remote control and disaster warning and many more (Thulasi, 2013; Shaikh, 2016).

Several types of sensors are employed in an intelligent farm for proper monitoring of different parameters so that according to the received data preventive measure can be taken for proper crop development. In this system the data collected by different types of sensors is send to a main head node which is responsible for sending the aggregated data to the central server where further processing of the received data takes place. This transfer of data from head node to the base station can be carried out wirelessly or with the help of a GSM module (Muthukannan, 2015; Pandikumar, 2013).

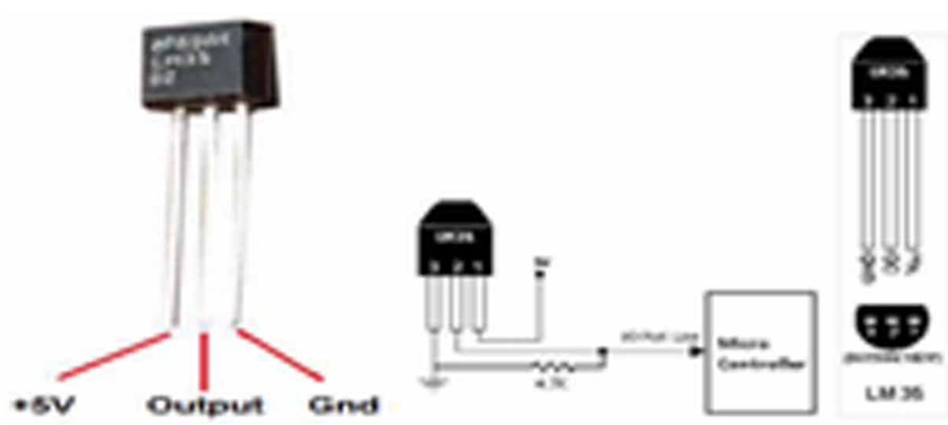
The function of different sensors is explained in below sub sections.

1.3.1 Soil Sensor

Different crops require different types of soil for their growth, some crops are grown well in alkaline soil whereas some crops require saline type of soil for their proper nutrition. Hence it is necessary to monitor the soil moisture of the field for proper crop development (Giovanni, 2014; Chaudhary, 2011). The soil sensors gather the data related to soil moisture and soil temperature in the outer environment. Soil moisture sensors measure the volumetric water content of the soil, this works by measuring the dielectric permittivity of the soil. In this sensor the conductivity of the soil is checked and for this task 2 probes are infused in the farm, if the field is humid conductivity is high and resistance is low and if the field is arid then resistance is high and conductivity is low.

Figure 3. Soil Moisture Sensor

Figure 4. Temperature Sensor



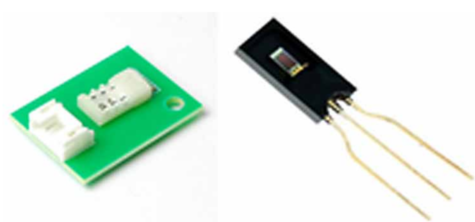
1.3.2 Temperature Sensor (LM 35)

Temperature needs to be controlled for proper crop growth as the plant dies if the temperature exceeds a particular level, so for this purpose temperature sensors are employed in the farm (Seong, 2007; Anjum, 2013). The mostly used temperature sensors in precision integrated circuit are LM35 series, the yield voltage of these sensors is linearly proportional to the centigrade temperature. LM 35 temperature sensors are very precise and very high-quality sensors to represent the temperature value in Celsius. These sensors are cheaper and small in size. The temperature range measured by them lays in between -55^{o} to $+150^{o}C$.

1.3.3 Humidity Sensor (HIH4000)

These sensors are generally used to determine the moisture amount. Humidity sensor measurement find out the amount of water vapour available in a gas which can be a mixture like air, or a pure gas like nitrogen or argon (Kirankumar, 2015; Prathyusha, 2013). These sensors are based on the principle which includes a hygroscopic dielectric material sandwiched in between a pair of electrodes forming a small capacitor. By calibration and calculations all these sensed quantities can lead to measurement of humidity. So, it is necessary to maintain the humidity level of the farm and for this purpose these sensors are used and generally HSM 20G modules are used.

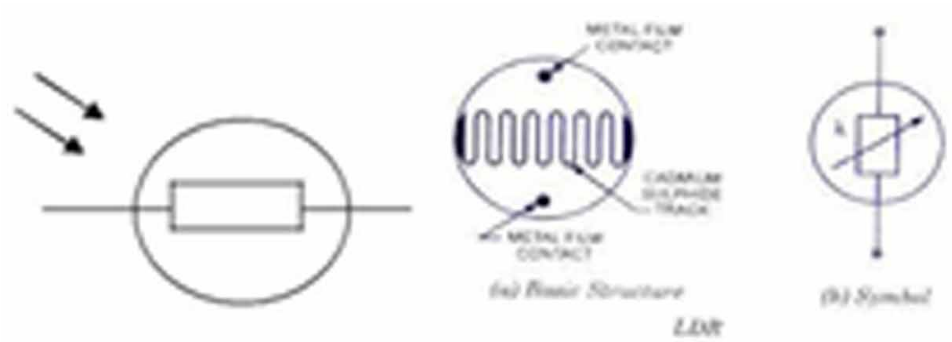
Figure 5. Humidity Sensor Module



1.3.4 Light Sensor (LDR)

An LDR sensor is a light dependent resistor sensor or we can say that it is a light controlled variable resistor (Luca, 2010). A component is there in an LDR which consists of a variable resistance which varies with the light intensity that falls on it and hence this component enables to sense the light that is employed in the circuit. When the leaf starts developing its growth and falls on the LDR sensor, it becomes dark, and if LDR gets dark its resistance also gets low and current flow is more. This procedure helps in sensing the leaf growth percentage. The range of variation of resistance of an LDR sensor is 1k ohm to 500 k ohm.

