User Friendly Acoustic System For Detection Of coconut Palms Infested By Rynchophorus Ferrugineus

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Declaration

We declare that this thesis is our own work and has not been submitted in any form for another degree or diploma at any university or other institution of tertiary education. Information derived from the published or unpublished work of others has been acknowledged in the text and a list of references is given.

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Date:

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Abstract

Android Mobile Application have been developed and used to detect insects in concealed habitats. The larvae of red palm weevil, Rynchophorus ferrugineus (Olivier), a serious pest of the coconut palm, Cocos nucifera L. feed on the soft tissues inside the stem and bud region. Detection of infested coconut palms in the early stages by the conventional method of checking for external symptoms is time consuming, labour intensive and costly. This paper describes the development of Android Mobile Application and its potential in detection of infested palms in the field. The device comprises a sensor to mount on the Stem of the palm tree and to acquire the sounds of red palm weevil larvae, Android Application that processes the acquired sounds and automatically detect detected RPW and send a notification for its users. Many difficulties encountered with conventional methods could be overcome by the use of this Android Application.

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Chapter1

Introduction

1.1 Background and Motivation

Red palm weevil ,Rynchophorus ferrugineus Olivier is a widespread pest of palms in Sri Lanka (Figure 1.1), it is the most serious pest causing fatal damage to young coconut palms of 3–10 years of age [1].young coconut palms in the country are lost due to its attack . Female Red Palm Weevils bore into a palm tree to form a whole (fresh wounds of palms) into which they lay eggs. Each female may lay an average of 250 eggs which take about three days to hatch [2] . Figure 1.3 Life cycle Red Palm Weevil .Larvae emerge and tunnel toward the interior of the palm, inhibiting the palms ability to transport water and nutrients upward to the crown . RPW larvae (figure 1.1) bore deep into palm crowns, trunks and offshoots, burrow into and feed on the soft tissues causing their destruction and leading to obstruction of water and nutrient flow. Generally they concealed from visual. Often, the symptoms become obvious in the advanced stage of infestation, when the leaves become yellowed and bud withers, damage from which the palm cannot recover. Nevertheless, one or few symptoms such as small holes on the stem, protrusion of chewed up fibers from the holes, oozing out of a brownish liquid and presence of cocoons on the leaf axils or near the base of the palm may be noted at the moderate stage, if careful examination is made by an experienced person. Careful inspection of infested palms may show holes in the crown or trunk possibly along with oozing brown liquid and chewed fibers. But, if the infestation is at the crown region none of the above symptoms may be visible before the palm is killed. Due to severe shortage of labour to carry out routine inspections on each and every individual palm and the time consuming nature of this practice, implementation of control methods are not being carried out at all or are delayed. The detection of infestations at an early stage is important to save the palms with less damage. When consider about coconut trade in Sri Lanka most of the time more contribution acquire from medium scale coconut land owners.

When the larvae are present in the palm they produce sounds, which are due to chewing of palm tissue, crawling, emission and quick oscillation [2]. If a considerable number of larvae are present these sounds can be heard by placing the ear on the stem of the palm. However, at this stage palm may be moderately to extensively damaged. Hence, detection of infestations at an early stage is important to save the palms with less damage.

Attempts have been made to automatically identify and classify singing insects based on a speaker recognition paradigm [2]. The sensitive automatic detection systems utilized state-of-the-art speaker recognition methods. However, they were not found applicable to the palm agro system. Some methods used microphone and sound amplifiers for the recording the sound of the RPW directly without any atmospheric noise which used an isolated atmosphere to record the sound from the palm [2]. However this method cannot be practically implemented in coconut farms because of the heavy rustling noises of the trees. Bucket trap methods were also used to capture RPW, but this system could only capture the RPW which live on the offshoot of the palms but the larvae which are present inside the tree trunk could not be detected [3].

Chemical insecticides proved to be inefficient due to the cryptic feeding habits of this insect inside the palm tree trunk [4]. Another method of eradicating red palm weevil is Microwave Irradiation. It uses microwave energy for irradiation of RPW adults and larvae using dipole antenna. This apparatus is quite bulky or practical purposes. The dipole antenna in this setup is loaded to a relatively high absorbing material (tree trunk) in its forward direction, thus totally altering the radiation pattern of the antenna, with the majority of the antenna power ref ecting backward. Thus, the microwavePower reaching the weevil larvae through the tree trunk is very small compared to the incident power.

Figure 1. 1Weevil Grub inside the Cocoon

Proposed User friendly System for detection of coconut palms infested by *Rynchophorus ferrugineus*.it is based on GPS, Acoustic and AI technologys . System software automatically plots real time location information on digitized map of the Land.

Acoustic methods have been developed and used to detect insects in concealed habitats . Utilization of sound methodology to detect red palm weevil infested date palms has been attempted. If the infestations havehappen the system will indicate which stage the infestation and it will be recorded for future references. In this system main advantage is without any trained person system will indicate the detection of infestations.

Figure 1.2 Red Palm Weevil(Rhynchophorus ferrugineus Olivier)

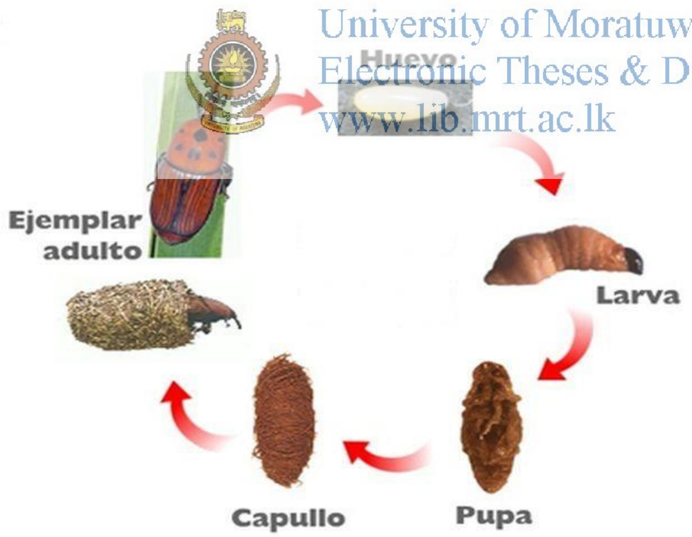

Figure 1.3 Life cycle Red Palm Weevil

Figure 1.4: Life Phoenix canariensis destroyed by Rhynchophorus ferrugineus

Figure 1.5 Life Phoenix canariensis destroyed by Rhynchophorus ferrugineus

1.2 Aim and objectives

1.2.1 Aim

The aim of this project is to development of Portable acoustic System for automatically early detection of coconut palms infested by Rynchophorus ferrugineus and develop an information system for data gathering .

1.2.2 Objectives

01. Study on the problem domain, to propose a solution based on sensor with Android based application for more efficiently user friendly manner.
02. To Study on sound processing technics, speaker recognition technics "Global Positioning System" (GPS), Electronic Technology, Android technology support to the implementation of it.
03. Design and Develop a User friendly Acoustic System for incorporating above technologies.
04. Evaluate the System
05. Prepare the final Report with evaluation results.

1.3 Purpose of the document

This Dissertation mainly show the achievement at various milestones of a project. This document is the most important deliverable of this project. Dissertation is the most tangible product of a research. This document contain full picture of this project, others work and the progress of them so far in the Literature review, System design Chapters. The various technologies and methodologies used are described in the technologies adapted chapter. Furthermore, the document provides a list of references, and gives an overview of our findings and a brief description of the implementation of the tool using appropriate diagrams in the Implementation chapter. How the system works include in this chapter .Evaluation chapter contain how does evaluate the solution to see whether objectives have been achieved. Conclusion & Further work chapter conclude the overall achievements quantitatively in the first place. After that this chapter state about the achievement of each objective. Also mention about problem encountered, limitations of your solution, and some further work.

1.4 Summary

This chapter consists of the following parts. The introduction part contain introduction of the project and background and motivation to it which shows the importance of the problem with the support from high potential of the subject area are described first. Then the aim and objectives of the project are under a separate heading and in the last section, briefly stated are the work outputs and the structure of the report. The next chapter will be discussing the various other approaches followed by other parties on similar topics.

Chapter 2

Literature Survey

2.1 Introduction

The preceding chapter described background information related to the project including the aim and objectives and the structure of this report. This chapter will discuss about some of the completed research work on the field of study and some tools developed by various parties being an active.

2.2 EXISTING METHODS OF RPWS DETECTION

2.2.1 Automatic acoustic detection of the red palm weevil using speaker recognition

Acoustic signals of boring RPW larvae can be recorded from the infested palms using off-the-shelf recording devices, but the resolution of the signals emitted by healthy palms is often difficult to discriminate. This system was to develop a mathematical method to automatically detect acoustic activity of RPW in offshoots and implement it in a prototype setup. The methodology applied was similar to techniques used in the field of speech recognition, utilizing Vector quantization (VQ) or Gaussian mixture modeling (GMM) [2]. The sensitive automatic detection systems utilized state-of-the-art speaker recognition methods. However, they were not found applicable to the palm agro system. Some methods used microphone and sound amplifiers for the recording the sound of the RPW directly without any atmospheric noise which used an isolated atmosphere to record the sound from the palm [2] . However this method cannot be practically implemented in coconut farms because of the heavy rustling noises of the trees and this system connect with desktop computer so this CPU or laptop unit is not portable devise . prototype that could detect larvae of red palm weevil in offshoots of date palms, which could be used in inspection of horticultural and ornamental palms traded between countries, but this device is not portable, hence it could not be used in field inspections.This system was not implemented for hand hell devises eg smart phones . This system use only for detection of red palm weevil this system not maintain information system and these information's are not stored database for future usage . Figure 2.1 show prototype of this system bellow .

