Neural Network Based Pest Identification and Control in Cauliflower Crop using Sounds of Pest

Adeline Sneha J, Rekha Chakravarthi

Abstract: The quantity of pesticides usage in the field increases every year, which in turn affects the nutrients present in the crop. These pesticides also cause water contamination, air pollution, serious health problems in humans and finally making the soil infertile. Necessary action has to be taken to protect the environment and crops from chemicals. A well-established automatic acoustic detection of pest for early pest detection is suggested in this paper. Acoustic identification technique of signal analysis is extensively implemented in agriculture to give maximum protection of crops, ultimately resulting in better production. Successful eradication of pest lies in identification of pest without damaging the nutrients and crops. The proposed technique detects the presence of pests in the initial stage. The sounds of different pests which are dreadfully affecting the agricultural crops are collected. The signals of pests are analyzed in time domain and frequency domain specifications. The features of different pests are extracted using Mat lab programming. The various statistical features of pest are trained and given to the hidden layer of neural network where it automatically classifies the pest indicating the presence of pest. The Back-Propagation algorithm is used for training the samples. When the identification of pest has been done, the pest can be killed by the microwave shock rather than applying highly toxic chemicals. This technique also benefits the farmer by avoiding contact with the pesticides. Direct contact with the pesticides sometimes causes skin cancer to farmers. The technique suggested in this paper is harmless to the farmers and crops, hence increases the production.

Keywords: Pest; Pest Identification; Pest Control; Acoustic Identification

I. INTRODUCTION

Pest are organism that feed on agricultural crops causing economic loss. Sometimes they act as the vectors for transmission of different chronic diseases in humans and livestock[-1]. Pesticides in large quantity is used for controlling the pest. 1·5 million tonnes of pesticides are manufactured every year, producing a business worth US$30 billion during the year 2000.[2] All over the world, the pesticide production increased at a rate of about 11% per year[3]. The pesticides increase the agricultural production, increases the crop protection and finally increases the profit of the farmer[4]. However, these pesticides are highly toxic and burdening all the living organisms. Exposure to pesticides causes acute leukemia [5]. There are also lined evidence of reduced weight of fetal, fetal death and fetal birth defects[6,7]. Nowadays, organic vegetation has been practiced in various countries to protect their younger generation from the impact of pesticides.

But organic vegetation has been practiced with frequent manual inspection which will not be effective at all time. Certain techniques are followed to do agriculture in a smart way. The smart agriculture are equipped with smart device, minimizing the use of pesticides, reduces the toxins, control the pest and increases the agricultural production. Many physical techniques for controlling the pest in agriculture are developed. One way of controlling the pest is using solar energy-based insect trap. This trap is energized by the solar power during day time which attracts the pest with the LED present in it [8]. When any pest is moving near the trap it will be attracted and killed by the shock[8]. The main drawback is it will do the control action during night time. Insect trapping lamp is suggested for the control of pest in winter wheat summer maize rotation system[9]. Wooded field margin is explained as a traditional pest control technique for a soybean, this is a sustainable form of pest control[10]. The Biological control of pest pathogen crop model has been implemented for the control of pest in agricultural fields [11]. In some agricultural fields the pests attacking the crops are attracted by the aroma which it likes, that will be used as a trap[12]. The ginger oil based pest trap is designed for the control and attraction of fruit flies. The ginger oil is used as the major attractant agent of fruit fly pest. The artificial female pheromone is also a technique for attracting the male pest and adversely affect the population of the pest[13]. The reproduction of the pest is diminished. There are so many techniques for pest control but they are having few limitations like it will not give immediate response to the pest action. In the cultural control, frequent observation of the crop and margin crops are needed. Proper pruning and tillage benefits the protection of agricultural crops. If the traps like sticky traps, black traps lead harmful to some environmental friendly insects. In pheromone traps its quite difficult to interpret the male attraction. The major drawback is only the third stage of pest is controlled. But the pests feed more on the crops during the initial stage of its growth. The devouring capacity of the pests is higher in the initial stage and spoils more number of crops. The initial stage larva consumes the crop and makes holes in the agricultural yields. The consumer cannot prefer the veggies provided with the holes even though it is not spoiled. This directly impacts the profit of the farmer causes the economic loss. Therefore, an effective method of identification of pest and control is needed. It is important to follow the correct identification of pest because always only the correct identification gives the accurate control of pest. The third stage of pest identification may minimize the pest damages but the initial stage of pest identification eradicates the pests. This paper provides an effective identification and control of pest using the sounds of pest. Sound is the major source for communication. Here in this paper the sounds produced by the larva, insects are playing