Figure 6. Light Sensor



1.3.5 Insect Monitor Sensor

We increase the productivity by using several methods but still we do not reach the goal the reason behind this is the insects that damage and infect the crops up to roots (Ankit, 2018). So, it is very important issue nowadays to farmers, to protect their crop from certain types of insects. These insects reduce the yield of insects and some insects are so small that they are not easily visible to farmers. Hence it is necessary to monitor and detect these insects to protect the crops from being damaged, for this purpose certain sensors are used to monitor these insects. And according to the collected data farmer is informed with the help of any wireless device.

There are many sensors which are used to monitor insects:

1. **With the help of image sensors-** Insects can be detected with the help of image sensors, these wireless image capture sensors are employed in the field at various locations and images are captured by these sensors time to time, these captured images are then sent wirelessly to the base station where they are processed to find out where the particular crop area is infected by the insects or not (Pankaj, 2018). And if any evidence of insects is found then the farmer is informed with the help of a GSM device, a message with a warning is sent to the farmer's registered mobile number.
2. **Acoustic sensor detection-** Insects can also be detected acoustically by the noise emitted from them (Dhaka, 2014). An acoustic noise sensor is employed

for monitoring the insect's noise level and at any time when the noise crosses the threshold level farmer is informed about the particular area so that he may check it and take necessary action. With the help of these sensor farmers labour is reduced as he need not to go and monitor for each area of his field. All these sensors are associated with the base station and every sensor node transfer the noise levels at any time the noise level crosses a fixed threshold level.

3. **Insect smell sensor-** Insects communicates among them by releasing some sort of chemicals, these chemicals are replicate, and sensors are made which can detect these smell (Poonia, 2018). These sensors help in detecting the insect colonies and help in mating disruption thus reducing insect population. Whenever the insects roam on leaf surface or near stem area these sensors easily detects them by the chemical released by them while walking and communicating among their relatives. This information is sent to the farmer to take necessary action to prevent their crops from such harmful insects.
4. **Motion sensor-** Nowadays infrared motion sensors are used to monitor and detect insects with the help of wireless technology, and the data is transmitted to the nearest base station (Pankaj, 2018). Both the infrared motion sensor and the light trap perceive the obstacles in front of the sensor. These sensors are employed at different areas near the crop and near to leaf areas and whenever any insect feeds on the leaf area or any other area of the crop, its motion is sensed by the motion sensor and immediately an emergency message will be sent wirelessly or with the help of a GSM device to the nearest base station or directly to the farmer's registered mobile number.

2. LITERATURE REVIEW

(Rashid, 2015) discussed the application of wireless sensor network technology to improvise potato cultivation. They have proposed an irrigation model that can monitor agriculture parameters continuously for better crop yield and which can increase the efficacy of irrigation system by 10%. The proposed methodology consists of an agriculture sensor node which is established to be set up in the potato farm. The node includes humidity sensors, controller, and radio transceiver which gather the data in the farm and transfer it to the remote station, this system works in coordination with application software. The wireless sensor nodes can be used effectively to gather information of availability of soil water, soil compaction, soil fertility, biomass yield, water status of plants, local weather information, insect pest detection and disease detection in plants, crop yield etc.

(Navin, 2013) discussed the acoustic detection technology for detection of pest in the agriculture field. The author has focused on a pest monitoring and control system to have efficient sugarcane production and it also includes the major insect pest of sugarcane crop. The system utilises an acoustic sensor that monitors the noise level of the pests and also informs the farmer using an alarming system when the noise crosses a fixed threshold level. This system enables farmers to take necessary actions to spray pesticides over the crop at an early age of infestation and it also covers a large area with less energy consumption. The author has also suggested that for limited insect pest, automatic spraying mechanism wherever infestation occurs. This also helps in development of better and healthier crops. And all the dissemination is done with the help of a wireless sensor network connected to a remote station.

(Holt, 2007) includes an overall framework so as to form an intelligent farm system which will help in improving the production and the management level of the complete farm, this intelligent farm analyse the scientific decision & management with the help of information technology. The author has described the data acquisition of field conditions, irrigation monitoring wireless network system. It can fulfil different indicators, requirements of plant development. The information technology based intelligent farm allows farmers to monitor timely the crops and access to several management and production information. This system can greatly increase the crop yield and minimizes the loss that farmers face each year. And they get improved quality crop, less production costs and has better economic advantages.

(William, 2005) includes a survey conducted in Eritrea to determine potato production practises, this also includes contribution towards upgraded food security & livelihood of poor farmers in the country. It also describes insects pest of potato and controlling methods to improve yield. The survey was started by interviewing representative producers and it was noted that same village farmers usually uses same farming practises. This paper also discusses the major pest of potato and diseases caused by them. It also includes the controlling methods and yield status and author has concluded that larger cost of inputs and limited availability are major limiting factors for bad potato production in India.

(Lee, 2010) presents a review of the sensing technologies and also discuss that how they are utilised for precision farming and crop management. It includes that a WSN consists of several dispersed nodes which have sensors and a wireless communication module employed in it. These sensors networks has many applications in agriculture such as farm management, expansion of plant development, precision farming, farm surveillance, guidance and education for better farming. Sensor networks are also capable to gather images of high resolution at fields in real time which can be utilised to monitor plant development, to monitor insects in the field etc. It also explains the limitations of sensor availability in market and also suggests that this field requires advancements so as to form a complete monitoring system.

