Master Project proposal

Project Details

Title	**Seeing in a hall of mirrors - a neural network solution for velocity analysis in multiple contaminated seismic data**
Institution / Company	**Aramco Europe, Delft Research Center**
Location	**Delft, the Netherlands**
Local Supervisors in Company	**Paul Zwartjes**
Miscellaneous	**This is a paid internship**

Seismic data is the only type of geophysical measurement that allows geophysicists to visualize the subsurface over a large area with a reasonable resolution. Whether it is for finding gold or copper deposits in mineral exploration (where do the mineral veins go below ground?), conventional energy sources like oil and gas or renewable energy like geothermal (where to place the wells?) and wind-energy (does the subsurface support windmills?) everyone that is interested in the subsurface sooner or later works with seismic data.

In order to transform the time series recordings of seismic reflections to an image in depth, the so-called “seismic velocity” is required. Seismic velocity analysis is a crucial step in seismic data processing. In the past numerous methods have been developed to retrieve velocity information from seismic data, such as for instance normal moveout (NMO) velocity analysis. When the data has a good signal-to-noise ratio and the geology is fairly simple (i.e. horizontal layering), velocity analysis by scanning a range of velocities can be automated. The optimal velocity will then perfectly align reflections from various recordings. In case of poor signal-to-noise ratio (high noise levels/weak reflection energy) and/or multiple contamination the analysis is more complex. Multiples are repeated reflections, as if one were in a hall full of mirrors, and the multiple reflections can occur both upwards and downwards. Multiples create ‘false positives’ in the semblance panels which fool most automatic picking methods that scan for the strongest energy in semblance panels to pick velocity. In this case a time consuming manual intervention is required, in which the seismic processor make a judgement call for a large number of gathers based on experience and auxiliary information such as well logs what the desired velocity profile should be.

The aim of this project is to investigate what kind of impact deep learning algorithms can make on the velocity estimation process in the presence of multiple reflection. The objective is to reduce human intervention and improve quality and consistency of velocity picks. As shown in the example below we can generate synthetics velocity models and seismic data, so generating training is not a problem. The kind of learning method to automatically select the right velocity profile, in the presence of noise and false events, is unknown and the main goal of this thesis work. Ideally, we should be able to derive it from the data, while at the same time being able to guide the process based on known velocity trends from, for instance, well data (measurement of velocity in a well). We consider this primarily a machine vision challenge where there appear to be parallels to topics such as pose estimation and object detection, but bi-directional recurrent networks may also prove useful because of the multiple reflections occurring in the data. However, we are open to the creativity and skills of the student to decide on a successful strategy.

References
Reetam Biswas, Anthony Vassiliou, Rodney Stromberg, and Mrinal K. Sen, (2018), "Stacking velocity estimation using recurrent neural network," SEG Technical Program Expanded Abstracts : 2241-2245.

http://cs230.stanford.edu/projects_fall_2018/posters/12350213.pdf

Work Environment

You will be working in our research team in Delft, where have several ongoing projects on seismic data processing and deep learning. Our office in Delft performs research in various signal processing method to improve seismic data processing workflows. We recently have started using techniques from Artificual Intelligence. Whereas in other fields many advanced tools have been developed, AI in seismic processing is only just getting started.

The team consists of a 11 researchers with varying university background and nationalities and is one of several worldwide that develops seismic data processing software for Aramco. Our office is located in the Delftech Park at Delft University and under normal (non-Covid19) circumstances the work is office based, but working from Amsterdam partially is possible. This is a paid internship.

Expectations

Autonomous, self-motivating and taking initiative. Good knowledge of Python is required. Knowledge and skill in machine vision will be helpful given the nature of the project.