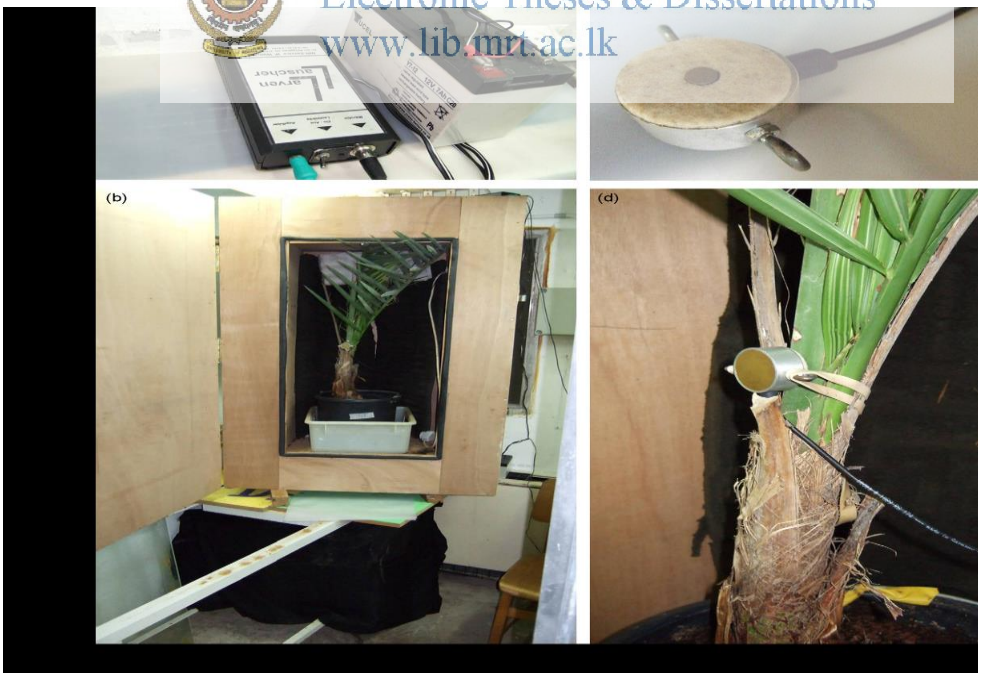

Figure 2.1(a) Amplifier and a 12V, 7Ah battery. (b) An offshoot inside the sound isolated box. (c) Piezoelectric microphone. (d)Microphone attached to offshoot's stem with a rubber band [5]

2.2.2 Portable acoustic device for detection of coconut palms infested by Rynchophorus ferrugineus (Coleoptera: Curculionidae)

Acoustic methods have been developed and used to detect insects in concealed habitats. The device comprises a sensor to mount on the palm and to acquire the sounds of red palm weevil larvae, an electronic unit that processes the acquired sounds and a set of headphones to receive the output sound by the listener [6]. This methods used microphone based sensor and sound amplifiers for the system .Amplified sound to receive the output sound by the listener. But existing system there are so many drawbacks of this system. It is an acoustic device essentially consisted of a sensor to acquire the sound signals from an infested palm, a signal processing unit to capture and amplify the sound acquired by the sensor while filtering out the environment noise signals and an output device that allowed the user to determine whether the palm was infested or not. It is the main drawback of this system without trained person unable to justify the detection of infestations. This system is not a Automatic the red palm weevil detection system .This system is not maintain information system for future prediction of RPW prevention systems. Figure 2.2 show this devise

Figure 2.2 The acoustic device comprising the sensor, main unit and the set of headphones [6].

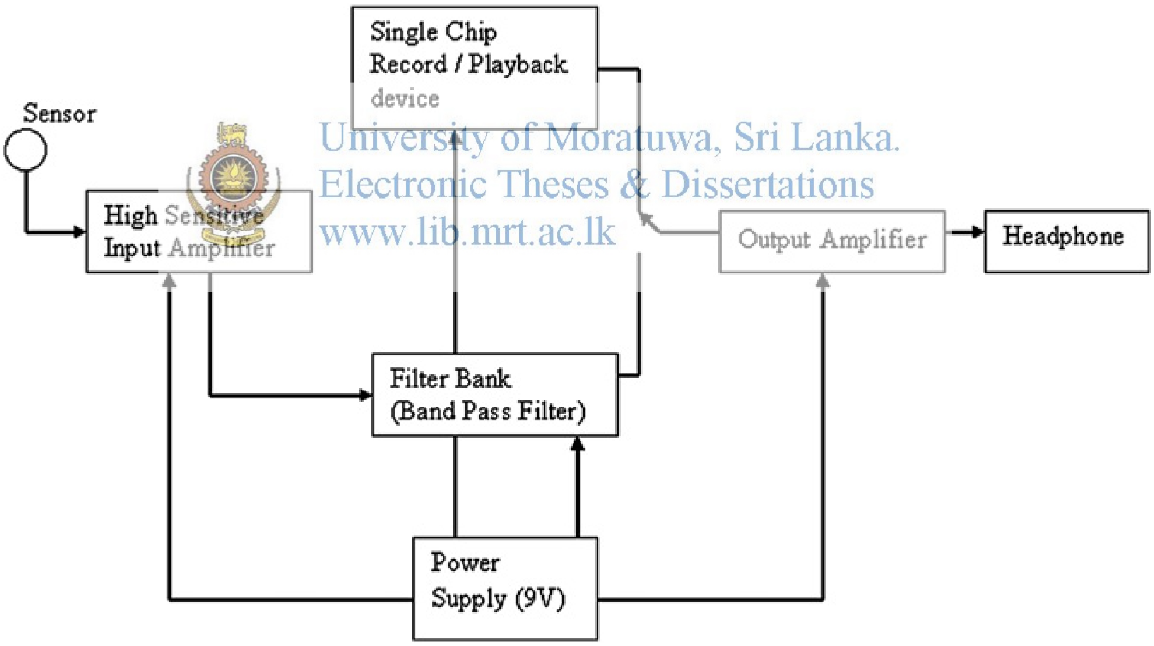

Figure 2. 3Functional block diagram of the Acoustic device [6]

2.2.3 Red palm weevil pheromone trap

Pheromone trapTaking advantage of the adult weevils attraction to the fermenting liquids especially sap from the palm, a poisonous broth was used to bait and kill the weevils the past. This techniques was continuously refined and sugarcane baited traps were successfully used for collection of weevils for a long time but this system could only capture the RPW which live on the offshoot of the palms but the *larvae* which are present inside the tree trunk could not be detected [3].fig 2.4 show this trap.

Figure 2. 4 Red palm weevil pheromone trap

2.2.4 Microwave Irradiation

Another method of eradicating red palm weevil is Microwave Irradiation. It uses microwave energy for irradiation of RPW adults and *larvae* using dipole antenna. This apparatus is quite bulky or practical purposes. The dipole antenna in this setup is loaded to a relatively high absorbing material (tree trunk) in its forward direction, thus totally altering the radiation pattern of the antenna, with the majority of the antenna power ref ecting backward. Thus, the microwave power reaching the weevil *larvae* through the tree trunk is very small compared to the incident power. This system is not portable and it is not user friendly system.

2.2.5 Protection of Palms from RPW Larvae using Wireless Sensor Networks

Red Palm Weevil (Rhynchophorus ferrugineus) is one of the most serious pests of coconut (Cocos nucifera L.) palms. It is known to attack 20 palm species worldwide. Due to the concealed nature of feeding RPW, infestation is detected during the last stages and farmers become aware of the problem only when the tree is about to die. The acoustic activity of RPW larvae (inside an offshoot and base of leaves) consists of chewing, crawling, emission and quick oscillating sounds. In this system, acoustic techniques are used to detect hidden larvae infestations of coconut palm trees in the early stages that are recorded using wireless sensor network establishing ad-hoc network. The fundamental frequency of the acoustic activity generated by the RPW larvae also contains environmental noise which is captured by the wireless sensors (nodes) fixed to the palms and transmitted to the server through access points covering number of palms arranged in the form of hexagon for processing using MatLab tools. This method is in expensive when compared to the existing methods for the detection of RPW larvae.

However this method cannot be practically implemented in coconut farms because of the heavy rustling noises of the trees and difficult to give electric power to those access points, FM radio receives and the FM radio transmitters .some time rain, thundering like environmental disturbance happen so these system are crashes .In Sri Lanka FM radio frequencies unable to use without get permission from government and sometimes these frequencies crash with FM radio channels .

2.3 Summary

This chapter described about various approaches other people have tried and. It includes the details of these different approaches and what technologies they used in achieving their goals. This chapter also summarizes the weaknesses and incompleteness's of the approaches considered above. In the next chapter the adopted technologies will be taken in to consideration.

Chapter 3

Technologies Required For Implementation

3.1 Introduction

The previous chapter explained about various other Acoustic System for detection of coconut palms infested by Rynchophorus ferrugineus. This chapter will discuss about the technologies that will be involved in the research and implementation phase of the project. This section will first discuss the technologies required for the website, web service and database. Discussion on the technical requirements for the Android application development will then follow, finishing with the supporting technologies and software needed for design, organization and quality assurance.

3.2 Web Service – PHP, JSON

Due to the restrictions on direct access to the database from the Android device for security reasons, a service layer has to be created on the web server to collect and serve data the required data. This service needs to be responsible for Store GPS locations on the Database.

PHP is the server side script of choice, as it has pre built functions for database queries. In order to store client information , data needs to be received by the service, which will utilise HTTP POST from the android application to pass the parameters.

