Seismic Data Visualization and Analysis

by

Muhammad Faithullah bin Harun

Dissertation submitted in partial fulfillment of
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CERTIFICATION OF APPROVAL

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Approved by,

....

(Mr. Jale bin Ahmad)

UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK
January, 2005

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.

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MUHAMMAD FAITHULLAH BIN HARUN

ABSTRACT

Seismic exploration is one of the central parts in petroleum exploration and production. In this exploration, seismic data visualization and analysis is a method to determine the structure of the earth's interior, which is a part of the whole process in predicting new oil field. SEGY (*.sgy) is one of the file formats that stores the seismic data. This paper presents the dissertation report on the development of seismic data visualization and analysis application using MATLAB. The main objectives of this project are to develop a functional application for seismic data visualization and analysis and to ensure that the application can load, read, visualize, and analyze the seismic data in SEGY file through MATLAB. This is because raw seismic data need to be converted into usable information and manual processing of the numerous data can be tedious and time consuming. The scope of study mainly focuses at SEGY file structure, seismic data reading and visualization techniques, and seismic data analysis method. Several findings of MATLAB functions on how to read the structure and content of SEGY file have been very useful for this project. In this application, seismic data analysis focuses at the study of the density variance of the earth's layer based on the seismic amplitude. This project applies evolutionary development method, which is effective as changes in requirements may appear in any phases of the application development. As overall, seismic data processing draws on the knowledge of wave propagation effects and acquisition geometry to create geologically meaningful images of the earth's subsurface.

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Last but of course not least, thank you to all of my supportive friends, who constantly companion each other and also to everyone that is not mentioned here but also gave me helps whether directly or indirectly. You know who you are!

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ABBREVIATIONS AND NOMENCLATURES

2D	Two-dimensional
3D	Three-dimensional
ASCII	American Standard Code for Information Interchange: The numerical representation of character such as 'a' '@' or an action of some sort.
CREWES	Consortium for Research in Elastic Wave Exploration Seismology: An applied geophysical research group concentrating on the acquisition, analysis, and interpretation of multi component seismic data.
EBCDIC	Extended Binary Coded Decimal Interchange Code: A group of coded character sets used on mainframes that consist of 8-bit coded characters.
GUI	Graphical User Interface
GUIDE	MATLAB graphical user interface development environment that provides a set of tools for creating GUI.
MATLAB	Matrix Laboratory: A high-performance language for technical computing.
PRSS	PETRONAS Research and Scientific Services Sdn. Bhd.: PETRONAS' wholly-owned research and development subsidiary
SEGY	Society of Exploration Geophysicists Y: A file format that digitally records the 3D seismic data.

CHAPTER 1
INTRODUCTION

1.1 Background

Petroleum exploration and development involves activities such as searching for new gas and oil fields and then directing the drilling of wells to exploit the fields. These activities are very critical as they occupy millions of dollars, in which any misconception will result huge losses. The risks may include a dry hole, an outcome after drilling that does not encounter commercial amount of gas and oil. Another risk is unexpected abnormal high pressure in the subsurface during the drilling process that can cause a blowout, which is an uncontrolled flow of fluids up the well.

Seismic exploration is one of the methods used to prevent these risks. It involves computer processing of digital seismic data, which can be recorded in either 2D or 3D. In seismic exploration, seismic data visualization and analysis is a method to determine the structure of the subsurface rocks, which is a part of the whole process in predicting new oil field in petroleum exploration and development. SEGY (*.sgy) is one of the file formats that digitally records the 3D seismic data. Seismic data processing is performed to examine the structure of the earth's interior, which is by studying the variations in the travel times of seismic waves. This can then be used to predict the location of new gas and oil fields as well as to identify which location that might restrain high pressure.

1.2 Problem Statement

The seismic data in the SEGY file are in raw facts that have not been processed yet. Thus the data need to be converted into usable information to create geologically meaningful images of the subsurface of the earth. The process of analyzing the seismic data such as to perform certain calculation to get certain output can be very tedious and time consuming if done manually. This is because the SEGY file consists of numerous amounts of data.

The tasks are focused at how to load and read the seismic data in SEGY file and then visualize it to 2D and 3D display to be analyzed. This project is at the same time can be considered as a good start for a beginner to study and understand the fundamental knowledge of seismic exploration especially in seismic data visualization and analysis.

1.3 Objectives

The first main objective of this project is to develop a functional visualization and analysis application for seismic data in SEGY file. A functional application here refers to the second objective, which is to ensure the application can successfully perform the tasks of loading, reading, visualizing, and analyzing the seismic data. First is to load the SEGY file into MATLAB. Next, the content of the loaded SEGY file needs to be read first to visualize the seismic data to 2D and 3D display and the final one is to analyze the seismic displays, which refers to the third objective.

The third objective is to implement basic seismic data analysis method inside the application, which is to examine the seismic amplitude to understand the variance of the density of the earth's layer. The fourth objective is an additional one, which is to acquire and to understand clearly the fundamental knowledge about seismic exploration for the beginner in this field. The tasks are basically to design the application interface and to program the source code to execute the functions of the application.

1.4 Scope of Study

The scope of study for this project mainly focuses at SEGY file structure, seismic data reading and visualization techniques, and seismic data analysis method. The SEGY file structure refers to the content and attributes of the seismic data. The seismic data reading, visualization, and analyzing will practice the MATLAB computation, programming, and visualization techniques. For the analysis part, the scope concentrates on the understanding and the implementation of seismic amplitude analysis method.

CHAPTER 2

LITERATURE REVIEW

2.1 Seismic Data Acquisition

According to Hyne (2001) in his book, "Non-technical Guide to Petroleum Geology, Exploration, Drilling, and Production", the seismic method uses sound energy that is put into the earth. A source and a detector are used. The source emits an impulse of sound energy at the surface of the ocean. The sound energy travels down through the subsurface rocks, is reflected off subsurface rock layers. The reflected energy then returns to the surface to be recorded on a detector as seismic data.

Normally, geophones are used as detector or receiver as shown in figure 2.1 below. Geophones generate voltages, which are proportional to their velocity. These voltages are converted to numbers by the recording system. The numbers are ultimately recorded to the SEGY file as a series of 2D arrays.

