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Modified Efficient Protection of Palm Disaster from RPW Larvae using WSNs

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Abstract*: Red Palm Weevil (Rhynchophorus ferrugineus) is the most dangerous and deadly pest to date for coconut, date, sago, oil, and other palms. Because of the dissemble nature of feeding, RPW infestation is detected in the last stage. RPW larvae acoustic activity consists of crawling, chewing, emission and quick oscillating sound. Network of wireless sensor are used to record the sound produced by the Weevil larvae and early stage detection of larvae infestation to coconut tree is conducted using Acoustic techniques. Coconut palm tree is fixed with wireless sensors to receive the sound wave produced by RPW larvae to transmit to server via access points which is capturing the signals from six tree arranged in hexagonal form to process using the Mat lab tools and fundamental frequency of received may also comprise of environment noise. Mel scale in frequency which is nonlinear for spectrum of log power to cosine transform of linear for power spectrum of short term to represent the cepstrum of Mel frequency for processing of received sound. Featured extraction is performed using the Mel Frequency Cepstral. Mel frequency for feature extraction is most used method for feature extraction in frequency domain. Algorithm model of back propagation with neural network of Feed forward are used to enhance the recognize performance. The adopted method is less expensive than current methods of RPW larvae detection. The results in simulation are stimulated in early stage larvae detection and before the damage affect the economic threshold helping the farmers to follow the control measures.

***Keywords:* MFCC, Neural Network, Ad-hoc Network (MANET), Acoustic activity.**

I. INTRODUCTION

Palm tree is pierce by RPWs to create a hole to lay eggs. Each female can lay between three hundred to Five hundred eggs to hatch it takes three days. Larvae emanate and burrow into internal part of the coconut tree, hinder palms ability to upward of water to the crown and nutrients transport .RPW larvae drill deep into crowns palm trunks and offshoots, normally till palm are almost dead larvae are dissemble to visual inspection. Adults can live for 2 to 3 month, during which they feed palms parts, lay eggs and also mate multiple times. Adult Weevils allured to dying and damaged palm and also can Pounce undamaged host trees. Wireless Sensor Networks is used by G Narendra Kumar @et al. [1] to detect RPW, the weevil symptoms and larval entry into holes are usually difficult to recognize due to the entry sites may be shielded with offshoots and palm tree fibres. Diligent observation of infested palm tree can show holes in the trunk or crown perhaps along with chewed fibres and oozing brown liquid.

Fig.1 The cocon with Weevil Grub

The uninfected offshoots acoustic activity consists of different sounds: sharp sounds of quick click or lengthy continuous sounds similar to sound produced in crashing of paper. Before RPWs make up new direct of dispersal of pest, it is essence to find the infested trees to control and eradicate the pest. Unfortunately, larvae which are source of damage to palm tree live at the base of leaves and inside stems and major cause of destruction and visible methods are not enough to find the larvae since pest are exiting inside the palm trunk, so better option is detection using acoustic method. The presence of larvae cannot be finding from the sounds coming out from a tree but heavy infestations produce the sound because of the damage of palm tree already occurred. The noise detected is combination of the noise due to environmental conditions and sound produced by larvae chewing. Early stage detection of larvae in palm tree using sound processing tools and advanced sensors are established and transmitter is attached to the each sensor in the coconut plantation can avoid damage using wireless sensor networks.

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Fig.2 Weevil Damage to Coconut Trunk

II. EXISTING METHOD OF RPWs DETECTION

Method of speaker recognition to identify and classify insects automatically is attempted. However, in the palm agro system these methods were not found applicable. To record the sound from the palm some of the methods are using the microphone and Sound amplifiers for recording the RPW sound directly without atmospheric noise. Because of the heavy rustling noise of the tree this method are unable to implement practically in coconut plantation .Approach of Bucket trap technique were as well used to receive RPW, but this approach could only catch the RPW that are living on the palm offshoot but the larvae present inside the tree trunk cannot be detected. Chemical insecticides demonstrate to be ineffectual because of the insect enigmatic feeding habits inner part of the tree trunk. Similar way by using the dipole antenna with Microwave energy Irradiation of RPW larvae and adult attempted to eradicate the pest. The instrument used in the system is quite bulky for practical benefit. In this setup microwave power arriving the weevil larvae is small than the incident power this is caused due to the majority of the antenna power reflecting backward since dipole antenna used in this system is loaded into comparatively high absorbing material in its leading direction, in consequence totally change the radiation pattern of antenna. Another technique which comprises the sensors with communication module carrying a transceiver attached. Every access point obtains the information from the six palms in the locality in its radio range. The obtained information is send to server through secondary access point in which wire connected to server. The major server processes the obtained information to examine the current situation in the palm tree. At the central location collecting the data from the dedicated sensor from monitoring of the environment physical condition referred as Wireless sensor Network(WSN).