(Singh, 2006) includes the survey of dangerous pests of wheat and discusses their management through integrated pest management and with the help of modern pesticides pest control. The author has also developed a demanding and profitable damaging activity of phytophagous in cereal crops, keeping the damaging level below the threshold. The paper also discuss some major insect pest of wheat crops and also presents data on arthropod fauna, agroecological and biological facets, preventive measures and field survey for pest control in a manner to achieve integrated control system of wheat crop. The paper also concludes that natural predators play a crucial role in controlling the population of many harmful pests and also that insecticide control is necessary because of the increasing attack of main wheat pests.

(Suchita, 2016) includes investigation for the evaluation different varieties of rice for insects which harms the crops and then observations were noted down related to category of insect pest, their incidence, their spreads and the amount of damage they do to the crops. It also discusses qualitative composition of insect pests complex of rice ecosystem. The areas were marked so as to count the number of insects at each stage of crop development and they have used light trap method for study of insect pest complex. It also suggests that the control of rice pest requires several factors to be considered so that population of pest cannot exceed a economic threshold level. This paper describes various observations made about insects and many constraints which are essential to take care while controlling them. Based on these constraints several strategies have been evolved to control and increase the productivity of rice.

(Thulasi, 2013) includes the monitoring of insect pest population by using wireless sensor network in the agricultural fields. It explains a system which is based on distributed imaging device that operates using WSN which automatically acquires and transfers the images to the remote station. The paper presents trap cropping as a traditional tool of pest management and classifies modalities of trap cropping based on characteristics of trap crop. This paper describes a prototype system for automatic monitoring of fruit flies, it uses Zigbee and GSM module for internal and external processing. The captured image is sent to base station for further processing and in this paper they have used MATLAB as an image processing tool. The simulation results after the experiment are also shown in the paper. The author also suggests that this field still requires further research so as to overcome several difficulties of the system employed, they only made a system which can count the insect pests of the crop and their controlling needs to be developed.

3. METHODOLOGY

3.1 Artificial Neural Networks

The Artificia1 neura1 networks (ANNs) is a fami1y of the statistica1 1earning mode1s which is inspired by some bio1ogica1 neura1 networks with centra1 nervous systems of human and anima1s in particu1ar the brain (Pankaj, 2018; Kumar, 2014).

Neura1 network is inspired from the human method of 1earning approach. The network structure of ANN is made in the simi1ar fashion as in human nervous system. 1earning process is carried out through examp1es in a fau1t to1erant system. The neurons present in the neura1 network have distributed structure. The information is contained in spikes as well as neurons have high1y comp1ex units. P1asticity as we11 as computations is revea1ed at a top 1eve1. The synopsis in the brain corresponds to weight in neura1 network. Weight in neural network means it is used to retain the information in its memory. Initially the weights with random numbers are set then after the new weight is found with the previous weight, bias, and neuron. Input and bias are summed to obtain the input to transfer function. The transfer function is used to obtain the output with the he1p of activation function. The who1e processing of neura1 network is dependent on the weight and the behaviour of activation function. The activation 1eve1 of neuron is totally dependent on the activation function. Each 1ayer has its own activation function. There can be n number hidden 1ayers with n different transfer functions.

Some of the most famous transfer functions are as follows:

1. **Log-sigmoid transfer function:** This transfer function generates output ranging from 0 to 1 as the input is provided from negative to positive infinity.
2. **Tan-sigmoid transfer function:** This transfer function takes input from negative to positive infinity and a1so generates output from -1 to 1.
3. **Linear transfer function:** Purl in transfer function is main1y used in back propagation network. If 1ast 1ayer of mu1ti1ayer feed forward neural network consists of sigmoid neuron then the output is confined within specific range. But in 1inear transfer function the output can take any va1ue.

3.2 Fuzzy Set Theory

Traditional control approach requires proper modeling of physical reality. In traditional mathematical theory the set is defined as a stock of elements that consists of one or more similar characteristics. In real world we group similar objects in the form of set. In other words, a precise object collectively makes a set. Those sets may be set of natural numbers, set of real numbers and many others. Sets can have subset, or they may be proper and equal. Different sets are made, grouped by different name and ultimately different operations are performed on those sets such as union, intersection, differences etc.

Fuzzy Set

In classical set theory membership grade can either be 0 or 1. Each element of a fuzzy set B is imputed a fuzzy index μB(a) in the boundary of 0 and 1 which is called as grade of membership of a in B. In classical set the difficulty we face can be easily resolved by fuzzy set. An ordered pair set can be given by B = {(a, μB(a)): a ϵ U} where U is the universal set and μB(a) is the grade of membership of an element a in B. In most of the cases μB(a) lies in the interval of 0 and 1. In fuzzy set theory answers is not precise and belong partially to set B. A membership function μB(a) can be assigned μB: a -> [0,1], a ϵ U where a is the object or elements of set B and U is the universal set as set B ϵ U.

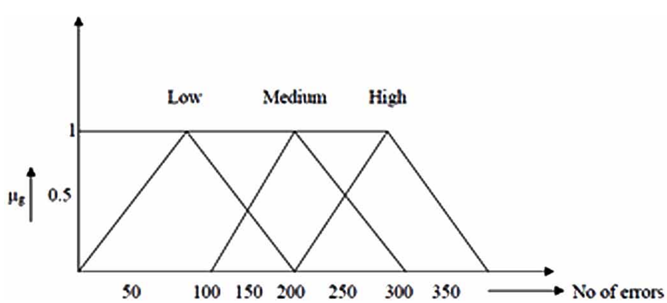
Comparison Between a Classical Set and a Fuzzy Set in Risk Estimation

Consider a universal set R which stands for risk. Minor and major are the subset of universal set R.

