CLUSTERING METHOD FOR BONE TISSUE CLASSIFICATION USING ACOUSTIC EMISSION TECHNIQUE

MOHD NORHAFIFI BIN ZAINUDIN

Thesis submitted in partial fulfillment of the requirements

for the award of

Bachelor of Mechanical Engineering

Faculty of Mechanical Engineering

UNIVERSITI MALAYSIA PAHANG

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UNIVERSITI MALAYSIA PAHANG

FACULTY OF MECHANICAL ENGINEERING

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I hereby declare that i have checked this thesis and in my opinion, it is fully adequate in terms of language standard and report formatting requirement for the award of the degree of Bachelor of Mechanical Engineering.

Signature : .....

Name of Supervisor : Madam Miminorazeansuhaila binti Loman

Date : 24th JUNE 2013

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I hereby declare that the work in this thesis is my own except for quotations and summaries which have been duly acknowledged. The thesis has not been accepted for any degree and is not concurrently submitted for award of other degree.

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Name : MOHD NORHAFIFI BIN ZAINUDIN

MATRIC ID : MA09148

Date : 24th JUNE 2013

I specially dedicate to my beloved parents

and those who have guided

and motivated me for this project

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ABSTRACT

Bone is one of the important parts of human, as main part of the body it will support the vital internal organs of man and it is also used to move or walk. There are two types of bone structure in the human body that is compact bone and soft bone. Compact bone is located at the top of the bone structure, it is hard and compact. While the soft bone is in bone structure, compact bone below it softer and less dense than compact bone above. This project was undertaken to identify the location of compact bone or soft bone during perforation process underway. With the advent of my study, it can be used as a reference to identify the position of medical officer to penetrate the sides of which are correct or not based the graph. That RMS versus kurtosis, the conclusion if the perforations run and AE signals received from the same or they are in the group of points of reference against kurtosis RMS graph therefore safe position from the position of the spinal cord penetrate.

ABSTRAK

Tulang merupakan salahsatu bahagian manusia yang penting, ianya sebagai bahagian sokongan bagi sokongan bagi organ-organ dalaman penting manusia dan ianya juga digunakan untuk bergerak atau berjalan. Terdapat dua jenis struktur tulang didalam badan manusia iaitu tulang padat dan tulang lembut. Tulang yang padat berada dibahagian atas struktur tulang,ianya keras dan padat. Manakala tulang lembut berada didalam struktur tulang,dibawah tulang padat, ianya lebih lembut dan kurang padat berbanding dengan tulang padat tadi. Projek ini dijalankan untuk mengenalpasti kedudukan tulang padat ataupun tulang lembut ketika proses penebukan dijalankan. Dengan adanya kajian saya ini, ia dapat digunakan sebagai rujukan kepada pegawai perubatan untuk mengenalpasti kedudukan tebukan itu berada diposisi yang betul atau tidak berdasarkan rujukan graf kajian yang saya lakukan. Iaitu RMS melawan kurtosis, kesimpulannya jika proses penebukan dijalankan dan isyarat yang diterima dari AE sama atau ianya berada didalam kawasan kelompok titik dari rujukan graf RMS melawan kurtosis makanya kedudukan posisinya selamat dari tertebuk saraf tunjang

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LIST OF SYMBOLS

E	Value Of The Quantity Of Time
k	Kurtosis
M	Number Of Data
x	Data
y	Root Mean Square
μ	Data input
σ	Standard Derivation

LIST OF ABBREVIATIONS

AE	Acoustic Emission
AET	Acoustic Emission Testing
C1-C7	C for Cervical shape
L1-L5	L for Lumbar
NDT	Non-Destructive Testing
PSD	Power Spectral Density
RMS	Root Mean Square
T1-T12	T for Thoracic

LIST OF APPENDICES

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JUDUL: CLUSTERING METHOD FOR BONE TISSUE CLASSIFICATION USING ACOUSTIC EMISSION TECHNIQUE

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Taman Kajang Mewah
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CHAPTER 1

INTRODUCTION

1.1 PROJECT BACKGROUND

This project is basically focusing on new invention for medical and engineering purpose as well. Based on my project “Clustering method for bone tissue classification using acoustic emission technique”, it is improvising the old method of classification the bone tissue. Acoustic emission technique is the latest technology tool for classification bone tissue failure loads of the spine is used to develop tolerance data and in turn there is used to develop injury prevention devices. Acoustic emission (AE) sensor could provide more objective data on the timing of injury as they record dynamic stress waves generated by the release of energy in a material, such as the initiation of a fracture and they have been used to identify the time of injury of skull, ankle and tibia bones. Frequency signal from AE data has led to the identification of failure mechanisms of composite material. So, through this tool the classification of the bone tissue will be fast and more precise.

1.2 THE OBJECTIVE OF THE PROJECT

The objective of this project is to clustering the type of bone tissue other it is a sponge or the compact by using the pedicle screw technique in the back bone. It is very vital for this project to understand the frequency from energy inside the bone from the sensor of the acoustic emissions. Review the data get from signal of acoustic emission and analyse the accurate data without have noise or error.

1.3 SCOPE OF PROJECT

This scope is more important to ensure the research is done by the right method. In this research, it will focus of the acoustic emissions technique to monitor the pedicle screw fixation procedure. In this procedure, the signal from the hole at the bone that was come up from the internal bone energy because of the fraction between the probe and bone or other.

This project using the acoustic emission technique method only to solve the problem in the bone. Using the matlab software to make a cluster in the suitable type of clustering

1.4 PROBLEM STATEMENT

The problem in medical is pedicle screw technique nowadays is using the human sense to penetrate the human bone by professional doctor to solve the problem in human vertebra. By using the human sense method the percentage to fail still occur and will cause the death or handicap due to the pedicle screw will be penetrate to the spinal cord.

CHAPTER 2

LITERATURE REVIEW

In this thesis, have 3 elements have relative to make the experiment will success andachieve the objective. It is major element it is about human vertebral column, pedicle screw fixation, pedicle screw fixation and the clustering method using matlab software.

2.1 BONE

Bone is very important for human body because to support the framework that hold the body.It also provide a protective cavity for the brain (skull), cord (vertebrae) and vital (rib cage).Human use the bone to movement in provide attachment points for skeletal muscles and are used as levers. Human anatomy has divides bones into two major group, it is long bones and flat bones. This classification based solely on the gross appearance of the type of bone. The long bone category was extended to include two further types of bone that neither flat nor long, short and irregular bones. About the flat bone is sternum bone, ribs, scapulae and cranium. (Summerlee, 2008)

The bone tissue was divided into two types. First is compact or lamellar bone is dense with a few spaces or cavities and is composed of structural units called osteons or haversian system. The osteons like have ring of matrix call lamella which contain collagen fibers. The center is a haversian canal containing small blood vessels and nerve fibers. Then is sponge or cancellous bone lacks haversian system and has numerous space and cavities. That consists of an irregular lattice or network of thin, flat plate of bone call trabeculae. (Harris et al., 2003)

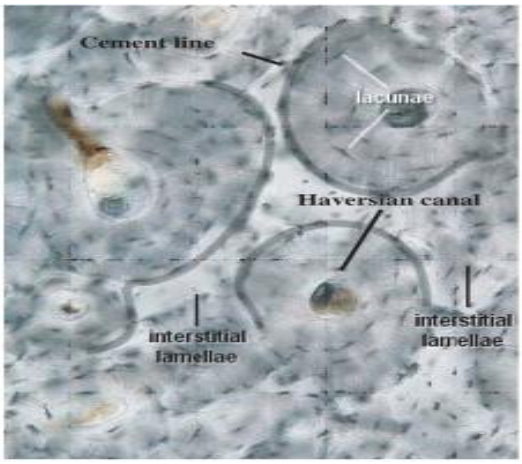


Figure 2.1: Compact bone

Source: Nather et al.,2002

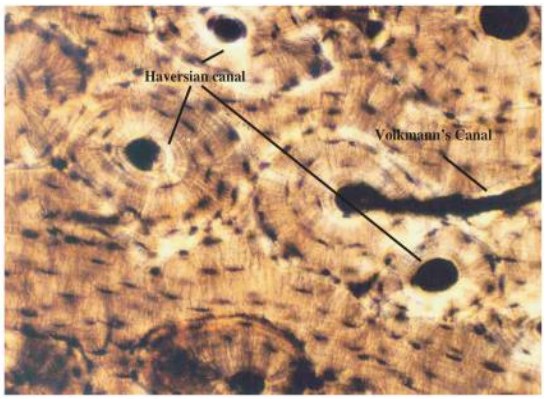


Figure 2.2: Sponge bone

Source: Nather et al., 2002

2.2 BASIC HUMAN VERTEBRAL COLUMN ANATOMY

2.2.1 Briefing Introduction Of Human Vertebral Column

In the human body has a lot of bones to support and protected the organs in the body, it provided a lot of shape and name. The bone also has a storage the site the mineral and provides the medium-marrow for the development and storage of blood cells. The basic concept is the bone have related in dense type of connective tissue impregnated with salt,

the salt of calcium such as calcium phosphate, calcium carbonate and other. The bone is a dense type of connective tissue by inorganic is compact tissue, cancellous tissue and the last subchondral tissue is the smooth at the ends of and it has covered with another type of tissue call cartilage. Compact and cancellous tissues are called the periosteum. Beneath the hard outer shell of the periosteum there are tunnels and canals through which blood and lymphatic vessels run to carry nourishment for the bone. Muscles, ligaments and tendons may attach to the periosteum. (Gray, 2001)

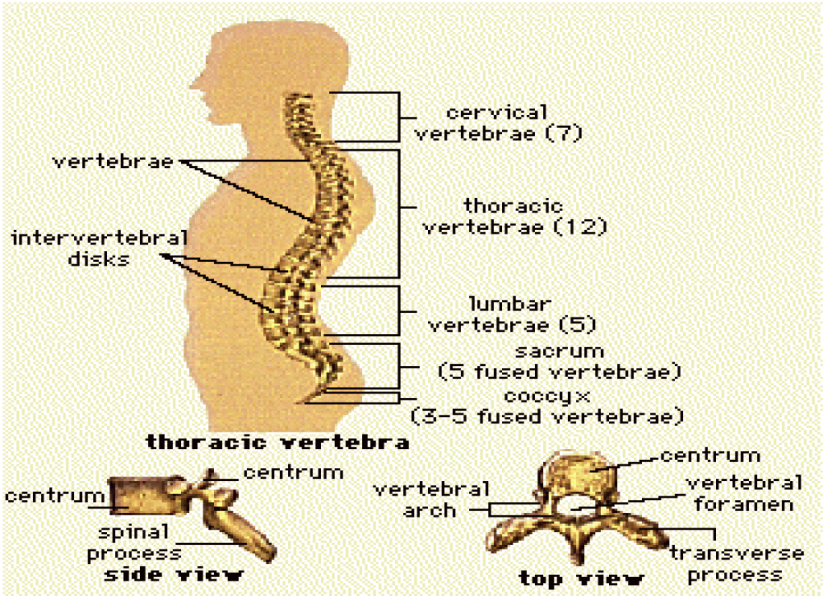


Figure 2.3: Human vertebral column

Source: Thesebonesofmine.wordpress.com

2.2.2 Cervical Vertebrae Spine

Usually the human cervical vertebrae are smallest than the true vertebrae in the thoracic spine (upper back) and the lumbar spine (lower back). It can be readily distinguished from the thoracic or the lumbar regions. The presence of the foramen (hole in the backbone) in the transverse process and also thorough which passes the vertebral artery.

