GEO 384U – Homework 4

300 Points

Assigned: Wednesday, October 25th at the beginning of class
Due: Friday, November 10th at the beginning of class

Your task: You are given a well data and seismic data set from the Heimdal field in the North Sea. The well data are divided into six facies, and three of those facies are then converted from brine to oil saturation. The seismic information consists of AVO intercept and gradient surfaces. You are to classify the seismic intercept and gradient data into the most likely of the 9 classes using the Mahalanobis Distance criterion. You may write the codes in any preferred language. The data provided to you is in Matlab format for ease of distribution and because it has been significantly cleaned up and reorganized relative to the original data.

The data. On the Canvas site, you will find Input_Data.mat. When you load that in Matlab, you will see a list of data structures. Structures help reduce the number of variables, in this case significantly. Further, they allow for common naming of variables from structure to structure (e.g., depth). Structures can be passed into and out of functions in the same way that a variable can be. The first nine structures correspond to the 9 facies you have seen in class. These include six brine-saturated classes and three oil-saturated classes. Fluid substitution has been for you to simplify the procedures (you're welcome). Each brine-saturated facies structure contains curves for depth, Vp, Vs, density, gamma ray, porosity, Ip, Is, Vp/Vs, Vclay, Sw, and Sxo. The oil facies contain the same plus some that resulted from the fluid substitution that you won't use.

The 'Seismic' structure contains the intercept and gradient surfaces and the inline and xline vectors. 'Well2' is the well data for the entire depth range.

To turn in. You will provide a screen recording of your results. This report must include:

a) Log data plot with facies indicated.
b) Plots of PDFs and CDFs for Vp, Vs, density, Ip, and Vp/Vs for all classes.
c) Reflectivity curves as a function of angle for all 9 classes.
d) Intercept-Gradient cross plots for all classes and the real data.
e) Image of most-likely facies
f) Image of most-likely grouped facies

Every figure must have easily readable axes values and axes labels. If you don't label the axes, I'll take off points.

Guidelines, hints, and suggestions

1) **START EARLY.**

2) Use the same range for a given property (e.g., Vp/Vs) for all facies when computing a PDF/CDF for that property.
3) Assume all PDFs/CDFs are Gaussian distributions.
4) When drawing Vp and Vs values to compute reflectivity, draw them from a bivariate distribution so that they are correlated. Density can be drawn independently.
5) You are provided a Matlab script to compute reflectivity. It has options for several different approximations as well as the Zoeppritz equations. When generating reflectivity, you can vary the number of simulations, the angle range over which to compute the reflectivity, and the way in which you compute the reflectivity (Zoeppritz versus an approximation).
6) Put facies IV above all nine facies including itself. See lecture notes for this.
7) You will have to write a function to give you intercept and gradient from the reflectivity. This will be only a couple lines of code.
8) The angle/offset range for the seismic intercept and gradient surfaces are not specified.
9) Compare the seismic-based intercept and gradient data to the intercept and gradient data for each class. The most likely class is the one with the smallest Mahalanobis distance. Construct the grouped classes (shale, brine sand, oil sand) from the most-likely classes (i.e., do not rerun the classification for grouped facies).
10) The Avseth et al., 2005 book can provide hints as well as the slides you've seen in class.

11) **START EARLY.**

Here's what my main script looks like, with some values missing. It's just a guide.

```
close all;
clear all;

load Input_Data.mat

ndraws =  ;   %Number of simulations
approx =  ;   %Choice of Zoeppritz Eqns or approximation
ang =     ;   % Angle Range

%%%%%% Specify minimum and maximum values (ranges) for Vp, Vs, Rhob, Ip, and Vp/Vs

Vpmin = ;
Vpmax = ;
Vsmin = ;
Vsmax = ;
Rhobmin = ;
Rhobmax = ;
Ipmin = ;
Ipmax = ;
VpVsmin = ;
VpVsmax = ;

%%%%%%%

MakeBrinePDFsCDFs; %Makes CDFs and PDFs for the 9 facies
MCDraw;            %Draws ndraws values from the PDFs made from the previous step
MakeAVOpdfs;       %Generates AVO curves, Int-Grad values,
ClassesMahal;      %Assigns to facies based on Mahal distance

save Mahal_Classification.mat
```