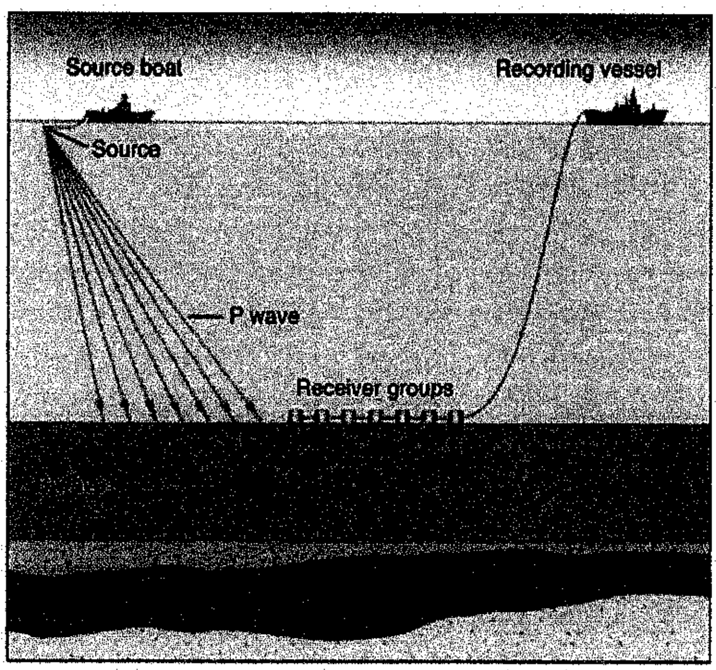

Figure 2.1 *Seismic data acquisition method*

2.2 The SEGY File Structure

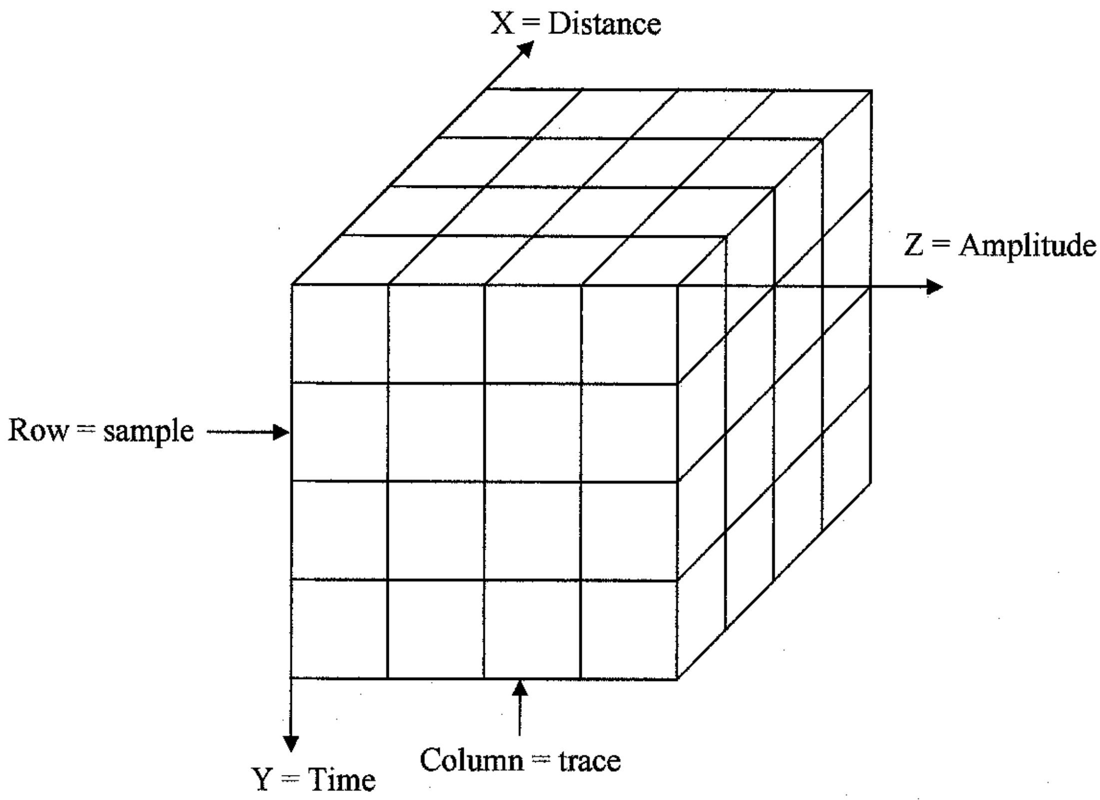

Figure 2.2 *3D seismic cube*

One of the file formats that record the seismic data is SEGY (*.sgy). The file consists of header and body, which is in ASCII format. The header displays information such as company name, crew number, area, seismic line number, coordinate units, how the data was acquired, processed, and displayed and many more. However, the information in the header often misses much of the important information. This is usually an oversight by the field acquisition staff or data processing staff. In many cases, the header has no valuable information at all. One normally needs the accompanying observer notes to completely understand the context of the data in the SEGY file.

The body stores the data to be read to do the visualization, which are sample interval and amplitude (Figure 2.2). Sample interval represents the interval of travel times of seismic waves in seconds. The Y-axis denotes the sequence of sample interval.

The amplitude, denoted by Z-axis is in a 2D matrix or array form containing the data of interest. The amplitude values range from negative to positive. One row in the matrix here represents one sample while one column in the matrix represents one trace. Sample refers to the interval of time of seismic wave propagating beneath the surface of the earth while a trace refers to a shot of sound energy of the area. The X-axis signifies the distance of the shot point locations from the source.

2.3 Reading SEGY File with MATLAB

After doing some research, several useful techniques or methods to read the SEGY files through MATLAB are figured out. These all can be good references in determining the most effective method to be used for this project. One of the methods is to use available MATLAB functions or M-files to read the SEGY data.

This project concentrates on MATLAB software library done by Consortium for Research in Elastic Wave Exploration Seismology (CREWES). The CREWES MATLAB library is a very large collection of geophysical routines for use in teaching exploration seismology (Margrave, 2001). The software contains numerous MATLAB files, which there is a section of them that can be used to read SEGY file.

The MATLAB functions for SEGY file in this library will read SEGY data by outputting the main data of interest, which are the header information, the time interval of the seismic waves, and the 2D matrix form or data array storing the amplitude value of the seismic waves. The function also gives the user option to force the SEGY data to be interpreted in ASCII format or in EBCDIC format. From the testing done, the interpretation of the data using ASCII format is faster compare to EBCDIC format.

