LIE DETECTION USING VOICE STRESS ANALYSIS

By

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CERTIFICATION OF APPROVAL

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Approved:

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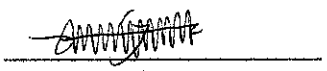
CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.



Hazlin Azmira Binti Zahar

ABSTRACT

In the existing technology, there are several ways for lie detection. Voice Stress Analysis is one of the methods for lie detection. It measures the amount of stress in the subject's voice to detect whether the subject is being truthful or not. The VSA is reported to be cheaper, easier to use, less invasive, less constrained in their operation and more accurate than polygraph with 90 to 95% accuracy. In this project, the theory of Voice Stress Analysis is used to detect deception. Developing the software of lie detection using MATLAB will help in the investigations of law enforcers to detect deception. There are two approaches that are used in this project which are frequency based system and energy based system. The frequency based system detects lie using the variation in the output graph. High variation indicates low stress or 'truthful' voice and low variation indicates high stress or 'lying' voice. The energy based system however, detects deception in the energy spectrum of the voice at 20 to 40 Hz frequency. A flat waveform indicates hard stress while a sharp waveform indicates low stress. Using MATLAB, the voice is processed and both methods are applied. The results for both methods are then compared with the result of a polygraph test. It is found that both methods have different results on certain voice samples and also similar results on certain voice samples. However, the energy based system has more similar results than the frequency based system. Thus, it is more accurate.

ACKNOWLEDGEMENTS

The author would like to express her deepest gratitude to the project supervisor, Miss Nasreen Badruddin for giving the opportunity to work under her guidance and support. Without her numerous advices and help, it would have not been possible for the author to complete this project successfully.

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CHAPTER 1

INTRODUCTION

This chapter is an introduction to the project. It would be discussing on the background of the project, problem statement, the objectives and the significance of the project.

1.1 BACKGROUND

Military Organizations and police departments are continuously handling interrogations with criminals. In the present situation, there are a lot of criminals to be managed that could be difficult to deal with. The presence of lie detectors in interrogation sessions would help the process of law enforcement and national security.

Voice Stress Analysis (VSA) is one of the existing methods of detecting deception. This method uses the psychophysiological approach by detecting deception through the measurement of the amount of stress in a person's voice. Currently, there are many techniques to detect deception and for different applications. For example, medical personnel, social workers, and mental health workers who all interview clients for various reasons may lie or withhold information from the interviewer to hide the truth.

Most importantly, VSA is used by the law enforcers in criminal investigations. This technique is designed to convince the suspect to a confession. In an event of crime, the suspects will be gathered and a questioning session will take place to search for the exact criminal.

During the process of detecting deception using VSA, a set of question is prepared for the suspect. The question set has comparison questions, as well as irrelevant questions which allow the examiner to distinguish between liars and truth tellers with high degree of accuracy.

VSA is a favored method of lie detection because they are relatively cheap and require almost no training for the operator. A person does not even have to know that VSA is being practiced, as the technology is said to be effective on tape recordings and telephone conversation. VSA is also believed to have a high accuracy on the results of detecting deception.

1.2 PROBLEM STATEMENT

Lie detection is important in law enforcement. During the interrogation process, criminals will be asked a lot of questions. There are many possible ways to detect lie such as polygraph, voice stress analysis, kinetic interviewing, and many more. Due to this concern, the project Voice Stress Analysis had been proposed.

For this project, a software that can detect lie by monitoring the amount of stress in voice is developed. This software is based on a developed algorithm. According to the algorithm, a recorded wav file is processed in MATLAB.

The recorded file contains the voices of the interrogator and the suspect. The second step is to segment the voices so that only the suspect's voice is processed for lie detection. The segmentation can be done automatically or manually. This project is demonstrating the manual segmentation using another software called Sony Sound Forge 7.0. After segmentation, the voice is passed through an 8 times oversampling to create the one-eighth tape play speed. The voice is then passed through a low-pass digital filter with passband frequency 12 Hz and stopband frequency 15 Hz. This is the range of frequency where the voice can be detected being deceptive or truthful.

1.3 OBJECTIVES

The objective of this project is to develop software that can detect lie using Voice Stress Analysis as an alternative to the other lie detecting methods. The software MATLAB version 6.5 is used to process the voices using the developed algorithm. The software developed is also to be proved whether it can detect deception by running tests on recorded voice achieved from interrogation session with students and also a real interrogation session obtained from the Malaysia Air Force.

1.4 SIGNIFICANCE OF PROJECT

This project develops lie detection software. This software can be a tool that is used by law enforcers to detect deception in the criminal's voice. It will enhance the possibility of getting the exact criminal during a crime investigation. This software is easy to use and it does not require any contact with the criminal investigated.

CHAPTER 2

LITERATURE REVIEW

Before proceeding with the project, it is crucial to know the fundamental principles of voice stress analysis. Articles and journals of previous studies on voice stress analysis had been the main source of literature review. There were not a lot of books related on voice stress analysis found in the library. It is also very hard to obtain the journals related to voice stress analysis because some of them are not available in the internet and library. In this chapter, the important information on the technique voice stress analysis is discussed.

2.1 LYING STATISTICS

The statistics have shown that people are lying almost all the time [12]. It need not be proved by any detection techniques that people all around the world are lying for various reasons. A child would lie to his mother about his failing grades or a politician would lie about accepting bribe. However, there are two types of lies which are lying under stress and lying without stress. People tend to lie under stress when they are in jeopardy that they are afraid the person they are lying to would know the truth. This kind of lie is the main concern of this project.

2.2 BEHAVIOR OF HUMAN VOICE

According to [10], tremor is defined as an involuntary periodic oscillation of a body part, such as the limbs, trunk, head, vocal folds, or facial structures. Tremor may occur when muscles are at rest (resting or static tremor), in maintaining a position (postural or action tremor), or during a movement (intention tremor). Voice tremor may or may not coexist with tremor involving head or limb. The source of tremor may presumably differ for voice tremors associated with different pathophysiologies.

Voice Stress Analysis measures stress using the tremors occurs in the voice when a person is lying. This tremor is called micro-muscle tremors (MMT). It occurs in the muscle that makes up the vocal tract which is transmitted through the speech. When a person is under stress or in jeopardy, the body increases the vibrations in the muscle. Physiologic tremors may be produced by anxiety, stress, fatigue or metabolic derangements or drugs.

2.3 TYPES OF LIE DETECTION

There are various ways of detecting deception. There are four different methods of detecting deception mentioned in [7] which are the polygraph method, Computer Voice Stress Analysis, Kinesic interviewing and scientific content analysis.The techniques of detecting deception falls into two broad categories: those that are psychophysiologically based and those that are not.

Polygraph, Kinesic interviewing and Voice Stress Analysis falls into the psychophysiologically based while the scientific content analysis falls into the other category.

Polygraph testing is the most widely known of these techniques. During an interview, polygraph instruments make continuous recordings of physiological reactions from the interviewee's autonomic nervous system. During the questioning session, the attachments monitor changes of at least three types: changes in respiration during the question set, changes in blood pressure, and changes in sweat gland activity. The reactions are being recorded and evaluated are stress or fear reactions.

As for Computer Voice Stress Analysis, it measures stress induced by questions only in the voice. These instruments are highly favored by some law enforcement agencies because it is relatively cheap and require almost no training for the operator. Failing the voice stress test is fairly common, so the procedure puts additional pressure on the guilty to confess – meanwhile increasing stress on the innocent, who are also pressed to confess. The Computer Voice Stress Analysis is claimed to have a high

accuracy by the manufacturer based on its own research. However, there are still doubts on the accuracy of this method by other law enforcement agencies.

Kinesic interviewing differs from polygraph and Computer Voice Stress Analysis as it is done without expensive instrumentation. This method is widely practiced than polygraph testing. This method requires the interviewers to make informed judgments about the truthfulness of their interviewees. The interviewer will observe the surface manifestations of the reactions by posture, involuntary hand and leg movements, eye movement, changes in the size of eye pupils, and many more manifestations of stress.

Kinesic interviewing involves making decisions as to truthfulness that are based on careful observation of nonverbal behavior, spontaneous verbal responses induced by stress, and typical verbal behaviors in response to structured questions. This method is used to quickly eliminate innocent people who are among those having access and opportunity to commit the crime. However, this technique does not come up as possible trial evidence the way polygraph testing does.

For scientific content analysis, it does rely on psychological principles, but it does not try to assess psychological reactions to stimuli as do the techniques discussed earlier. A written statement is taken from the suspect and then analyzing the statement to determine if the writer is hiding information that may be damaging. It does not involve handwriting analysis but rather, it involves analyzing the form and content of the written statement of a subject as described by the name.

Before reading the article, there were only two techniques of detecting deception that was known which are polygraph method and Voice Stress Analysis. After reading this article, there were more techniques that have been discovered.

2.4 METHODS AND APPROACHES FOR VOICE STRESS ANALYSIS

According to [6], VSA is currently divided into two different categories which are energy-based systems and frequency-based systems.

Table 2.1: Characteristics of Energy-based system and Frequency-based system.

Energy-based system	Frequency-based system
▪ Majority VSA uses energy-based system ▪ Not measuring micro-muscle tremors ▪ Measures the change in energy of the spectrum envelope between 20Hz and 40Hz. ▪ Non-stress – graph will take the shape like a Christmas tree. ▪ Hard-stress – graph will have a flat curve.	▪ Derive results from multiple features, primarily identifying changes within frequency bands and the distribution of frequencies within those bands. ▪ Examination of frequencies and their distribution ▪ Provides textual responses ranging from truth, through confusion to false statement, with various intervening responses.

From the research done, there are 5 VSA systems found using either energy-based system or frequency-based systems.

1. VSA-2000: This is a hardware-based system that uses a digital readout to determine stress levels of the speaker. Tests are recorded and the audio input is processed.
2. Computerized Voice Stress Analyzer (CVSA): This system uses energy-based system that evaluates using waveform and is computer based. The testing uses real time voice and displayed by computer.
3. Digital Voice Stress Analyzer (DVSA): This is also an energy-based system. The testing for this type is however different from CVSA as it tests data that is recorded, digitized, and then stored in the computer.