III. PROPOSED METHOD OF DETECTION OF THE RED PALM WEEVIL LARVAE USING WIRELESS SENSOR NETWORKS

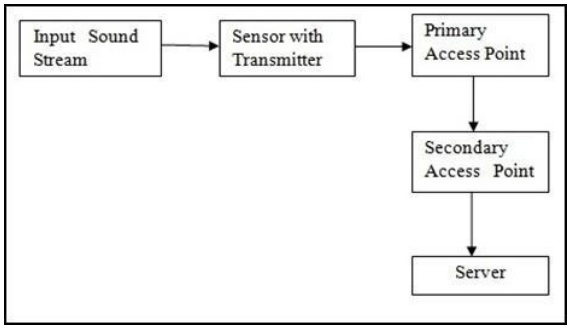

Fig.3 Block Diagram

The earlier method proposed by G Narendra Kumar @et al.[1] , Palm tree are attached with sensors containing the transceiver for communication to network of access points close by. Six palm tree is in the radio range vicinity of the access point, each get the signal from the palm tree. The information which is received in the access point is send to the server via the secondary access point. Current scenario analysis is in the main server on received information by the palm tree.The incoming sound signal is then converted into analogous electrical voltage/current by the microphone (transducer). The output from microphone is then amplified by the microphone pre-amplifier and then modulated by frequency (for longer distances trasmission). A power amplifier class C is used for amplification of the modulated signal and then this amplified signal is radiated via transmitting antenna by using the simplex mode of the transmission.

1) Microphone: Capsule or microphone element is the sensitive transducer portion. Radio transmitter is used in the wireless microphone which is being used in this setup. Transmission of audio signal as a radio rather than via a cable. Transmitter of FM radio is used to transmit to a nearby receiver to which sound system is connected, if the receiver and the transmitter is within the sight of each other then infra-red waves can also be used. In general response of the microphone which is Omni directional contemplated to perfect sphere for 3 dimensions. At high frequency the smallest diameter microphone gives the best Omni directional characteristics. Response of low-frequency can be very flat which is down to twenty hertz or below though pressure-sensitive. Microphones which are pressure-sensitive also respond much less to wind plosives and noise.

2) Pre amplifier: To process the microphone signal by other equipment a device used in the sound engineering is microphone pre-amplifier. Normally transmitted signal recording devices and modulators from the microphone is too weak. Pre amplifiers provides the stable gain which increase a microphone signal to line-level thus preventing distortion of the signal because of the induced noise The dynamic microphone's output voltage may be very low, typically in the zero to hundred micro volt range. A level is increased up to seventy db around zero to ten volts by the microphone pre-amplifier.

Microphone may be loaded to low impedance by preamplifier, which may change the output sound quality

3) Frequency Modulator: When the microphone is strike by the sound waves produce the varying current in the modulation process. Output of the microphone is then sending to modulator circuit in which carrier waves and audio are combined. By changing the frequency of the carrier wave modulation of the carrier the performed by the alternating current from the microphone in FM process.

In phase modulation, a varicap diode in Indirect FM to impose a phase shift in a tuned circuit that is fed with a plain carrier. FM Receiver is sufficient to understand the modulated signal from a phase-modulated stage but for better quality of audio, the audio signal is applied to the phase modulation stage. The deviation amount is referred by the modulation amount that the frequency of the carrier instantaneously deviates from the centre carrier frequency.