This cervical vertebra is like a ring that rotates around the second vertebral body and this is unique compare the other vertebral.

The spine has 24 spinal bones call vertebrae. Vertebrae position is on top of each other to form the spinal column. At the human body, the spinal column in the upright support to make the human stronger. In the side, three curves from the spine. It called the cervical spine as a neck, curves slightly inward. The middle back in the backside it call thoracic spine, curves outward. The outward curve of the thoracic spine is kyphosis. The low back also called the lumbar spine and curves slightly inward. An inward curve of the spine is called lordosis.

In the vertebrae, doctor was use classes using the C1 to C7 to refer part in the vertebrae. The C1 start from the top of the cervical spine is connects to the bottom of the skull. Then the end of the vertebrae is the C7 is curves slightly inward where join the top of the thoracic spine in the chest area. The based in C1 also call the atlas is the two thickened bone arches form a large hole through the center of the atlas.

The large opening is because of the spinal cord is wider where it first exits in the brain and skull. In this case the atlas also has much wider bone have projections point compared to each side. In the top of the C2 vertebra is called the axis, has a large bony knob on top and also called the dens. Then for the dens points up and fits through a hole in the atlas is a joints of the axis give the neck most of its ability to turn to the left and right. In the cervical vertebra, has main section it is from C2 to C7 is formed by a vertebral body in the round block of the bone. The vertebral body where attaches to the bone ring and this two pedicle bones it was connected directly to the back of the vertebral body. (Burwell et al., 1983)

In between the vertebrae of each spinal segment are have two facet joints. The facet joints are located at the back of the spinal column. There are two facet joints between each pair of vertebrae on the right. The intervertebral disc sits directly in front of the opening. A bulged or herniated disc can narrow the opening and put pressure on the nerve. A facet joint sits in back of the foramen. Bone spurs that form on the facet joint can project into the tunnel, narrowing the hole and pinching the nerve. (Burwell et al., 1983)

The complete ring has two lamina bones joining the pedicles and it forms the outer rim of the bone ring. When the vertebrae are stacked with each other it has gone hollow tube that surrounds the spinal cord. They have provided a protective roof over the spinal cord. At the back of the spinal have two laminar join together and have the projections call spinous processes. The process can be felt as you rub with a finger move in the back of your spine. The spine is the spinous process of C2 is the larger bump near the top and the neck where the cervical and thoracic spines join together it is in C7. (Burwell et al., 1983)

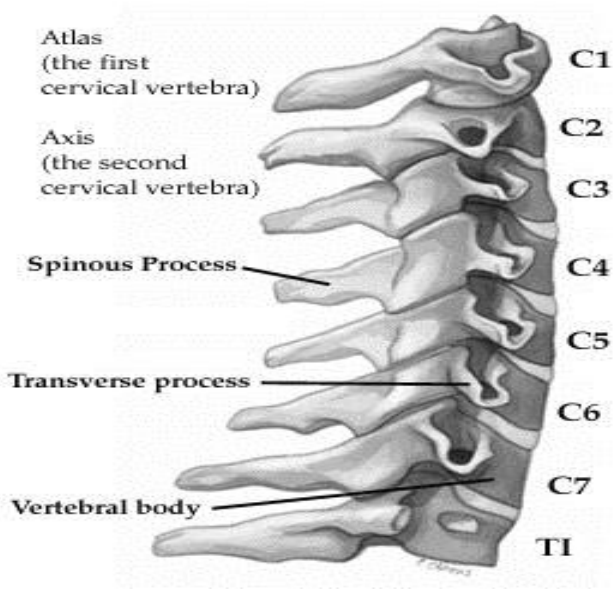


Figure 2.4: Cervical vertebrae spine

Source: Parker et.al., 1999

2.2.3 Thoracic Vertebrae

Thoracic vertebrae are distinct in featuring costal facets on their transverse processes and bodies. Basically a thoracic vertebral body articulates have two costal heads with while the transverse process articulates with the tubercle of one of these ribs with these articulations form the costo vertebral joints. It will increase the anterior posterior and transverse diameters of the thoracic cavity in these joints serve to elevate and depress the

ribs. For posteriorly permitting rotation and some lateral flexion, the thoracic spine is the superior will inferior articular facets face anteriorly. (Oldnall, 2000)

The severely restricts flexion and extension of the thoracic because of the orientation in these facts, as well as the unfairly directed spinous processes it also the costovertebral joints. It different, in the medially and laterally facing articularfacets of the five lumbar vertebrae allow for a great deal of flexion and extension but restrict rotation. (Oldnall, 2000)

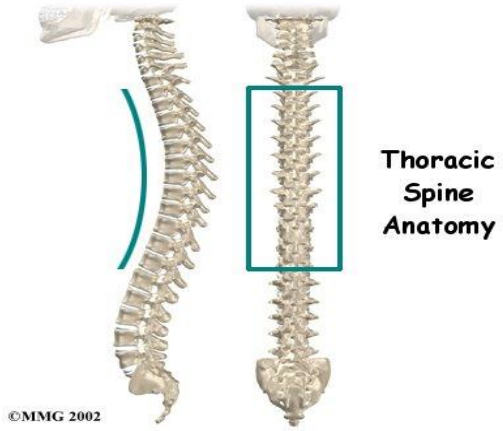


Figure 2.5: Thoracic spine

Source: Patient Educatio-Thoracic Spine, 2002

2.2.4 Lumbar Spine Vertebrae

The lumbar spine is the lower five vertebrae. Doctors class it to these vertebrae as L1 to L5.The L5 part is the lower vertebra is join to the top of the sacrum, the base of the spine that fits between the two pelvic bones like shape triangular. The normal person has five lumbar vertebras but the special person has a sixth lumbar vertebra. This case doesn't usually cause any particular problems of each vertebra is formed by a round block of bone it call a vertebral body.

The taller and the bulkier in the vertebral bodies in lumbar part to compared the rest in the spine. To support the withstand pressure from body weight and from movements such as lifting, carrying and twisting. In the lumbar vertebral also carried the large and powerful muscles attaching or near the lumbar spine place extra force on the lumbar vertebral bodies. (Botwin et al., 2003)

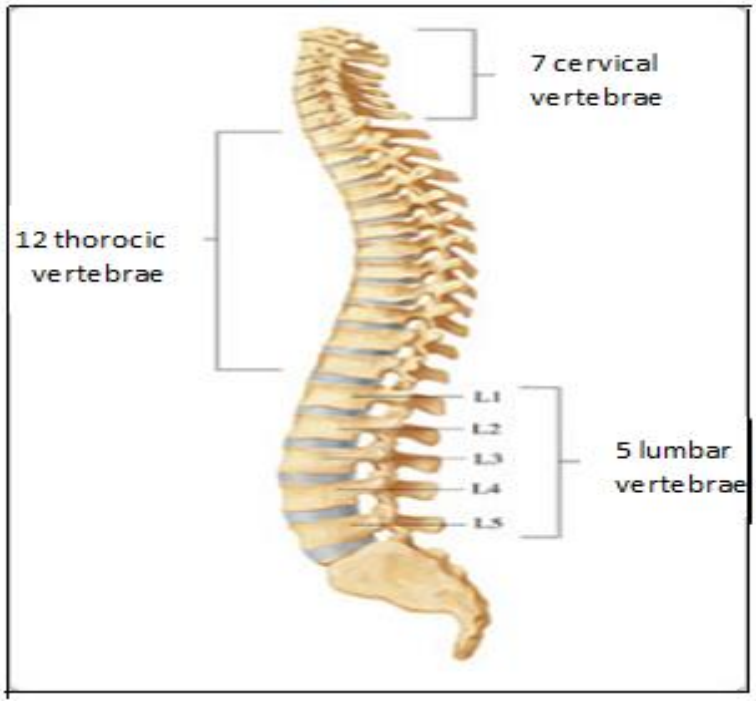


Figure 2.6: Lumbar spine vertebrae

Source: www.nebh.org

2.3 PEDICLE SCREW FIXATION

2.3.1 Briefing History Of Pedicle Screw Fixation

Boucher has been widely credited with the first use of pedicle screws in North America, his report suggests that his innovation was a longer facet screw that occasionally obtained oblique purchase across the pedicle. His screws were not aimed down the long axis of the pedicle. Thus, it seems that Harrington and Tullos deserve credit for the first

deliberate attempt to put pedicle screws through the isthmus of the pedicle. Their report, published in 1969, described the attempted reduction of two cases of high-grade spondylolisthesis.

2.3.2 Briefing About Pedicle Screw Fixation

The anatomy of the human pedicle has been studied exhaustively in different races in children and adults. Patterns of pedicle anatomy unique to the cervical spine the thoracic and the lumbar spine and the sacrum have been clearly identified. Measurements of the outer and inner diameters of the pedicle have been performed extensively. The inner diameter of the pedicle the critical surgical dimension has been shown to be more directly related to the height of the patient than to the gender. However, wide individual variations within common patterns of anatomy are the rule.

This forces the surgeon to understand the individual anatomy of the patient, in order to achieve clinical success and to appreciate the patterns of pedicle anatomy that are common to the human race in general. There do not seem to be more than modest differences in pedicle anatomy from race to race.

The screws are designed to connect with certain fixation devices, most commonly either a plate or a rod. Linkages can be rigid as with plate systems, internal fixators or various rod systems or have a coupling allowing some motion. Some systems also allow for interval pedicle fixation to control or apply either lordotic-kyphotic or rotational forces on the vertebra. The first issue regarding complications based on the large number of instrumentation systems their rapidity of change and limited universal usage relates to instrument mechanical failure. Each has its own strengths and weaknesses and it is important for the user to recognize these facts and to select the appropriate construct for each surgical need and each functional spinal unit pedicle screw. It should be introduced by drilling the path and then applying the screw.