4. TiPi 6.40: This is a frequency-based system and is the most recent iteration of the TrusterPro. It automatically segments narrative responses and analyses each phrase for stress. It also processes real time voice and can digitize audio in off-line mode.
5. Digoenes Lantern: This is an energy-based system that uses real-time voice or digitally stored audio. The waveforms are displayed individually.

The graphs in Figure 2.3 are the indication for non-stress response and hard-stress response. When there is a small amount of stress or no stress, the graph will be in the shape as the Christmas tree while for the graph of hard stress, when the subject is under stress the graph will appear to be flat. The more flat the graph is, the more stress is present is the subject's voice.

Figure 2.1: Non-stress response and Hard-stress response.

CHAPTER 3

METHODOLOGY

This project is developing a software that can detect lie using voice stress analysis. After doing research, there were no algorithm on implementing the project is found. Therefore, an algorithm was developed with consultation from the supervisor of this project. The steps taken during the implementation of the software is discussed further in this chapter.

3.1 BREAKDOWN OF STEPS TAKEN

The project starts with doing a lot of literature review to gather all the information needed to implement the project. The sources of research include articles found on the internet, journals and related books from the library and also magazines. After that, a brainstorming of possible approaches for the project is done.

To implement the project, a valid algorithm is needed. From the research done, there was no voice stress algorithms found. However, from studying the information, an algorithm is developed and tested. The software MATLAB version 6.5 was used to apply the algorithm. Any problem occurred during the process was referred to the supervisor to be corrected.

The third process is to test and trouble shoot the algorithm with a recorded file. The recorded file contains the voices of the interviewer and the suspect. If the trouble shooting succeeded, the next step will be taken. However, if any problem occurs, the previous step will be studied again. A new algorithm might be needed.

When the test and trouble shooting is completed, the voice stress output display will be done. The graphical analysis will contain the output graph of the analyzed voice and also the percentage indicating the amount of stress in the voice processed. Once all the steps stated above are completed, the analysis and display will be integrated.

Lastly, it is planned that the software will work with real time voice input. The suspect's voice will be inserted using a microphone and processed immediately. This will

make the software to be able to analyze and detect deception similar to the existing voice stress analyzers used by the law enforcers. The methodology can be seen in Figure 3.1.

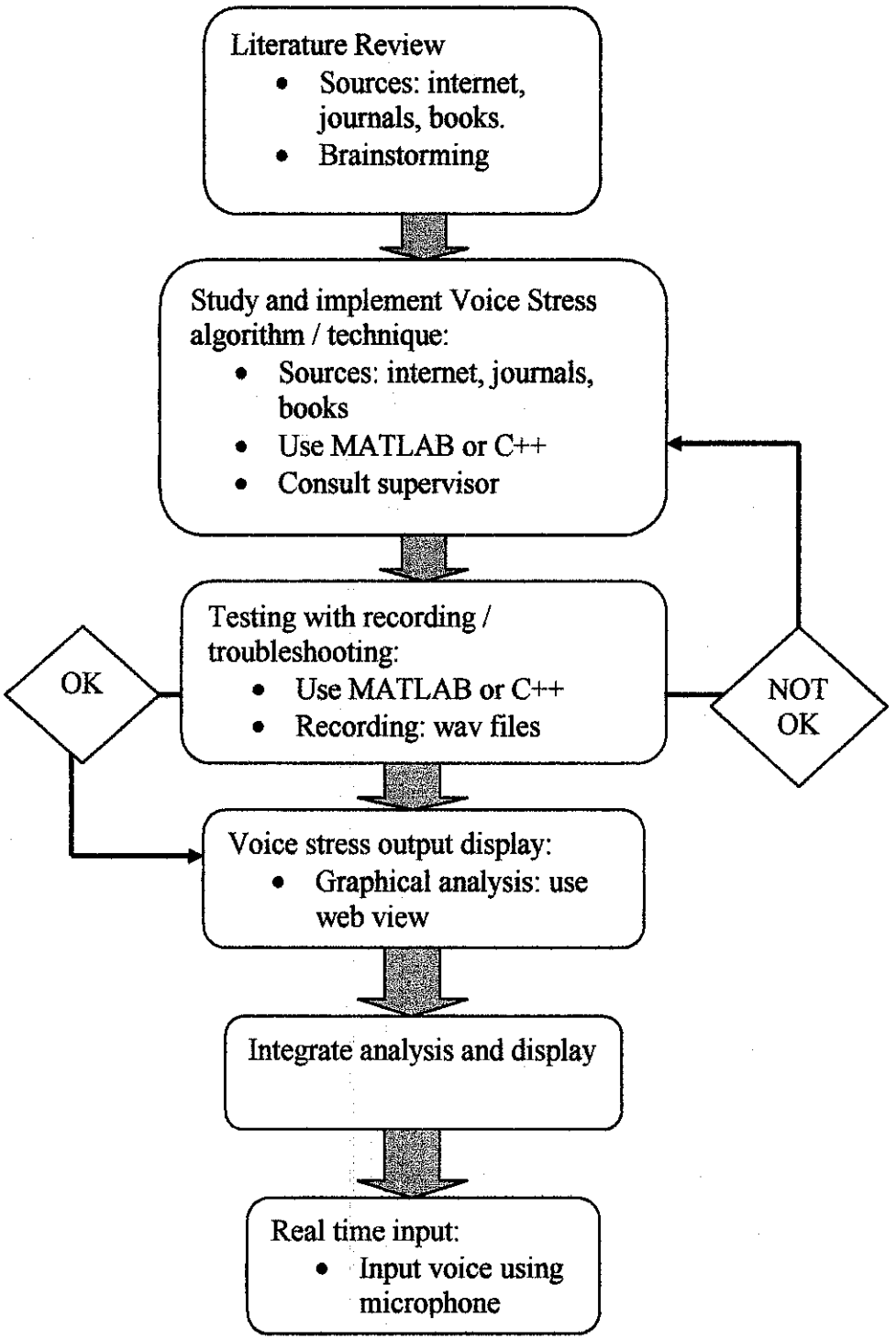

Figure 3.1: Methodology

3.2 DEVELOPED ALGORITHM

As stated earlier, there was no exact algorithm found on voice stress analysis. To take the next step, an algorithm was developed based on the information found in the articles.

Firstly, the input voice is recorded using Windows Sound Recorder. The file is saved as a .wav file. However, after processing the sound files, there were difficulties in obtaining a 'lying' sample. To solve the matter, an interrogation tape was obtained from the Malaysia Air Force Army. The interrogation tape was first transferred from magnetic cassette tape to digital audio (.wav file) using the software Sony Sound Forge 7.0. The voices were segmented to separate between the suspect's voice and the interviewer's voice. Once the voices were segmented, the suspect's voice is saved in different files for each question. The audio files were resampled to 11025 sampling rate, 8-bit mono file to facilitate the acceptance of the signal for the system.

The segmented voices are then processed in MATLAB to obtain the energy spectrum. This is because, according to [9], the level of stress is analyzed in the energy spectrum of the suspect's voice.

After obtaining the energy spectrum, the voice is bandlimited between the range of 20 to 40 Hz. According to [9], the change of energy in the speech envelope at this range determines stressful and non stressful voice. Then, the waveforms are analyzed. If the waveform appears to be sharp, the suspect is telling the truth while if the waveform appears to be flat, the suspect is said to be lying. Lastly, a decision is made to confirm whether the suspect is lying or not. The results of the decision will be displayed in a graph stating the percentage of the voice to be truthful or otherwise. The developed algorithm is illustrated in Figure 3.2.

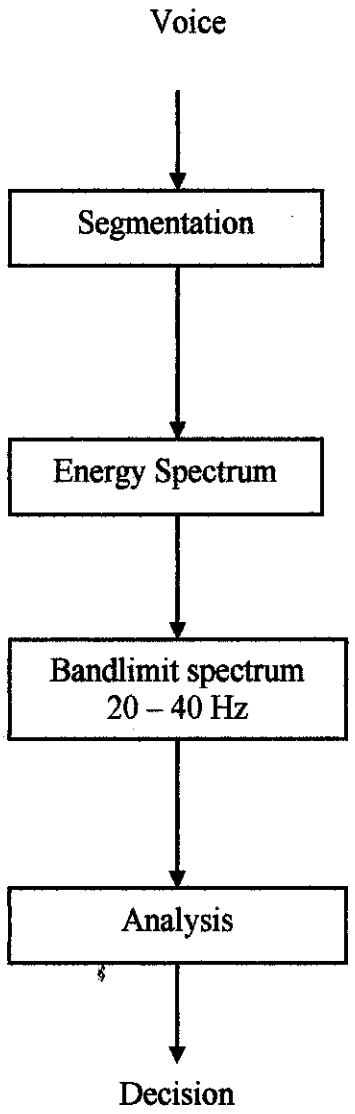

Figure 3.2: Developed algorithm

Table 3.1: Description of terms in algorithm

Voice	The voice recorded in .wav file is inserted as input.
Segmentation	The resulting graph of both suspect's voice and questioner's voice is segmented.
Energy Spectrum	Fast Fourier Transform is done to the suspects voice to obtain the energy spectrum.
Bandlimit spectrum	Limiting the frequency spectrum from 20 – 40 Hz
Analysis	Analyzing the graph obtained.
Decision	Deciding whether the subject's answer is truthful or not

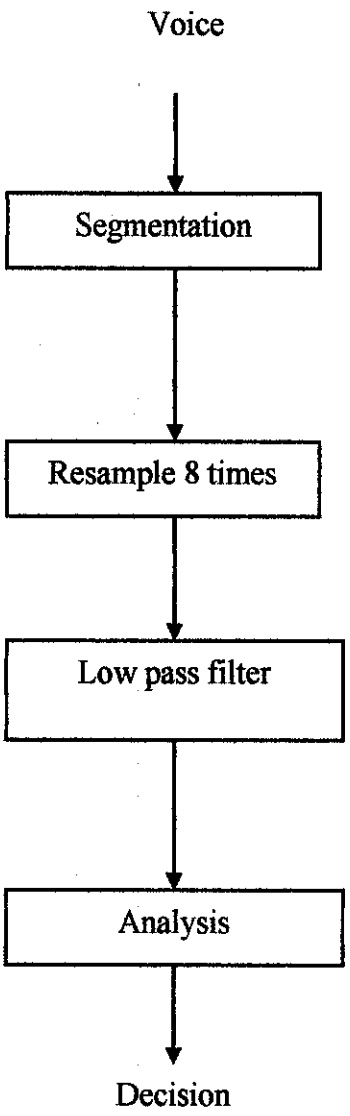

Figure 3.3: Developed algorithm

Table 3.2: Description of terms in algorithm

Voice	The voice recorded in .wav file is inserted as input.
Segmentation	The resulting graph of both suspect's voice and questioner's voice is segmented.
Resample 8 times	Voice is resampled 8 times to create the one eighth tape play speed
Low pass filter	Voice is passed through digital low-pass filter with pass band frequency 12 Hz and stop band frequency 15 Hz.
Analysis	Analyzing the graph obtained.
Decision	Deciding whether the subject's answer is truthful or not

3.3 CHANGE IN ALGORITHM

After doing more research, a new method was found and used in the project. There were also alterations done to the algorithm.