4) Power Amplifier: Most Efficient amplifier are class-C Amplifier Class-C amplifiers which is non-linear in nature. The non-AM modes such as RTTY, FM or CW can use this amplifier. The vacuum tube or semiconductor can only conducts for less than half the RF cycle. This amplifier can deliver more RF power than Class A or AB, since the increase in the efficiency. 5) Antenna: The FM band commonly uses antenna of type Folded dipole antenna. To comprise one entire wavelength antenna has to met the feed point which can be done by folding the antenna tip. Compare to the standard half-wave dipole this arrangement can achieve greater bandwidth. Input impedance is four times than the half-wave dipole if the conductor at resonance has a cross-section and constant radius.

In general as compare to whip antennas the dipoles are more efficient. The radiation resistance and total radiated power of the dipoles are two times t of the quarter-wave monopole.

6) Radio repeater

To receive the signal from the radio transmitter of low-level or weak signal and to retransmit it of higher power or at higher level as to cover longer distance without degradation is termed as Radio repeater. In general basic repeater has same radio band in which one frequency for the FM receiver and other frequency for FM, so that transmitter rebroadcast the signal when the receiver pick up the transmitted signal.

In the modified process recorded sound stream is fed to the MFCC block for feature extraction and Neural Network model is used to decide which tree is infected. Frequency on Mel scale of nonlinear on spectrum of log power of cosine transformation based on linear for sound of short term power spectrum is termed as Mel scale cepstrum. Feature extraction uses MFCC. By using Mel scale for Coding of Mel frequency cepstrum is most often used method of feature extraction in frequency domain. Recognition performance enhancement is done using the neural network model. For the algorithm model neural network with back propagation with feed forward is used. If the tree is found affected message is sent to the farmer which tree is being infected used with Bluetooth technology.

IV. PROCESS

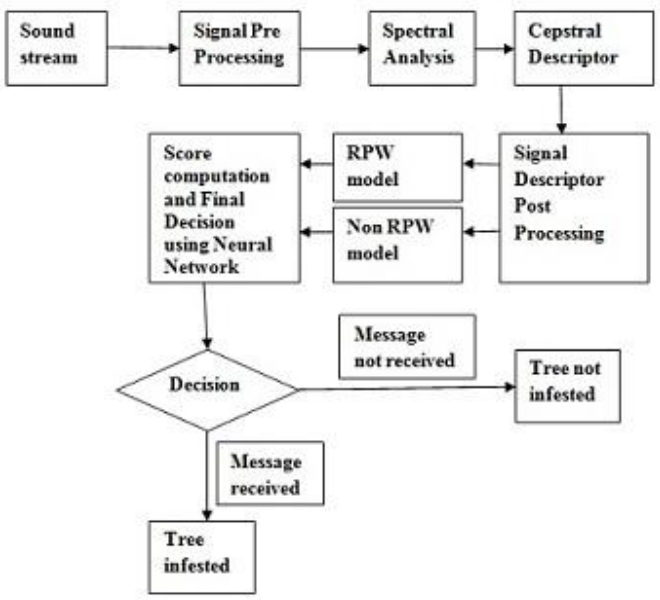

Fig.4 Flowchart

In the earlier work by G Narendra Kumar @et al. [1], the sensor is attached to each palm tree. The tree receives the sound signal through microphone termed as node. Amplification of the signal without filtering using the simple electronics device is performed as first step in the recording process. The main server receives sound signals are continuously transmitted to the closest access point. For sound fundamental calculation MATLAB program are used on the recorded sound. For the pass band of the Band pass filter sound signal's range of two hundred to three hundred hertz of fundamental Frequency is considered. Low Noise amplifier is used for the sound amplification. The received sound signal is passed to the Band Pass filter and then transmitted signal is the output of Band Pass filter, consists of only clicks via speaker. If the clicks signals are heard, then palm tree can be considered as infested, else the tree is not infested.

The above mentioned procedure is applicable for each tree which is in the plantation.

A. Decimation

The process of reducing the number of samples in discrete-time domain is termed as Decimation. The process has two strep: Down sampling and Filtering process using Low-pass anti-aliasing filters.

The recorded sound frequency without sampling rate changes can be down sampled by eliminating every other sample. This result in the aliasing if the sound signal contains of overtones of which frequency can exceed half of the sampling rate. Decimation aliasing will be avoided with elimination of those overtones which has a low pass frequency later prior to down sampling.