major role in identification of pest in its initial stage. The butterflies could be identified by the wingbeat frequency[14]. Many recording devices are specially designed for recording the sounds of pest. Small insects, young larva are very week emitters of sound but there are devices to capture these sounds and eliminates the background noise by filtering[15]. The automatic detection of pest and recognition using the neural network classifier is presented in this paper. The pests affecting the cauliflower sounds are collected from various internet databases and few sounds are collected from the fields of Orrisa, India. Cabbage and Cauliflower are the major crops produced and consumed in India [16]. These crops resulted in higher pest infestation and pesticide use. The cauliflower crop is nourished with rich antioxidants and nutrients but due to the excessive use of pesticides and residue of the pesticides present in the crop makes the nutrients diminished. This paper presents a technique which identifies the pest in time and takes the control action without diminishing the nutrients present in the crop. The sounds of 20 dreadful pest affecting the cauliflower are collected. The signals have been generated from the sounds of pest and it has to be analyzed. Each pest is provided with the three different samples. Totally for the identification of pest in the cauliflower crop the 60 pest samples are used. There are 20 different temporal and spectral features are extracted from the signal which uses the Mat Lab Programming. The extracted features are given as the training data to test the neural network. Along with this 20 pest signals 5 other signals are given for analyzing about the noise and disturbance in the environment. Since the neural network is highly inter connected in nature and ability to mimic human brain it can easily classify the features based on the training given to the network. This work uses the back propagation algorithm for classifying the n number of inputs. This algorithm uses bottom up approach in order to get the correct value. This analysis also gives proportion of repeat analysis which sometimes repeats the same value with the same confidence level. This automatic identification process eliminates the human flaw [17] such as false assessment, inaccurate identification, fatigue, and limited time. When the presence of pest has been identified then the corrective control action has been taken unless to avoid the spreading of pest throughout the field. The presence of pest information has been forwarded to the farmer's mobile. The farmer should take effective control region only by applying the shock to the pest infected region. This technique can also improve with the help of automatic spraying of microwave to the pest infected region. This acoustic form of identification does not destroy the environment and does not kill the environment friendly pest. This will lead to give the high quality of food with minimum effort. The need for nondestructive, quick, economical means of spotting hidden insects through several acoustic approaches are likely to magnify the requirements of the entomologist, business, regulators and agriculturist are going to be implemented in the forthcoming years effectively [18]. Since this technique is very effective and user friendly which does not disrupt the environment.

II. CAULIFLLOWER PEST

The survey in 2016 gives the report that the US spends 92.4% of pesticides in 86.9-million-acre corn plants[19]. The usage of pesticides is increasing every year. Therefore, a nondestructive technique for an effective identification of pest is suggested in this paper. Few pests like cicada are identified by the number of pulses, mean, peak frequency using Principal Component Analysis [20]. The Cauliflower (Brassica oleraceae Botrytis Group) is affected by many pests therefore it is frequently fertigated. This crop is not only affected by pests but also affected by various diseases. The edible part of the cauliflower is known as curd. The pest consumes the leaves, stem and the curd. Almost all the parts of the plants are affected by different pest. Among all the pest, the sounds of 20 dreadful pests which are affecting the cauliflower in all stages are collected. The main pests are given in table 1. The complete growth of the cauliflower takes three different stages shown in Fig 1. The sowing stage is the time taken for the seed production into the plant. The fertigation starts from the week 1. Transplanting stage, the cauliflower plants are moved and planted in the rows with the space of 40 cm within the number of rows. Cauliflower makes white curd with the diameter of 5-7 cm. In order to protect the curd from sun exposure the leaves are joined together tries to hide the curd. At once the curd is completely formed with white color, the curd is ready to harvest in the harvesting stage. The Figure 2 gives the impact of damages caused by the pest which results in economic loss. Therefore, to protect the crop from pest and diseases many pesticides are applied which will harm all the living beings and the environment.