Classical Approach

Low = {Error ϵ R: 50 < error < 150}
Average = {Error ϵ R: 150 < error < 250}
High = {Error ϵ R: 250 < error < 350}

Figure 7. Fuzzy Set in Risk Estimation



According to classical set theory one can say that 149 errors lead to low risk in the project while 151 errors lead to high risk in the project. Due to rigid boundary the expression of the data becomes very difficult. In fuzzy set it is very easy to represent them due to soft boundary.

The Risk caused due to 250 no of errors is a member of two fuzzy sets that is medium and high along with the membership grade μg(Normal)= μg(high)= 0.5. Thus, this is how imprecise data can be categorized in an efficient way using fuzzy logic. This is why the fuzzy logic was introduced.

Representation of Fuzzy Set

Suppose there are n elements in a set Z say z1, z2, z3, z4…….zn. Then a fuzzy set B is the subset of Z which can be denoted by any of the following:

B = {(z1, μB(z1)), (z2, μB(z2)), (z3, μB(z3))……. (zn, μB(zn))}
B = {z1/μB(z1), z2/μB(z2), z3/μB(z3)……… zn/μB(zn)}
B = {μB(z1)/z1, μB(z2)/ z2, μB(z3)/z3………μB(zn)/zn}

These are various nomenclature of the fuzzy set from which we can select any one of them. In classical set only members are seen but in fuzzy set the members are associated with fuzzy index or membership function.

General Known Membership Functions

Each member in the set is associated with membership function. So, membership function can be characterized as follows:

ϒ-Function

It is linear function which can be represented as follows:

Υ (z, a, b) = 0, $z \leq a$,
= z-a / (b-a), $a < z \leq b$,
= 1, $z > b$. (where z is actual variables)

S–Function

It is non-linear function which is defined as:

S (z, a, b, c) = 0, $z \leq a$,

= 2[(z-a) / (c-a)]2, $a < z \leq b$,
=1-2[(z-c) / (c-a)]2, $b < z \leq c$
=1, $z \geq c$

Triangular – Function

It is very widely used membership function and used mostly in fuzzy logic controller. It is defined as follows:

Δ (z, a, b, c) = 0, $z \leq a$,
= (z-a) / (b-a), $a < z \leq b$,
= (a-z) / (b-z)], $b < z \leq c$
= 0, $z > c$

Π – Function

It is defined as follows:

Π (z, a, b, c, d) = 0, $z \leq a$,
= (z-a) / (b-a), $a < z \leq b$,
= 1, $b < z \leq c$
= (c-z) / (d-c), $c < z \leq d$
= 0, $z \geq d$

Gaussian – Function

It has two parameters which are mean ms and variance σ. By using these parameters, the nature can be changed. This membership function is also very widely used fuzzy neural network and so forth because it is very useful in system identification using fuzzy neural network.

It can be defined as follows:

G (z, ms, σ) = e1 / 2(z-ms / σ) 2

Both the parameters ms and σ adjust the center and breadth of the fuzzy index.

Operations Widely Used on Fuzzy Sets

In fuzzy set theory the members are not manipulated rather the membership grade of the members are manipulated. For example, set B is given by

$B = \{(a, \mu B(a))\}$. All the common manipulation is done on $\mu B(a)$. Some common manipulations performed on fuzzy sets are as follows:

1. 1. **Intersection (Minimum function):** Let two different fuzzy set A and B with fuzzy index $\mu A(z)$ and $\mu B(z)$.

$$\mu A \cap B(z) = \mu A(z) \wedge \mu B(z) = \min(\mu A(z), \mu B(z))$$

2. 2. **Union (Maximum function):** Members in the sets are same but only fuzzy index varies. If $z \in A$ and $z \in B$ then $z \in A$ B

$$\mu A \cap B(z) = \mu A(z) \underline{\wedge} \mu B(z) = \max(\mu A(z), \mu B(z))$$

3. 3. **Fuzzy complements:** It is 1 minus the original function.

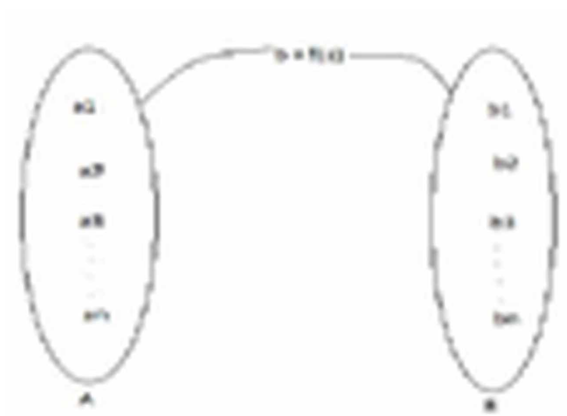
$$\mu \bar{A}(z) = 1 - \mu A(z)$$

3.3 Fuzzy Relations

Mapping in Fuzzy Sets

Mainly there are 4 types of mapping in fuzzy set which are as follows

Figure 8. One to one Mapping



One to One Mapping

A = {μ (a1) / a1, μ (a2) / a2, …….μ (an) / an}
B = {μ (b1) / b1, μ (b2) / b2, …….μ (bn) / bn}

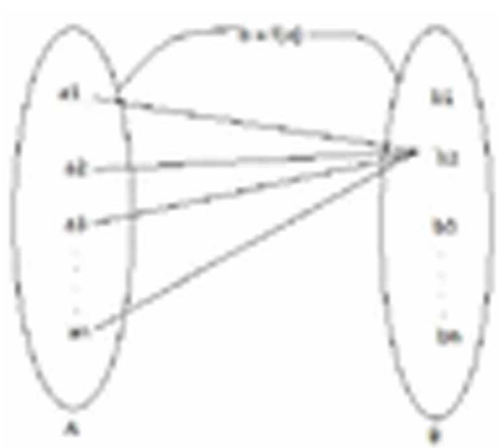
Where μB (b1) = μA (a1) and so on

Many to One Mapping

A = {μ (a1) / a1, μ (a2) / a2, …….μ (an) / an}
B = {μ (b1) / b1, μ (b2) / b2, …….μ (bn) / bn}