The PHP service will then be able to access the database and create results to be passed back to the device, such as a result code to signify the user has successfully logged in. As PHP is server side, it means that the username and password for the database can be hidden within the code and never sent to the clients machine, however it does have some security issues which unless considered may allow a user to run malicious scripts on the web server or attack the database. For that reason security needs to be a concern when working with the input parameters, which should be stripped of any special characters such as apostrophes or slashes .PHP required for retrieve Location information from the google api.

The JSON data format is well suited to the mobile environment (Riva & Laitkorpi, 2009). These can be sorted when called in the database query using SORT. PHP has a tool for creating JSONs (Javascript Object Notation) which can be parsed by the java JSON library (org.json).

3.3 Database – MYSQL

MySQL is the world's most popular open source database. With its proven performance, reliability and ease-of-use, MySQL has become the leading database choice for web-based applications, used by high profile web properties including Facebook, Twitter, YouTube, Yahoo! and many more.

A simple MYSQL database is required to store Location information, Date and GPS data. The database does not require any table relationships, but simply one table holding the aforementioned data.

Field	Type	Null ?
ID	Int(11)	No
Name	Varchar(60)	Yes
Address	Varchar(80)	Yes
lat	Float(10,6)	NO
long	Float(10,6)	NO
type	varchar(30)latin1_swedish_ci	Yes
Date	date	Yes
EmiID	Varcha(30)	No

Figure 3. 1 Database Location Table

3.4 Android SQLite database

Simple SQLite database require for temporally application data storing purpose. Because each and every time Application unable to access the hosted database so at that movement these information stored in client side database so we use for SQLite database for it.

SQLite is an Open Source database. SQLite supports standard relational database features like SQL syntax, transactions and prepared statements. The database requires limited memory at runtime (approx. 250 KByte) which makes it a good candidate from being embedded into other runtimes.

SQLite supports the data types TEXT (similar to String in Java), INTEGER (similar to long in Java) and REAL (similar to double in Java). All other types must be converted into one of these fields before getting saved in the database. SQLite itself does not validate if the types written to the columns are actually of the defined type, e.g. you can write an integer into a string column and vice versa.

3.5 Android Application – Eclipse, Android SDK, Logcat, DDMS

These software packages are chosen for the development environment. Eclipse is used as it is recommended by the official Android Application development , and as the Android plugins are available for eclipse simplify building and running for the Android emulators..

System messages from the Android device or emulator are important for debugging. The logcat details from the device/emulator shows information about the phone state, details, and every user interaction, along a stack trace of any uncaught exceptions. This tool also allows a filter, to show only messages from the Spindroid application as messages from other services can cause unnecessary noise making the log difficult to analyze.

DDMS is a tool which comes with Android, called the Dalvik Debug Monitor Server (Android, 2012). It provides useful tools such as screen capture, thread and heap information. It can be used for incoming call and SMS spoofing and has a plug in for eclipse which makes it easy to access from within the IDE. It is an aid to debugging throughout development process, looking into the memory usage and finding any possible leaks. It also helps to create screenshots which need to be posted on the android market when marketing the application. A typical DDMS debugging screen can be seen in the appendix, figure 3.2.4 A. These are all features of the Android SDK to help with development.

3.6 Sensor

The sensor used to collect sound recordings from the trees was difficult to mount on the stem. Therefore, Sensor wants to create for this research because other sensors are not sensitive for Android phones.

3.7 Android (operating system)

Android is a mobile operating system (OS) based on the Linux kernel and currently developed by Google. With a user interface based on direct manipulation, Android is designed primarily for touchscreen mobile devices such as smartphones and tablet computers, with specialized user interfaces for televisions (Android TV), cars (Android Auto), and wrist watches (Android Wear). The OS uses touch inputs that loosely correspond to real-world actions, like swiping, tapping, pinching, and reverse pinching to manipulate on-screen objects, and a virtual keyboard. Despite being primarily designed for touchscreen input, it also has been used in game consoles, digital cameras, and other electronics.

3.8 GPS technology

This GPS technology used for Rhynchophorus Larval detected palm tree GPS Based location details retrieving pupas So using the GPS technology access the GPS devise of the mobile phone and retrieve those parameters.

The Global Positioning System (GPS) is a space-based satellite navigation system that provides location and time information in all weather conditions, anywhere on or near the Earth where there is an unobstructed line of sight to four or more GPS satellites.The system provides critical capabilities to military, civil and commercial users around the world. It is maintained by the United States government and is freely accessible to anyone with a GPS receiver

The GPS project was developed in 1973 to overcome the limitations of previous navigation systems, integrating ideas from several predecessors, including a number of classified engineering design studies from the 1960s. GPS was created and realized by the U.S. Department of Defense (DoD) and was originally run with 24 satellites. It became fully operational in 1995. Bradford Parkinson, Roger L. Easton, and Ivan A. Getting are credited with inventing it.

Advances in technology and new demands on the existing system have now led to efforts to modernize the GPS system and implement the next generation of GPS III satellites and Next Generation Operational Control System (OCX). Announcements from Vice President Al Gore and the White House in 1998 initiated these changes. In 2000, the U.S. Congress authorized the modernization effort, GPS III.

In addition to GPS, other systems are in use or under development. The Russian Global Navigation Satellite System (GLONASS) was developed contemporaneously with GPS, but suffered from incomplete coverage of the globe until the mid-2000s. There are also the planned European Union Galileo positioning system, India's Indian Regional Navigation Satellite System, and the Chinese Beidou Navigation Satellite System.

3.9 Audio Processing Technologies and Analysis Tools

3.9.1 Audacity (audio editor)

In this project Audacity used for Rhynchophorus Larval audio bandwidth, aptitude and frequency analysis purposes .It help to audio visualization purpose (Figure 3.2). Audacity is a free open source digital audio editor and recording computer software application, available for Windows, OS X, Linux and other operating systems.Audacity was started in the fall of 1999 by Dominic Mazzoni and Roger Dannenberg at Carnegie Mellon University and was released on May 28, 2000 as version 0.8.As of 10 October 2011, it was the 11th most popular download from SourceForge, with 76.5 million downloads.[8] Audacity won the SourceForge 2007 and 2009 Community Choice Award for Best Project for Multimedia.

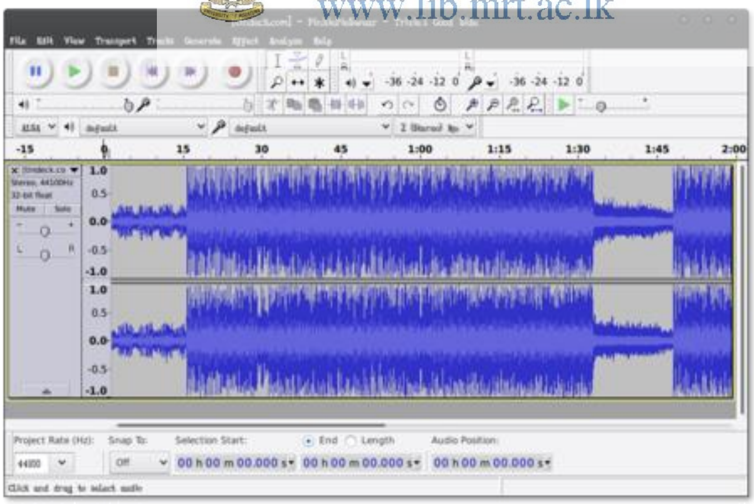

Figure 3.2 Audacity (audio editor)

3.9.2 Sonic Visualiser

This is a another tool for that use for audio processing purpose .Sonic Visualiser is an application for inspecting and analyzing the contents of music audio files. It combines powerful waveform and spectral visualization tools with automated feature extraction plugins and annotation capabilities.

3.10 Speaker recognition Technology

This Rfw Application used some of those speaker recondition algorithms for Rhynchophorus Larval sound clearly identification .in this Application used FFT Algorithum algorithms for it.In this chapter bellow discuss about those technology's .

3.10.1 FFT (Fast Fourier Transform)

"Fourier Transform" is a process that takes in samples of data, and outputs its frequency content. Its general application can be summarized as follows.

- Take in an audio signal and find its frequency content
- Take in an image data and find its spatial frequency content

The output of the Fourier Transform contains all of its input. A process known as the Inverse Fourier Transform can be used to retrieve the original signal.

The Fourier Transform is a process commonly used in many fields. Many programs use this procedure which is required for an equalizer, filter, compressor, etc.The mathematical formula for the Fourier Transform process is shown below

$$X(\omega) = \int_{-\infty}^{\infty} x(t) \exp(-i\omega t) dt$$

The "i" is an imaginary number, and ω is the frequency in radians.

As you can see from its definition, the Fourier Transform operates on continuous data. However, continuous data means it contains infinite number of points with infinite precision. For this processing to be practical, it must be able to process a data set that contains a finite number of elements. Therefore, a process known as the Discrete Fourier Transform (DFT) was developed to estimate the Fourier Transform, which operates on a finite data set. The mathematical formula is shown below.

$$X_j = \sum_{k=0}^{n-1} x_k \exp(-\frac{2\pi i}{n} jk) \qquad j = 0, 1, ..., n-1$$

This formula now allows processing of digital data with a finite number of samples. The problem with this method, however, is that its O(N^2). As the number of points is increased, the processing time grows by a power of 2.

3.10.2 Speaker recognition

The goal of automatic speaker recognition is to identity the speaker by extraction, characterization and recognition of the speaker-specific information contained in the speech signal.

Generally it involves two major tasks, speaker identification and speaker verification. The speaker identification task is to determine who the speaker is among a group of known speakers. The voice sample of the test speaker is compared to all the known speaker models, to find the model with the closest match. The speaker verification (authentication) task is to determine whether the speaker is the person he or she claims to be. The voice sample of the test speaker is compared to the target speaker model, if the likelihood is above the threshold, the test speaker is accepted. Figure 1 illustrates these two tasks.