Figure 1 Different Stages of Cauliflower

Figure2Cauliflower pest and diseases

Table 1 Pest used for analysis

Sl.No	Common Name	Scientific Name	Order	Family
1	Aphids	Myzuspersicae(Sulzer)	Hemiptera	Aphididae
2	Asian Citrus Psyllid	Diaphorinacitri	Hemiptera	Liviidae
3	Brown stinkbug	Halyomorphahalys	Hemiptera	Pentatomidae
4	Braconid Parasitoid	Cotesiaplutellae(Kurdj.)	Hymenoptera	Braconidae
5	Butterfly	Rhopalocera	Lepidoptera	Lycaenidae
6	Cicada	Cicadoidea	Hemiptera	Cicadidae
7	Cricket	Grylluscampestris(L.)	Orthoptera	Gryllidae
8	Cutworms	Agrotisipsylon(Hub.)	Lepidoptera	Noctuidae
9	Flea beetle	Phyllotreatacruciferae(Go.)	Coleoptera	Chrysomelidae
10	June beetle	Phyllophaga *sp*	Coleoptera	Scarabaeidae
11	Grasshopper	Atractomorphacrenulata (F.)	Orthoptera	Pyrgomorphidae
12	Green stinkbug	Pentatomidae	Hemiptera	Pentatomidae
13	Greenback grubs	Cotinus nitida (Linnaeus)	Coleoptera	Scarabaeidae
14	Asianhornedbeetle	Anoplophoraglabripennis	Coleoptera	Cerambycidae
15	Painted Bug	Bagradacruciferarum (Kirk.)	Hemiptera	Pentatomidae
16	Root Maggots	Delia radicum	Diptera (Flies)	Anthomyiidae
17	Root borer	Prionus laticollis	Coleoptera	Cerambycidae
18	Soapberry bug	Hemiptera: Rhopalidae: Serinethinae	Hemiptera	Rhopalidae
19	Swedge Midge	Chironomus spp	Diptera	Chironomidae
20	White grubs	Holotrichia serrata	Coleoptera	Scarabaeidae

Table 2 Quantity of pesticides in cauliflower farming

Frequency of Application of Pesticides	Pesticide Name	Quantity Used	Land Used
			1. 2. 3.
Weak 1-Weak 12	Tracer,Proclaim,Roger	(700litres of H20 with 250 ml Pesticide)	1 Acre

Table 2 data is based on the inputs from the formers from Krisnagiri, India. Even though lots of pesticides are being used Tracer,Proclaim,Roger are perdominantily used in all stages of cauliflower farming.

III. SOUND BASED IDENTIFICATION OF PEST

The sound-based analysis literary dealt with the processing of pest signals. The speech recognition refers to the extraction of features from the input signal and categorizing into the specific pattern or class. These extracted features give the properties of the acoustic signal. Generally, the signal is the variation of pressure, from the atmospheric pressure as a function of time, caused by traveling waves from the speaker's mouth. Here in this work the speaker is nothing but the pest. This paper the work has started with the collection of sounds of pests attacking the cauliflower crop. The 20 pest's sounds are collected from different internet databases.
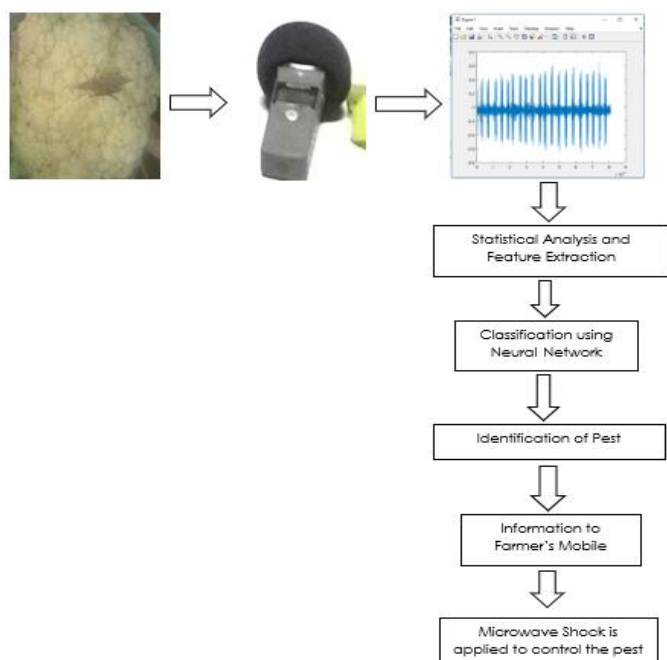