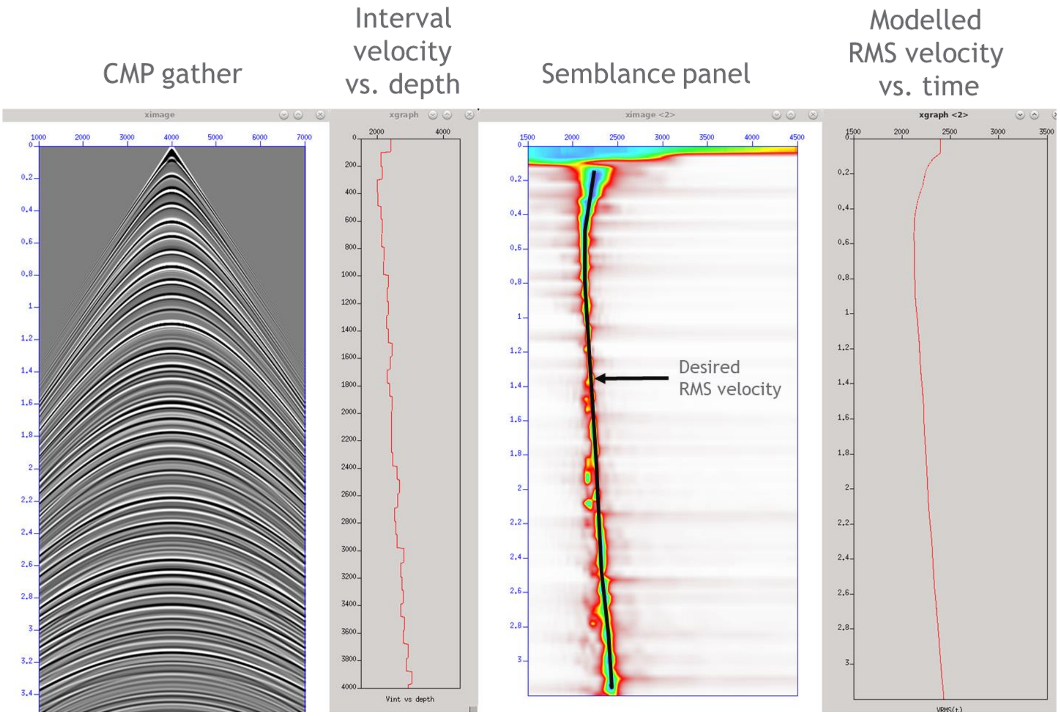


Figure 1. Textbook velocity analysis using semblance panels. The peak semblance value occurs at the desired velocity for a given time sample thus yielding the root-mean-square (RMS) velocity as a function of recording time (as apposed to a geological layer velocity as a function of depth).