Other available MATLAB files packages to read or interpret the SEGY file are also beneficial and useful for comparison as well as to give additional support to the understanding in reading and processing seismic data in SEGY file through MATLAB.

2.4 Seismic Data Analysis

In this project, seismic data analysis concentrates on the analysis of seismic amplitude. One of the areas focused is the acoustic impedance. Acoustic impedance refers to the study of density and acoustic velocity variance of the earth's layer. Earth's interior consists of many layers and each of these layers varies the structure that they form.

Reflection and refraction are two important concepts in seismic propagation to study the differences of structures between layers. Figure 2.3 shows a two-layer model with a higher velocity layer over a lower velocity layer. According to Kessinger (2005) in his paper, "Overview of Seismic Exploration", all changes in density and acoustic velocity in a layer model are assumed to occur at the layer interfaces. When a seismic wave encounters an interface, it is partitioned into a reflected wave that bounces off the interface and a refracted wave that crosses the interface. A change in velocity will cause the transmitted ray path to bend or refract. V1 and V2 are velocities in the upper and lower layers while with respect to the vertical, α_1 is the incident ray path angle and α_2 is the refracted ray path angle.

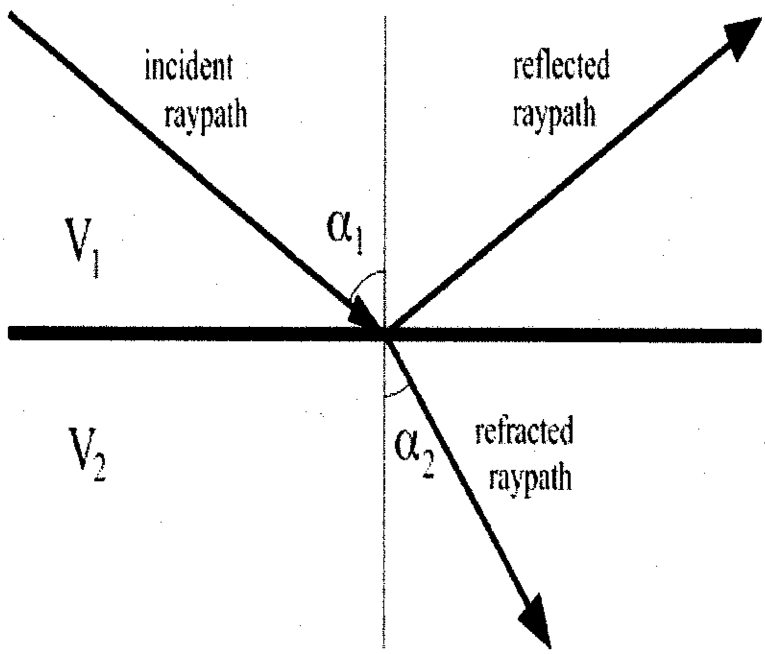

Figure 2.3 *Refraction and reflection of a ray path at planer interface*

Seismic propagation gives an output of 2D arrays amplitude data as mentioned previously. This is obtained using the following formula:

$$\text{Amplitude} = \frac{\text{Lower layer's velocity (V2)} - \text{Upper layer's velocity (V1)}}{\text{Lower layer's velocity (V2)} + \text{Upper layer's velocity (V1)}}$$

From the above calculation, positive amplitude means lower layer's density is higher than upper layer's density while negative amplitude means upper layer's density is higher than lower layer's density. Based on the relationship, the higher the acoustic velocity, the higher the density of the earth's layer. Higher density means smaller porosity while lower density means larger porosity. Porosity means the pore spaces of the earth's rock layer. Generally, the larger the porosity, the more possibility of a formation to contain more fluids such as water, oil, or gas. With adequate calibration, the amplitude can be used to determine the composition of pore fluids.

CHAPTER 3
METHODOLOGY AND PROJECT WORK

3.1 Procedure Identification

This project implements evolutionary development (Figure 3.1) as the software requirements are changing constantly throughout the development process. Evolutionary development implies that the requirements, plan, estimates, and solution evolve or are refined over the course of the iterations, rather than fully defined and frozen in a major up-front specification effort before the development iterations begin. Evolutionary methods are consistent with the pattern of unpredictable discovery and change in new product development.

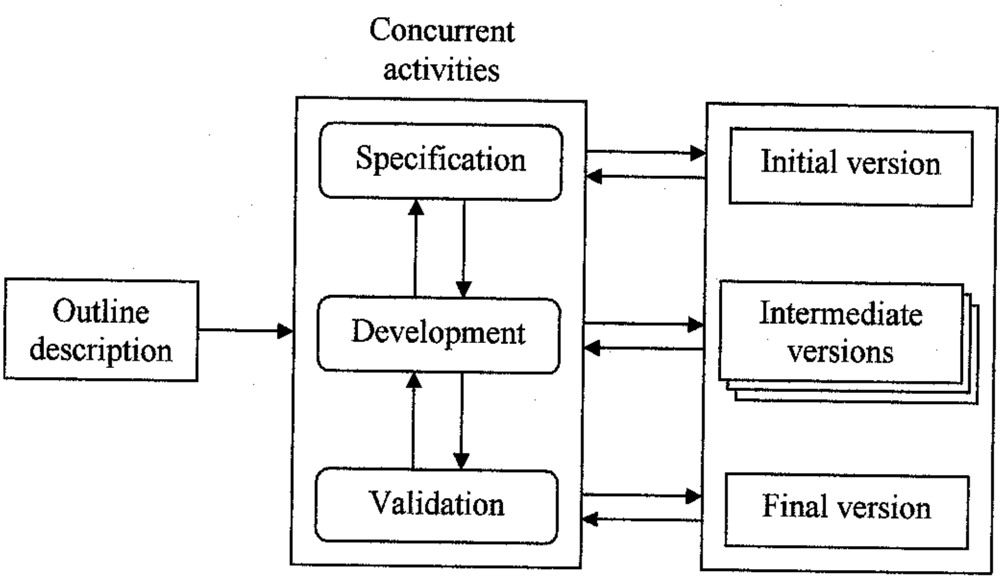

Figure 3.1 *Evolutionary development*

3.2 Tools Required

The main tool required for this application development is MATLAB 7 Release 14. MATLAB is a high-performance language for technical computing. It integrates computation, visualization, and programming in an easy-to-use environment. Typical uses include math and computation, algorithm development, data analysis and visualization, and application development, including graphical user interface building.