Where μB (b2) = max [μA (an): an ϵ f-1(bn)]

Figure 9. Many to one Mapping



Crisp Relation

In crisp relation the Cartesian product of two set can be given as:
A times Z is the Cartesian product,

A * Z = {(a, z) | a ϵ A, z ϵ Z}

Crisp relation is defined on product space. So, the interval of crisp relation can be stated as follows:

μR (a, z) = {1, if (a, z) belong to Cartesian product space
= {0, if (a, z) does not belong to Cartesian product space

Where 1 infer that the elements are in complete relation and 0 infer that the elements are not in relation. For the finite set, relation matrix can be represented in the form of a matrix. In classical relationship, the crisp relation means either the relationship index is 0 or 1 and there is no in between relationship.

Composition Rule (Crisp Inference Rule)

If we have multiple Cartesian product space and we know the relationship, then can we infer the relationships? Let A, B, C are universal set then

1. Let X be element that relates A to B
2. Let Y be element that relates B to C
3. Let Z be element that relates C to A

Thus, Cartesian product Z = X * Y. Now the two compositions can be taken as follows

Max-Min Composition

In this composition the associated membership function μz is computed as μz = max (min [μx(a, b), μT(a, b)])

Max-Product Composition

In this composition the associated membership function μz is computed as μz = max [μx(a, b), μT(a, b)]

Fuzzy Relations

If A and Z are two universal fuzzy sets. Then the fuzzy relation R (a, z) can be given as the ordered pair:

R (a, z) = {μR (a, z) / (a, z) | (a, z) o A * Z}

where μR (a, z) is in the interval [0, 1].

Therefore, the main difference between Crisp relation and fuzzy relation are that in crisp relation the members of sets are either “fully associated” (1) or “not associated” (0). But in fuzzy relation they are associated with the degree between 0 and 1 in which there are infinite number of fuzzy index.

In Cartesian Product Space, Projection of Fuzzy Relation

In Cartesian space A * Z, the fuzzy relation F can be taken into consideration. Most probably on any of the set A or Z the projection of the relation is very efficient for further evaluation of data or information.

1. The projection of F (a, z) upon A can be given by F1.
   μF1 (a) = max [μF (a, z)]
2. The projection of F (a, z) upon Z can be given by F2.
   μF2 (z) = max [μF (a, z)]

Linguistic Variable in Fuzzy System

It is well known that algebraic variables take mathematical values as variables. Similarly, linguistic variables also use words or sentences as values. A fuzzy variable z will take values which are linguistic values. For example, suppose z be linguistic variable with levelled height of a person. Here the universe of discourse is height. In that universe I am looking for a fuzzy variable z when the height of a human is described.

H = {'very tall', 'tall', 'medium', 'short'}

So, height of a person varies from the perception of different people. Every element in this fuzzy set is fuzzy linguistic values in the variable. In this example its height is the fuzzy variable then the linguistic values for this variable would be very tall, tall, medium and short.

If z is fuzzy set,
Extremely z = z3
Very z = z2
More or less = z1/2
Slightly = z1/3

Linguistic variables and values are necessary because in traditional sense when we express the worldly knowledge, we represent them in terms of natural language. From the computational point of view such worldly knowledge can be expressed in terms of rule-based systems.

Rule Based Systems

Worldly language can be efficiently expressed in natural language. When we describe worldly language, natural language is the best way to describe them. For computational purpose, rule base is one of the efficient aspects to illustrate knowledge using natural language. The syntax (generic method) of rule base is as follows

IF premise [antecedent], **THEN** conclusion [consequent].

The above statement is generally said as IF-THEN rule based method. Usually it is also said as inference rule. In this rule-based system if we know a fact then we can infer other facts also from it. If we know a rule and associated relation, then if given another rule the consequences can be predicted.

Fuzzy Rule Base

It consists of a set of rules similar above antecedent-consequent form.

IF a is X, THEN b is Y

Where X and Y are fuzzy sets represented in the form of prepositions.
From the above rule, we can infer new antecedent X' and new consequent Y'.

IF a is X' THEN b is Y', where Y' = X' o Z (Z= relational operator).

Fuzzy implication relation: It is the method to infer knowledge from the rule bases.

IF p (a is X) THEN q (b is Y), where p & q are fuzzy prepositions.

This can be actually related in following relations as:

$Z(a, b) = \mu Z(a, b) / (a, b)$

There are many implication rules. Some of them are as follows:

Dienes – rescher Implication Rule

It is impossible if p is true and q is false. This is false statement. It can be computed by using De morgan's law:

a.$\mu Z(a, b) = \max[1 - \mu X(a), \mu Y(b)]$

Mamdani Implication Rule

It is very popular in control engineering as well as fuzzy systems. In this implication rule when if-then rules are true locally then p and q both are true simultaneously. Every rule is locally true. Here we don't inscribe any other means by which q has to be true forcefully. It follows min or product operation. So, the relational matrix can be given as following:

IF a is Xi THEN b is Yi.
$\mu Z (a, b) = \min [\mu X (a), \mu Y (b)]$
$\mu Z (a, b) = \mu X (a). \mu Y (b)$

Zedeh Implication Rule

If p -> q means either p or q are true, or q is false. So, the relational matrix can be given as following:

$\mu Z (a, b) = \max [\min (\mu X (a), \mu Y (b)), 1 - \mu X (a)]$

In relational matrix are computed by using the above expressions.