Firstly, the segmentation part is changed. Previously, the segmentation was done in MATLAB by extracting only the signals needed. However, it was very hard to achieve good results. A software, Sony Sound Forge 7.0 was found that can be used to complete the segmentation part. Using this software, the voice of the suspect can be cut out easily. Each answer is separated from the original recording and saved as a different file.

A MATLAB software tool named Colea that is used to process voice is also found. The features of this tool are

- Dual time-waveform and spectrogram displays
- Records speech directly into MATLAB
- Displays time-aligned phonetic transcriptions (e.g., TIMIT's .phn files)
- Manual segmentation of speech waveforms - *creates label files which can be used to train speech recognition systems*
- Waveform editing - *cutting, copying or pasting speech segments*
- Formant analysis - *displays formant tracks of F1, F2 and F3*
- Pitch analysis
- Filter tool - *filters speech signal at cutoff frequencies specified by the user*
- Comparison tool - *compares two waveforms using several spectral distance measures*
- Speech degradation - *adds noise to the speech signal at an SNR specified by the user*

This tool however does not help in doing the project. Figure 3.4 is an example of an answer processed using Colea.

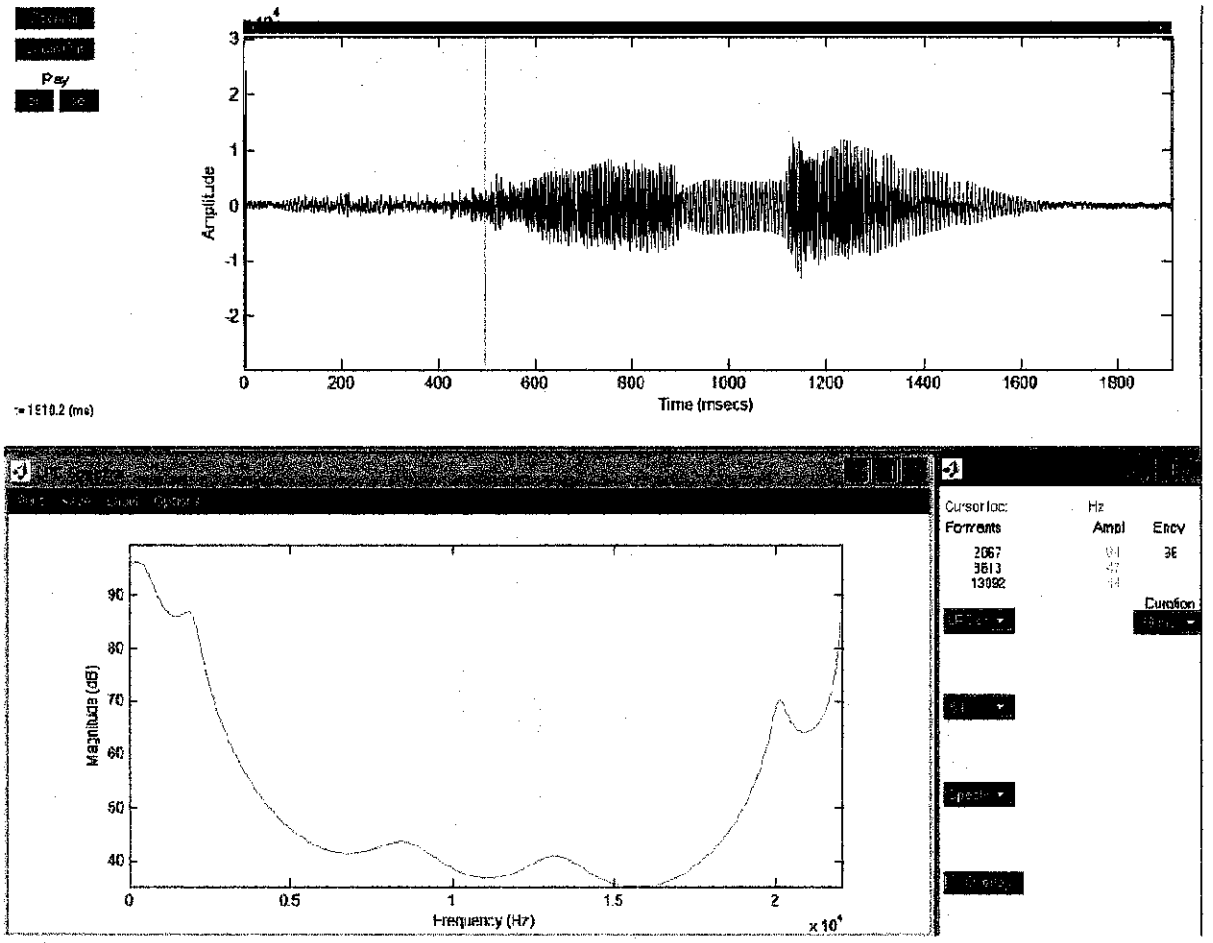

Figure 3.4: Example of voice processed using Colea.

CHAPTER 4

RESULTS AND DISCUSSION

After the algorithm was developed, a lot of tests had been made to prove that the algorithm is working correctly. There were a few changes made to the first algorithm and also a MATLAB code was found on the internet to measure voice stress analysis using frequency based system. Tests had been done on both methods and compared with the results of the polygraph technique. The matters are explained further in this chapter.

4.1 SAMPLE TESTING

The graph in Figure 4.1 is the graph for the whole questioning session. The graph contains extreme high amplitudes and low amplitudes. The extreme high amplitude indicates the suspect's voice while the low amplitude indicates the interviewer's voice. The arrows above, points to the low amplitude components while the arrows below shows the extreme high amplitude components. [*see appendix 1 and 2 for the questions asked and code used*]

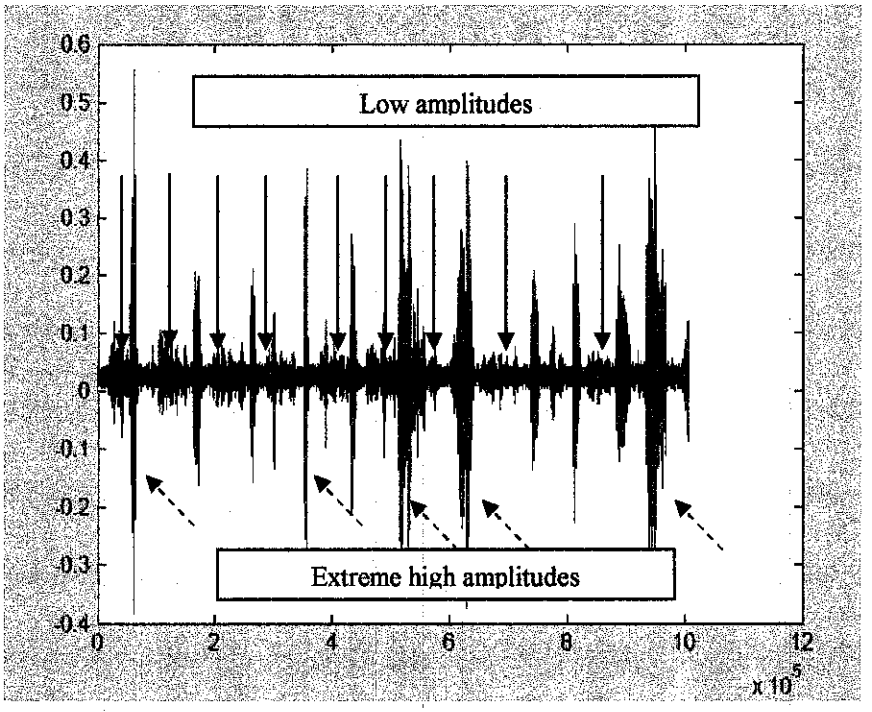

Figure 4.1: Plotted graph of questioning session

For the segmentation process, it can be done either automatically or manually. For the first attempt, the signals for each question and corresponding answer were plotted separately. The idea was to separate between each answer and combine all the answer for each question in one plot. The resulting graph for this technique is shown in Figure 4.2 and 4.3:

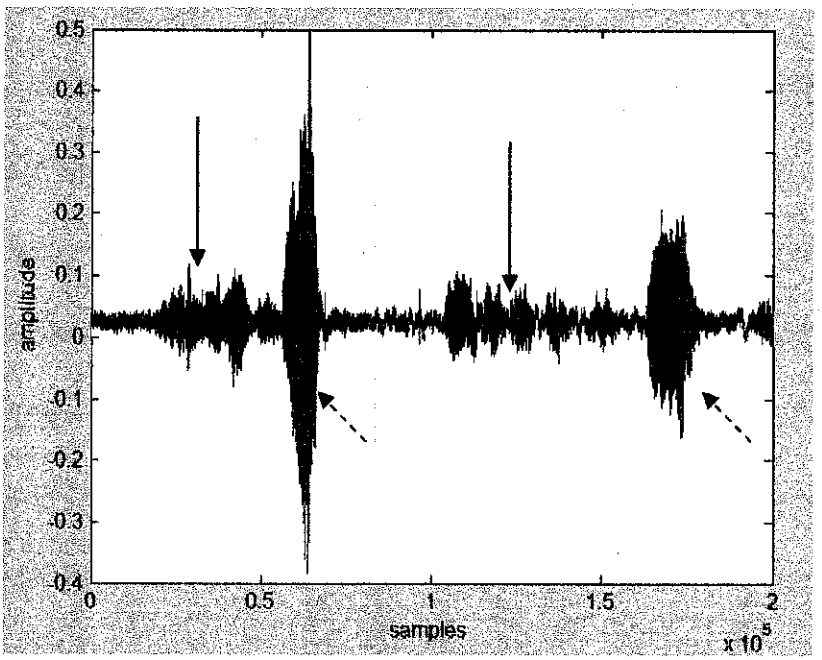

Figure 4.2: Plot of questioning session for question 1 and question 2 (2000000 samples)

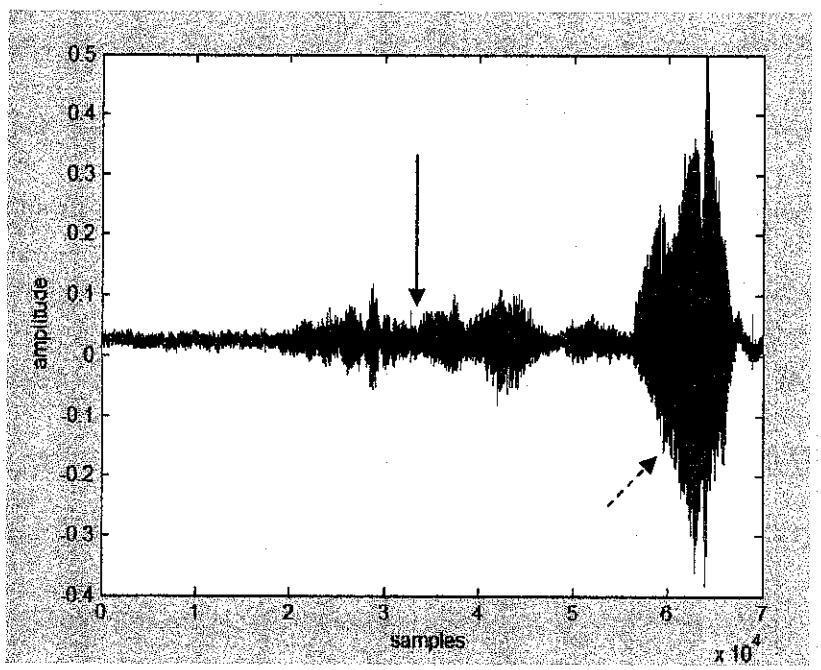

Figure 4.3: Plot for Question 1 and answer for question 1(70000 samples)

As can be seen in the figure, it is hard to achieve the exact no of sample for the question or answer. The code had only changed the range of plot. Due to that, the segmentation part is still not finalized. [*see appendix 3 for the code used*]

4.2 ENERGY SPECTRUM OF VOICE

In the previous algorithm, all the results appeared to be a sharp graph which indicates no stress or truthful. The code was run by various voice samples and still the results were all truthful voice. The figure 4.4 shows the results achieved using the first algorithm.

The figure 4.4 is monitored at 8 to 12 Hz which is element 3 to 5. It can be seen as stated by the circle, that the shape of the graph from sample 3 to 5 neither is flat nor the shape of a Christmas tree. This could not conclude anything. After realizing this, the algorithm is revised by doing more research and reading more journals on voice stress analysis.The voice recordings are once again been processed.

It is found that the exact frequency to monitor stress is in the range 20 to 40 Hz. The result of the FFT of the voice sample is zoomed in to show the frequencies between 20 to 40 Hz. This is depicted in figure 4.5. For this graph, 20 to 40 Hz is the samples number 13 to 28, respectively. It can be seen that the shape, as indicated by the circle, is somewhat similar to the shape of a Christmas tree, which indicates truthful voice. However, after running the code on various types of voice recordings, the results were all truthful results. No stressful voice is detected. This method was revised by reading the journal on energy based system and it is found that the voice should be monitored in the energy spectrum graph in 20 to 40 Hz frequency.

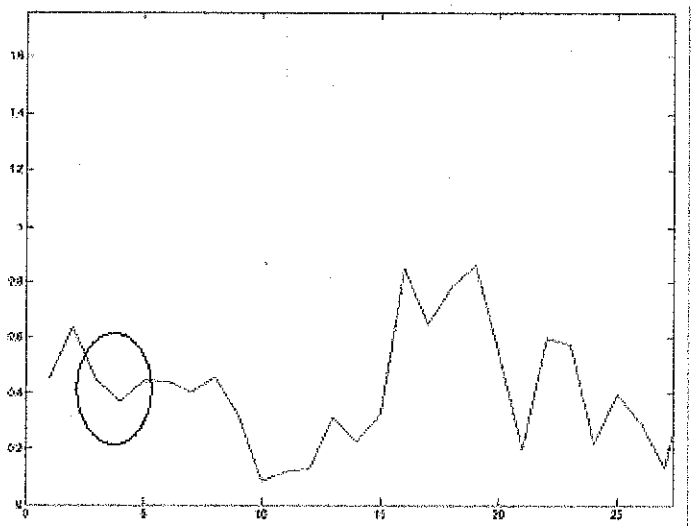

Figure 4.4 : Plot of Question 1 zoomed at 8 to 12 Hz

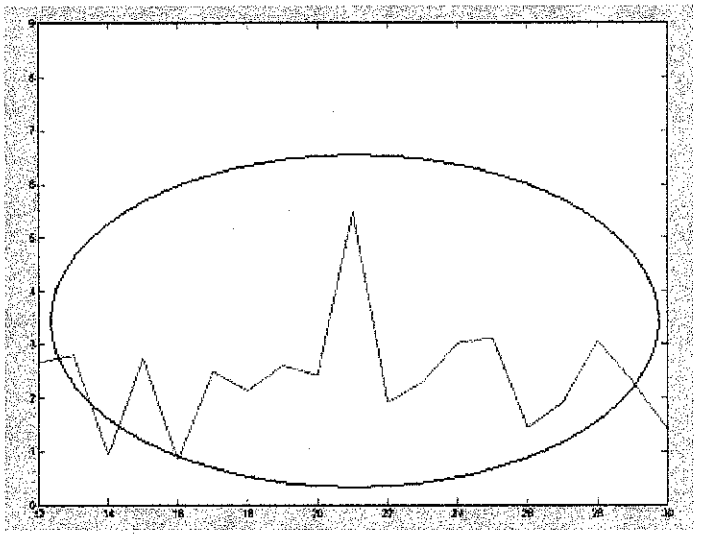

Figure 4.5 : Plot of Question 1 zoomed at 20 – 40 Hz

The new algorithm is implemented and the results are shown in figures 4.6 to 4.10. The voice sample is obtained from the Malaysia Air Force Army. Using MATLAB, the energy spectrum of the segmented voice files is processed. From the energy spectrum graph, it is zoomed to the range 20 to 40 Hz.

From the figures 4.6 to 4.10, it can be seen that the results are varied. Both flat graphs and pointed graphs are obtained. For figures 4.6, 4.7 and 4.10 the graphs appear to be flat. This, according to the theory, indicates hard stress, which also means the person is lying. Meanwhile, in figures 4.8 and 4.9, the graph appears to be triangular shape which indicates low stress and the person is telling the truth.