Figure 3Acoustic identification of cricket pest

Few samples of pest sound like grasshopper, cricket is collected using the H1 recorder. The recorded sounds are processed with the support of MATLAB Programming. In order to control the pest, proper identification technique has been followed, therefore statistical analysis is needed. The pest signal during 1 sec is considered as $2*10^{-5}$ Joules. The feature extraction techniques are classified into

Linear Predictive Coding (LPC)
Mel Frequency CepstrumCoefficient(MFCC)
Perceptual Linear Prediction(PLP)
Mostly MFCC and PLP are used for Automatic Speech Recognition [22]. The MFCC method and LPC method are used for the extraction of features in this paper. The MFCC are quite fruitful for the frequency analysis. This extracts the statistical parameters from the speech similar to the human hearing sense and finally deemphasis the data [23]. Then each individual signal is divided into few frames. Then the discontinuity in the edges of the signals are removed by Hamming window. In most of the cases the noise has more impact on the higher modulating frequencies rather than the lower modulating frequencies. When the signal is about to transmit over the cable the signal which is susceptible to the noise is boosted. The name of this process is known as preemphasis. Then the next step of signal analysis is blocking of the frame, When the frame of the signal is too long, then the properties of the signal will change. May be the signal is too short it directly affects the frequency of the signal. Then the spectral information has been calculated. The spectral information gives the energy Level of the signal. Here the sound of pest is processed and converted into the signals using mat lab programming. The signals are converted into the wav format, since the complete data of the signals are used for the analysis. Then the signals of pest are splitted into the frames. The Hamming windows are applied to remove the discontinuity. The FFT is applied for the conversion of time domain to frequency domain analysis. More than 20 features are extracted from the signal, whereas ten features can be selected for the further analysis. The ten selected features are geomean, variance, standard deviation, kurtosis, skewness, energy, pitch. entropy, correlation, signal to noise ratio. These extracted features are given to the neural network for testing and training. Totally 200 samples are given to the Neural Network for training the hidden layer. The signal has been analyzed with the time domain specification first, then frequency domain. The fast Fourier transform is used for the conversion of frequency domain. The output response of the FFT is a set of complex values that contains real and imaginary parts. But the audio signal processing will have only the real value. Basic working model of acoustic identification of pest are shown in Figure 3. The cricket is affecting the cauliflower. The sound of pest cricket is recorded using H1 recorder. This recorder is a handy recorder and very accurate in recording the sounds. The recorded sounds are converted into wav format and the signal is generated with the MATLAB programming. The statistical features are extracted from the signal. These extracted features are given as the training samples to the neural network. More than 200 samples are used for training the neural network. When the signal is selected the signal with maximum similarities with the trained features are accepted as the pest signal, which indicates the presence of pest in the crop. Thereby the identification has been done. As soon as the correct identification has done the control action has been implemented with the application of microwave shock. This microwave shock effectively kills the pest in the crops without damaging the crops.

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3130

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IV. EXPERIMENTAL RESULTS AND DISCUSSION

The recorded pest signals are examined with time domain specification and frequency domain specification. Then with time and frequency domain analysis. Therefore, through various analysis and examination different kind of signals the pest peak frequency has been identified.Fig.4 shows the various analysis done in the cricket pest signal
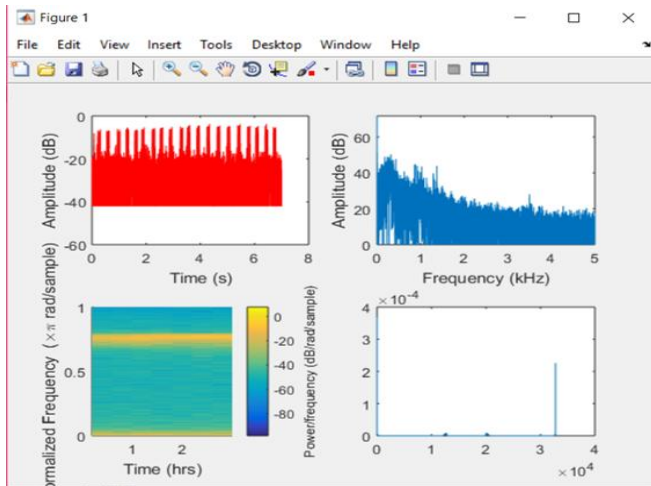