The pass band frequency in the recorded sound of the Red Palm weevil is in the range of two hundred to three hundred hertz and sampling frequency of 11025Hz is sufficient. Therefore, recorded sound can be down sampled to required frequency by any factor and hence it does not require the anti- aliasing filter.

The original sound signal and the decimated signal Fig 5 and Fig 6.

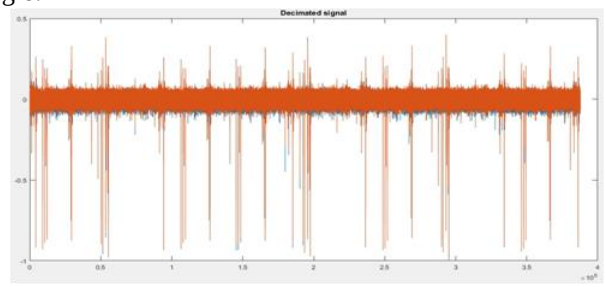

Fig.5 before Decimation

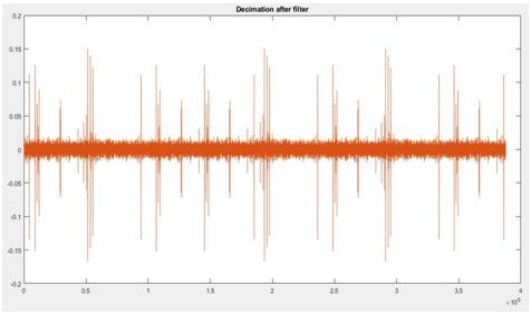

Fig.6 after Decimation

B. Filter Design

In the pass band of flat frequency a Butterworth IIR filter is used. The Butterworth filter of order N is an ideal filter approximation, in which first 2N -1 derivatives of its magnitude squared is zero. Due to which filter frequency response decreases monotonically with increasing frequency. In pass band of the response decrease is slow but in the stop band it is very quick. If the design of no ripple acceptance in stop band and pass band, better choice is Butterworth filter.

C. Filtering

The received sound consists of the surrounding noise because of the weather disturbances and environmental noise of the palm trees using the acoustic sensors. These recorded signals are consider of vast range of frequencies. To retain sound of the RPW larvae and eliminate all other frequencies an efficient band pass filter is designed. For the sound of RPW larvae fundamental frequency uses design of the band pass filter. The RPW larvae sound is obtained then import to determine the fundamental frequency of larvae using the MATLAB program."United States Department of Agriculture - Agricultural Research Service (USDA-ARS)" website sample of the RPW larvae sounds are obtained. By using the method of trial and error the fundamental frequency of the RPW larvae is found to be in the range of 200-300Hz. The Band pass filter of pass band 200-300Hz.The first stop band frequency is given as 150Hz and the second stop band frequency is given as 350Hz.