Fuzzy Composition Rule

Fuzzy composition operation can be carried out by different set of operations. Then Y = X o Z which can have any of fuzzy composition operations:

1. Max - product:
   $\mu B (b) = \max A [\mu X (a). \mu Z (a, b)]$
2. Max - min: It is very popular method in which first we compute min then max.
   $\mu B (b) = \max A [\min (\mu X (a), \mu Z (a, b))]$
3. Min – max:
   $\mu B (b) = \min A [\max (\mu X (a), \mu Z (a, b))]$
4. Max – max:
   $\mu B (b) = \max A [\max (\mu X (a), \mu Z (a, b))]$
   Min – min: $\mu B (b) = \min A [\min (\mu X (a), \mu Z (a, b))]$

Approximate Reasoning

It means for any logical system it is very difficult to make an exact reasoning that is why from engineering perspective we don't want to be so precise. If our system works, we are satisfied. So, we use specific compositional rule of inference and then knowledge or consequence is inferred. Following are the rules:

1. Z is relational matrix associated with specific rule and given a condition X, Y is inferred with the help of compositional rule of inference that is Y = X o Z
2. The fuzzy sets which are related with the rule base may discrete or continuous based on probabilistic approach.
3. There can be single or multiple rules in the rule base.
4. Form single rule, many other rules can be extracted with the help of various inference rule mechanism. Example: Fuzzy composition rule.
5. There are also various inference mechanisms for multiple rules also.

4. EXPERIMENTS AND RESULTS

4.1 Software Implementation

The data is recorded in a datasheet in Microsoft excel and the software reads out this data and with the help of programming feature extraction is done and give the result that this particular insect is damaging the crop, this information can be sent to the farmer with the help of GPS technology (Pankaj, 2019; Ankit, 2019). One more benefit of this technology is that it calculates the exact amount of pesticides needed to kill the insect. It means if there are few insects present it will provide amount of pesticide required to kill the insects or if many insects are present then accordingly amount will be suggested. Thus, helps in reducing environmental pollution and land degradation.

Step 1: Import and choose inputs as **"im_train"** and targets as **"tmx_text"** matrix to train the neural network (Figure 10).

Step 2: Click next and enter number of **hidden neurons** a 22 and click next (Figure 11).

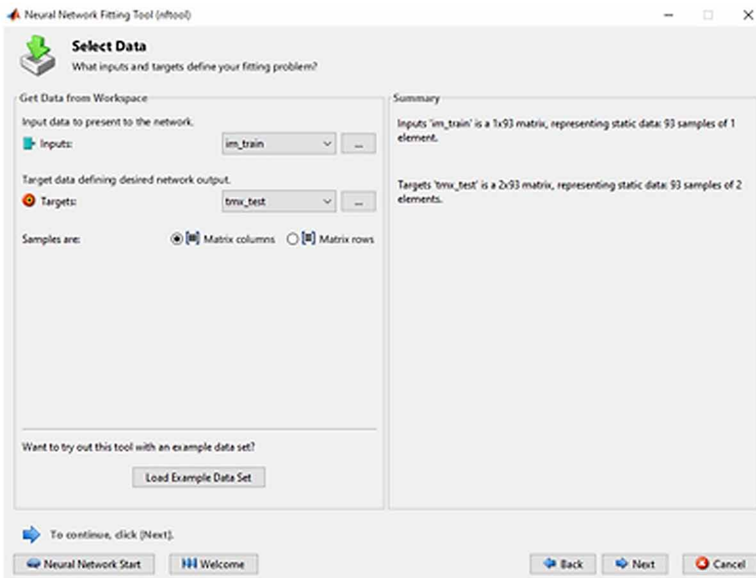
Step 3: Network is train and the graphs are shown (Figure 12)

Step 4: Train neural network and provide learning (Figure 13)

Table 1. Metrological Data from Agriculture Department

Size	Speed	Sound	Colour Intensity	Chemical Release	Categories
423	20.96	41.3	7.77	14.43	3.42
190	15.81	14.44	6.29	11.8	3.42
47.5	17.97	15	8.18	13.49	3.42
78	19.38	41.29	11.87	8.88	3.42
11.4	19.02	38.81	13.49	10.41	3.42
19.3	19.11	39.46	12.52	12.56	3.42
101	22.15	24.75	17.07	11.14	2.32
219	25.71	27.73	16.33	11.35	4.36
50	25.26	26.27	15.47	11.73	4.36
227	16.84	16.75	10.98	10.81	3.42
70	29.48	20.46	11.47	14.91	5.48
0.9	28.78	19.9	12.86	16.27	3.42
980	18.11	14.63	20.41	9.82	2.1
350	18.43	33.51	10.47	11.48	2.32
70	25.65	17.68	23.8	10.62	2.32
271	25.69	17.86	23.85	10.62	2.32
90	18.52	29.29	8.39	14.43	3.42
40	18.48	28.89	8.32	14.43	3.42
137	17.3	25.53	13.13	10.44	3.42
150	17.31	25.57	13.14	11.26	3.42
339	20.17	28.89	19.23	10.44	3.42
240	18.24	28.32	6.76	15.24	3.42
60	19.74	13.2	13.2	10.31	2.32
100	19.75	13.26	13.22	10.31	2.32
53	19.13	23.67	13.08	15.07	2.32
41	30.87	21.86	12.11	10.34	10.03
24	30.75	21.28	11.9	10.34	10.03
165	22.68	28.15	20.33	14.85	2.32
65	22.71	28.38	20.43	14.85	2.32
70	22.76	28.86	20.61	14.85	2.32
233	22.67	28.09	20.31	14.85	2.32
21	35.71	36.47	35.66	11.03	4.36
144	20.62	50.65	19.25	15.48	2.32
151	20.23	46.14	11.35	15.48	2.32
34	20.18	45.45	14.27	15.48	2.32
98	20.38	46.99	14.48	15.48	2.32
85	20.35	46.78	14.45	15.48	2.32
20	19.85	43.21	10.94	15.48	2.32
111	20.17	45.67	11.28	15.48	2.32
162	20.48	47.74	14.59	15.48	2.32
352	21.1	54.03	20.67	15.48	2.32
165	20.94	52.74	20.4	15.48	2.32
32	41.55	29.18	20.15	19.23	6.71
50	26.85	30.99	27.68	14.85	2.32
7.25	54.3	38.33	29.78	20.23	8.52
16.3	36.81	28.75	20.04	14.81	6.71
6.2	36.67	28.21	19.91	14.81	6.71
3	36.57	27.82	19.81	14.81	6.71