Figure 4Time and frequency domain analysis of cricket pest

The final graph gives the information about the pitch of the signal. The peak frequencies of the pest signals are tabulated in table3. In this paper a soft computing-based approach is used to identify and classify the pests affecting the cauliflower. It deliberately uses Artificial Neural Network for recognition of pests from its sound. Generally, speech recognition is quite complex and it consists of huge number of sampling points, therefore the extraction of features from the time and frequency domain is very complicated by using complex analytical methods. But the neural network always estimates the complex functions and provides reliable solution based on the application[24]Here the classification of pest is purely based on features extracted from the pest. The selected features are the key components for any kind of correct classification. Once the pest signal has been given to the neural algorithm, the ANN should identify and classify the given sample signal is a pest or not.

Table 3 Peak frequency of 20 pest

| Sl. No	Pest Name	Amplitude(dB)	Peak Frequency(KHz)
1	Aphids	48	20
2	Asian Citrus Psyllid	40	10
3	Brown stinkbug	24	12
4	Braconid Parasitoid	30	25
5	Butterfly	40	2
6	Cicada	45	33
7	Cricket	50	32
8	Cutworms	20	40
9	Dung beetle	40	120
10	June beetle	31	50
11	Grasshopper	35	6
12	Green stinkbug	17	29
13	Greenback grubs	39	4
14	Asianhornedbeetle	32	18
15	Painted Bug	26	9
16	Root Maggots	20	26
17	Root borer	36	2.2
18	Soapberry bug	48	3
19	Swedge Midge	45	2
20	White grubs	28	28
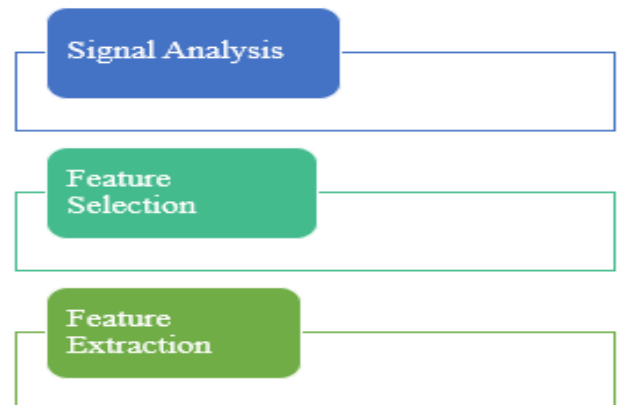
Figure 5 Basic analysis with signal

This work has been framed into three major analysis shown in Figure 3. Signal Analysis dealt with the clear visualization of each frame of the signal in terms of time and frequency in fig3. Totally 20 pest signals and 5 signals of music, human voice, wind, rain and noiseare chosen. The pest signals are in the class 1. The other signals which are not a pest are contributed into the class 2. The feature must differentiate two or more classes. The features are extracted from the signals. The feature must be correlated with another

feature whichhave high degree of correlation[25]. feature must be meaningful. Feature should have large variance. In this work more than 20 features are selected for the analysis. But 10 features are extracted from each signal since these features makes high impact on the identification of pest. The statistical features are given to the neural network which is trained gives the value to the hidden layer, the statistical features which are close to the class 1pest are being identified as pest. The statistical features which are close to class 2 are being identified as a non-pest. The feature extraction of 20 pest signals are given in table.4. The steps of the neural algorithm followed in this paper is given in fig 6. The Back-Propagation algorithm is used for training the samples. There are different algorithms like feed forward algorithm, radial basis function, general regression algorithm is there, but comparing to all algorithms Back Propagation is very effective since it produces minimum number of errors. It can have n number of inputs and one output. In this work the neural network consists of 1 input layer, six hidden layer and one output layer shown in fig 7. Here the hidden layer is meant for the mathematical calculation based on the gradient descent rule with momentum. In short, the output from the output layer is back propagated to the input layer in order to minimize the number of errors. The activation function used in this work is sigmoid. The Hamming window is used for windowing technique.
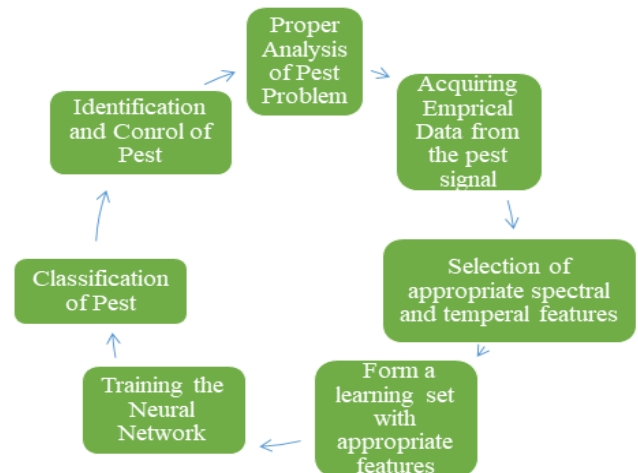
Figure6 Steps of neural model