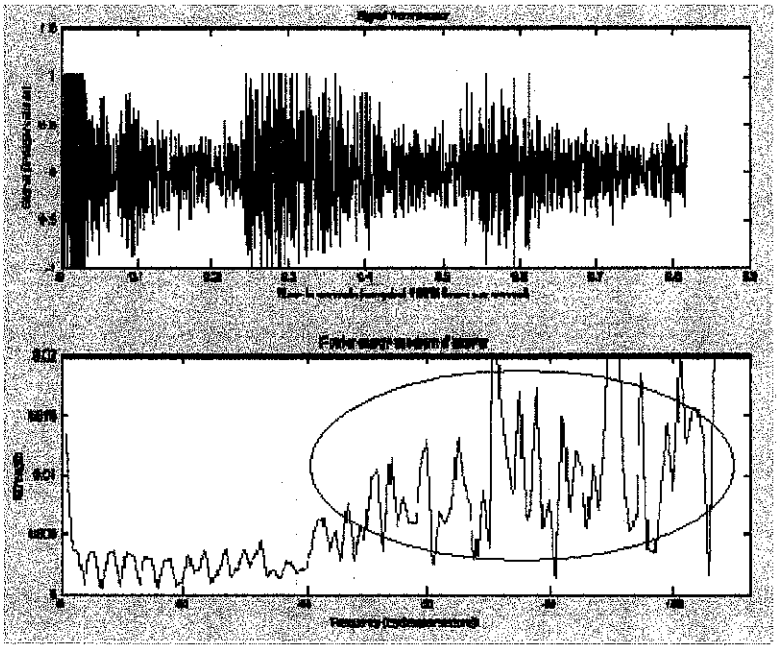

Figure 4.6: Plot of signal and energy spectrum of answer 1

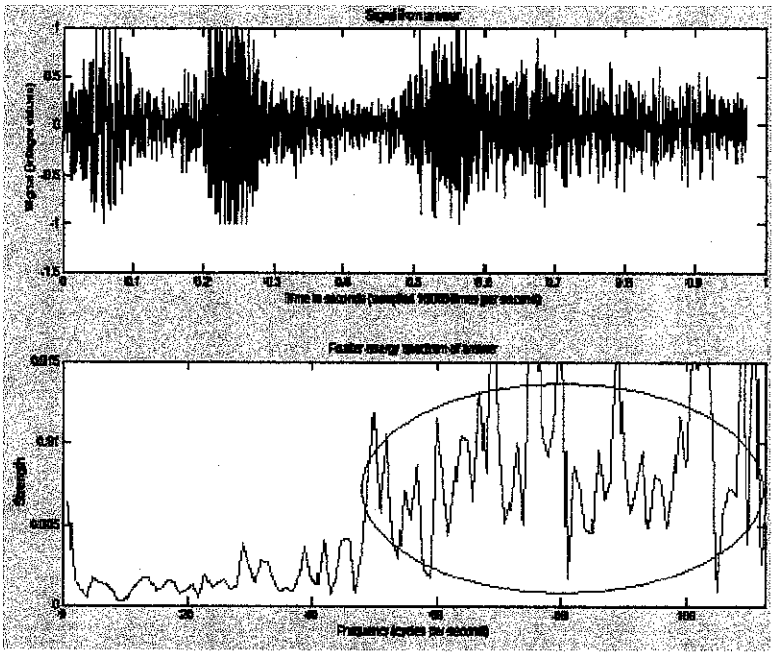

Figure 4.7: Plot of signal and energy spectrum of answer 2

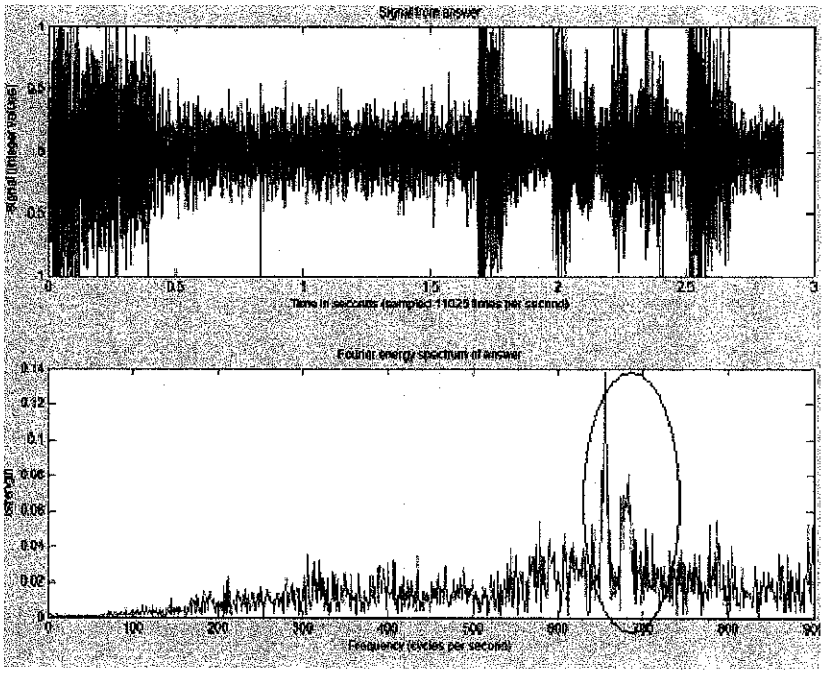

Figure 4.8: Plot of signal and energy spectrum of answer 3

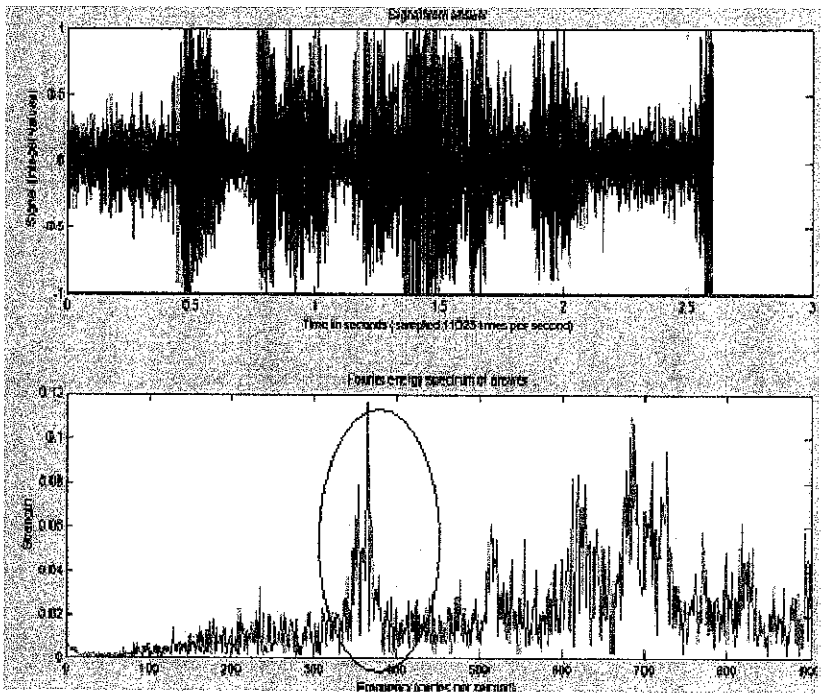

Figure 4.9: Plot of signal and energy spectrum of answer 4

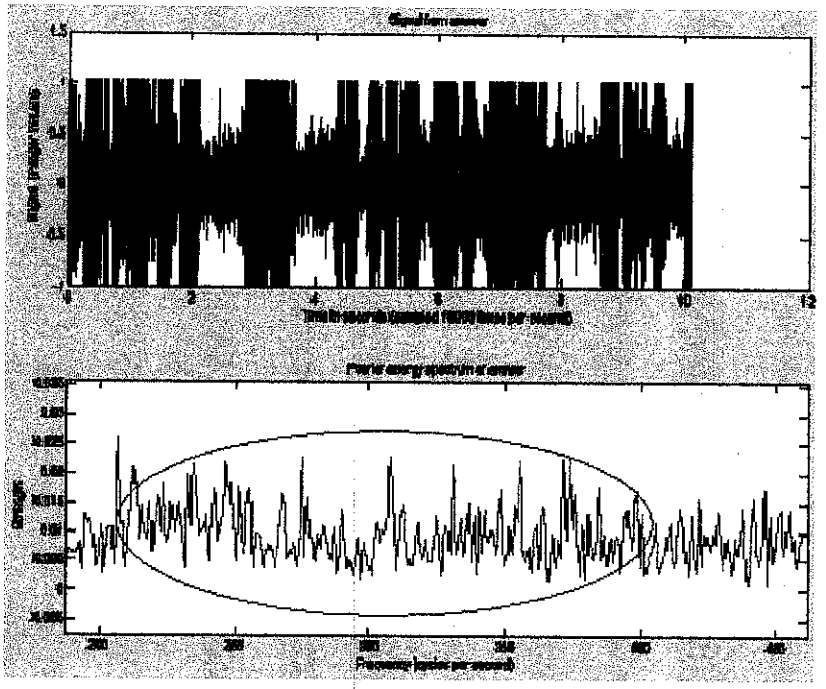

Figure 4.10: Plot of signal and energy spectrum of answer 5

4.3 VARIATION IN GRAPH

After the segmentation is completed, the voice is then resampled 8 times to simulate the one-eighth tape play speed. The voice is then filtered using low-pass digital filter with passband frequency of 12Hz and stopband frequency 15Hz. [*see appendix 8 for source code*]

Using this method, deception is detected in the variation that appears in the output graph. Low variation or no variation means that the voice is a stressful voice which means the voice is a 'lying' voice. High variation in the output graph denotes that the output graph is low in stress and can be concluded as 'truthful' voice.

The graphs in Figures 4.11 – 4.16, and 3.18, show high variation. This denotes that the voice processed is a 'truthful' voice. However, the graph 4.17 shows low variation in the graph. Thus, it is a stressful voice or 'lying' voice.