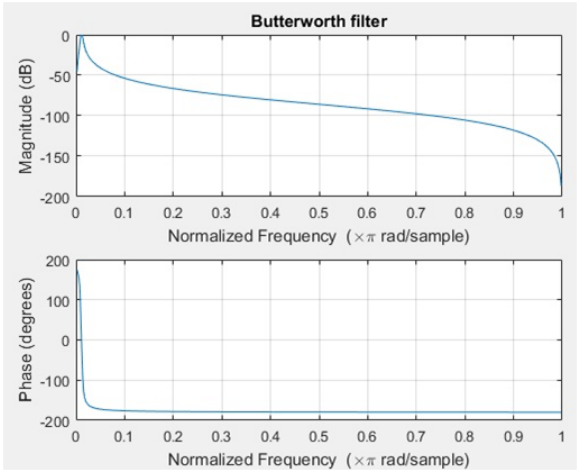

Fig.7 Magnitude and Phase Response in Butterworth Filter

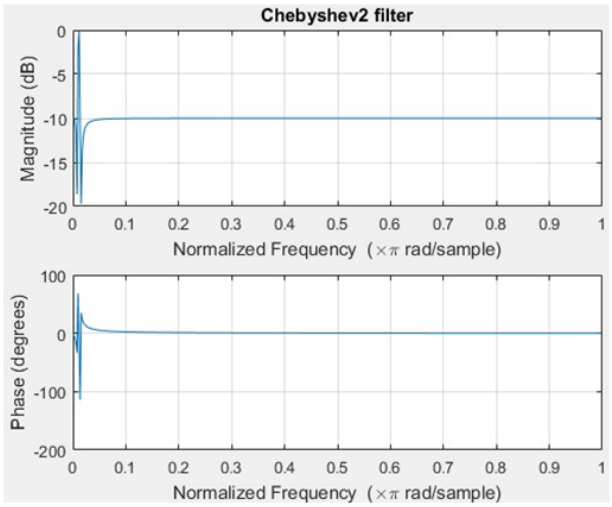

Fig.8 Magnitudes and Phase Response in Chebyshev Filter

In the modified process the sensor is attached to each palm tree. The tree receives the sound signal through microphone termed as node. Amplification of the signal without filtering using the simple electronics device is performed as first step in the recording process. The main server receives sound signals is continuously transmitted tree to the closest access point. The recorded sound signals are continuously transmitted to the nearest access point (Repeater),and same sound signal is received by the 3 closest adjacent primary access point, therefore signals from the all access points is ANDed to detect which tree is infested, fed to the MFCC block for feature extraction and Neural Network model is used to decide which tree is infected. Frequency on Mel scale of nonlinear on spectrum of log power of cosine transformation based on linear for sound of short term power spectrum is termed as Mel scale cepstrum. Feature extraction uses MFCC By using Mel scale for Coding of Mel frequency cepstrum is most often used method of feature extraction in frequency domain. Recognition performance enhancement is done using the neural network model.

For the algorithm model neural network with back propagation with feed forward is used confirms the targeted tree and message is sent to the farmer regarding tree being infected through Bluetooth technology.

A. Neural Network and Mel Frequency Cepstral Coefficient

The process of extracting the small amount of data from the signal which is then used to represent the signal is termed as Feature extraction. The process of Feature matching consists of the identifying unknown sound by comparing extracted features from input with the ones from a set of known signal. The system overview of feature extraction is

A. Sound Database

Creating the database of sound containing digitized sound recordings from the different RPW infested trees and the non RPW sound that is required is first step in the process.

B. Mel Frequency Coefficient Characteristics

Frequency on Mel scale of nonlinear on spectrum of log power of cosine transformation based on linear for sound of short term power spectrum is termed as Mel scale cepstrum. By using the MFCC matrices obtained training matrices for each of the signals were later formed. MFCC were introduced as a compact perceptually based representation of sound frames.

C .Materials and Methods

For the next step the input signal is trained and passed process further in the feature extraction. Computation of the Mel spectrum is the next step in the process. The MATLAB is used for the computation. MATLAB is an integrated technical computing environment which combines advanced graphics, visualization numeric computation, and a high level program language.

The feature extraction by using MATLAB

- Fourier transform of the signal.
- Map spectrum powers, obtained result into the Mel scale with triangular overlapping of windows.
- Log of power in every Mel frequency.
- Just as signal on DCT of Mel log power.
- On the resulting spectrum on amplitude the MFCC's are obtained.

MFCC for feature extraction is explained as follow.

Pre-emphasis: In this first step, pre-emphasis of the signal spectrum is performed and then DC offset is detached, digital system of low order (commonly filter type is FIR of first order) applied to digitized speech signal x(n) to flatten the signal spectrally to make it less prone to find precision effects in signal processing.

In the modern system pre-emphasis has moderate affect, mainly due to almost all motivations for pre-emphasis filter can also be achieved by using mean normalization.

A. Framing

The N number of frames can obtained by separating the frames of M<N from the input .The N samples in The 1st frame. The 2nd frames start with M samples following the first frame and overlaps it with N-M samples. This process pursue until all samples put up in one or more number of frames. Generally values of M and N are N=256.Depends on the sampling frequency to construct frame.

After pre-emphasis, the signal has split into frames of short time.

B. Windowing

Windowing is applied on the frames which are obtained in the framing process. To window each and every individual frame can reduce signal discontinuities frames beginning and end of the each frame. The spectral distortion can be minimized to decrease signal into zero.

After dividing the signal into the frames, window function is applied such as the Hamming window to each frame.

C. Fast Fourier Transform – FFT

FFT is used to convert the n samples of each frame from the time domain to the frequency domain in consecutive processing step. Frequency spectrum can calculated by applying the N-point FFT on each point.