The transverse pedicle diameters range from 4.5 mm at T5 to 18 mm at LS and the sagittal diameter is generally slightly larger than the transverse slant diameter. The angle at which the pedicle emerges from the vertebral body in the transverse plane also varies with

craniocaudal location, being less than 10 inch in the thoracic spine with a slight anterolateral angulation at T12, it progressively increases in the lumbar spine to a maximum of almost 30 inch medial angulation from posterolaterally to anteromedially. (Gaines, 2000)

The pedicles also exhibit varying angles in the sagittal plane. The pedicles are directed approximately 15-17 inch cephalad for the majority of the thoracic spine and neutral (90 inch) for the majority of the lumbar spine with the exception of L5, which angles caudally an average of 18 inch. The distance to the anterior vertebral cortex as measured from the posterior aspect of the pedicle, through the pedicle is approximately 40 to 45 mm in the thoracic spine and 50 mm in the lumbar spine. (James et al., 1992).

2.3.2.1 Prepare screw hole and determine screw length

In this pedicle screw fixation, have use three type of screw to penetrates and determine the deep of the hole. Firstly is the pedicle awl (probe a) to make the penetrates in the compact layer, then went the pedicle inside the sponge layer the pedicle probe (probe b) has to use until the pedicle thru the end of the layer and with pedicle probe also use for enlarge the hole. For determine the length of the pedicle screw (probe c) using the depth gauge for pedicle screw. (Aebi et al., 2007)

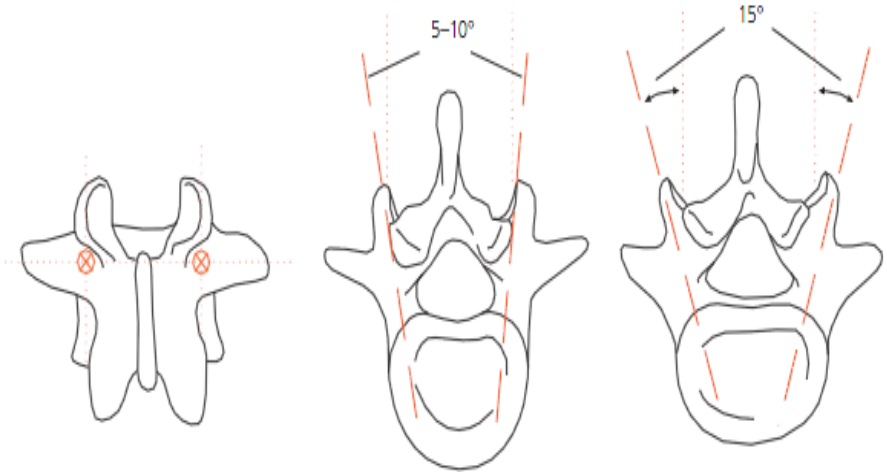


Figure 2.7: Point and position of pedicle screw in lumbar spina

Source: Aebi et al.,(2007)

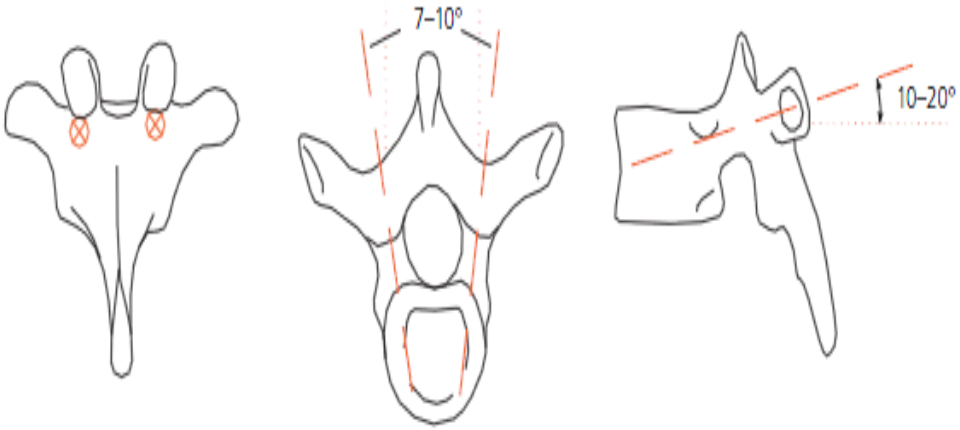


Figure 2.8: Point and position of pedicle screw in thoracic spina

Source: Aebi et al.,(2007)

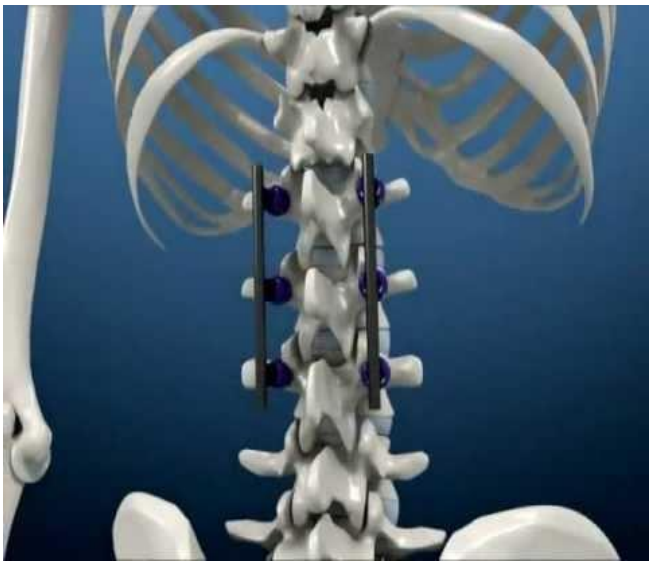


Figure 2.9: Lumbar spine

Source: article.wn.com

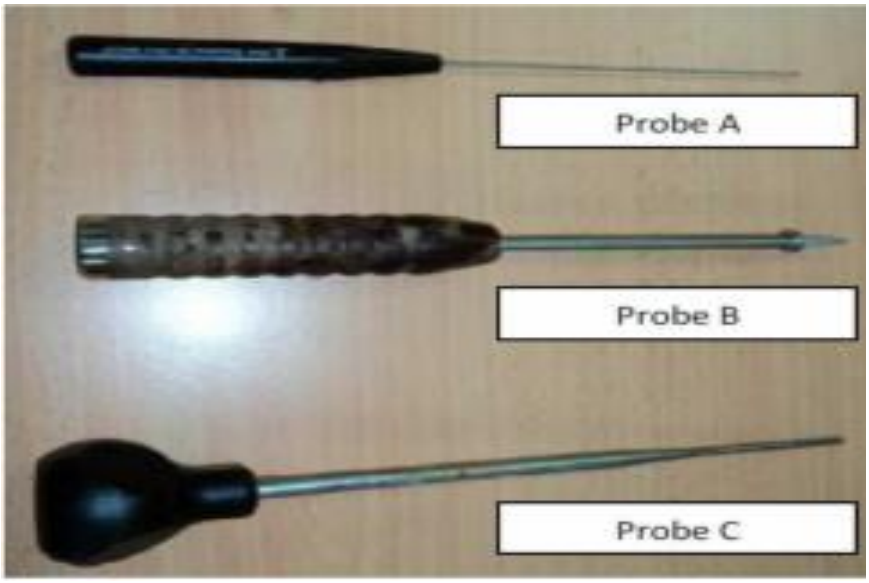


Figure 2.10: Pedicle probe

Source: www.wseas.us

2.4 ACOUSTIC EMISSION

Acoustic emission activity is occurring phenomena. Although it is not known exactly when the first acoustic emissions were heard, fracture processes such as the snapping of twigs the cracking of rocks and the breaking of bones were probably among the earliest. The first acoustic emission used by an artisan may well have been in making pottery. Acoustic Emission is the elastic energy that is spontaneously released by materials when they undergo deformation. In the early 1960s, a new nondestructive testing technology was born when it was recognized that growing cracks and discontinuities in pressure vessels could be detected by monitoring their acoustic emission signals. Although acoustic emission is the most widely used term for this phenomenon, it has also been called stress wave emission, stress waves, microseism, micro seismic activity and rock noise.

The defined of acoustic emission is the class of phenomena where transient elastic waves are generated by the rapid release of energy from localized sources within a material or the transient elastic waves so generated.

This is a definition embracing both the process of wave generation and the wave itself AET is a NDT method that is used to analysis emitted sound waves caused by defects or discontinuities. These acoustic waves are induced by small deformations, corrosion or cracking, which occur prior to structure failure. It is therefore possible with AET, to locate structural defects and to monitor the propagation and development of discontinuities. (Shrivastava, 2000)

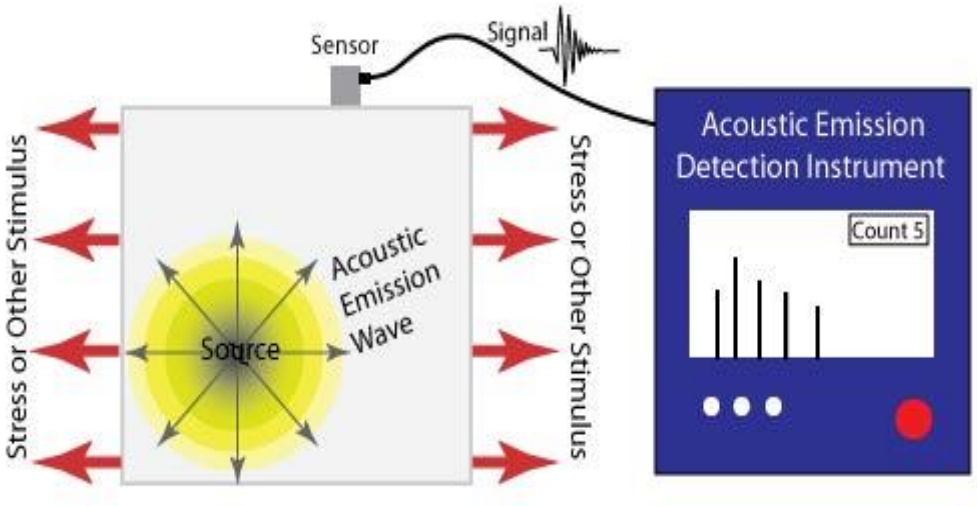


Figure 2.11: Acoustic Emission testing

Source: www.ndt-ed.org

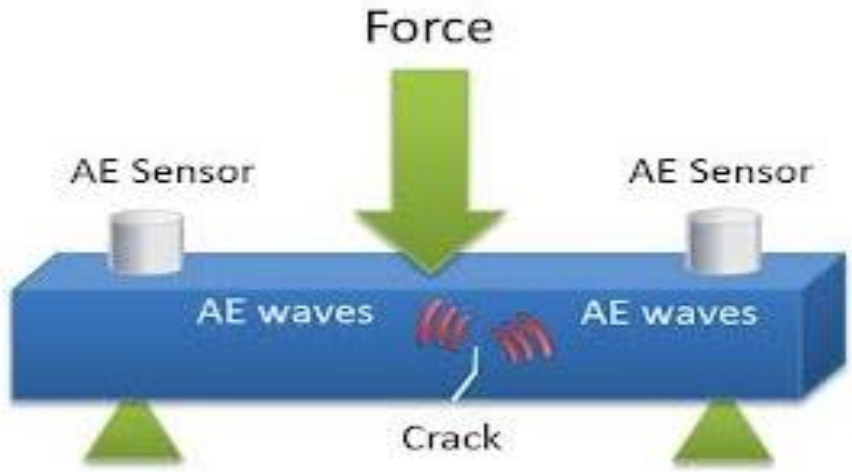


Figure 2.12: Acoustic Emission diagram

Source: https://my.vanderbilt.edu/ozguryapar/research-experience/ae/

Figure 2.13: Acoustic Emission using in industry

Source: http://www.tisec.com/services/acoustic_emission.htm

2.5 TYPE OF CLUSTER

2.5.1 Hierarchical Clustering

Hierarchical cluster is one of the most frequently used methods in unsupervised learning. Given a set of data points, the output is a binary tree which called dendrogram that leaves are the data points and the internal nodes represent nested clusters of various sizes. Organizing hierarchical cluster tree, where the hope is this hierarchical organization agrees with intuitive real-world data. Hierarchical structure is always there in the natural world. For example, the tree of evolution of living organisms and the characteristics of an organism such quences of homologous genes has been natural hierarchy. Representation of the hierarchical structure is also natural for .data produced by the process of evolution. (Heller et al., 2005)