Speaker recognition methods can also be divided into text-dependent and text independent methods. In a text-dependent system, the recognition system has prior knowledge of the text to be spoken (a user specific pass-phase or a system prompted phrase) and expects the user to be cooperative. The performance of a recognition system is often better than text-independent system because of the prior knowledge of the text. In a text-independent system, the system does not know the text to be spoken by the user. Text-independent recognition is more difficult but also more flexible. For example, the speaker recognition task can be done while the test speaker is conducting other speech interactions (background verification). Of all the biometrics for the recognition of individuals (DNA, fingerprint, face recognition), voice is a compelling biometric. Because speech is a natural signal to produce, and it does not require a specialized input device. Also, the telephone system provides a ubiquitous, familiar network of sensors for obtaining and delivering the speech signal.

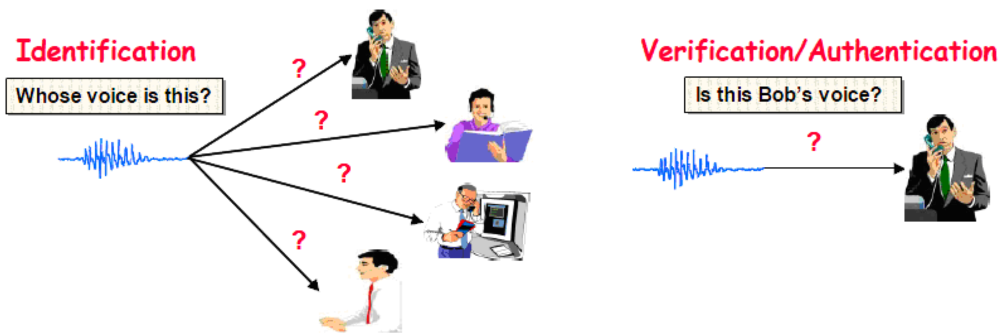

Figure 3.3

3.10.3 General Structure of speaker recognition system

The basic structure for speaker identification system and speaker verification system are shown in Figure 2.

The front-end processing module generally includes silence detection, pre-emphasis, and feature extraction. Silence detection is performed to remove non-speech portions from the speech signal. Pre-emphasis is needed because high frequency components of the speech signal have small amplitude with respect to low frequency components. A high pass filter is utilized to emphasis the high frequency components. The feature extraction process transforms the raw signal into feature vectors in which speaker-specific properties are emphasized and statistical redundancies are suppressed.

The speaker modeling is based on the feature vectors extracted in the front-end processing. In the enrollment mode, a speaker model is trained using the feature vectors of the target speaker. In the recognition mode, the feature vectors extracted from the test speaker's speech are compared against the models in the system database and a score is computed for decision making.

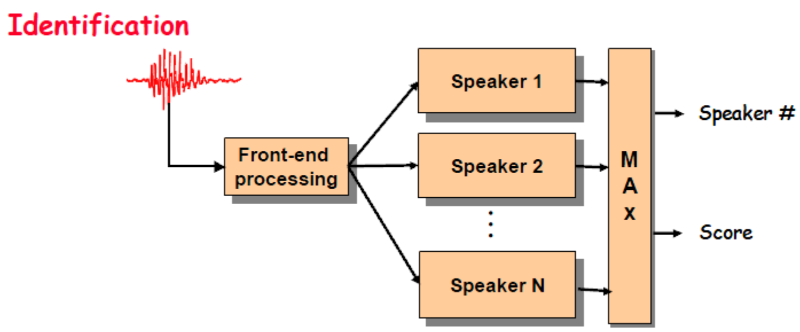

Figure 3. 2

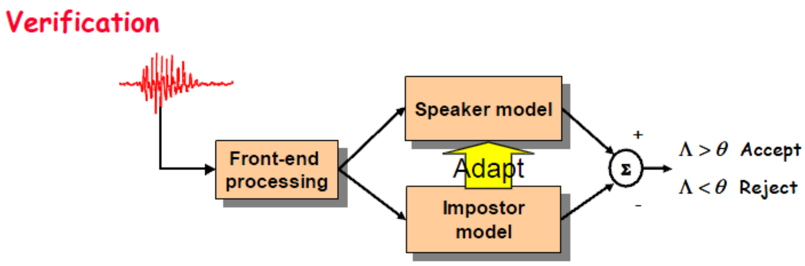

Figure 3. 3

3.11 Summary

This chapter described about the technologies involved in this project. The proceeding chapter will discuss about how we took the approach to research and develop a tool to demonstrate our findings.

Chapter 4

The Process of Red Palm Weevil Detection

4.1 Introduction

This section of the report describes about the approach taken to complete the project using the technologies mentioned in the previous chapters. Also it gives an outline idea of what kind of inputs, outputs and processes will be used for the process of the system that will ultimately be developed.

4.2 Outline of the Approach

In the agricultural sector, there is growing need for information Technology usage in machinery level. In the modern world most of equipment's, machines are computerized. The proposed solution is using Android Mobile devise based android application system, Information communication has been considered as the key and ICT being used effectively and efficiently for the overcome the existing situation.

4.3 Proposed Methodology for the System

As the first step of the recording process android phone with high quality audio recording Application, but without any filtering was developed to capture the acoustic sounds of the red palm weevil larvae inside palm stems. A magnetic cartridge head was used as the sensor for this device. The cartridge was pressed on to the palm stem and held in place by laying a strip of hard paper over it with 2 pins pushed on to the stem at either sides of the strip. The output was directed to a computer installed with a digital audio editing and sound utilization software, using the Audacity (audio editor) mention in the previous chapter. Recordings were made from each of 10 palms of 5-years of age at different test conditions; six artificially infested palms with a known number of red palm weevil larvae, two naturally infested palm with unknown number of larvae and two uninfested palm in the coconut plantation at the Kochchihena state.The artificially infested palms were introduced with each of 1, 5, 7, 10, 13, 15 of medium-sized red palm weevil larvae, 4 days before the recording. Infestation was done by making 3 holes of 3.5 cm diameter and 5 cm depth in the palm stem 50 cm above ground level and inserting the larvae into the holes after which they move inside. After all larvae were inside the stem, the holes were covered with a fine metal mesh and later with a mixture of cement and sand mortar. Sound waves were recorded at 30 cm above the point of infestation. A total of 10 wave files of 50–60s, were recorded from each category of palms. The recording was carried out in an early morning when other environmental noises were minimal.

Sound profiles were subjected to time-frequency wavelet analysis to relate the spectral frequencies available in the unique acoustic signature of red palm weevil larvae to its time of occurrence. A personal computer installed with using the Audacity (audio editor) mention in the previous chapter, software was used for the analysis. The samples of the signals were stored in a format based mainly on coefficients, which gives a better understanding about the digital signature of the red palm weevil sound.

4.3.1 Development of the acoustic detector

The Android Phone essentially consisted of a sensor to acquire the sound signals from an infested palm, a signal processing Application to capture and amplify the sound acquired by the sensor while filtering out the environment noise signals and process the sound signal and using sound recognition algorithms determine whether the palm was infested or not .it gives notifications to user palm was infested or not. Also, as a portable field device it needed to be compact, lightweight and multifunctioning unit. After several pre-tests and modifications, a detector with these features was developed. Additionally, it featured a GPS Location of the infected palm tree it recoded on the hosted database, user can view daily detected palms on this phone application in other hand these information valuable for the Coconut research institutions for red palm weevil distribution prediction purposes. The 4.1 figure shows the Functional block diagram of the signal processing system It clearly show the inputs, out puts and process of the system.

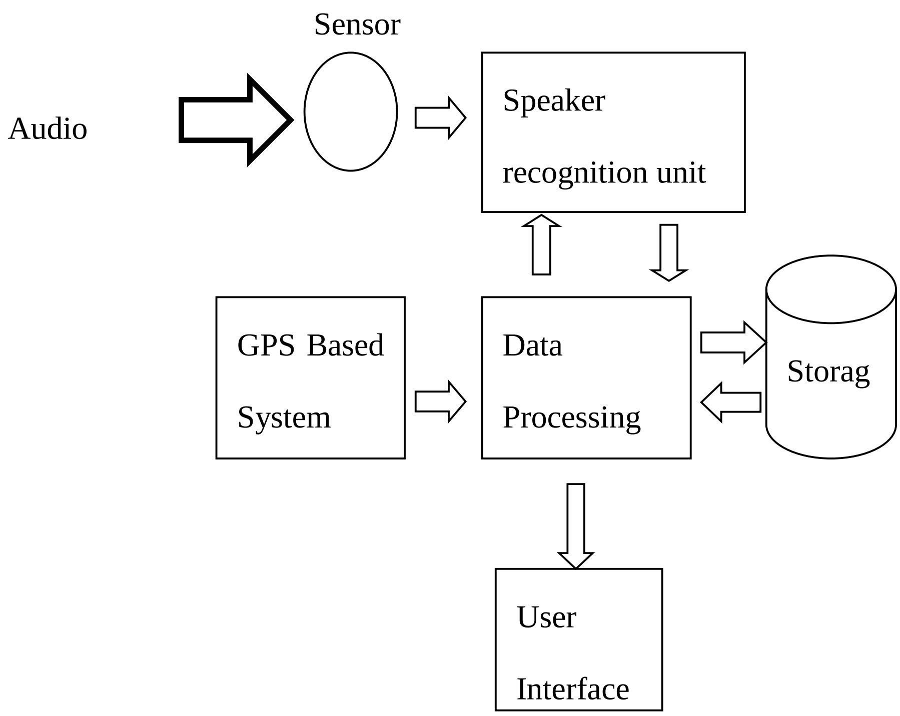

Figure 4. 1Functional block diagram of the signal processing system

4.3.2 Inputs of the system

There is an urgent need to monitor and identify concealed RPW larvae that might otherwise spread rapidly through commercial channels. Distinct acoustic signs of RPW larvae activities are produced while the larvae are chewing and moving. Thus sounds emerging from a tree do not directly indicate the presence of larvae. Sound produced By heavy infestations can even be picked up by the human ear [7] [8] so using sensor collect the sound profiles from the tree. Those are the main inputs of this system other than that GPS data are the secondary inputs of this system.