3.3 Project Work

The project starts with the process of studying and understanding the basic knowledge of seismic exploration. This includes overview of seismic exploration such as seismic data acquisition, seismic data attributes, and seismic data processing methods. The knowledge was gained by meeting and contacting several geophysicists, and by reading the materials such as reference books, journals, websites, and others.

Under completing the application of this project, the project work is divided into another three main tasks:

1. Specification

   This is the initial activity of the project, where the primary purpose is to identify the application requirements and specifications. The activities include appointment, meeting, and discussion with several staffs from Geoscience Group, PRSS to gather the needed information. They provided a lot of useful and vital information and guidelines. For example, how the seismic data was acquired, the structure of the seismic data, the functions of each data attributes represented in the SEGY file, the flow of the seismic data processing, and others.

2. Development

The next activity is development, which is the process of converting the software specification into an executable application. As this project implements evolutionary development method, this activity is concurrent with the previous activity and the next activity. The idea is to develop the specification incrementally as better understanding of the problem being expanded. This involves refinement of the software specification. The development starts with the parts of the tool which are understood. The tool evolves by adding new features. The development task is divided into several more sub-tasks as described below:

a. Interface design and specification

Interface design is the process of constructing a set of data types or objects that can be used as a crossing point to access the data or to perform operations. One of the main activities here is to design and to lay out the GUI using MATLAB GUIDE. GUIDE is the MATLAB GUI development environment that provides a set of tools for creating GUI. The usability of the GUI is among the essential areas to be stressed.

b. Component design and programming

Services are allocated to different components and the interface of these components is design. This also involves the programming of the GUI controls. The application is partitioned into four main components as illustrated in the diagram below:

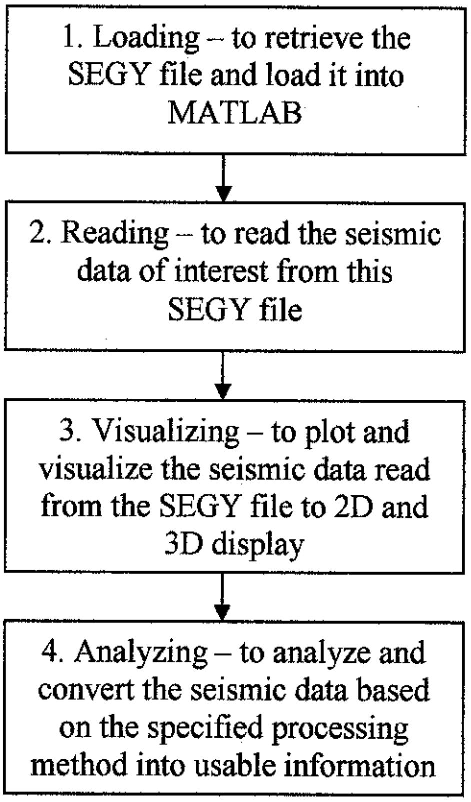

Figure 3.2 *The four main components of the application*

3. Validation

   This activity starts with the process of testing and verifying that the user interface and the functionality of the application are in accordance with the specifications and requirements. This involves checking, review processes, and application testing to make sure that input, processing, and output are also as specified by the requirements. Application testing involves executing the application with test cases that are derived from the specification of the real data to be processed by the application. When satisfied that the application executes proper operation and that everything is in order, the preparation of the version for final sign off can be accomplished.

CHAPTER 4
RESULTS AND DISCUSSION

4.1 The GUI Design

In this project, the application is developed using MATLAB. The GUI of the application is divided into four panels and one axes. Panels are used to group GUI components and can make a user interface easier to understand by visually grouping related controls. Axes are used to enable the GUI to display graphic, in this case to plot the graph of the seismic data. Table 4.1 below summarizes all the panels with their controls and functions.

Panels	Controls	Functions
1. Load SEGY	1. Push button, 'Load'	This button when clicked will open a dialog box used to retrieve files. The dialog box is set to display only the SEGY files with *.sgy extension. The dialog box is used to retrieve and load SEGY file into MATLAB.
2. Read & Visualize SEGY	1. Static texts and edit texts	There are two edit texts respectively for the user to enter the range of sample and the range of trace based on the loaded SEGY file. The static texts are used to guide or to direct the users to which edit texts are for sample range and which edit texts are for trace range.
	2. Pop-up menu	There is one pop-up menu that has two strings, '2D' and '3D' for the users to select whether they want to plot the seismic data to 2D graph or 3D graph.

	3. Check box, 'Undock figure'	The checkbox provides the options to the user on where to plot the seismic data. It is when selected will plot the graph on a MATLAB own figure window while when not selected will plot the graph on the axes provided on the GUI.
	4. Push button, 'Plot'	This button is used to plot or visualize the graph of the seismic data on the axes provided based on the loaded SEGY file and based on the range of sample and trace as entered by the user.
3. Analyze SEGY	1. Static texts	There are several static texts used to display the coordinates (x, y, z) based on the current mouse press over the axes background as well as the general interpretation of seismic amplitude with subsurface rock information. The coordinates refer to the seismic data, which are amplitude, time interval, and distance.

Table 4.1 *The description of the GUI components designed*

In terms of human-computer interaction, the project implements heuristic evaluation. The important factors that are taken into account are both cognitive and physical aspects. Cognitive aspect refers to the process by which users become acquainted with things. Physical aspect emphasizes on the usability of the application with human physical interaction. During the heuristic evaluation, the user interface of the application is inspected informally whether it conforms to the principles or not. The GUI controls are placed on the left side of the application while the graph display is placed on the right side (Figure 4.1). This is because user normally or generally navigates a user interface from upper left side to lower right side.

The panels of each section are also arranged in right order. This is good as a task sequence is enforced, which shows the flow of process of loading, reading, visualizing, and analyzing the seismic data. The grouping of sets of controls using this panel can also support the users' interaction with the application. The GUI uses easy-to-understand language and the critical display, the visualization area is visible and at eye level.