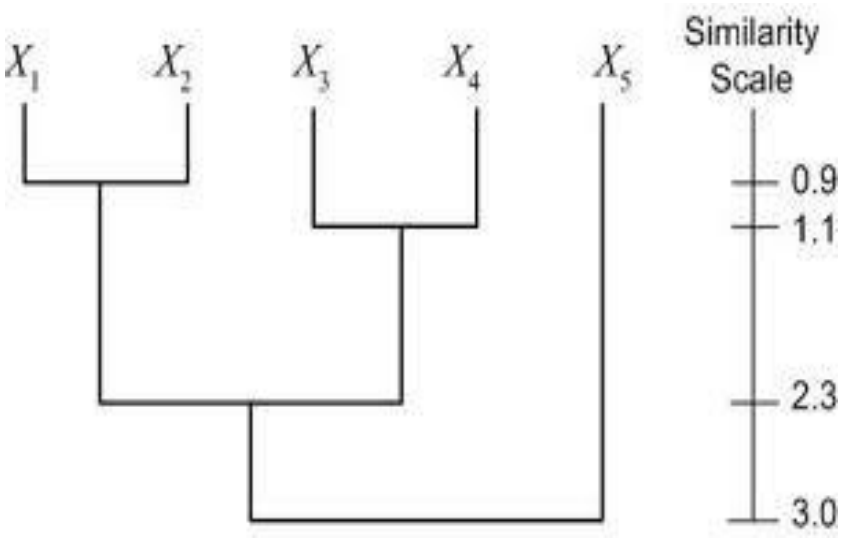


Figure 2.14: Hierarchical clustering

Source: Dhruv., 2008

2.5.2 K-Means Clustering

Simply speaking it is an algorithm to classify or group objects based on attributes or features into K number of group. K is a positive integer number. The group is committed to reducing the number of square of the distance between the centroid of the data and the corresponding cluster. Therefore, the purpose of the K-means cluster is to classify the data. (Kardi, 2007)

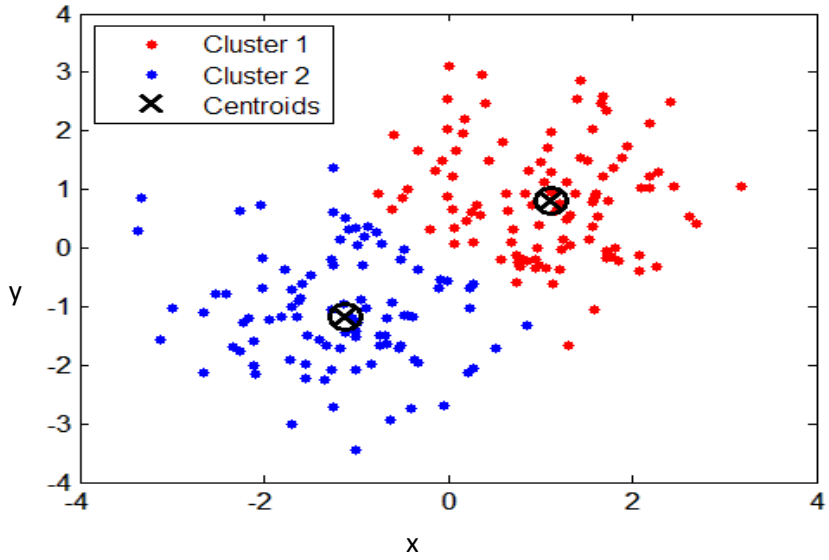


Figure 2.15: K-means clustering

Source:www.mathworks.com/

2.5.3 Fuzzy Clustering Algorithms.

These fuzzy cluster algorithms have been widely studied and used in a variety of substantive areas. They also become the main technique of cluster analysis. In this paper, we provide a review of fuzzy cluster in three categories. The first category is based on a fuzzy cluster of fuzzy relations. The second is based on a fuzzy cluster objective function. Finally, we give a parametric classifier. That is the general fuzzy k-nearest neighbor rule. (Yang, 1993)

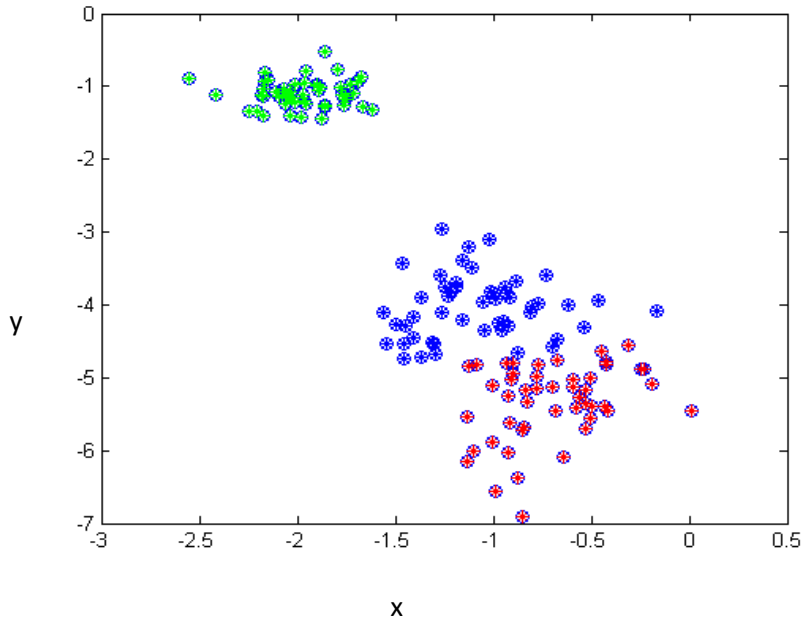


Figure 2.16: Fuzzy clustering algorithms

Source: neuron.csie.ntust.edu.tw

2.5.4 Subspace Clustering

Subspace cluster is an extension of the traditional group that aims to find clusters in different subspaces within a dataset. Traditional cluster algorithms consider all data input dimensions specified in order to learn as much as possible about each condition. In high dimensional data.However, many dimensions often irrelevant in this cluster.

These Irrelevant data cluster algorithm misleading by hiding clusters in noisy data. In very high dimensions, it is common to all conditions in the dataset to be nearly the same distance from each other, completely masking the cluster. Subspace cluster algorithm to localize finds relevant dimensions allowing them to find clusters that exist in different, possibly overlapping subspaces. (Parsons et al., 2004)