4.3.3 Outputs of the system

In this system main outputs of the system is On Automatic Detected the Pests and notify the RPW larvae infected or not to the palm tree other output is the GPS based map and information store in this system.

4.3.4 Process of the system

This system is a fully automated process Based on the sound profiles obtained from the acoustic recordings .those sound profiles are the main inputs to the automation process. This automation process use speech recognition technology AI technologies for RFW verification process.

4.4 Summary

This section described about the approach expected to be followed within the scope of the project and discussed of the procedure that is to be followed and the figures showed the flow of the system being developed. In the next chapter the design and the analysis of technologies will be discussed.

Chapter 5

Analysis & Design

5.1 Introduction

The previous chapter described about the approach towards researching and implementing the findings as a prediction tool. This chapter will discuss and illustrate the way data is analyzed and how the findings of different types be utilized for the tool design.

5.2 Sound recordings and analysis

A sample sound profile of each test condition is given in Fig. 5.1. Irrespective of the number of larvae present in the infested palms the highest amplitude of the acoustic sound was found in the frequency band of 500–1000 Hz. The uninfested palm did not yield any significant noise. Data coefficients extracted from time-frequency wavelet analysis also showed a clear difference in the coefficient values of infested (0.3441 and 0.6584) and uninfested (0.0063) trees and it was possible to distinguish sounds of red palm weevil larvae from the rest of the signals. Since, signal processing by this method now a days it can be done by Android Mobile Phone it is light weight product and using application we can get most accurate Result.

According to above analyst Android RPW system wants to sensitive for these frequency ranges .Otherwise it unable to detect those sounds.

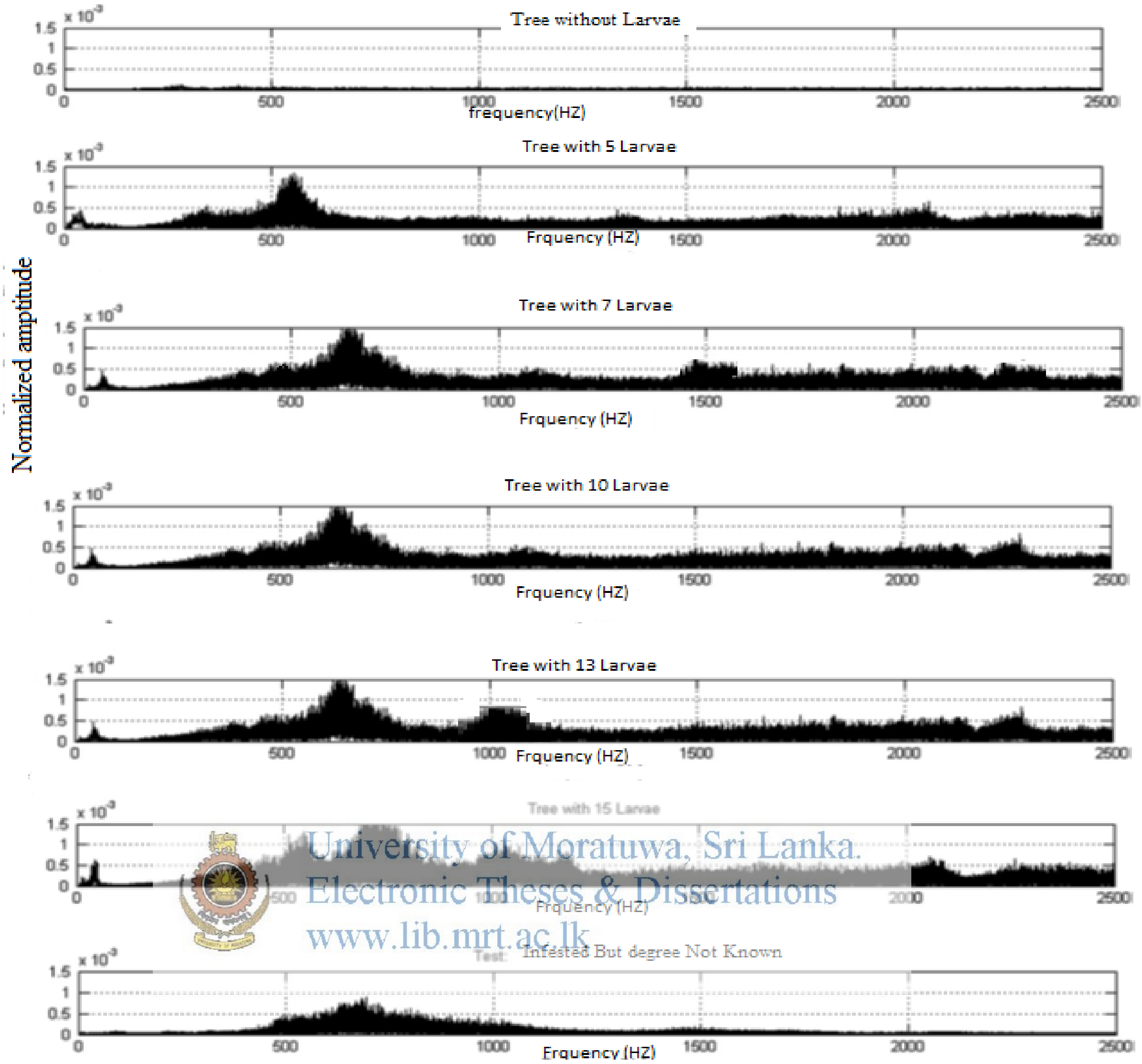

Figure 5. 1The frequency spectrum of sounds for five different test conditions. From top to bottom, a tree free from weevil infestation, a tree with five red palm weevil larvae, a tree with 10 larvae, a tree with 15 larvae, and a tree with unknown number of larvae

5.3 Architecture of this System

The Figure 5.2 shows the context diagram of the tool that is expected to finally implement through this project. It consists of the following main External Entitles, Main process, Data store and data flow of the system. The Figure 5.3 shows main modules of this system. The data store does not directly connected to the system it connected through the system it connect through the webservers.