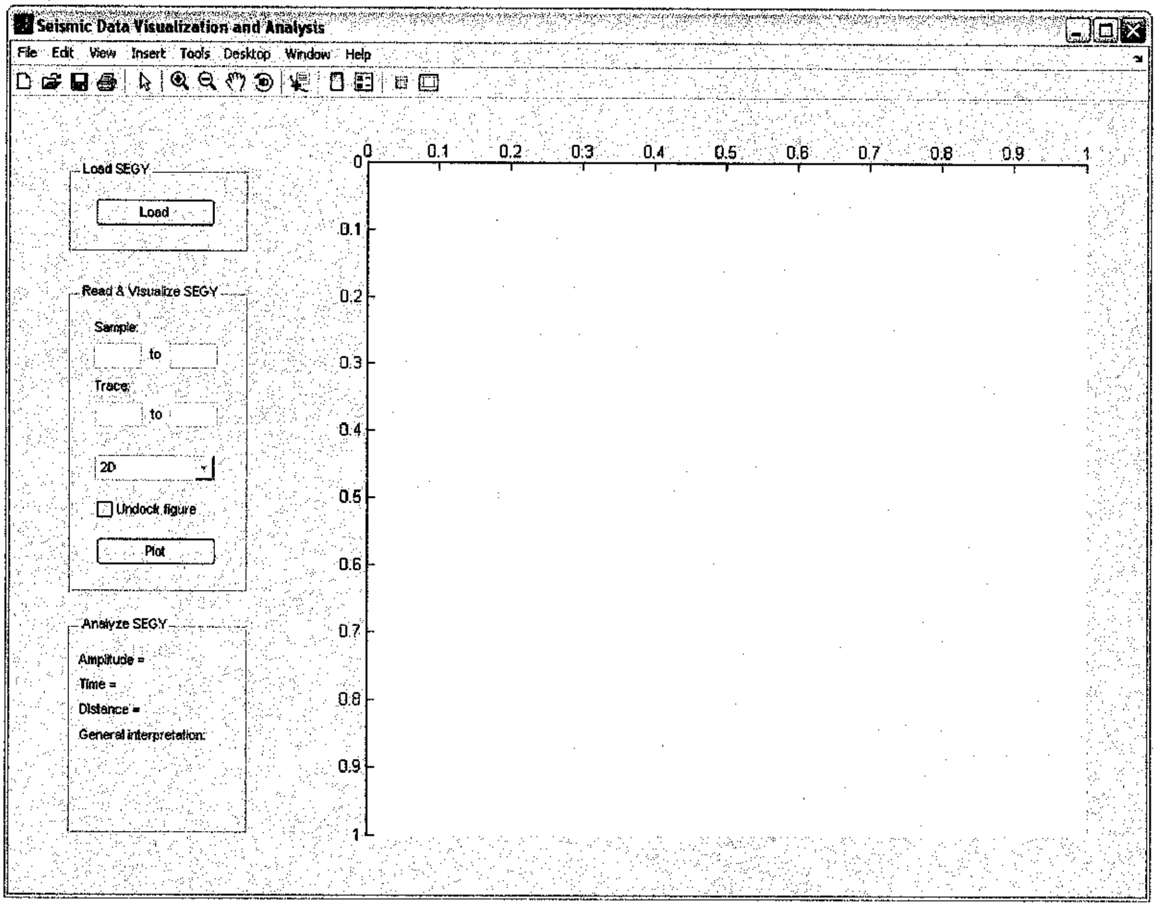

Figure 4.1 *The GUI design of the application*

4.2 Findings and Outcome

This section provides detailed explanation on the findings and outcome as well as the GUI programming of the four main tasks of this application, which are loading SEGY file into MATLAB, reading the seismic data in the SEGY file, visualizing the seismic data, and analyzing the visualized data using general seismic interpretation method.

To load the SEGY file into MATLAB, the application applies the existing MATLAB function, *uigetfile* that is used to retrieve and open a file from standard dialog box.

[FileName, PathName] = uigetfile('*.sgy', 'Select the SEGY file');

The coding above will open a dialog box that will only display the files with *.sgy extension as shown in figure 4.2 below:

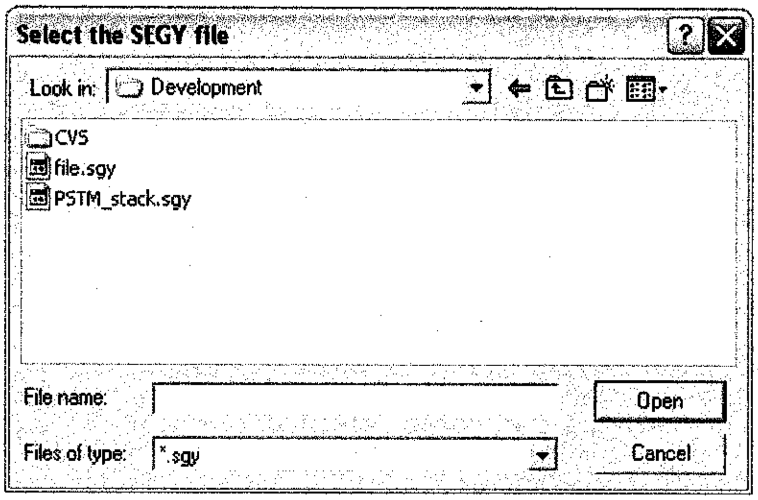

Figure 4.2 *The dialog box to retrieve SEGY file*

After the loading process of the SEGY file is done, the task continues to read the seismic data in the SEGY file. To do this, the application implements the function *altreadsegy*, which is obtained from CREWES MATLAB software library. This function will also call several other functions done by CREWES while reading the data. The coding below shows the example of how to use the function:

[dataout, sampint, textheader] = altreadsegy('file.sgy', 'textheader', 'yes');

As shown above, there are two main inputs required to produce the three main outputs. The two inputs are the SEGY file, and the text header. The 'file.sgy' inside the coding above will open a SEGY file named file.sgy and 'textheader', 'yes' will send the text header to one of the output arguments.

The three outputs or variables are *dataout*, *sampint*, and *textheader*. The *dataout* is the 2D array containing the data of interest, which is seismic amplitude. The *sampint* is the sample interval or time interval in seconds. The output of the time interval from this example of SEGY file is 0.002, thus the sequence of time produced is 0.002, 0.004, 0.006, 0.008, 0.010, and so on. This sequence represents the travel time of seismic waves in the earth's subsurface during seismic data acquisition. These *dataout* and *sampint* are the two main outputs needed to visualize and analyze the seismic data. The *textheader* is the output of the SEGY file header information. Figure 4.3 shows the output of the 2D array data from this SEGY file for trace one to five and for sample one to fifteenth.