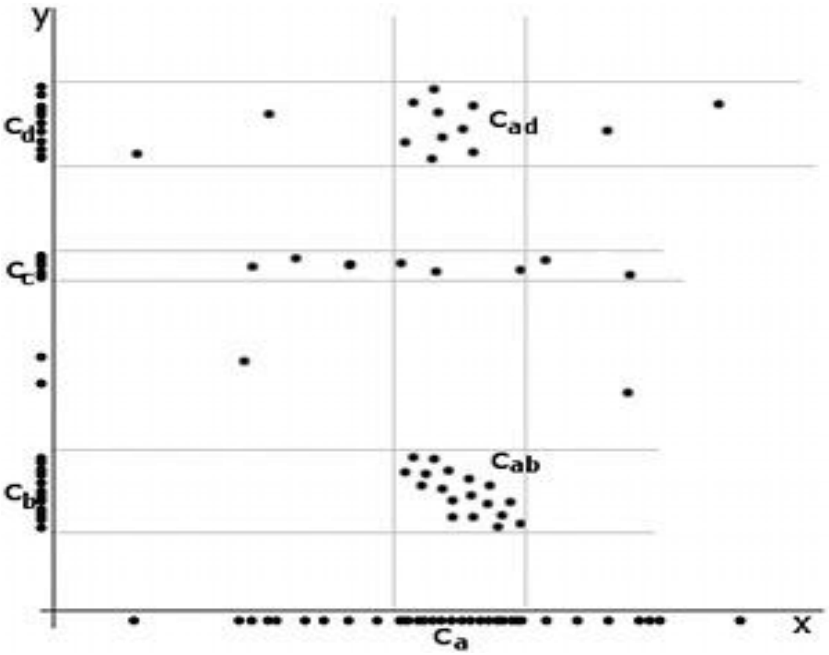


Figure 2.17: Subspace clustering

Source: www.wikipedia.com

CHAPTER 3

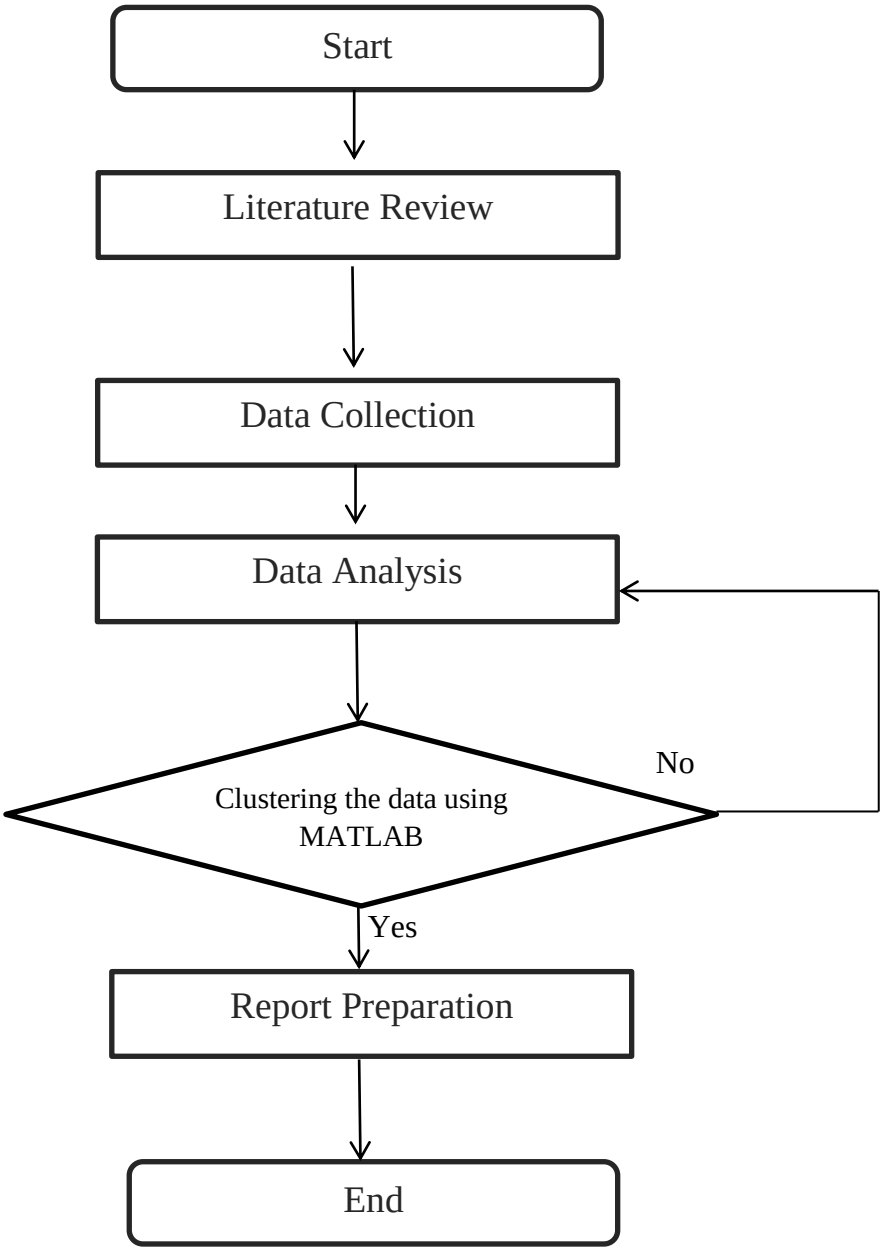
METHODOLOGY

3.1 INTRODUCTION

This chapter is the most important and should have to focus more in this chapter to complete within the success any research and development. This methodology is vital because to assure this project will do follow the flow chart. It's also to make sure the project did not delay to finish on the date. By focusing the methodology, it makes sure the project will follow the objective and it will start earlier which mean it will follow the guideline based on the objective. Most important subject in the methodology is the procedure of the project and experiment related to the research. The methodology should refer anything that can be contained in a series of process, activities and tasks. For the documentation of the process will follow the rule of method or process research. Easier to indicate the problem in this research by doing the methodology in step procedure. The research will be run smooth and faster with flow chart in methodology.

3.2 FLOW CHART

The function of the flow chart is to achieve the objective with successfully by given the guidelines and the right direction.


Start
Literature Review
Data Collection
Data Analysis
Clustering the data using MATLAB
No
Yes
Report Preparation
End

3.3 LITERATURE REVIEW

Measurement are used in this experiment is broadband acoustic sensor and pre-amplifier. After test was done, have to fine the signal from acoustic emission in the spinal bone especially at cervical vertebrae during the pedicle screw fixation process. By using the bovine vertebrae it still can be used as the result, because the anatomy and characteristic of the vertebrae are same. The bovine vertebrae is suitable to replace the human vertebrae because it is cheaper and easier to get in Malaysia.

Figure 3.1: The bovine vertebrae

Source: www.wseas.us

3.4 DETAIL SPECIFICATION

The measurement tool have be a detail specification about every each tool to get the accurate result. In this experiment the tool use it like sensor, preamplifier, filters, DiSP card and computer with suitable software to analyzing the acoustic emission signal. Sensor use for convert the acoustic wave energy emitted by the source into usable electric signal to typical voltage time signal. The amplifier is first stage of instrumentation system and the

function for enhance the signal level against noise. When the sensor produces change proportional to the source intensity, the amplifier must detect the near sensor.

Beside that preamplifier normally used along with transducer and two together form the front end of acoustic emission instrumentation. The filter as an important role in allowing the amplified signal from sensor and cut the unwanted noise. It also design for different bandwidth and can be plug in into preamplifier to meet the specific requirement. So, the correct specification for these tools are important in make sure the accuracy of the signal for acoustic emission.

3.5 DATA ANALYSIS

The data is set with simple data, the simple data of time domain are using matlab software will show the graph pattern. From the graph, the data taken will be chosen for clustering method or not. The wave of the fft graph have to sine wave or look like the sine wave.

3.6 CLUSTERING THE DATA USING MATLAB

3.6.1 Matlab software

Matlab was began as a "Matrix Laboratory" program, intended to provide interactive access to the libraries Linpack and Eispack. It has since grown well beyond these libraries to become a powerful tool for visualization, programming, research, engineering and communication. It presenting several programs that investigate elementary but interesting in mathematical problems. It was originally a package for matrix algebra function. It has evolved to include strong graphics abilities and an extensive programming language. Matlab have any variable is an array by default it almost no declarations.

Matlab strengths include cutting-edge algorithms, enormous data handling abilities and powerful programming tools. Matlab is not designed for symbolic computation but it makes up for this weakness by allowing the user to directly link to Maple. Typical uses include math in computation, algorithm development, application development, including

graphical user interface building, modeling, simulation data analysis, exploration, visualization scientific also in engineering graphics and prototyping

This software has evolved over a period of years with input from many users. For university user it is the standard instructional tool for introductory and advanced courses in mathematics, engineering and science. In industry, it is the tool of choice for high-productivity research, development and analysis. The most important tool in Matlab is toolboxes allow you to learn and apply specialized technology. Toolboxes are comprehensive collections of Matlab functions (M-files) that extend the Matlab environment to solve particular classes of problems.

Figure 3.2: Coding from the data

Source :Matlab software

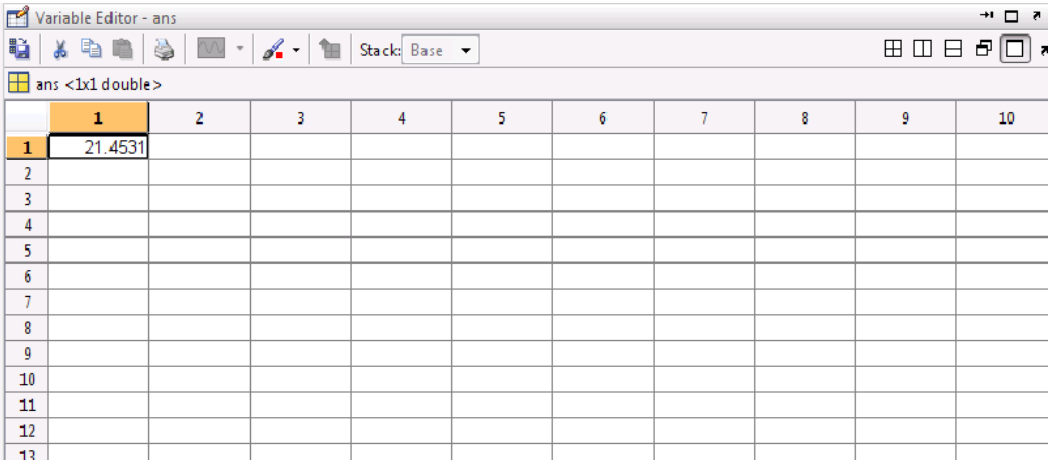


Figure 3.4: Kurtosis answer

Source :Matlab software

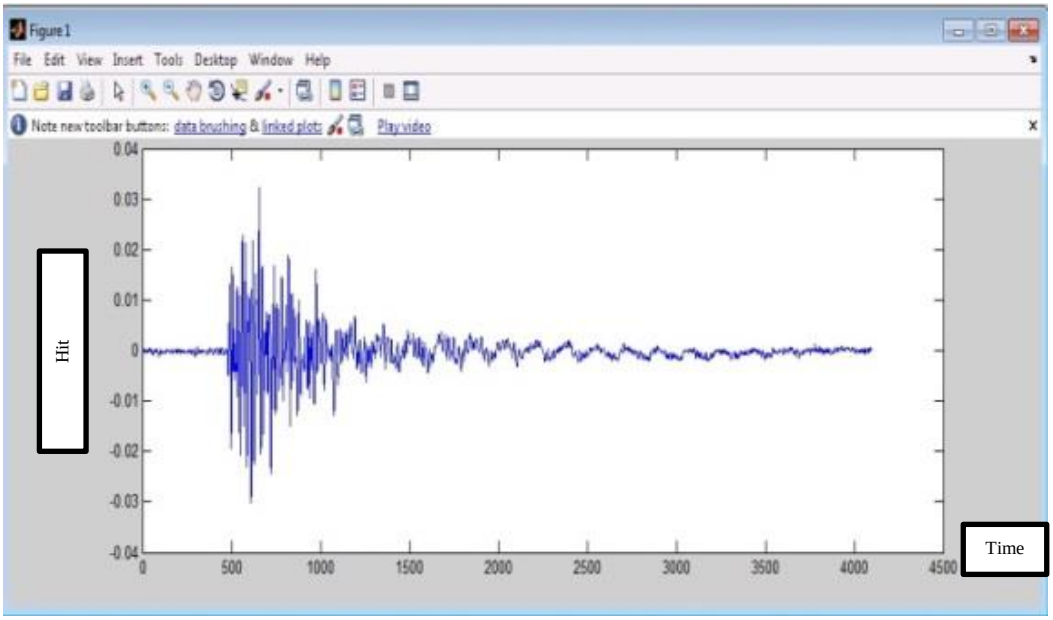


Figure 3.3: Graft for time domain

Source :Matlab software

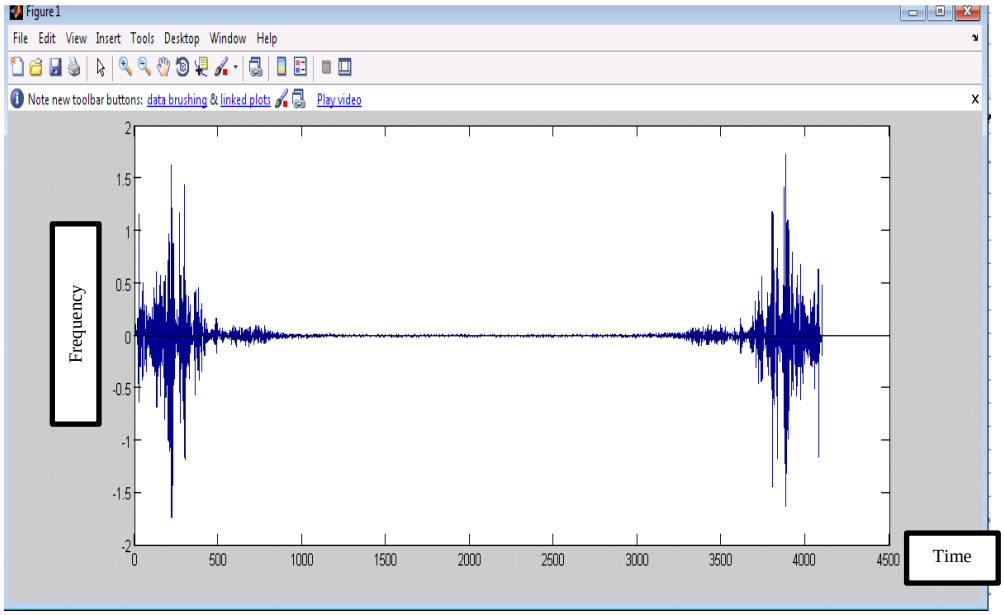


Figure 3.5: Graft for FFT function

Source :Matlab software

3.6.2 Type Of Clustering Using This Method.

3.6.2.1 Graph kurtosis vs skewness

Skewness function is to return the skewness of the distribution. Skewness characterizes the imbalance in the distribution around the mean. Positive skewness indicates the distribution with asymmetric tail extending towards higher values positive. Negative skewness shows the distribution with asymmetric tail extending towards higher values negative. Although the exact definition, it does not explain the resulting amount and not helpful to the actual ways in its entirety.