Table 4 Feature extraction of 20 pest

| Pest Name	Mean	Std Deviation	Varience	Skewness	Kurthosis	Entropy
Aphids	-1.24E-06	0.0129	1.66E-04	-2.24E-04	12.3551	1.6211
Asianhornedbeetle	0.0021	0.0139	1.95E-04	-6.0544	2.30E+03	2.0803
Bug	-0.0511	0.0534	0.0029	-1.2957	12.1342	0.3934
Butterfly	4.20E-05	0.0286	8.17E-04	0.1892	6.5593	2.248
Cicada	-0.011	0.0347	0.0012	0.0238	11.6652	1.862
Cricket	-0.0671	0.0653	0.0043	0.1689	4.0169	1.1617
Cutworms	4.84E-06	0.0103	1.06E-04	0.3031	130.9807	1.5203
Flea Beetle	-0.0152	0.0576	0.0033	0.449	63.7636	1.3565
Magnoliarootborer	-0.0047	0.0182	3.33E-04	-0.0305	62.3396	1.4907
Moth	0.6835	0.0204	4.15E-04	1.15E-14	1	1
Painted Bug	-0.0096	0.0149	2.22E-04	-5.1019	360.0864	0.187
Root Meggots	7.58E-06	0.0108	1.16E-04	-7.6124	712.5909	1.2583
Root borer	-0.0047	0.0182	3.33E-04	-0.0305	62.3396	1.4907
White grub	0.5473	0.1161	0.0135	2.06E-15	1	1
Weevil	-0.0757	0.5552	0.3082	0	1	1
Brown stink bug	0.0237	0.2094	0.0438	-0.6487	9.9314	4.9004
Dungbeetle	-0.0152	0.0576	0.0033	0.449	63.7636	1.3565
Greenstink bug	8.16E-04	0.2148	0.0461	-0.1274	10.224	3.8528
Greyback grubs	-5.44E-06	0.0356	0.0013	-0.0025	3.7921	2.9868
Grasshopper	0.0026	0.00348	0.0012	2.8072	161.317	2.735
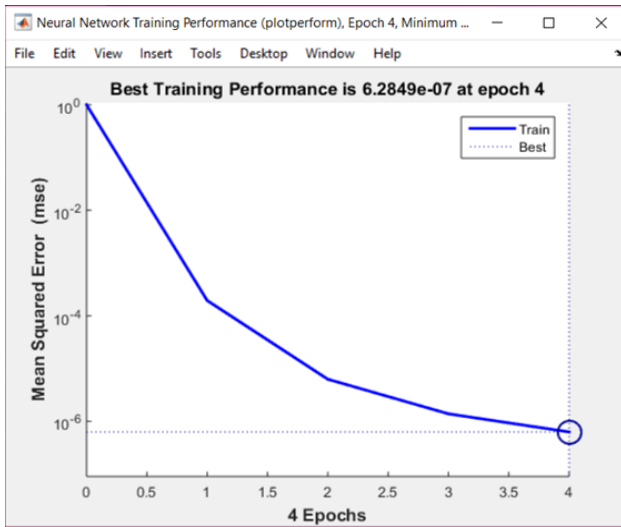
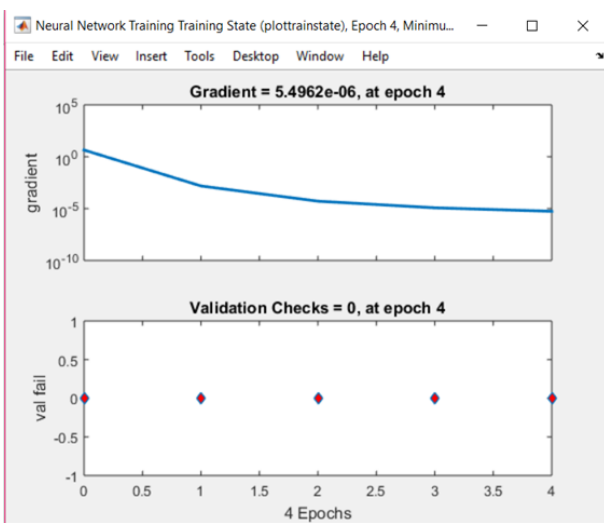**Figure8 Training of neural network**
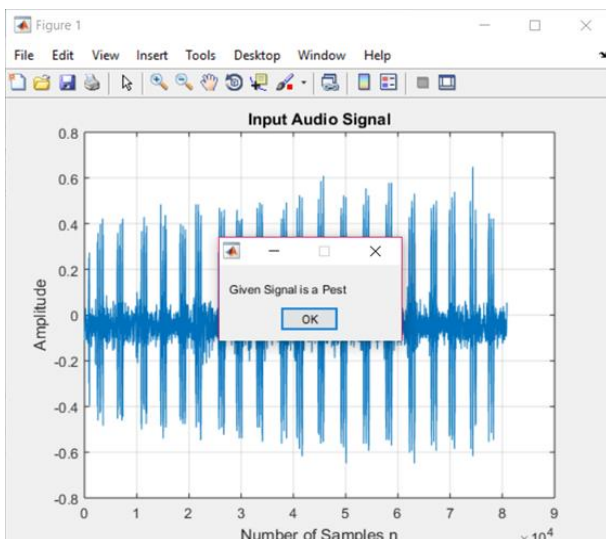