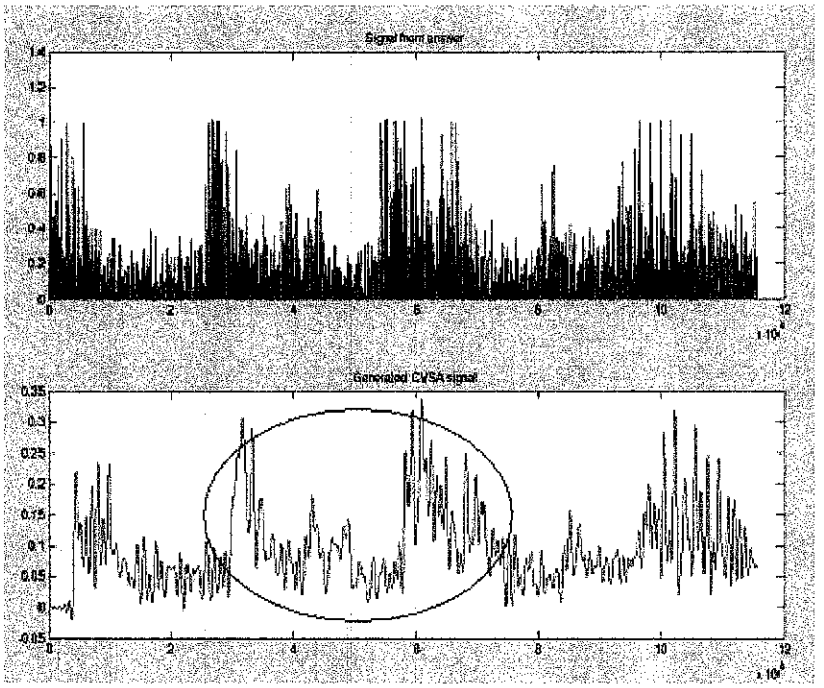

Figure 4.11: Plot of signal and filtered voice

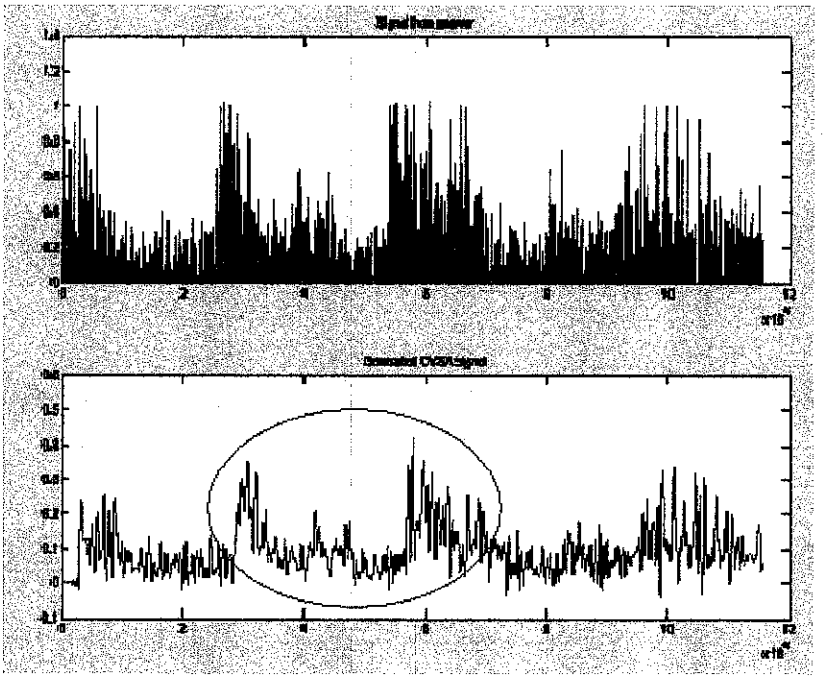

Figure 4.12: Plot of signal and filtered voice

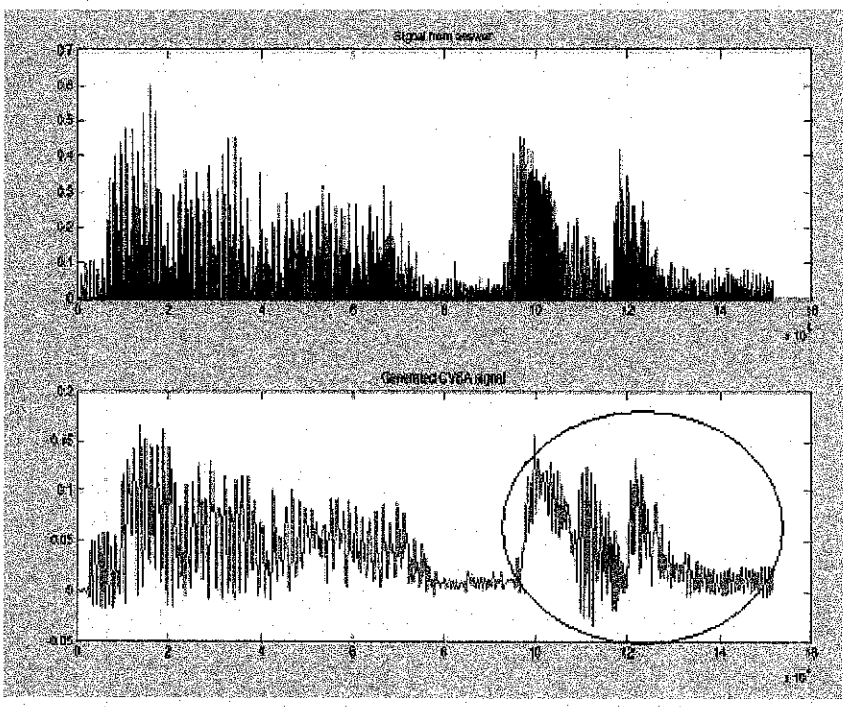

Figure 4.13: Plot of signal and filtered voice

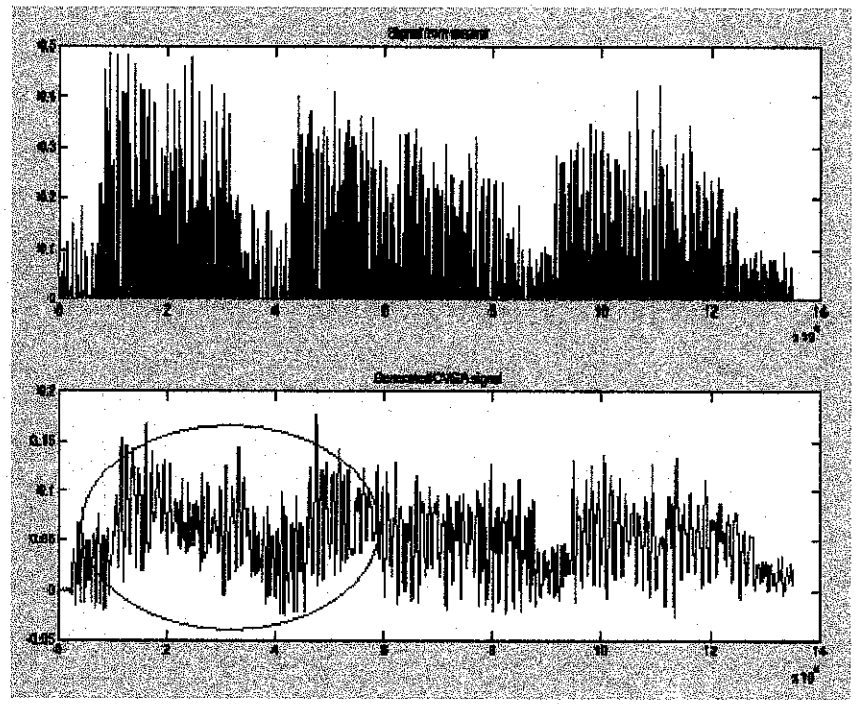

Figure 4.14: Plot of signal and filtered voice

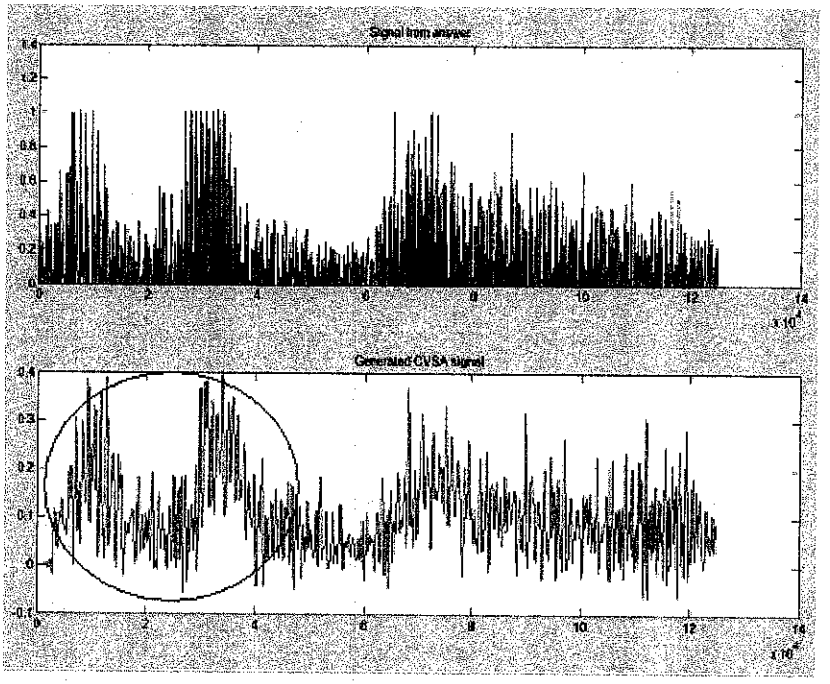

Figure 4.15: Plot of signal and filtered voice

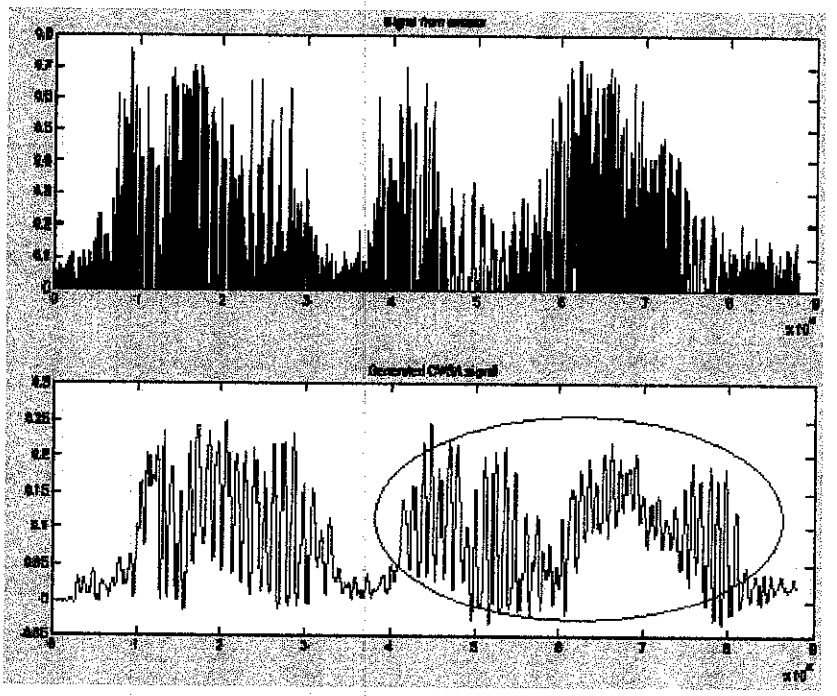

Figure 4.16: Plot of signal and filtered voice

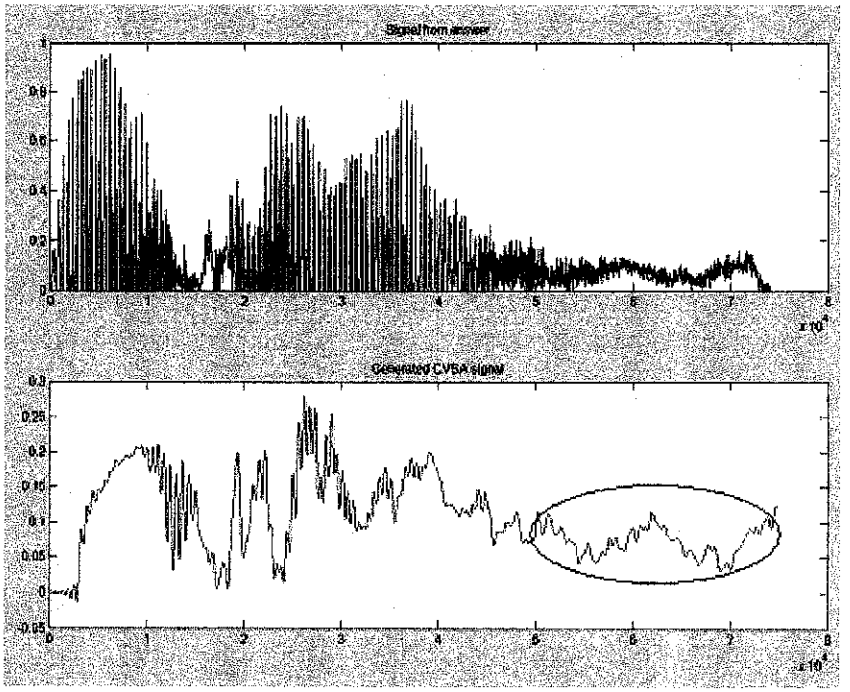

Figure 4.17: Plot of signal and filtered voice

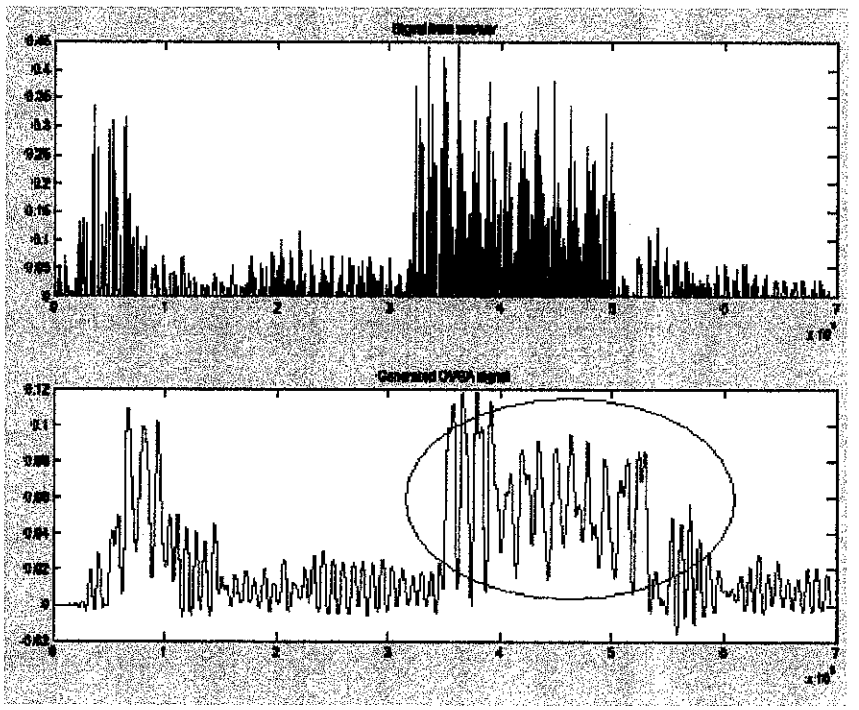

Figure 4.18: Plot of signal and filtered voice

4.4 PERCENTANGE OF CONSISTENCY

After tests were done to the voice recording, the results from both methods are compared to the results achieved from the Malaysia Air Force Army and the percentage of consistency of the results are calculated. The results for the truthful voice were all similar to the polygraph results in both methods. However, there were differences in the results of the lying voice.

The energy – based system has a lower accuracy with a percentage 95% compared to frequency – based system which has a percentage of 97.6%. This proves that frequency – based system has greater precision compared to energy – based system. The results of both methods compared to the polygraph method for each question can be referred to Table 4.1.

Table 4.1: Comparison of results for polygraph, energy – based system and frequency – based system

Question No	Polygraph	Energy - based system	Frequency – based system
1	Truthful	Truthful	Truthful
2	Truthful	Truthful	Truthful
3	Truthful	Truthful	Truthful
4	Truthful	Truthful	Truthful
5	Truthful	Truthful	Truthful
6	Truthful	Truthful	Truthful
7	Truthful	Truthful	Truthful
8	Truthful	Truthful	Truthful
9	Truthful	Truthful	Truthful
10	Truthful	Truthful	Truthful
11	Truthful	Truthful	Truthful
12	Truthful	Truthful	Truthful
13	Truthful	Truthful	Truthful
14	Truthful	Truthful	Truthful
15	Truthful	Truthful	Truthful
16	Truthful	Truthful	Truthful
17	Truthful	Truthful	Truthful
18	Truthful	Truthful	Truthful
19	Truthful	Truthful	Truthful
20	Truthful	Truthful	Truthful
21	Truthful	Truthful	Truthful
22	Truthful	Truthful	Truthful
23	Truthful	Truthful	Truthful
24	Truthful	Truthful	Truthful
25	Truthful	Truthful	Truthful
26	Truthful	Truthful	Truthful
27	Truthful	Truthful	Truthful
28	Truthful	Truthful	Truthful
29	Truthful	Truthful	Truthful
30	Truthful	Truthful	Truthful
31	Truthful	Truthful	Truthful
32	Truthful	Truthful	Truthful
33	Truthful	Truthful	Truthful
34	Truthful	Truthful	Truthful
35	**Lying**	**Lying**	**Truthful**
36	Truthful	Truthful	Truthful
37	**Lying**	**Truthful**	**Lying**
38	**Lying**	**Truthful**	**Lying**
39	Truthful	Truthful	Truthful
40	Truthful	Truthful	Truthful
41	Truthful	Truthful	Truthful

CHAPTER 5

CONCLUSION

In this project, lie detection has been done in two methods. Both results were then compared to each other and also to the polygraph results from the Air Force Army. There were similar results and also different results for both methods. However, when compared to the polygraph results, both methods have similar and different results with the polygraph results.

The energy based method has more similar results to the polygraph results when compared to the frequency based method. This means that the energy based method is more reliable than the frequency based method. However, there were also some results where the frequency based method is similar to the polygraph results. It can be concluded that, deception can be detected using voice stress analysis and energy based system has more accuracy than frequency based system.