Produce a normal distribution skewness statistics about zero. So the value of skewness is acceptable for skewness statistics normally distributed set of test scores because it is very close to zero and may only chance fluctuations from zero. As skewness statistic off again from zero, positive values indicate the possibility of a skewed positive distribution with scores bunched at the low end of the scale or negative score indicates the

possibility of negatively skewed distribution which with scores bunched at the high end of the scale.

Kurtosis function is described relative peakedness or flatness of distribution compared with the normal distribution. Positive kurtosis indicates a relatively peaked distribution. Negative kurtosis indicates a relatively flat distribution. Produce a normal distribution kurtosis statistics about zero because small changes may have occurred by chance alone. So kurtosis statistics of kurtosis value of 0.09581 would be acceptable to mesokurtic, the distribution is usually high because it is close to zero.

As kurtosis statistics are off again from zero, positive values indicate the possibility of leptokurtic distribution that is too high or negative values indicate the possibility of platykurtic distributions, too flat or concave if the value is large enough.

Kurtosis value of 2 or more standard errors regardless of the sign may differ from mesokurtic to a significant degree. (Brown, 1997)

When demonstrated in the turbulent dispersion, there exists a quadratic relationship between the skewness (S) and kurtosis (K) statistics obtained from continuous. The elevated sources of scalar contaminant released into both convective and stable atmospheric boundary layers.

Analysis waves become a common tool for analyzing localized variations of power within a time series. By decomposing a time series into time frequency space, one is able to determine both the dominant modes of diversity and how different ways. Waves is a wave like oscillation is localized in the sense that it grows from zero, reaching a maximum amplitude and then decreasing back to zero amplitude. It thus has a location where it maximizes the oscillation characteristics and also the scale on which it strengthened and weakened. (Torrence et al., 1998)

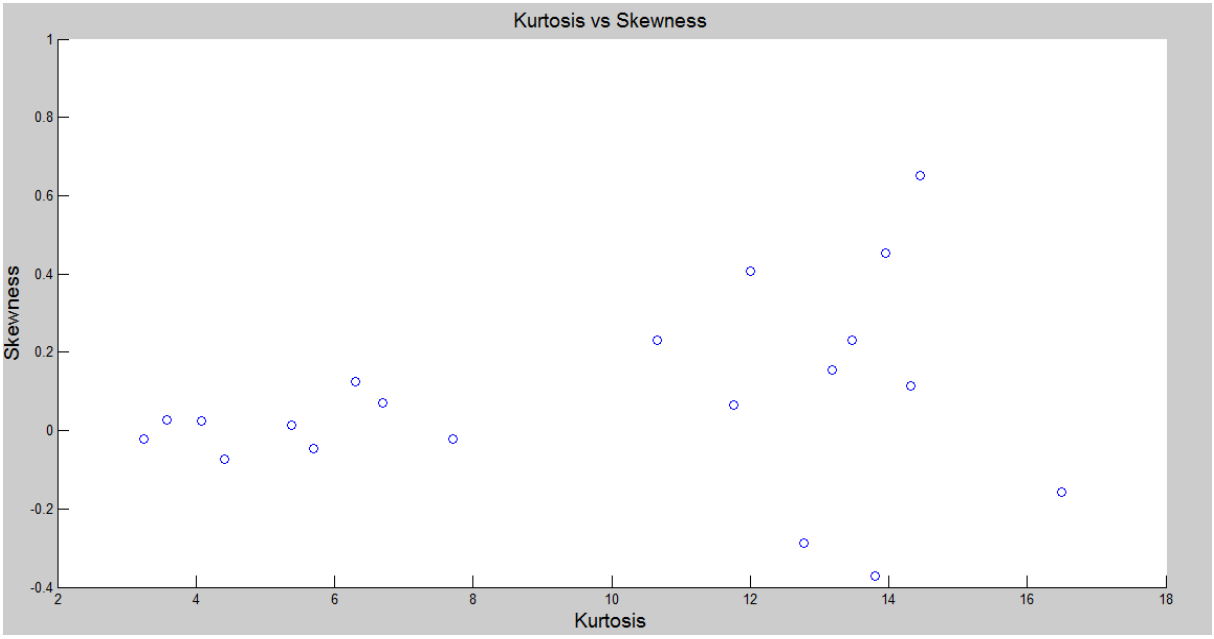


Figure 3.6: Graft skewness versus kurtosis

Source : Matlab software

3.6.2.2 RMS versus kurtosis graph

Defination of rms is root mean square value of a quantity is the square root of the mean value of the squared value of the quantity taken over an interval. Kurtosis for know the variable when run a random vibration test. Kurtosis its normally is define as he fourth statistical moment divided by the square of the second statistical moment. It is to remove variability due to waveform amplitude from the measurement. The kurtosis for Gaussian data is always 3 regardless of the RMS level or PSD.

$$y = \sqrt{\frac{\sum_{i=1}^{M} |u|^2}{M}} \qquad \textbf{(3.1)}$$

This equation 3.1 to find the RMS answer.It is the statical formula to identify the data based on the coding of Matlab software. The function of the μ is the data input of the data in the text. About the M is function is the number of the data in the one set of the data. This equation is standard used in RMS equation in statistical.

$$\mathbf{k} = \frac{\boldsymbol{E}(\boldsymbol{x}-\boldsymbol{\mu})^4}{\boldsymbol{\sigma}^4} \quad \textbf{(3.2)}$$

This is equation 3.2 used for find the kurtosis answer in Matlab software and it is general using in the mostly calculation to find kurtosis function. The function of the E is represents the expected value of the quantity of t(time), σ is the standard derivation of x, x the input from the data and μ is the mean of the data

CHAPTER 4

RESULT AND DISCUSSION

4.1 INTRODUCTION

This chapter will show and discuss about the result that have been obtained from the analysis. The main part in this project was proved the objective that we do in chapter 1. The result will be taken from the previous student was done the project for cervical pedicle screw fixation procedure using the acoustic emission technique. The data that was taken from the previous research is improper. In his research also, he provide the data without the pattern and it is difficult to understand

The first procedure for this project is to investigate the pattern of the data collected from the data acoustic emission signal by doing the time domain graph to know the pattern of the graph, other than that data have some error or not like electric wave in the time domain graph, it will be the data in the set have not accurate. Then by using the MATLAB software.

RMS is defined as an averaged acceleration. The primary benefit of random vibration testing is that it produces a waveform similar in appearance to those actually measured in the field. Kurtosis is a statistical term used to describe the relative distribution of data. Kurtosis is defined as the ratio of statistical moments. Normalized kurtosis is defined as the fourth statistical moment divided by the square of the second statistical moment. This was done to eliminate diversity as a measure of the amplitude of the wave. In this normal form, the kurtosis for Gaussian data is always 3, unless the RMS or PSD.

After converting the data to the kurtosis and RMS, the data are studied either the data is occurring to do the standard scatter graph using the matlab coding. From that we will know the pattern of the graph is suitable to make the cluster. From the graph, the analysis is made from the pattern of the group of that data and it is influenced by several factors.

Table 4.1: Table for the RMS and the kortosis result for the compact bone.

RMS (V)	**Kurtosis**
0.00682102	6.50604109
0.00718027	3.28664048
0.01258592	6.44135017
0.02376732	6.33880783
0.02840342	5.53746225
0.00757531	5.96950483
0.03008162	4.25361981
0.00839089	4.32283837
0.01291994	4.05827329
0.00906945	6.57210872
0.01472943	5.24481682
0.00546857	4.32265835
0.0076077	3.2876683
0.01037741	4.13344282
0.01525846	3.14952906
0.010811	8.33118272
0.00849509	2.51073319
0.02860209	3.23287106
0.01686981	6.32275115
0.00930274	3.32428968

0.01548836	4.8570363
0.00693712	6.61602714
0.01329192	6.52087651
0.00956589	5.76336753
0.01469963	5.76336753
0.00774906	3.19988013
0.00932214	6.20330293
0.00732115	6.15899122
0.01185655	3.50757252
0.00662821	2.75531091

This table 4.1 shows the result compact bone from matlab software converted to RMS based on the signal from acoustic emission software was save in the text format. Normally the answer for RMS will be get in small amount and different compare to the kurtosis among more larger that the RMS amount. Event the value of the RMS in the on the compact bone is lower than the sponge bone.

Table 4.2: Table for the RMS and the kortosis result for the sponge bone.

RMS(V)	**Kurtosis**
0.003204	10.42057
0.002702	18.37778
0.006468	8.409413
0.003806	10.06277
0.006418	8.285061
0.003362	14.998
0.002537	17.4993

.

0.00338	16.79843
0.005086	20.70366
0.00509	18.07244
0.004222	14.58522
0.00336	22.55924
0.003728	20.53517
0.002498	22.7755
0.004154	9.279709
0.004794	9.123752
0.00301	12.56363
0.003679	12.44028
0.002986	19.86673
0.003126	14.3332
0.003961	20.19796
0.00576	9.825298
0.003008	16.05615
0.003157	26.40094
0.007034	18.71378
0.005735	17.03353
0.004868	14.37328
0.004302	15.60288
0.004287	22.62977
0.003556	12.03857

This table 4.2 shows the result sponge bone from matlab software converted to kurtosis and RMS based on the signal from acoustic emission software was save in the text format during doing the experiment. Normally the answer for RMS will be get in smaller value and different compare to the kurtosis more larger that the RMS amount. It because of the formula the mathematical is defferent.