Filter Banks

To extract the frequency band in the power spectrum on the Mel-scale ,the computing filter banks is applying triangular filters, generally 30 filters, n filter = 30. In Mel-scale signal in lower frequencies with more discriminative and also higher frequencies with less discriminative is focus to duplicate the non-linear human ear perception of the sound can convert between Hertz (f) and Mel (m).Reponses of Every filter of the filter bank is 1 which is triangular at the center frequency and also decrease linearly so as to near zero until it reaches the center frequencies of the two adjacent filters.

Neutral Network

Artificial Neural Network (ANN) is used for classification of infested and non-infested class .By using back propagation (BP) algorithm the neural networks (NN) are trained in supervised manner. On the basis of test procedure the network is trained and new data is classified with much variation. Neural Network, consist of the nodes which are inter connected is organized in layers. For the neural network as data set different samples from the Feature vectors are used. Three data sets can be obtained from the feature vector data set. These are testing data set and validation data set training data set. According to the requirement the weights are adjusted. The result is displayed on output layer is linked with hidden layer IS.

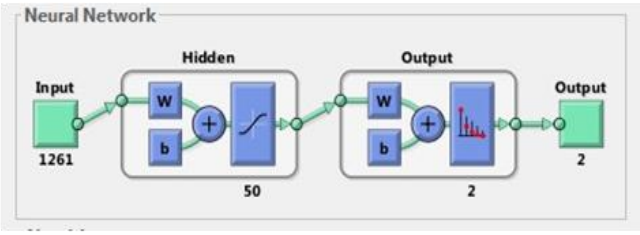

Fig.9 Neural Network

V. WIRELESS SENSOR NETWORK

In the networking research commonly used simulator of discrete event is Network Simulator-2(NS-2). Network Simulators support substantially for TCP simulation, routing, and multi cast protocols over wireless (satellite and local) and wired networks.

Network Simulator-2 is developed using the C++, provides simulation interface via OT cl, an object-oriented dialect of Tcl. Network Simulator- 2 stimulate the network topology of specified parameter which is described by writing OTcl scripts.

A Experimental Scenario

***1. Basic Model Configuration*:** In the earlier work, G Narendra Kumar @et al.[1] , palm tree of the form nodes are arranged in star Topology. To the single hub node (Access Point)in the network all nodes are connected. The hub requires routing, decision-making, and message handling capabilities compared to the other nodes in the network. In situation of disconnection of communication link, it can only affect one node and if the hub incapacitated the network is destroyed.

In the modified work, the nodes are positioned for palm trees in the hexagonal pattern, Fig.10 .Six trees are connected to a single hub node (Primary Access Point). Each tree send signal to 3 closest access point. In occurrence of disconnection of a communication link , it can only affects one node and during one Primary Access Point is incapacitated the network still work since it gets signal from remaining two Access Points.

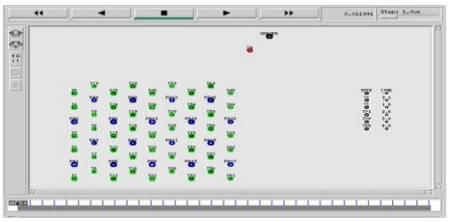

Fig.10 Topology of Wireless Network

2. Experimental Analysis and Results: A TCL program is used for simulation of the wireless network scenario in Network Simulator-2.The parameters related to wireless simulation defined as follows:, Radio-propagation model-Two Ray Ground, MAC type-Mac/802 11 ,Channel Type-Wireless, Network interface type-Wireless Phy, Link layer type-LL , Interface queue type-Queue/DropTail/PriQueue, Antenna model-Antenna/OmniAntenna, Max packet in ifq-50, Number of mobilenodes-75 and Routing protocol-AODV.

Signals from the node(nodes T1 to T45) is send to the nodes named as Primary Access point (nodes PA0 to PA18) positioned at the centre of the hexagonal pattern, then transmitted to the Secondary Access point (node 74) and received at the Server (node 75) Fig. 11 and Fig. 12.