To make the project better, it is recommended that the analysis of lie detection can be done automatically. This would make the process of lie detection faster. It is also recommended that a lot more real interrogation voice files could be processed to determine a much more accurate results.

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APPENDICES

Appendix 1

Questions asked during the recorded session:

1. Are you (subject's name) ?
2. Do you live in rembau?
3. Are you an alcoholic?
4. Do you like spicy foods?
5. Do you like tennis?
6. Are you a drug dealer?
7. Do you like swimming?
8. Do you have a pet?
9. Do you smoke?
10. Are you hungry?

Time taken: 22.87 seconds

Appendix 2

Questions and answers during the Air Force Army interrogation session:

Q1: What is your appointment in the sqn?

A1: I'm an instructor for Hawk and also the SMO (Students Management Officer).

Q2: When did you start reporting to the sqn?

A2: I reported in Sept 2004, started my IP conversion and got my CAT in Nov 2004.

Q3: You arrive 0600H, what time did the students come to the sqn?

A3: My estimation will be 30 min before time.

Q4: Have you point covered on special subject, during the briefing did the GCI attend the briefing?

A4: Yes sir 3 of them, 3 controllers.

Q5: What was covered during your emergency brief, other than the special subject?

A5: At this stage we don't go everything in detail, I only covered in detail in aborting on ground, aborting procedures and the selected emergency that I covered for the day was collision in which I also introduced what we call the breakaway minima for intercept sorties.

Q6: Looking at the situation, in the morning how did you perceive Kapt Yusari attention during the brief?

A6: Attentive, very attentive, He looked fresh and he was listening attentively to whatever I was saying in fact all the students were attentive.

Q7: Did he ask any question during the brief on top of your question that you gave him?

A7: He didn't ask me sir, but I think Kapt Yazmi ask me question, I can't really remember what he asked me about sir.

Q8: Meaning to say that you did not brief anything on fuel?

A8: We take selected emergency sir so I didn't cover on fuel on that day sir, I cover collision and also on RT failure.

Q9: Is Kapt Yusari your personal student?

A9: We don't have any personal student sir in 15 Sqn but I have flown quite a number of sorties with him in fact he flew the first sortie in Labuan with me sir.

Q10: How many sortie has he flown in Labuan?

A10: Before the AWI sortie, he has flown 2 sorties, the first famil sortie with me that involve practice diversion and the second sortie PI with Mej Zahani.

Q11: I believe he should take 2 PI sortie prior to AWI?

A11: Yes sir.

Q12: Only one PI sortie flown over here?

A12: That's right sir, may be I can clarify that sir because Mej Azman Jantan did speak to me and Mej Zahani on his performance prior to this sortie, I assessed him as a high average student so we recommended him to proceed based on his good domestics and circuit work.

Q13: Talking about briefing again do you think Kapt Yusari understood, first the briefing for this exercise and of course the emergencies?

A13: Yes sir he did, why I say that is because they have flown a lot of simulator on AWI before his actual flying and I have given a mass brief covering all the emergency procedures before we come here.

Q14: How many passes did you plan for the sortie, 5 or 6?

A14: 4 passes each student meaning 8 passes in total.

Q15: You did 6 passes correct?

A15: We did 7 passes, 4 passes for Kapt Shamsul and 3 for Kapt Yusari.

Q16: In term of personal question on that day on Arwah Kapt Yusari, in your opinion do you think he is confident enough to fly this sortie, taking into account that his hours only 3.3 and especially he is away flying in Labuan?

A16: Yes sir, this is based on my flights with him, his flight conduct was good sir and I didn't encounter any major problem with him and his circuits work was fine.