Figure9 Validation of neural network
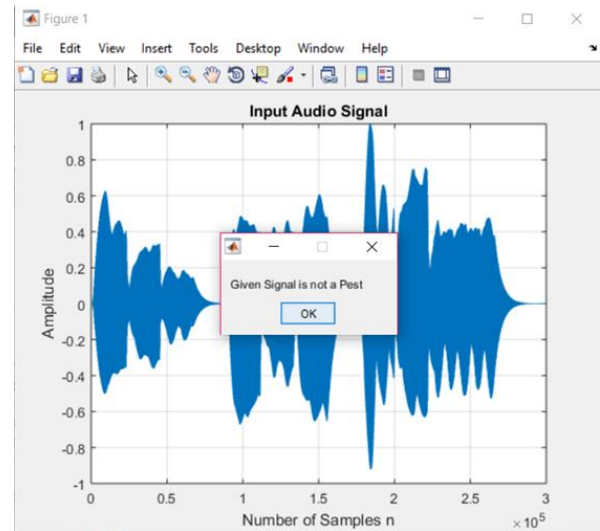

Figure10 Cricket pest identification

Figure11 Identification of signals other than pest

The neural network is accurate and gives the efficiency of 98.9 % in classification of pest. The efficiency can also have improved by taking more features from more number of pest samples. As soon as the identification of pest is done the data is transmitted to the farmer's mobile to perform effective control action. This can help the farmer to identify the pest investigation region without damaging the crops. Then the shock is applied manually to the pest investigated region. Application of shock manually takes time, amount of shock applied must be considered etc. Therefore, the future work implies the automatic spraying of microwave shock in the pest infected region.

V. CONCLUSION

The demand of food is increasing every year. It's important to increase the production to feed the growing population. Additional 70% of food production is required to meet the requirements of food in the year 2050. The chemical farming has been practiced in many areas to minimize the loss of crop due to pests, weeds and diseases. But the chemicals present in the food affects all the living organisms on the earth. Therefore, in order to minimize and eradicate the use of chemicals in agriculture, few smart technologies are used. The neural based pest identification using the sounds of pest is one among the smart technologies. It gives 98.9% efficiency in eradicating the pest from the crop without damaging the crops. This technique is very easier but the major challenge is measuring and recording the low-level sound signals. This smart technology safeguards the crops from pest and eliminate the usage of pesticides.

VI. ACKNOWLEDGEMENT

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