0.58005	0.60927	0.63677	0.64792	0.64126
0.59471	0.62515	0.64521	0.64596	0.63481
0.61114	0.63798	0.6479	0.64047	0.62968
0.6268	0.64578	0.64543	0.63405	0.62744
0.63914	0.64784	0.63969	0.6292	0.62781
0.64631	0.64488	0.63333	0.62732	0.62821
0.64773	0.63893	0.62878	0.62788	0.62409
0.64431	0.63266	0.62725	0.62805	0.60989
0.63819	0.62842	0.62796	0.62309	0.58067
0.63205	0.62723	0.62783	0.60743	0.27095
0.62813	0.62804	0.62195	0.57629	-0.24158
0.62727	0.62754	0.60476	0.23506	-0.60239
0.62813	0.62067	0.57168	-0.29637	-0.67576
0.62718	0.60188	0.20878	-0.61089	-0.73679
0.61923	0.56683	-0.36064	-0.68352	-0.7736

Samples (Rows)

Amplitude (Row x Column)

Traces (Columns)

Figure 4.3 *2D array containing data of interest*

The input argument of this function can also be added another parameter, 'textformat', 'ascii' to force text header to be interpreted as ASCII or 'textformat', 'ebcdic' to force text header to be interpreted as EBCDIC. From the results, it shows that the reading process using ASCII is faster than using EBCDIC.

The next task is to visualize the data that have been read. For the 2D graph, this is done using the *plot* function. This function is used to plot linear 2D graph. In plotting both 2D and 3D graph, the 2D array of amplitude is plotted on the X-axis, while the time interval is plotted on the Y-axis. The coding below shows the example of how to plot the data:

```
time = 0:sampint:(size(dataout(1:100, 1:10),1)-1)*sampint;
plot(dataout(1:100, 1:10), time);
```

The variable *time* is defined to produce the sequence of time interval. 1:100 and 1:10 inside the parameter of *dataout* correspond to the range of sample and the range of trace respectively to be plotted. In this case, the range of sample is from 1 to 100 and the range of trace is from 1 to 10. Figure 4.4 shows the plotted seismic data in 2D graph.

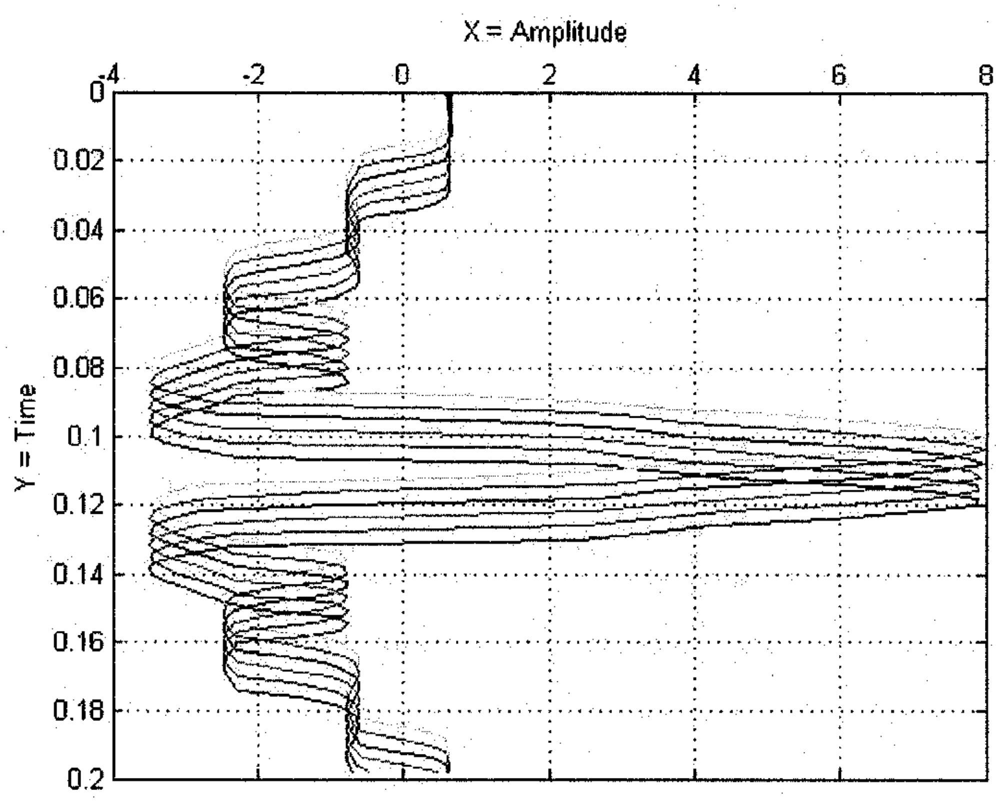

Figure 4.4 *Seismic data in 2D graph*

For the 3D graph, the desired output is to plot each of the traces separately so that they are not overlapped as in 2D graph. The separated traces are plotted along the Z-axis. This is done using the *mesh* function as shown in the coding below. Figure 4.5 shows the plotted seismic data in 3D graph.

```
mesh(dataout(1:100, 1:10));
```