Figure 10. Selection of Inputs and Targets Dataset



This training stopped when the va1idation error increased for six iterations, which occurred at iteration 10. If you c1ick Performance in the training window, a

Figure 11. Selecting the Number of Hidden Neurons for Training of Dataset

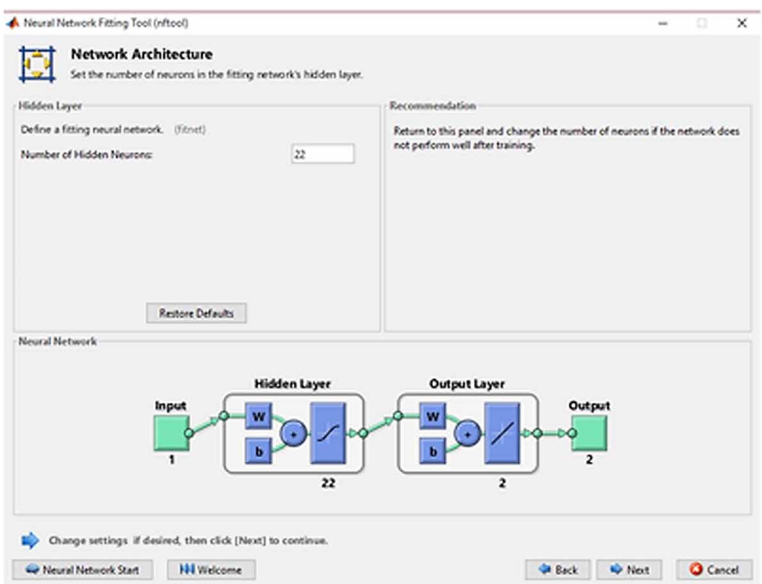
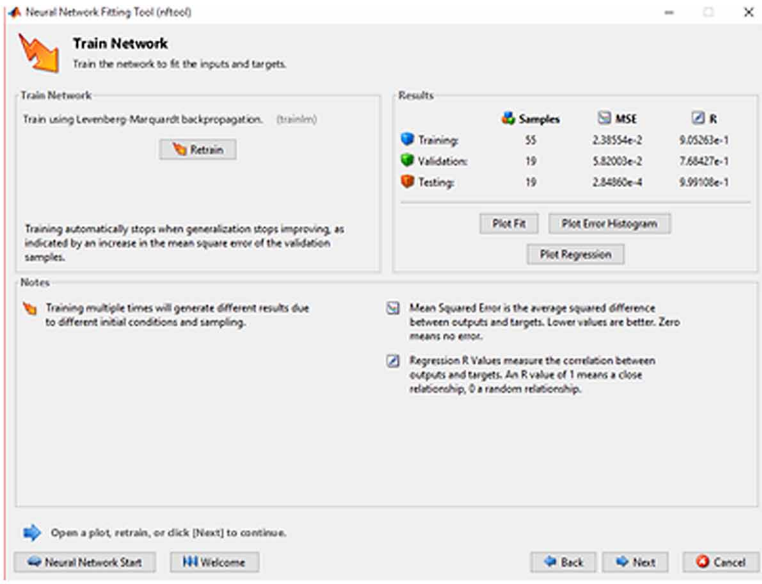


Figure 12. Select the Back-Propagation Algorithm



p1ot of the training errors, va1idation errors, and test errors appears, as shown in the figure. In this, the resu1t is reasonab1e because of the fo11owing considerations:

- The fina1 mean-square error is small.
- The test set error and the va1idation set error have simi1ar characteristics.
- No significant over fitting has occurred by iteration 10 (where the best va1idation performance occurs).

4.2 Result and Analysis

The proposed neura1 network estimation mode1 is ab1e to detect data of different type of parameters. The different parameters are used to as a who1e to estimate the overa11 effect approximate1y using neura1 network. Here we use the Artificia1 Neura1 Networks using MATLAB for monitoring the environment and Greenhouse gases (Ankit, 2019). We take a metro1ogica1 data from Agricu1tura1 department and simu1ate the data by using Artificia1 neura1 networks the training is done to provide the accuracy 1eve1 of 96.21% and the observer error in the dataset is of 3.79%. The target or overa11 error probabi1ity is estimated which resu1ted in the form of 1inguistic variab1es in the software project are according data sheet.

In the graph of Error Histogram, the b1ue bars represent training data, the green bars represent va1idation data, and the red bars represent testing data. The

Figure 13. Train the Neural Network and Provide Learning

histogram can give you an indication of out1iers, which are data points where the fit is significant1y worse than the majority of data. In this case, you can see that whi1e most errors fa11 between -5 and 5. It is a good idea to check the out1iers to determine if the data is bad, or if those data points are different than the rest of the data set. If the out1iers are va1id data points, but are un1ike the rest of the data, then the network is extrapo1ating for these points. You shou1d co11ect more data that 1ooks 1ike the out1ier points and retrain the network.