4.2 TIME DOMAIN WITH COMPARE THE COMPACT AND SPONGE BONE

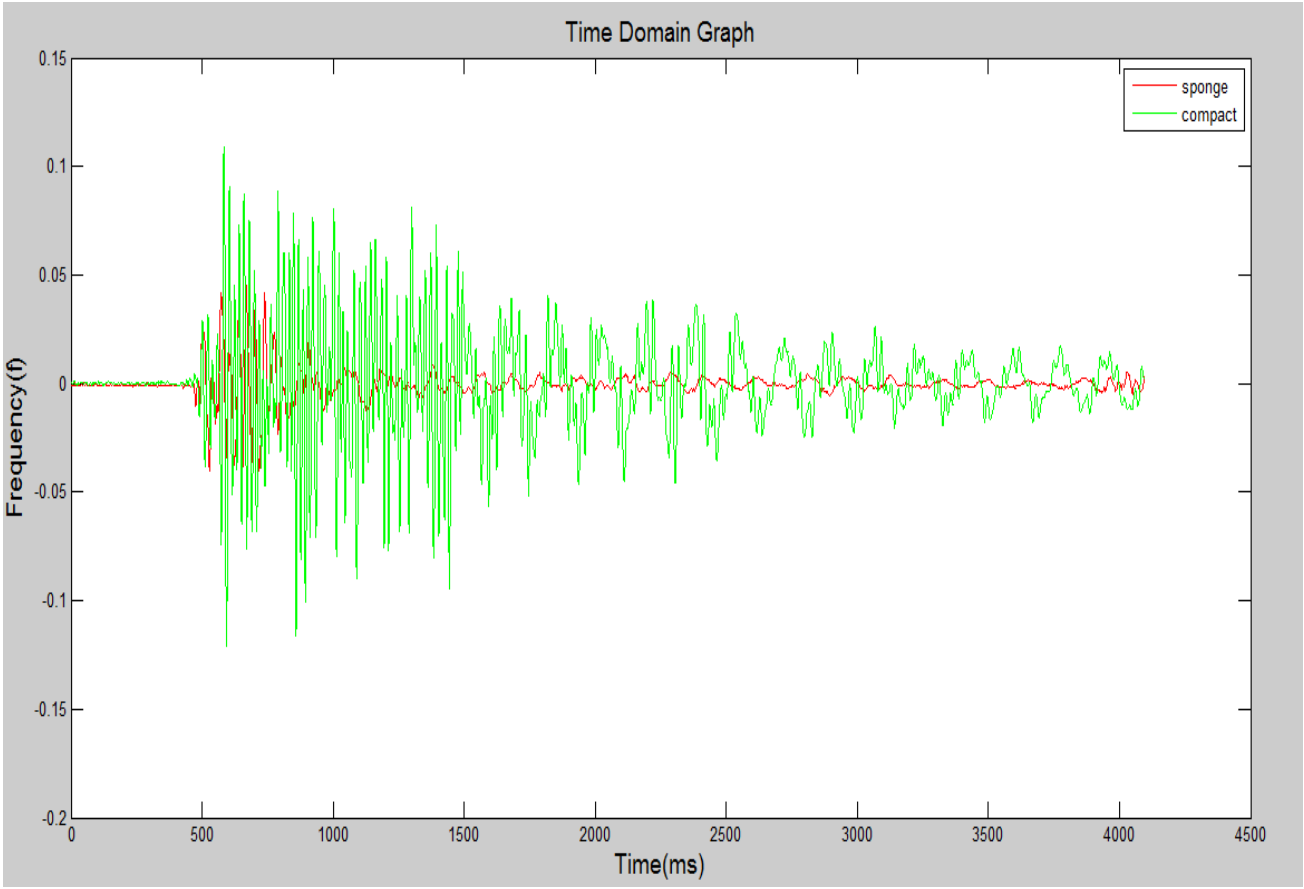


Figure 4.1: Time domain with compare the compact and sponge bone.

The graft show the time domain with two difference amplitude and colour, the green one show the compact bone base on the data and the blue one is show the sponge bone data. Based on the graph, the amplitude of the green one is compact bone more high peak in the pattern of the graph compare the blue one is lower in the peak of the amplitude. It because of went doing the experimental high frection on the hard part want the penetrate the compact bone. The data subtuble to taken in using the rms function because in the wave from it show that the different peak between of the sponge bone and compact bone is quite high. From that,the data show it can use in the cluter method.

It is a method of averaging where you take the squares of a bunch of samples, average them with an ordinary mean and then take the square root. This gives greater weight to larger values. To find the root mean square of a set of numbers, square all the numbers in the set and then find the arithmetic mean of the squares. Take the square root of the result.

4.3 GRAPH OF DENSITY PROBABILITY

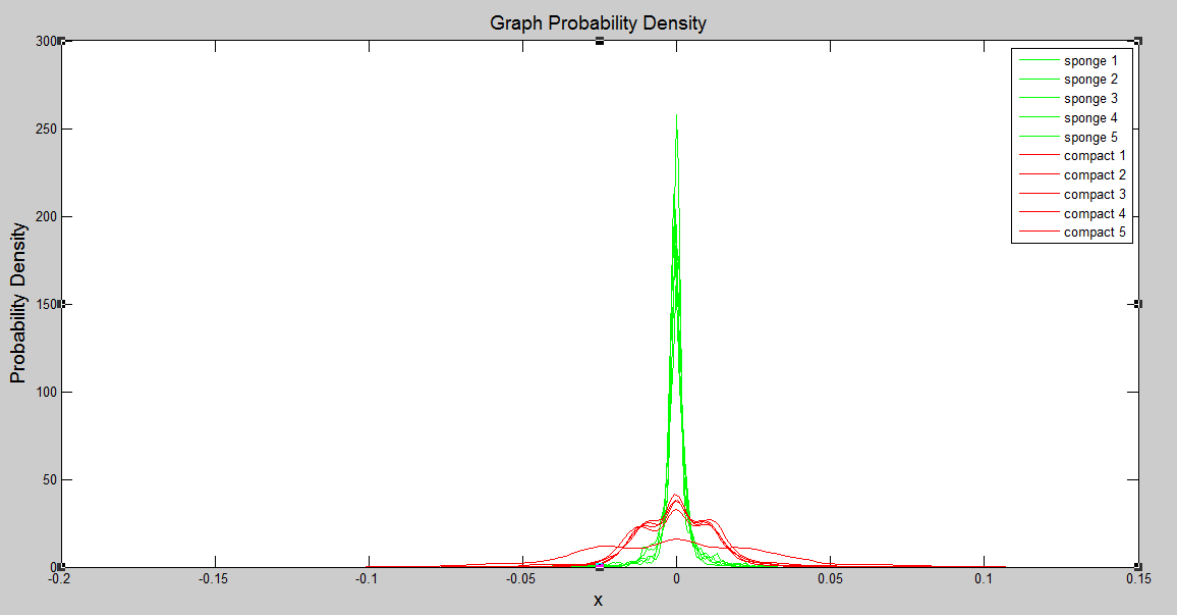


Figure 4.2:Graph of density probability for compact and sponge bone

Kurtosis is a measurement of the size of the distribution tails. A set of data with a high kurtosis value will produce a distribution curve with higher peak value at the mean and longer tails or in other words, more data points at the extreme values from the mean. From the graph show that the peakedness of the graph is high and the position or shape of the in the middle of the graph to show that it kurtosis is not a skewness.

The shape skewness will more to right side or left on the peaknedness it is probable can’t use in this method. Even the graph for the compact is more short that the sponge

graph but it still on the center of the peakedness. From that it suitable to use to make the clustering and it prove that it is kurtosis distribution.

In probability theory and statistics, kurtosis is any measure of the peakedness of the probability distribution of a real valued random variable. In a similar way to the concept of skewness, kurtosis is a descriptor of the shape of a probability distribution and just as for skewness, there are different ways of quantifying it for a theoretical distribution and corresponding ways of estimating it from a sample from a population.

There are various interpretations of kurtosis and of how particular measures should be interpreted, these are primarily peakedness (width of peak), tail weight and lack of shoulders the parent of the graph.

4.4 GRAPH RMS VERSUS KURTOSIS

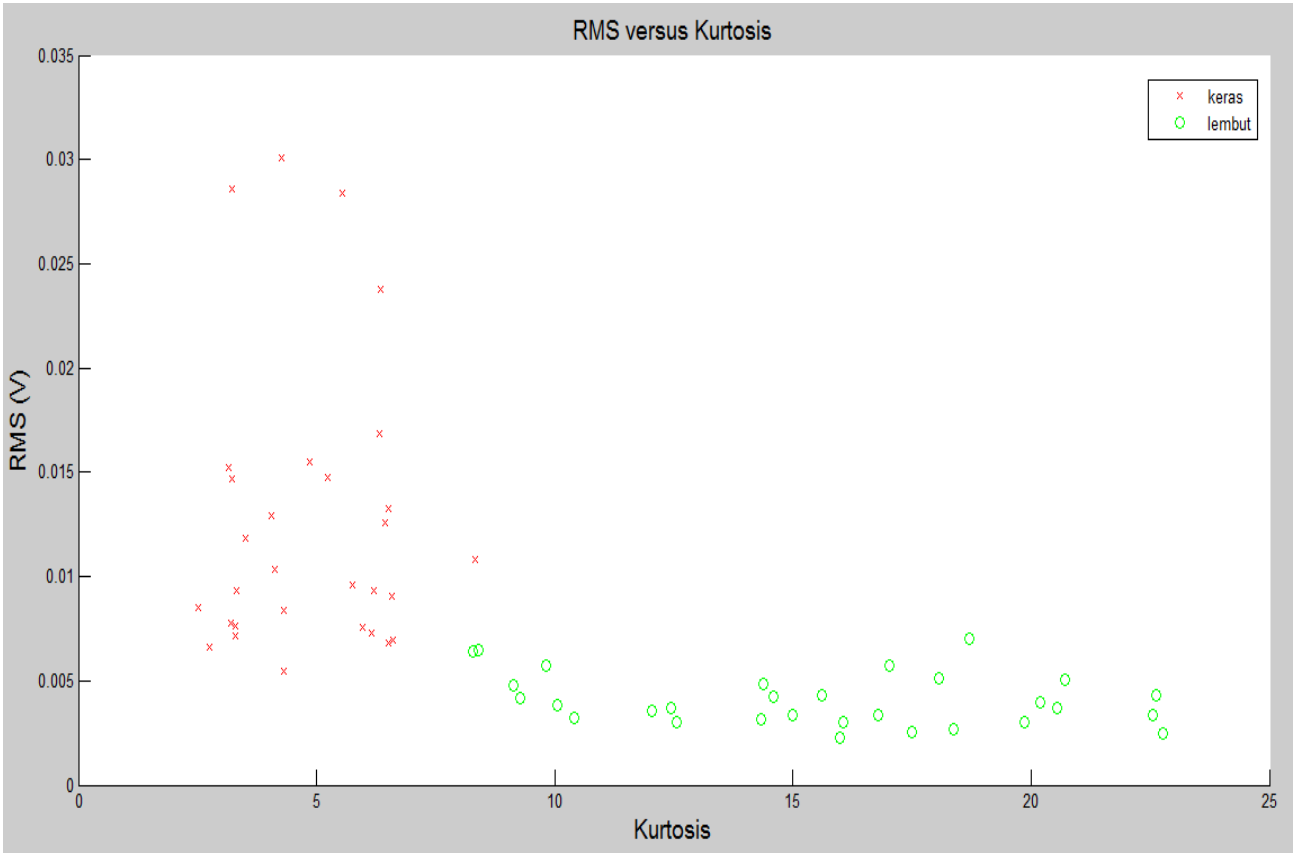


Figure 4.3:Graph RMS versus Kurtosis

This graft show the root mean square versus kurtosis. Then it was make the cluster between the compact bone and the sponge bone in one graph and prove that it successful to make the cluster on the two type of bone tissue either have a lot of data and random data. From the graph it show that the sponge bone more clustered compare the compact more scattered that sponge, but it still clustered just four point was out from the clustered. It happen because have some error on the data or maybe time doing the experiment have parallax they.