01. Audio Processing Module

GPS Processing module

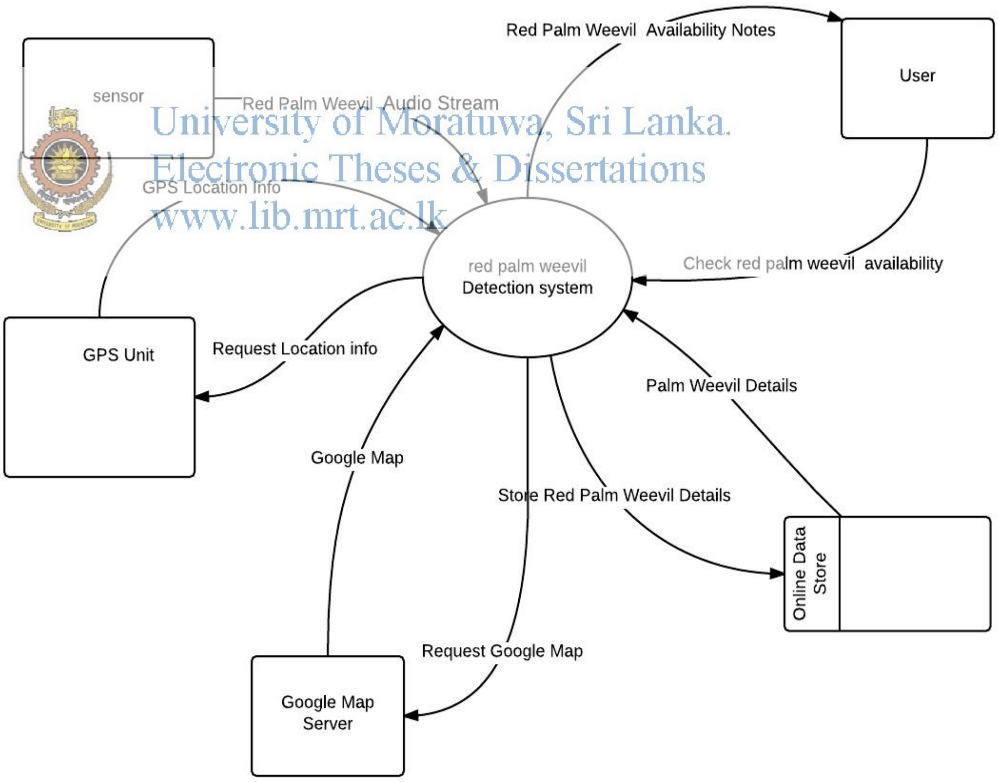

Figure 5. 2Context diagram of the System

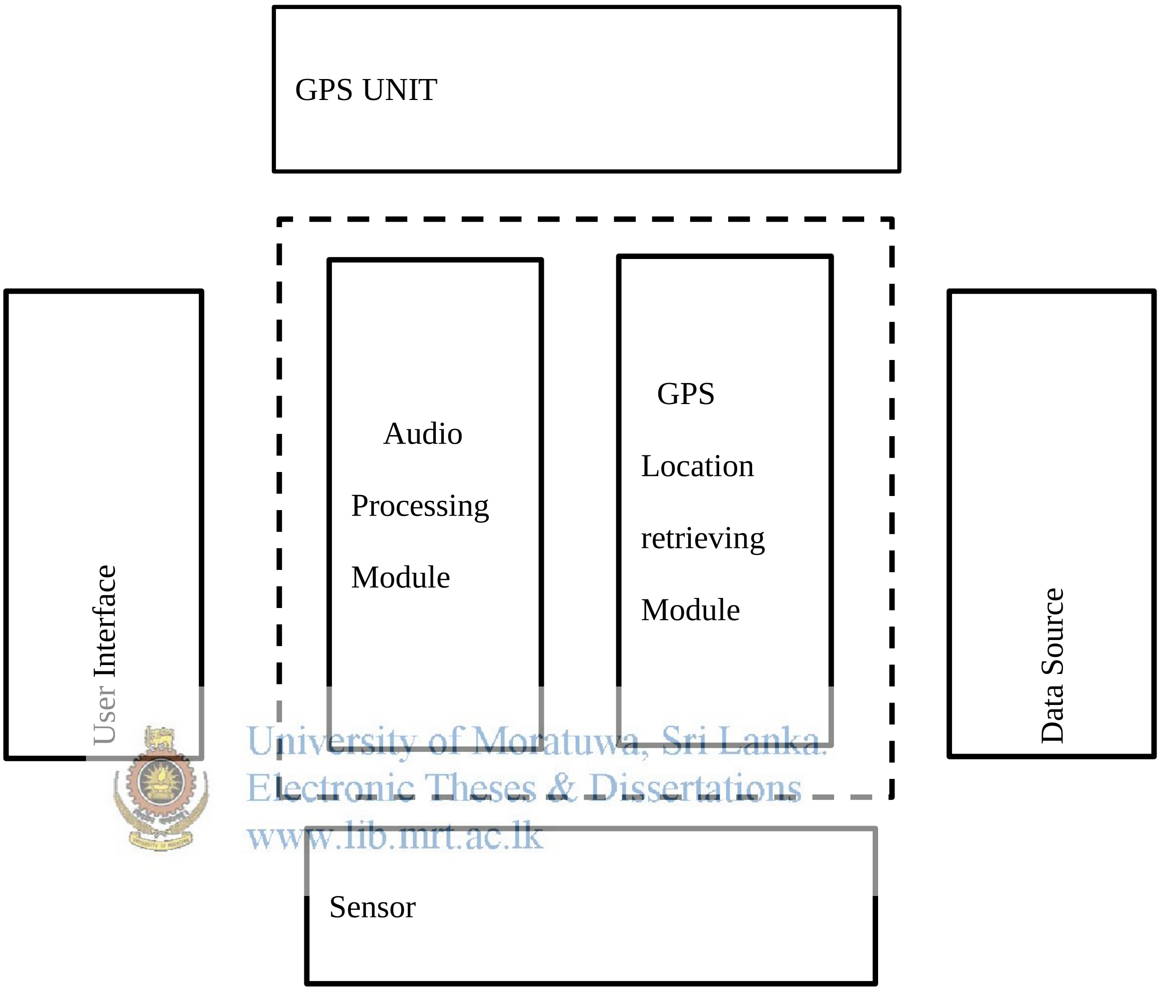

Figure 5.3 Component diagram of the System

5.3.1 Audio Processing Module

This is the module responsible for the collecting sound from the sensor and the extract necessary information through this module.

5.3.2 GPS Module

This module responsible for the retrieving data from GPS unit and indicate those information in a map and store information on hosted database.

5.4 Summary

This chapter presented the architectural design, which will be used to implement the "User friendly Acoustic System for detection of coconut palms infested by Rynchophorusferrugineus" application. In the next chapter the implementation phase of the project will be discussed with more detail.

Chapter 6

Implementation

6.1 Introduction

As the previous chapter described the Design Architectures for the tool that we are building in the project. This section will describe in more detail the techniques used for implementation. As this project includes code, only the sections of particular interest will be discussed, including code which is core to the main functionality of the application and those which caused particular difficulties. The challenges faced during implementation will be discussed in detail, along with their resolution.

6.2 System Configuration

6.2.1 Sensor

The sensor used to collect sound recordings from the trees was difficult to mount on the stem. The developed sensor is based on a condenser microphone WM-034DM with sensibility of 30 dB, frequency response (from 10Hz to 30kHz) in the audible spectrum as the signal magnitude obtained from the plant is very small but Android phones sensitive for those frequency range and the dB ranges . *Figure 6.1* shows the Mic that used for sensor creation purpose it is Electret microphone capsule .Sensor creation mechanism shows *Figure 6.2 One* side of the cylinder was welded with a 6 cm long pin and the other side dip the rubber cork into the cylinder for environmental noise proofing purpose finally it is showing in the Figure 6.2 picture .

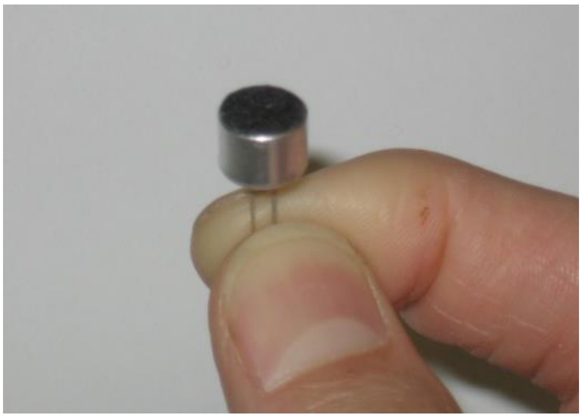

Figure 6.1Electret microphone capsule

Figure 6.2 Sensor Creation Process

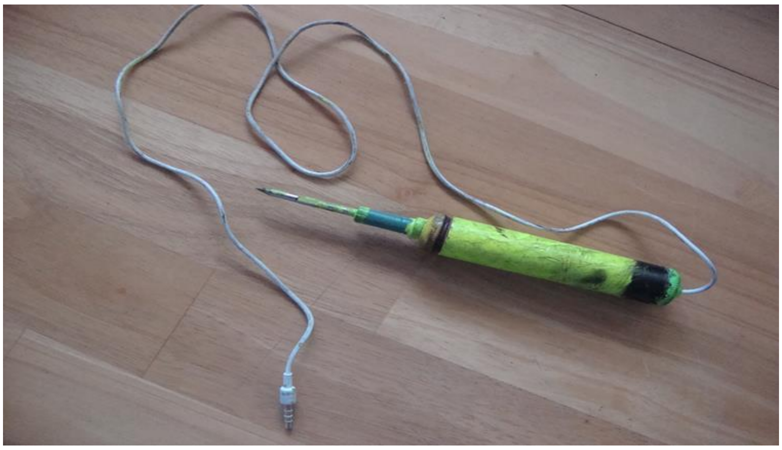

Figure 6.3After assembling the sensor

6.2.2 Android Application Implementation

The activities which are needed for the application are discussed within this section with a discussion about implementation and any difficulties for each activity. For screenshots to aid with the illustration, please see the Figure 6.4 picture a. shows the icon of the application call RFW Reader, b. and C pictures are showing process of the application.

This project implementation is mainly done through two modules RFW Detection module and the GPS Based Module modules. In the RFW Detection module the data is extracted by earlier section 6.2.1 discussed sensor those audio data processing using the FFT Algorithm and retrieve the amplitude and the frequency of this audio wave in given time period and it check amplitude and frequency related to our Analysts after that check number of time it reaches to the given frequency range within a given time frame and compare with the previous patterns of sound waves then it is ok it give notification to the its user It shown in Figure 6.4 in C. Picture .

This project there is a separate section call GPS Based system when RFW diction process complete application ask “Are you sure to save this Corruption” then press save button, it communicate with GPS unit of the Android phone and store those location information on a hosted database using the web services if the Internet not available then those information store in a temporary database if again internet connection is available those information uploaded into hosted database .if someone wants to see the where the tree located number d. picture shows it .figure 6.5 shows the ER diagram of the GPS module it is consist with two tables.

6.3 Summary

This chapter briefed about the progress on the development phase of the project so far. Next chapter will state the details of the units of work completed and the evaluations has be don discuss in next chapter.