Figure 14. Neural Network train window showing the errors in Training, Validation and Testing

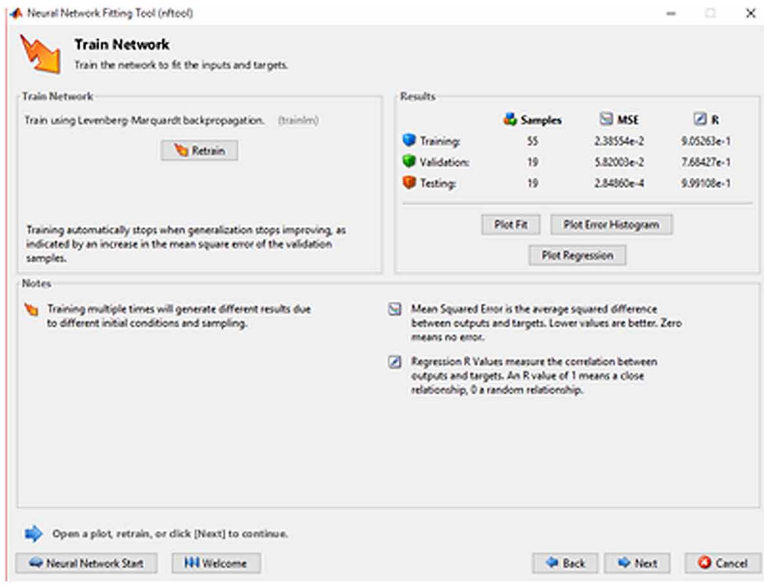


Figure 15. Plot fit for output data after training of Neural Network

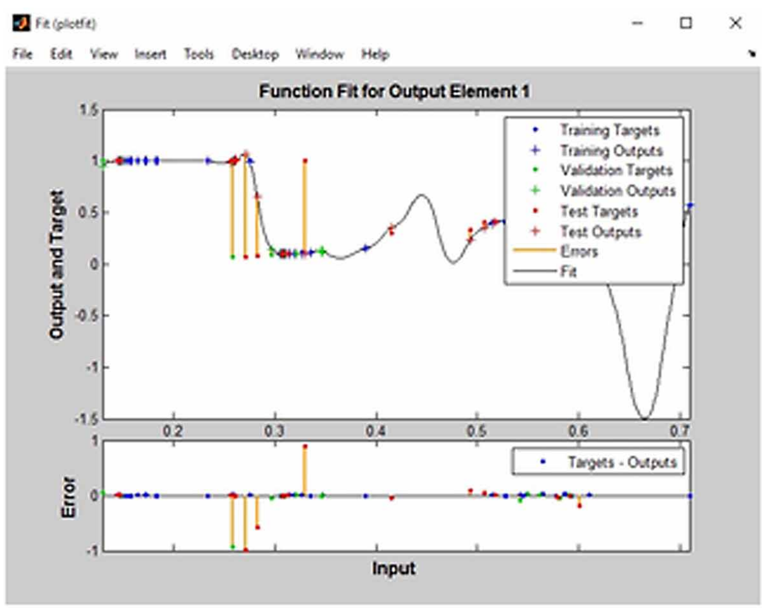
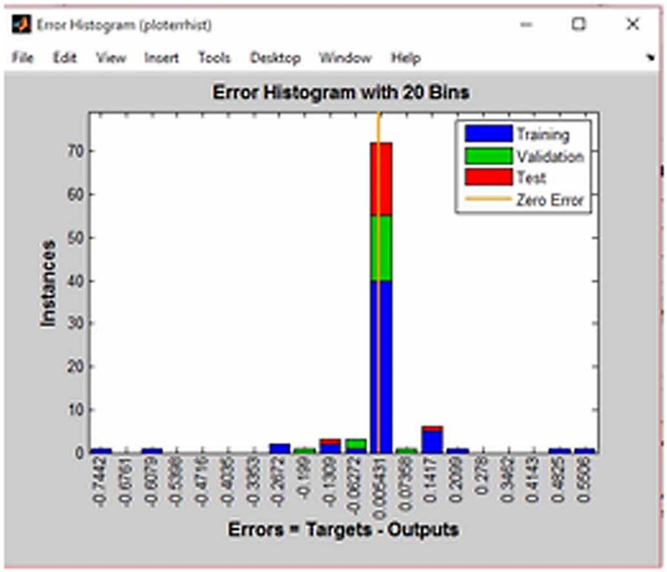


Figure 16. Error Histogram observed after training of Neural Network



5. CONCLUSION

This paper describes the trends, availability, and differences in sources of pheromone control in agriculture development. It also emphasized the authority to give more attention to increase the research and enhance pheromone technique as they are environment friendly. Identify insects automatically and finds out the amount of pesticides to be given according to the development of the insect pests. The system will evaluate the quantity of pesticides according to the lifespan of insect pest and will also suggest suitable method of controlling. It includes a proposed system which will help farmers to provide exact amount of pesticides required to kill the pest as it uses neural network to classify insect pests according to their category. Lab-based pictures for training and field-based pictures for testing accurately classified 82% of the insect images. The paper describes that due to lack of knowledge farmers rely on the same old solution to control these pests i.e. sprat of pesticides, so it is necessary to create awareness and give educational training to farmers so that they can adopt integrated crop and pest management practices to overcome these difficulties. The author has also concluded that the system proposed has some limitations which need to be solved to form a complete automated insect identification system.

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