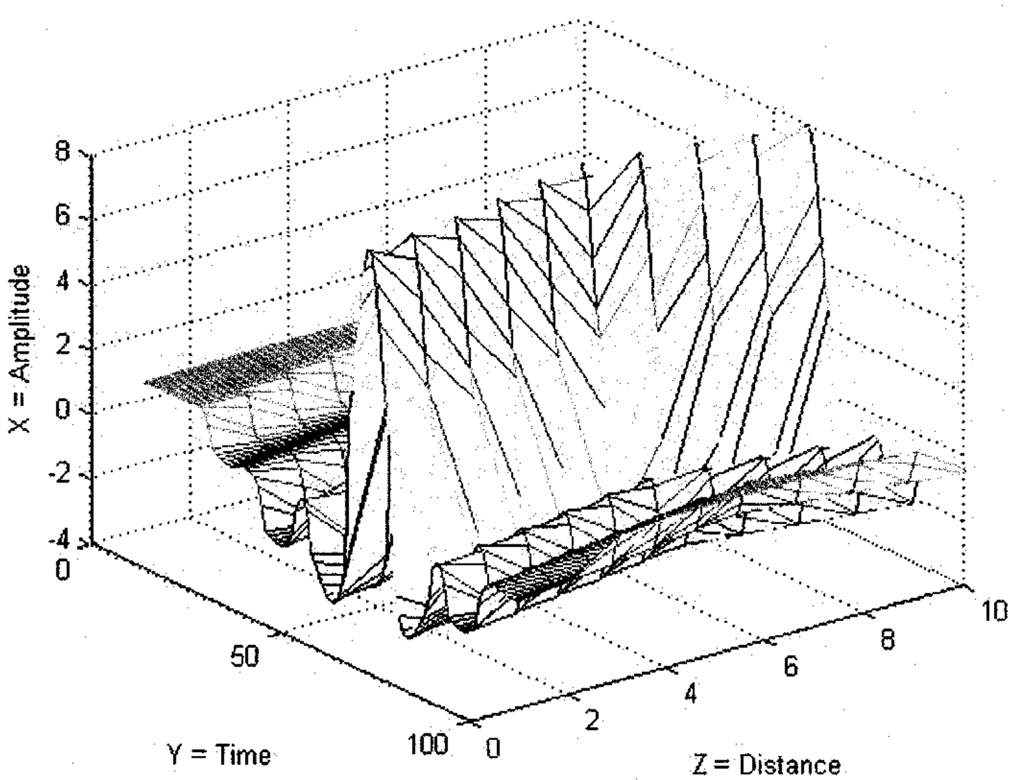

Figure 4.5 *Seismic data in 3D graph*

Finally, the visualized data can be analyzed. This application uses general interpretation of seismic amplitude. This is done through the study of the relationship between the amplitude, the acoustic velocity, the density of the earth's layer, the porosity of the rocks, and the possibility of the rocks to contain fluids such as water, oil, or gas. Recall back, negative amplitude means lower earth layer's density is smaller than upper earth layer's density. Smaller density means larger porosity, while larger porosity means more fluids. Thus, generally in this case, the lower layer may contain more fluids than the upper layer.

Under the analysis section of the GUI, the application will display the seismic amplitude, the time interval, and the general interpretation information based on the current selected point of the mouse press over the axes background in the graph as shown below.

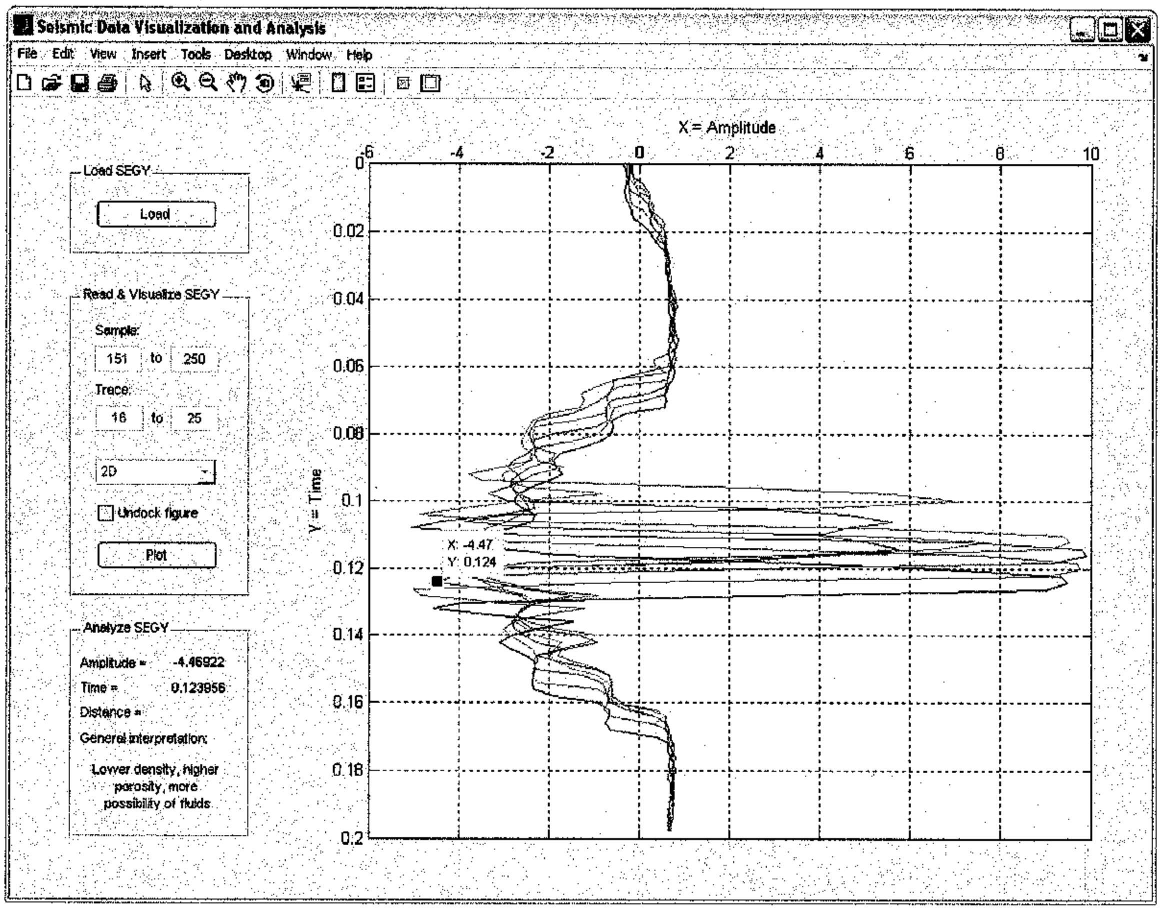

Figure 4.6 *Example of seismic data visualization and analysis*

4.3 Discussion

This application is proven applicable for small size SEGY file only and it has not been tested for large size SEGY file. However, the aspect where the user can select the range of sample and the range of trace to be plotted is a good feature of the application. This is because for large size SEGY file with thousands of samples and traces, the user does not necessarily have to read and visualize the data all at once that will slow down the process.

The 2D visualization is recommended when the user only interested to obtain the amplitude and time interval from the seismic data for example in the task to analyze and compare only few traces. This is because the processing time will be faster compare to 3D visualization. However, 3D visualization is better in terms of it displays the distance or the shot point locations of the trace resulting better and more accurate imaging and defining subsurface reservoir. The available of existing MATLAB figure menu bar allows the user to perform extra tasks such as rotating and zooming the graph.