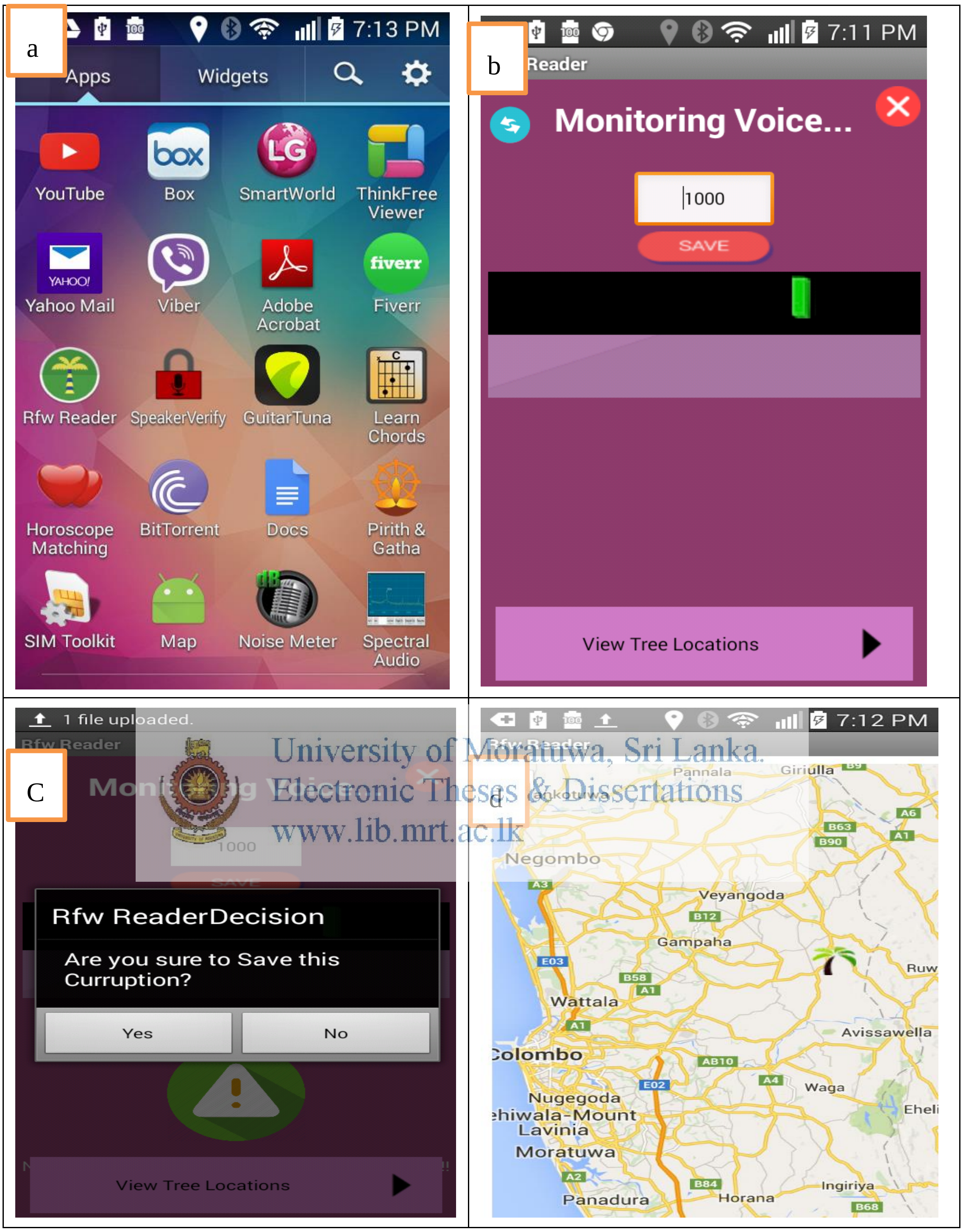
a
7:13 PM
Apps
Widgets
YouTube
Box
SmartWorld
ThinkFree Viewer
Yahoo Mail
Viber
Adobe Acrobat
Fiverr
Rfw Reader
SpeakerVerify
GuitarTuna
Learn Chords
Horoscope Matching
BitTorrent
Docs
Pirith & Gatha
SIM Toolkit
Map
Noise Meter
Spectral Audio
b
7:11 PM
Reader
Monitoring Voice...
1000
SAVE
View Tree Locations
C
1 file uploaded.
Rfw Reader
Rfw ReaderDecision
Are you sure to Save this Curruption?
Yes
No
View Tree Locations
d
7:12 PM
Negombo
Veyangoda
Gampaha
Wattala
Colombo
Avissawella
Nugegoda
Moratuwa
Panadura
Horana
Ingiriya
Waga

Figure6.4

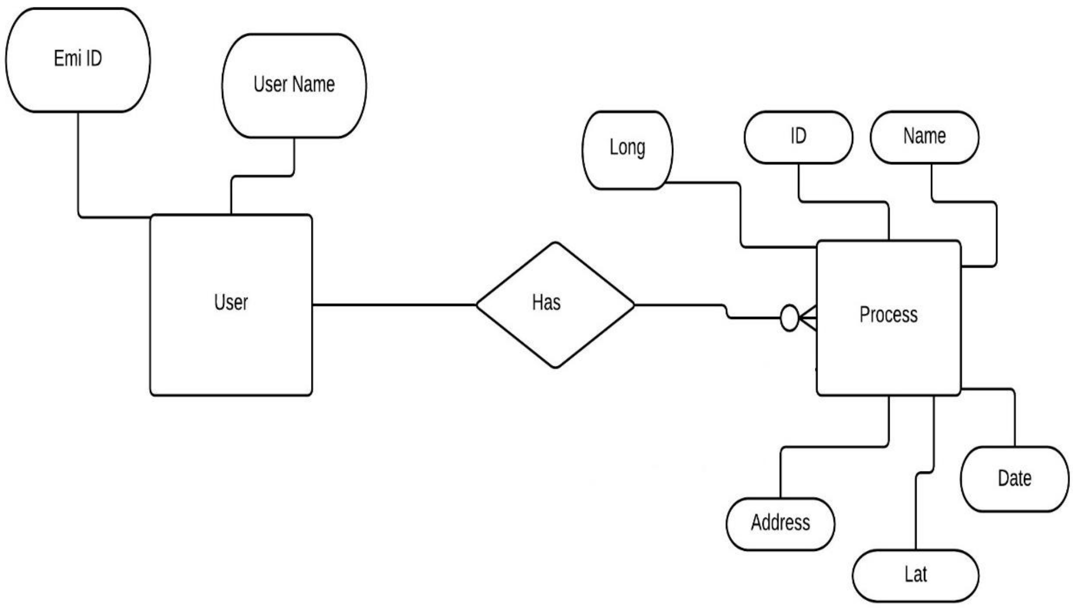

Figure 6. 5

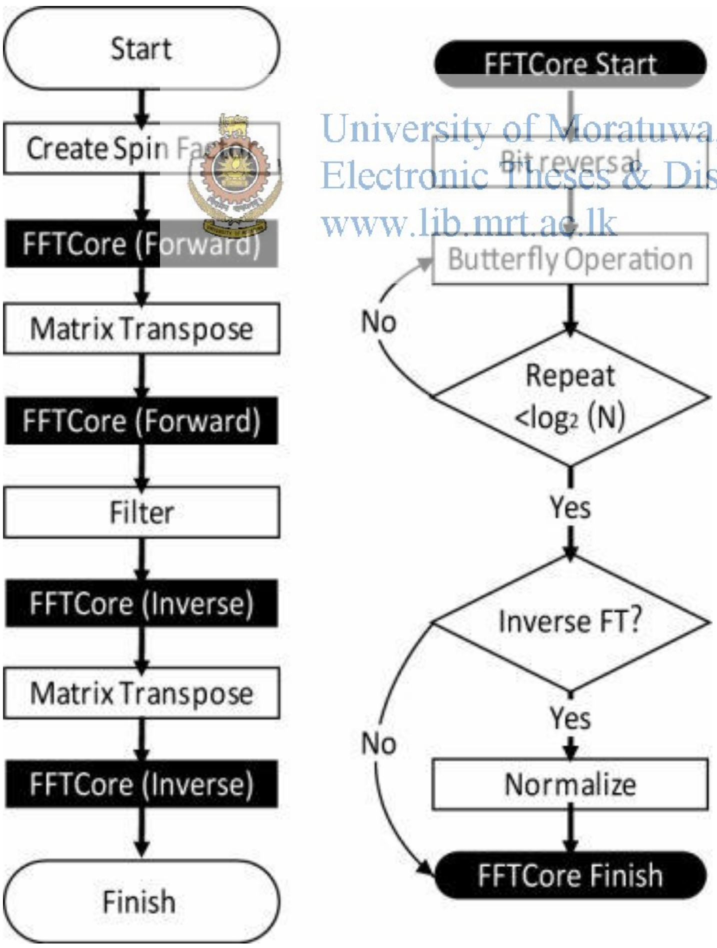

Figure6.6

Chapter 7

Evaluation

7.1 Introduction

Field studies were carried out in plantations infested by red palm weevil to determine a suitable position for the placement of the sensor on the infested palms that would effectively detect the presence of larvae and maximize the accuracy of the mobile device in detecting infested palms.

7.2 Determination of a suitable position for placement of the sensor

The study was carried out in two estates at Kirindiwela (Gampaha District, Western Province, Sri Lanka) and kuliyapitiya (Kurunegala District, North Western Province, Sri Lanka). In each estate, red palm weevil infested blocks comprising of young palms Were selected and all palms were checked using the device. Generally, the palms vulnerable to red palm weevil attack are between ages 3 and 8 years of age palms trees , hence heights of the palm stems were up to about 2.5 m. On each palm, the sensor was mounted on 4 positions; either side of the base of the stem (positions A and B) and on the leaf bases of the two lowermost fronds (positions C and D) because a previous study had indicated that placing the sensor on these 4 positions would enable detection of infested palms. The sensor was mounted on the palm by pressing the needle of the sensor on each position. On each palm, the sensor was mounted on each of the above-mentioned positions and Run the android application on the mobile phone .This application take 40s and its give notification of presence or absence of larvage if it detected on that palm tree GPS data automatically stored on a hosted database. The main sounds produced by the larvae resemble the sounds of breaking dry twigs or disturbing a heap of twigs. A total of 600 palms were checked in this manner. Afterwards, each palm was cleaned by removing dry fronds and other debris and presence of any red palm weevil damage symptoms on the stem or canopy was recorded. Generally, infested palms show external symptoms if thoroughly examined except, at the very early stage of infestation. Hence, for this study it was assumed that only palms with at least a slight damage symptom were infested by red palm weevil.

7.3 Determination of accuracy of the device

Two studies were carried out to determine the accuracy of the device. For Study 1, the data collected from the 600 palms for determining the suitable position of the sensor was used. In those palms, if the sound of red palm weevil was detected at any of the positions, but the symptoms were absent, then the palm was marked for subsequent checking. Those palms were rechecked in the same manner 3–4 weeks later, allowing a period for development of symptoms if the pest was present.

In study 2, the device was tested in heavily infested blocks at Ganewaththa estate (Puttalum District; North-western Province, Sri Lanka) and Gasnawa estate (Nelumdeniya , Sabaragamuwa Province, Sri Lanka). Two hundred palms were each checked as described for the previous experiment. Symptoms present on the palms were recorded as ‘clearly visible’ and ‘hardly visible’ to the grower.