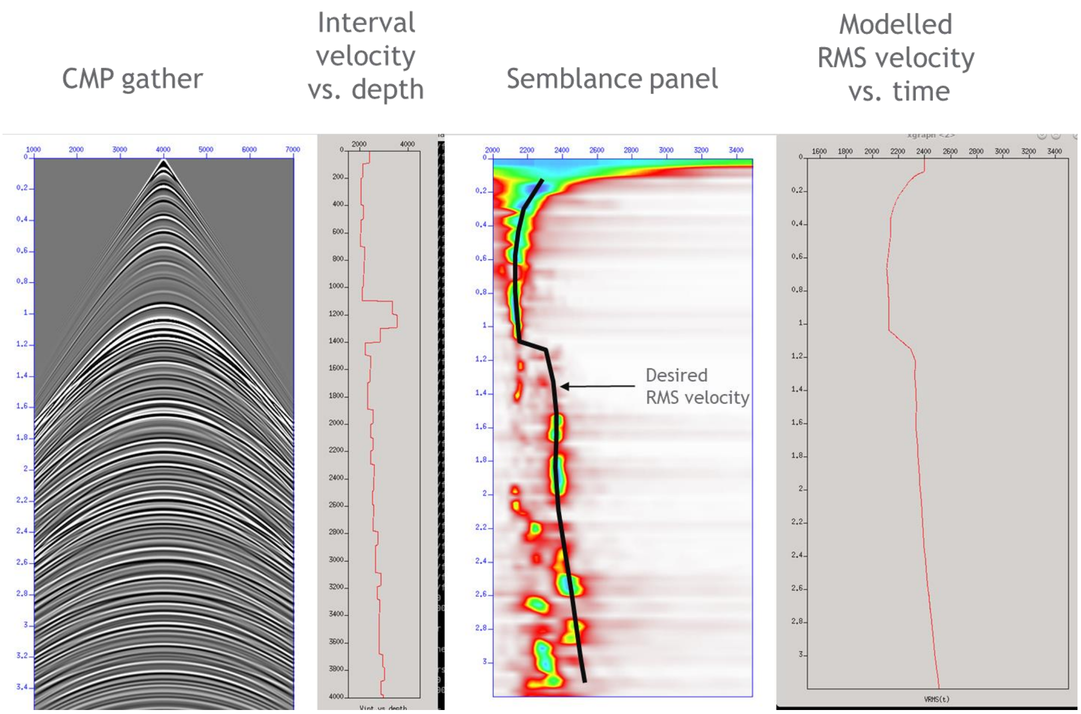
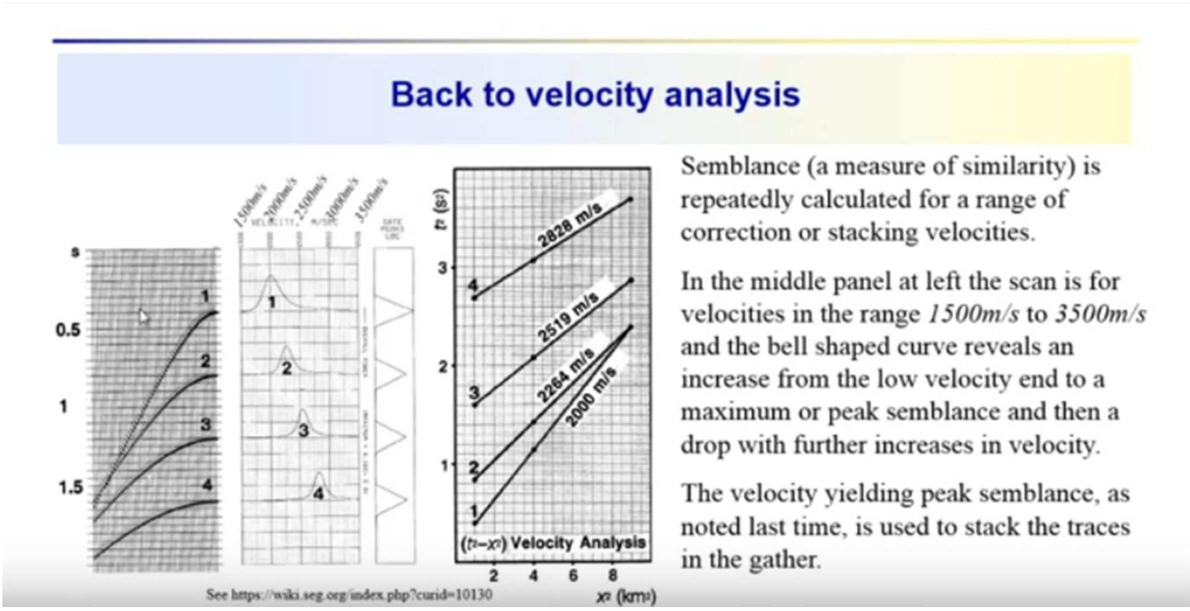
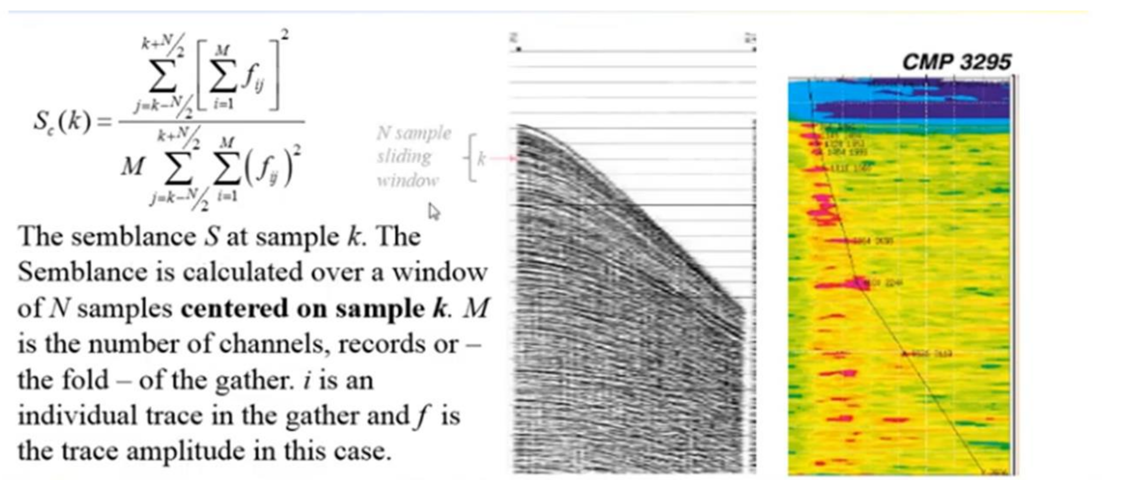


Figure 2. Velocity analysis is more complicated in the presence of multiples. The lower stacking velocities of the multiples create undesired semblance peaks which are as strong or stronger than the semblance peaks corresponding to the primary RMS velocity

https://www.youtube.com/watch?v=X8TbFmXW3Go





Seismic gathers and associated velocity semblance panels