The analysis of the seismic data in this application focuses on the general concept of seismic amplitude interpretation and does not provide 100% accuracy of information. The analysis needs to be integrated with other methods of interpretation to obtain precise prediction of the variations of rock composition and porosity. But on the other hand, it is a good way for a beginner to understand easily the basic concept of this fascinating topic.

CHAPTER 5
CONCLUSION AND RECOMMENDATION

The completed project can be said is concurrent with the overall objectives. The project managed to develop successfully an application that centers at a part of the fundamental knowledge in seismic exploration focusing in seismic data visualization and analysis. The application can successfully load, read, visualize, and analyze seismic data in SEGY file through MATLAB. The understanding on how to apply CREWES MATLAB software library to read the SEGY file, the 2D and 3D visualization of seismic data and the implementation of general seismic amplitude interpretation inside the application are among the significant results of this project. As overall, this application is useful for a beginner to learn about seismic data and its general interpretation.

The recommendations for future project work will include the study and completion of what is the most effective way to load large size of SEGY file that can be up to hundreds of gigabytes. Among the methods that have been identified are to use parallel computing, to apply virtual memory, or to improve the existing M-files program that is used to read the SEGY file. Another recommendation is to add more seismic data analysis method inside the application so that the combining and comparison of analysis can be made to produce more precise results in predicting the new oil field. This is to increase the usages of the application as well as the users from beginners to experts.

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APPENDICES

Project milestone:

No.	Detail/ Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Selection of Project Topic	■													
	-Propose Topic														
	-Topic assigned to students														
2	Preliminary Research/Design Work		■	■											
	-Introduction														
	-Objective														
	-List of references/literature														
	-Project planning														
3	Submission of Preliminary Report (Initial Proposal)			●											
4	Project Work				■	■	■	■							
	-List of Reference/Literature														
	-Practical/Laboratory Work														
5	Submission of Progress Report								●						
6	Project work continue								■	■	■	■			
	-Practical/Laboratory Work														
7	Submission of Dissertation Final Draft												●		
8	Oral Presentation													●	
9	Submission of Project Dissertation														●

● Suggested milestone

■ Process

The GUI Programming:

Function for 'Load SEGY':

```
% --- Executes on button press in loadButton.
function loadButton_Callback(hObject, eventdata, handles)
% hObject    handle to loadButton (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

global filedir;

[FileName,PathName] = uigetfile('*.sgy','Select the SEGY file');

filedir = strcat(PathName, FileName);
```

Function for 'Read & Visualize SEGY':

```
% --- Executes on button press in plotButton.
function plotButton_Callback(hObject, eventdata, handles)
% hObject    handle to plotButton (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

global filedir;

[dataout,sampint,textheader] = altreadsegy(filedir,'textheader','yes', 'textformat', 'ascii');

sflength = str2num(get(handles.samFrom, 'String'));
stlength = str2num(get(handles.samTo, 'String'));
```

```
slength = stlength - sflength + 1;
tflength = str2num(get(handles.traFrom, 'String'));
ttlength = str2num(get(handles.traTo, 'String'));
time = 0:sampint:(size(dataout(sflength:stlength, tflength:ttlength),1)-1)*sampint;
dimen = get(handles.dimenPopup, 'Value');
dock = get(handles.ufCheckbox, 'Value');

switch dimen
  case 1
    if dock == 0
      plot(dataout(sflength:stlength, tflength:ttlength), time);
      set(gca,'XAxisLocation','top');
      set(gca,'YDir','reverse');
      xlabel('X = Amplitude');
      ylabel('Y = Time');
      grid on;
    else
      figure
      plot(dataout(sflength:stlength, tflength:ttlength), time);
      set(gca,'XAxisLocation','top');
      set(gca,'YDir','reverse');
      xlabel('X = Amplitude');
      ylabel('Y = Time');
      grid on;
    end
  case 2
    if dock == 0
      mesh(dataout(sflength:stlength, tflength:ttlength));
      set(gca,'YDir','reverse');
      xlabel('Z = Distance');
      ylabel('Y = Time');
```

```
        zlabel('X = Amplitude');
        grid on;
    else
        figure
        mesh(dataout(sflength:stlength, tflength:ttlength));
        set(gca,'YDir','reverse');
        xlabel('Z = Distance');
        ylabel('Y = Time');
        zlabel('X = Amplitude');
        grid on;
    end
end
```

Function for 'Analyze SEGY':

```
% --- Executes on mouse press over figure background, over a disabled or
% --- inactive control, or over an axes background.
function projectFigure_WindowButtonDownFcn(hObject, eventdata, handles)
% hObject    handle to projectFigure (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

pt = get(gca, 'CurrentPoint');
xLim = get(gca, 'xLim');
yLim = get(gca, 'yLim');
zLim = get(gca, 'zLim');
dimen = get(handles.dimenPopup, 'Value');

switch dimen
  case 1
```

```
if ((xLim(1)<pt(1,1) & pt(1,1)<xLim(2)) & (yLim(1)<pt(1,2) & pt(1,2)<yLim(2)))
%the point is in the range
   set(handles.xCoord, 'String', pt(1,1))
   set(handles.yCoord, 'String', pt(1,2))
   set(handles.zCoord, 'String', '')
   if str2num(get(handles.xCoord,'String')) > 0
      set(handles.velocity, 'String', 'Higher density, smaller porosity, less possibility
      of fluids');
   else
      set(handles.velocity, 'String', 'Lower density, higher porosity, more possibility
      of fluids');
   end
else %the point is out of range
   set(handles.xCoord, 'String', '')
   set(handles.yCoord, 'String', '')
   set(handles.zCoord, 'String', '')
   set(handles.velocity, 'String', '')
end
case 2
   set(handles.xCoord, 'String', pt(1,3))
   set(handles.yCoord, 'String', pt(1,2))
   set(handles.zCoord, 'String', pt(1,1))
   if str2num(get(handles.xCoord,'String')) > 0
      set(handles.velocity, 'String', 'Higher density, smaller porosity, less possibility of
      fluids');
   else
      set(handles.velocity, 'String', 'Lower density, higher porosity, more possibility of
      fluids');
   end
end
```