7.4 Statistical Analysis

It was assumed that all infested palms show at least a slight external damage symptom at the time of testing, although this may not always be the case, especially at the very early stages of infestation. The reliability of the device was assessed by the following two statistical indicators;

a) Index 1 =100 * [Probability of detecting the presence of the pest by the device when the damage symptoms were present]

b) Index 2=100 * [Probability of not detecting the presence of the pest by the device when the symptoms were not present]

Thus, if both indices were high it confirmed that the device was effective. The data was analysed using 2-way frequency tables and based on those tables the above indices were computed. For determining the suitable position, the probabilities at each position (A, B, C, D), two positions (A&B, B&C) and all 4 positions (A&B&C&D) were calculated. For determining the accuracy of the device only data on all 4 positions was considered.

7.5 Results

7.5.1 Acoustic device

The Android device comprising of the sensor, Android Phone and the its Application is shown in Fig. 3. The sensor could be easily mounted on the palm by pressing the needle on to the required position of the stem. The Android phone with 4.4.2 Operating system , 11 x 6.5 x 2.5 cm in size and 120 g in weight and powered by two 6 V batteries, which could be easily recharge using power unit . There is a separate icons call RFW Reader with indicators to turn on the application and to start/stop the process there is a another button in the application .

3.3. Field studies

7.5.2 Determination of a suitable position for placement of the sensor

Out of the 600 palms checked, 30 palms showed damage symptoms. Those palms were correctly detected (larval sound present) by the device (Index 1) at various probabilities when the sensor was placed at different positions (Table 1). The highest accuracy of 100% was obtained when checked at all 4 positions. The palms without damage symptoms were not detected as pest present (Index 2) at very high probability levels (Table 1). In contrast to the detection of infested palms, the accuracy of not detecting palms without symptom reduced when the sensor was placed on more than one position, with the lowest probability at all 4 positions.

7.5.3 Determination of accuracy of the device

At the first observation of study 1, all the 30 palms that showed symptoms were detected as infested by the device (Index 1 =100%). But, out of 570 palms without symptoms, only 530 palms were accurately detected as uninfested (Index 2 = 93%). Thirty palms without symptoms were misclassified as infested (Table 2). At the second observation, 2 of these palms developed

Figure 7.1 Android mobile device comprising the sensor

symptoms and detected as infested indicating the ability of the device to detect infested palms, even before symptoms are visible. Out of the 40 palms without symptoms, 21 were confirmed as not infested increasing the index 2 to 98.6%. However, 9 symptomless palms were still misclassified as infested.

Out of the 200 palms checked in study 2, 130 palms showed symptoms of infestation. Of these, 97.1% palms (Index 1) were accurately detected as infested. Also, out of 70 palms without symptoms, 92.9% (Index 2) were correctly detected as uninfested (Table 3). Out of the 130 palms that showed symptoms of the damage, 28 palms showed only very slight symptoms such as formation of gum from the liquid oozed out from the tissues, which could be easily missed by the grower checking palms by the conventional way.

7.6 Summary

In this chapter it is discussed the how the final evaluation has been done and the what are achievements this project discuss in this chapter.

	Percentage palms correctly detected	
Sensor placement Times	Symptoms present (Index 1)	Symptoms absent (**Index 2)**
A	71.3	97.9
B	65.7	98.5
C	45.3	98.5
D	30	97.6
A&B	71.3	97.4
C&D	45.3	96.8

(Table 1)

Status of palms	Detected	Not detected	Total
Symptoms present			
No. of palms	30	0	30
Percentage out of all palms	5%	0	5%
Percentage out of all palms with symptoms	100%	0	100%
Percentage out of all palms detected/not detected	42.80%	0	42.80%
Symptoms absent			
No. of palms	40	530	570
Percentage out of all palms	6.6	88.3	94.90%
Percentage out of all palms with symptoms	7	93	100%
Percentage out of all palms detected/not detected	57.14	100	---
Total	70	530	600
ToTal %	11.60%	88.33%	100%

(Table 2) Frequency of detecting palms with and without symptoms of red palm weevil infestation at all four positions at the first observation in study 1.

Status of palms	Detected	Not detected	Total
Symptoms present			
No. of palms	126	4	130
Percentage out of all palms	63%	1.9	65%
Percentage out of all palms with symptoms	97%	2.9	100%
Percentage out of all palms detected/not detected	96.10%	5.5	
Symptoms absent			
No. of palms	5	65	70
Percentage out of all palms	2.5	32.7	35.20%
Percentage out of all palms with symptoms	7.1	92.9	99%
Percentage out of all palms detected/not detected	3.9	94.5	---
Total	131	69	200
ToTal %	65.50%	34.50%	100%

(Table 3)Frequency of detecting palms with symptoms and without symptoms of red palm weevil infestation by the device in study 2

Chapter 8

Conclusion and Further Work

8.1 Introduction

The preceding chapter described Evaluation information related to the project including testing of the project achievements against objectives. This chapter will discuss about conclude the overall achievements quantitatively, achievement of each objective, problem encountered, limitations of your solution, and some further work.

8.2 Conclusion

The acoustic device developed has a very high accuracy (over 97% in this study) in detecting red palm weevil infested palms, when checked on either side of the stem base and bases of the two lowermost leaves. The use of the Android device has many advantages over the conventional methods currently in use to detect infested palms. Saving of time and cost of labour are the biggest advantages and it is unnecessary to clean the palms to check for symptoms as required currently. The Android devise can use this application without training and the proper knowledge for using this application .Also, a single palm could be checked in about 40s, which is considerably less than the time spent in checking for symptoms by the conventional way. The Android device can detect infested palms, even before they show external damage symptoms and when slight damage symptoms such as presence of gum, which could be easily missed out by external examination. Hence, early detection by using the Android device allows early treatment.

However, there was a low probability (<3%) of misidentifications of infested palms as well as uninfested palms (<8%). Generally, red palm weevil larvae do not make sounds continuously and have resting periods. If there are a large number of larvae inside the trees, resting periods of individual larva may not overlap and do not affect the overall sounds produced. If few larvae are present in the palm and if most of the pest is at the pupal stage, there is a possibility that they will not be producing sounds during the period of checking and will be missed. The sound frequencies produced by movement of small insects, such as ants inhabiting the coconut palms and swaying of coconut leaves due to light breezes may lie in the range of the frequency emitted by the red palm weevil larvae. In such cases, there is a possibility of misidentifying an uninfected palm. It was shown that the rate of misclassification of palms could be reduced if a second round of checking was done 3–4 weeks later. Also, better results could be achieved by carrying out the checking at times when environmental noises are low.

This Android mobile device is portable and convenient for use in the field. It is a self-contained unit in which uses Rfw Reader application for this purpose. It uses algorithms and mathematical equation for filtering unwanted sounds and palm weevil larvae automatically detection purpose. Hence, it is unique and a further step forward in the development of an Android device to detect red palm weevil infested palms compared to other acoustic devices already available, which either require carrying a computer with high processing power to provide the output instantly or the output is provided later, after signal processing where the farmer could not determine the status of the palm instantly). This Android device could be carried in the pocket of the user and easily operated even by an untrained person. There is a another option in this application if palm weevil larvae detect by this application user can get the exact location of the tree using the GPS technology, There is a another advantage of this application these individual GPS data stored in the hosted database .Those information useful for predict red palm weevil distribution and future forecasting purposes .

8.3 Facture Developments

- Information system has to develop for prediction purposes
- Sensor should convert in to Bluetooth data transferring format

8.4 Limitations

- Within the given time frame difficult to evaluate this project its take time to evaluation process.
- Mobile Phone Processing power
- Environmental noises

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Appendices

9.1 *Appendix A – Sample of Coding*

```
public class Locations extends Activity {

        GoogleMap map;

        // Hashmap for ListView
        ArrayList<HashMap<String, String>> locationList;

        @TargetApi(Build.VERSION_CODES.HONEYCOMB)
        @Override
        protected void onCreate(Bundle savedInstanceState) {
                // TODO Auto-generated method stub
                super.onCreate(savedInstanceState);
                setContentView(R.layout.view_list_items);

                WebView engine = (WebView) findViewById(R.id.web_engine);
                engine.setWebViewClient(new WebViewClient());
                engine.getSettings().setJavaScriptEnabled(true);
                // engine.loadUrl("https://www.google.com");
                engine.loadUrl("http://www.poornabiz.com/Webservices/index.html");

        }

}
```


Figure 9.1Web Servises Colling Class

```
public SoundLevelView(Context context, AttributeSet attrs) {
        super(context, attrs);

        mGreen    = context.getResources().getDrawable(
                    R.drawable.greenbar);
        mRed      = context.getResources().getDrawable(
                    R.drawable.redbar);

        mWidth    = mGreen.getIntrinsicWidth();
        setMinimumWidth(mWidth*10);

        mHeight = mGreen.getIntrinsicHeight();
        setMinimumHeight(mHeight);

        //Used to paint canvas background color
        mBackgroundPaint = new Paint();
        mBackgroundPaint.setColor(Color.BLACK);

}

    public void setLevel(int volume, int threshold) {
        if (volume == mVol && threshold == mThreshold) return;
        mVol = volume;
        mThreshold = threshold;

        // invalidate Call onDraw method and draw voice points
        invalidate();
    }

    @Override
    public void onDraw(Canvas canvas) {

        canvas.drawPaint(mBackgroundPaint);

        for (int i=0; i<= mVol; i++) {
            Drawable bar;
            if (i<mThreshold)
                bar = mGreen;
            else
                bar = mRed;

            bar.setBounds((10-i)*mWidth, 0, (10-i+1)*mWidth, mHeight); //
            bar.draw(canvas);
        }
    }
}
```

Figure 9.2sound Level meater