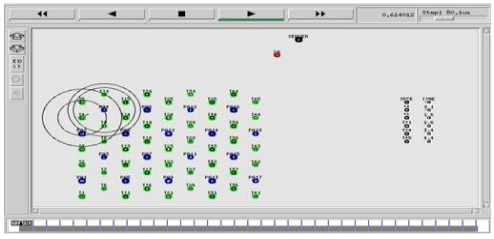

Fig.11 Transmission of Signal from Node to primary Access Point

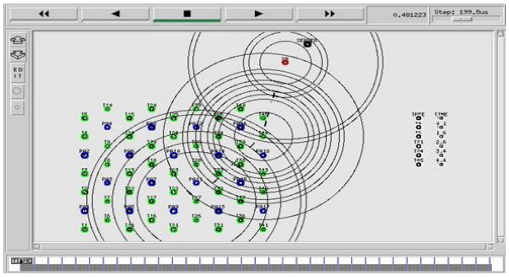

Fig.12 Transmission of Signal from Primary to Secondary Access Point

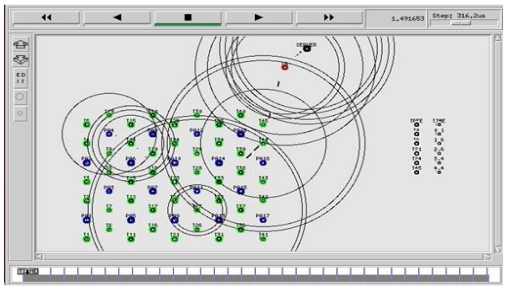

Fig.13 Signal Transmission from Secondary Access Point to Server

Signal is send from T4 which may be infested by RPW send to the nearest Access point PA4, Fig. 20. Signal received at PA4 is send to the Secondary Access (SA) and forwarded to the Server, Fig. 13.

VI. RESULT ANALYSIS

As a result of experiment carried out by using MATLAB. MFCC coefficients are extracted as features from 637 RPW Signals and 234 Non RPW Signals. A database is formed for 10 audio in which 7 are RPW signal and 3 are non RPW signal by using extracted MFCC coefficients. The database can be divided into two categories which is corresponding to the data positive and negative. MATLAB on recognition tool of neural network pattern is used in the categorization of obtained MFCC pattern..

The diagonal of matrix gives the correct categorization sufficient for the recognition of true data which is in the form of a category. During the signal is infected message will send to Android is implemented through Bluetooth technology using Arduino Microcontroller

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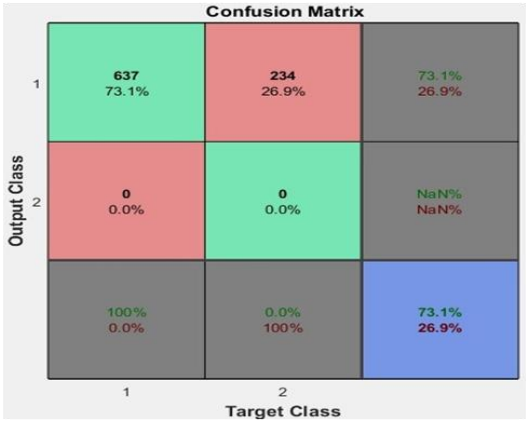

Fig.14 Confusion Matrix of Neural Network

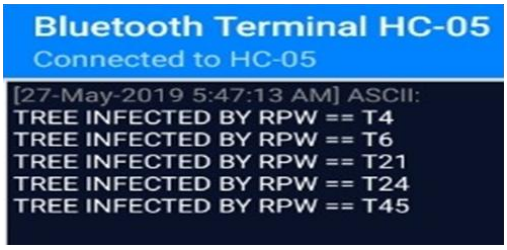

Fig.15 Display of Message on Bluetooth Terminal

VII. CONCLUSION

Acoustic instruments, wireless sensor networks and signal processing tool for earlier detection of Red Palm weevil larvae using can put stop to destruction of palm tree plantations. The sharp bang sounds produced by the weevil are obtained using the band pass filter from the recorded sounds. For efficient detection of infestation in any part of the tree network of sensor for every tree of 45 is set up at different height. wireless sensors is used to capture the sounds of weevil in noisy environment so helps in the larvae(grubs) detection therefore controlling to prevent the life cycle before cocoon of RPW is formed. This is relatively more efficient than earlier works which are being followed.

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