The function of this method is to make the doctor easier to refer the graph when doing the pedicle screw fixation. By using this graph the doctor enable to know the position of the pedicle probe on doing the penetrates process. For the standard method, the doctor has do the x-ray a many time to know the position of the pedicle probe when doing the penetrates, if the doctor don’t do the x-ray, percentage for the operation failure is high because maybe the doctor will penetrate goes to spina cord. It will effect the human die or handicap because of the spina cord broken.

CHAPTER 5

CONCLUSIONS AND SUGGESTIONS

5.1 INTRODUCTION

This chapter will summary all the result that was collected on the previous chapter and will be evaluate. In this chapter also will justify the objective of this study. The objective of this study is achieved by clustering based on data collected. This chapter also will eloberate more about the recommendations and suggestions for future study.

5.2 CONCLUSION

From this result or cluster, it will make the doctor easier to penetrate the bone tissue before inserting the screw into the bone without using human sense or have to make the x-ray for a many time. With this also can avoid o reduce the failure in doing the pedicle screw fixation, if this method is failed the human will be die or handicap because of the spina cord broken. From this result, the clustering method can reduce the time taken of the process in pedicle screw fixation

5.3 SUGGESTIONS

The graph from the matlab result can make the more specified pattern by using the other method or make a lot of analysis in the cluster in matlab to make the different method to get different pattern graph in the result itself.

Furthermore, to get better results the abundance of data collection is needed. The better result is obtained from the graph that obtained from the data collected. It will give more choices in selecting the best graph

In other hand, the next suggestion is try to apply another type of clustering software such as GUI,wavelength or other. May be the different software will come out with different pattern of clustering.

In order to get better findings, try to get accurate time domain for amplitude graph. Besides, experimental results also needed from the human vetebratae to study the structure of the bone.

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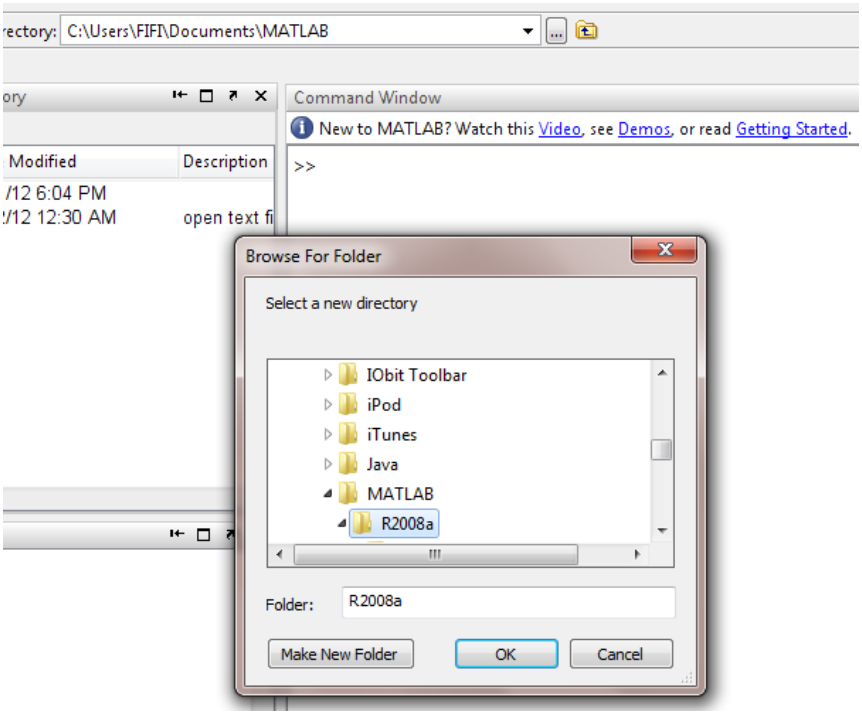
APPENDIX A1

Gantt chart for Final Year Project 1

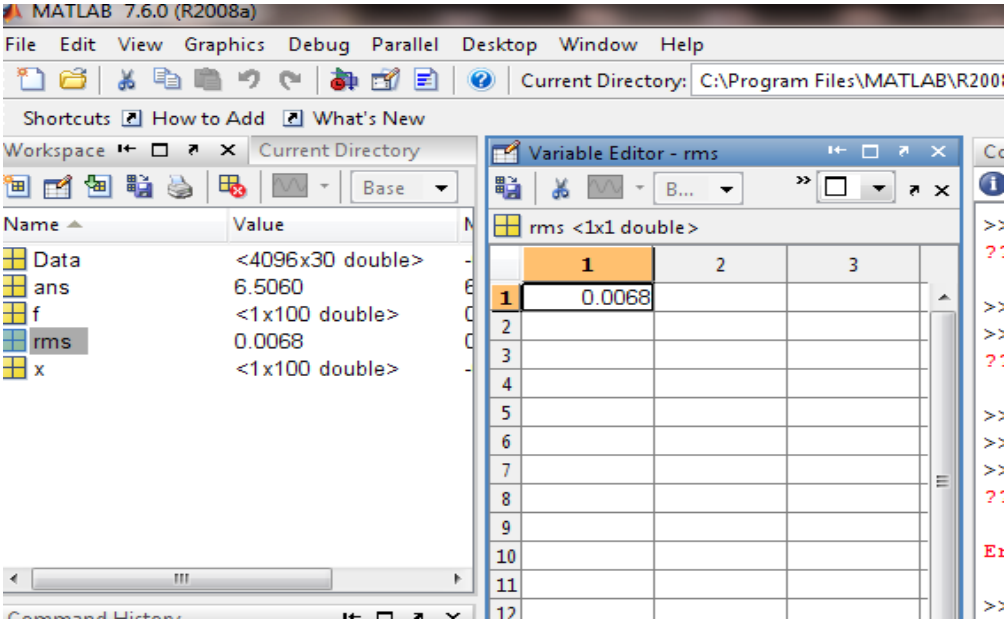
APPENDIX B



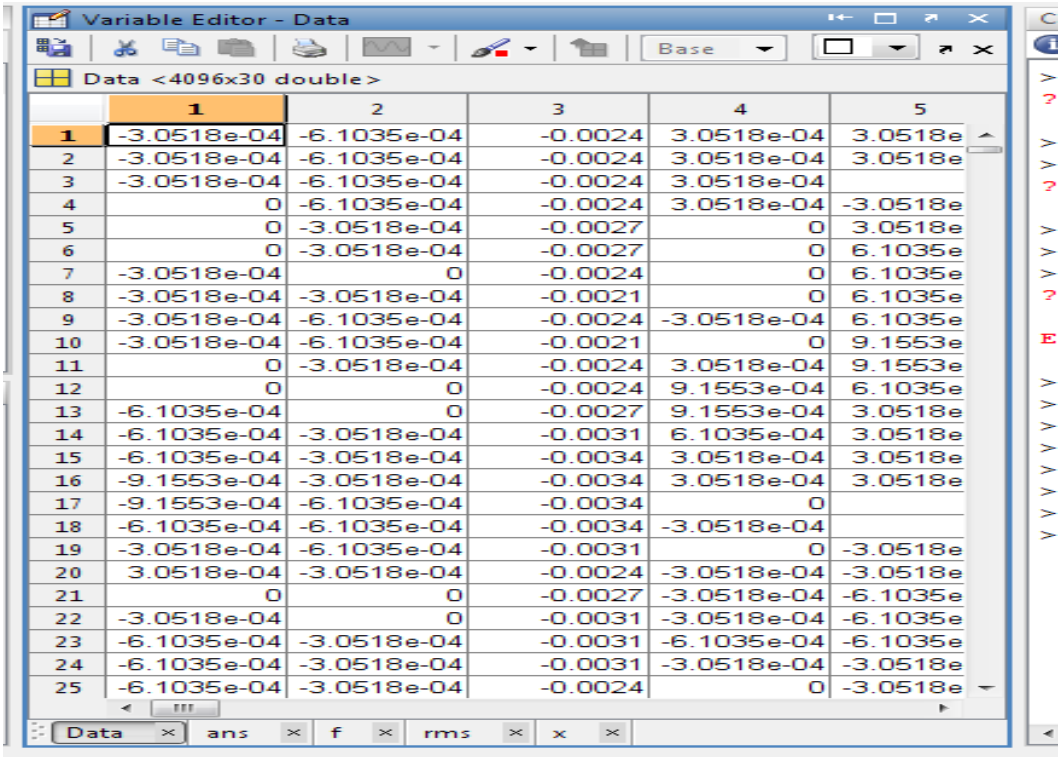
To select the data from the folder.

```
>> Data=xlsread('keras 30.xlsx');
>> plot(Data(:,1));
>> kurtosis(Data(:,1));
>> rms=sqrt(var(Data(:,1)));
>> [f,x]=ksdensity(Data(:,1));
>> plot(x,f)
>> title ('keras 30');
>>
```

One of the coding using in matlab.



The answer for RMS function.



Upload the data into Matlab

APPENDIX A1

Gantt chart for Final Year Project 1

Project activities	Weeks													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Get the project title and arrange discussion time with supervisor														
Objective and Scope														
Pedicle Screw Stabilization														
Acoustic Emission														
Methodology														
Study of Matlab software and Its application														
Draft report and presentation for FYP 1														

APPENDIX A2

Gantt chart for Final Year Project 2

Project activities	Weeks													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Convert data to time domain														
Find coding for Matlab														
Find and make a table for RMS and kurtosis														
Result and Discussion														
Conclusion														
Compile chapters														