Q17: You did mention that his performance is on a high average site, how about his attitude in general and flying?

A17: Among the student that I had, he was one of the very hardworking guy beside Arwah Zamir who passed away in a road accident. This guy was putting a lot of effort, for instance, when I walked out on that particular morning he took effort to prepare a log card for himself, inside the log card I saw he had all the AWI

geometry written neatly which is similar to what we do in 6 Sqn those days. I don't see other student do it. That shows me that he was really keen. I think other instructor will also concur his hardworking attitude.

Q18: What did you think about his knowledge?

A18: The knowledge wise, I would say this guy are on the average, there still a lot of thing that he did not know and unsure but being a student sir of course they cannot absorb everything. Average, there are lots of room for improvement.

Q19: For the squadron ground school training, can you please confirmed that you have about one and half month for the ground school?

A19: Yes sir.

Q20: How often do you practice the written Boldface test, once a week?

A20: Yes sir, every Monday or the first working day of the week and Limitations was done every first working day of the month.

Q21: Another formal question would be authorizing officer, I believe you were the authorizing officer and IP right?

A21: Yes sir.

Q22: Talking about normal practice is it normal for the IPs to bring 2 students up solo in any mission because I've seen it in the program, throughout the program instructors were carrying 2 students and instructors were flying 3 missions a day.

A22: On the first part of the question it is normal for us to do this only for AWI phase, when I came over I noticed that on the AWI phase usually the instructor bring 2 students up so that we can cover both student at one time. As for instructors flying 3 sorties in a day is as and when required sir, not a normal practice.

Q23: Are you aware of the previous accident that pilot ejected on 108 on the runway and from there on there is a kind of a unwritten rules and regulation stating that no

solo flight for student in Labuan. Do the sqn aware of that or probably it is a practice for that particular CO of that time?

A23: Sir on that question, I don't know whether the sqn is aware about that part but personally I'm not sir, I'm not sure about that because it is not written.

Q24: Talking about IP bringing 2 students up in a formation, do you have kind of a lay down and all that?

A24: No sir, this planned was done by the sqn programmer after getting advice or I would say approval from the OC flying in this case, Mej Zahani.

Q25: Explain what is the standard emergency procedure for low fuel?

A25: Actually for low fuel there is no standard way of recovering to the base, it involves a lot of judgment but most of the time ever since I was a student we were taught that it is good that you come back high to reduce the fuel consumption and in case anything happened, you can go for forced landing or precautionary landing pattern, most of the time this what we have practiced.

Q26: Is it land as soon as possible?

A26: Yes sir land as soon as possible, affirmative.

Q27: Just to confirm again on what is in the book. When will a low fuel light come out and how do you know that the fuel transfer failure?

A27: The low fuel warning light come out as per the book 350 +- 50 but based on my experience as FCF pilot sometimes it come out way below that sir, so it depends whenever that happens we will inform the ground crew to rectify that and what was your next question sir?

Q28: Fuel transfer.

A28: How do we know the fuel transfer failure sir? First of all if you have a fuel transfer failure, you will have a fuel transfer warning sir, amber warning on your CWP. If the fuel transfer warning does not come on there is other means to tell

you that the fuel is either transferring slowly or not transferring at all by looking at your EMP. If you have more than 60lbs of fuel on external tank with less than 2400lbs in internal tank than your total fuel will start flashing. And if your port and stbd is not transferring at all it will also start to blink. If the fuel continue to transfer it will stop flashing somewhere at about 2700lbs. That is another means of telling you that you might have fuel transfer failure.

Q29: Talking about the fuel, in your opinion do you think that Yusari realized that he has that problem earlier or not at all?

A29: In my judgment he did not realized it at all until the point that low fuel warning came out. In every DEGAP that we did his fuel call were normal as per No. 2. I cannot compare with me sir because I was carrying 4.8 fuel so I could only compare with No 2 because they were carrying the same fuel configuration.

Q30: Assume that he understands what has been briefed, do you think in term of emergencies will he be distracted or panicked?

A30: You were talking about actual emergencies or simulated emergencies. We have some emergencies practice sir especially during their GF phase and when we came back from Tac Nav. As far as I flew with him at the back seat for the sorties, his capabilities of handling the emergencies was average sir. Yes, there were times that he panicked but not to the extent that he didn't know what to do.

Q31: Did he ever commit a breach of any type of procedures?

A31: Never so far.

Q32: Do you think that Yusari may be unsure and anxious during handling of that emergency?

A32: To answer that question I would like to add on something here to the BOI team, that it is one of the main reason why I didn't call MAYDAY because in my judgement, I tried to minimised the pressure on him to avoid panic. In fact I talked through the sequence of activity for him as smooth as possible in order not

to alarm him unnecessarily. I'm sure that he should be able to handle it in that calm environment.

Q33: Did you patter him?

A33: I pattered him initially until the point where I peeled off.

Q34: You said that you declare emergency because you declare low fuel or emergency fuel?

A34: I called low fuel sir.

Q35: What did you do during recovery, were you in front of him and how far were you at that position?

A35: I was behind him sir, from him about 45°,40°-60° off. Initially, I was at 1000' but as we were closing in, I can't remember the figure sir because I was actually looking at him while talking but roughly it was approximately 15 – 20 nm. I was actually moved out to about 3000' – 6000', still monitoring him flying all the way down to final and I pattered up to the point I split.

Q36: Why don't you go to Tower Freq, I mean the whole formation go to Tower Freq and hold at about 10nm?

A36: Because initially when I called up Approach to get him the priority, we were outside, about 25 nm so I maintained on Approach Freq moreover the other student were on approach control.

Q37: Do you think it will be easier for the whole formation to be in the same freq and you just let him be in front of you and escort him back instead of doing that?

A37: I did escort him sir, the only thing was I didn't go to Tower Freq. It would have been better sir if we were in Tower Freq.

Q38: Just curios, in fact many people asking, why didn't you escort him until touchdown?

A38: Actually sir, at the point of time based on my judgment, I have positioned him nicely on the approach and it was a clear weather, he was visual with runway. I was with him initially and his approach was good, he was fine I was also concerned about the other student up there. Based on this, I concluded that he can go and land safely but may be it was a wrong decision. I felt that everything was going well and nice, he was at the right position, right glide path so I made that decision.

Q39: Did you realize that after you broke off, your student was at 5.9miles at altitude 1700ft while having a very high speed of 391k which was too fast? Did you know about that?

A39: I'm not sure about that sir.

Q40: Escorting, we have been escorting all the way until touch down and going to same freq everybody which is easy to advice each other, you don't know what happened the other guy right and you ask him individually to go to Tower right?

A40: Yes sir.

Q41: Did you realize that the tape you were carrying is good for only 45 minutes? Why didn't the squadron ensure that you have a 90min tape that can cover the whole sortie?

A41: Yes sir but we always selected LP (Long Play option) that provides recording up to 90 minutes. But on why not get a 90 min tape, I do not have a concrete answer.

Appendix 3

For the recording session, the questions set are simple. After recording the voice, the file is processed in MATLAB. Below is the code used:

```
clf;
y = wavread ('test1.wav');      - to enable MATLAB to read file
fs = 44100;                     - sampling frequency of recorded file
sound (y,fs);                   - to play the file
plot (y);                       - to plot the file
```

Appendix 4

```
y=wavread('test1.wav');         - to enable MATLAB to read the file
plot(y);                        - to plot the input signal
xmin=0;                         - setting the minimum for x-axis
xmax=70000;                     - setting the maximum for x-axis
ymin=-0.5;                      - setting the minimum for y-axis
ymax=0.5;                       - setting the maximum for y-axis
axis([xmin xmax ymin ymax]);    - change the range of the x-axis and y-axis to the
                                  values above
```

Appendix 5

For both graphs, the code used was:

```
y=wavread('test1.wav');         - to read the file in MATLAB
p=find(y>0.1);                  - get the samples for amplitude bigger than 0.1
q=find(y<-0.1);                 - get the samples for amplitude smaller than -0.1
plot(p);                        - to plot the samples bigger than 0.1
plot(q);                        - to plot the samples smaller than 1
```

Appendix 6

```
N=input('Type in the length of DFT = ');          - setting the length of DFT
T = input('Type in the sampling period = ');      - setting the sampling period
freq= input('Type in the sinusoid frequency = '); - setting the frequency of signal
k=0:N-1;                                          - setting the value of k
f=sin(2*pi*freq*k*(1/T));                         - the equation of f
F=fft(f);                                         - FFT of f
stem(k,abs(F));grid                               - plot the FFT of F in stem
xlabel('k')                                       - labeling x-axis
ylabel('|X[k]|')                                  - labeling y-axis
```

Appendix 7

```
[w]=wavread('nadia2.wav');                        -reading the input .wav file
figure(1);
subplot(211);                                     -making subplots
n=size(w);                                        -returns the two element row vector
w=w-median(w);
t=(1:n)/16000;


plot(t,w);
title ('Signal from answer');
xlabel('Time in seconds (sampled 16000 times per second)');
ylabel('Signal (integer values)');
subplot(212);
ws=fft(w);                                        -get the FFT of w
k=[1:1:900];                                      -setting the k
plot(k,abs(ws(k))/5000);                          -plot the energy spectrum
ylabel('Strength');
xlabel('Frequency (cycles per second)');
title ('Fourier energy spectrum of answer');
```

Appendix 8

```
function z =cvsa(x)
x=wavread('killer3.wav');

samp = 8000;
pass=12;
stop=15;
x = resample (x,8,1);                                    resampling voice 8 times
x(find(x<=0))=zeros(length(find(x<=0)),1);
y=x;
[n,Wn,beta,typ]=kaiserord([pass stop],[1 0], [0.01 0.1], 11025);     filtering voice
b=fir1(n,Wn,typ,kaiser(n+1,beta),'noscale');
z=filter(b,1,y);
subplot (211);
plot(x);
title('Signal from answer');
subplot(212);
plot(z);
title('Generated CVSA signal');
```