Master Project proposal

Project Details

Title	**3 D first arrival picking in seismic data using machine vision**
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. In case of near-surface geophysics the number of applications is large: soil properties are estimated from seismic data and used in engineering studies (can the soil support a building or windmill), mineral exploration, geohazard identification or oil/gas/geothermal exploration to build better velocity model for deep seismic imaging.

Land seismic data processing is challenging due to complex near-surface conditions. The seismic wavefront propagation velocities are low in unconsolidated sediments and due to rapid varations in landscape large variations in near-surface rock properties can occur. A key step is to estimate the near-surface velocity profile via refraction tomography. The tomography takes pairs of distance-traveltime observations and calculates in a least-squares sense the subsurface velocity matching those observations. The key is therefore to get accurate distance-traveltime pairs. And that is done by so-called “first break” (FB) picking, which is the goal of this project. The first break is basically the first recorded arrival in seismic data.

It is well known that experienced processors can pick (or select/interpret) first breaks (FB) to near perfection, but that manual picking is not cost effective of large seismic surveys. Automated FB picking is therefore essential. Historically, there have been three categories of such methods: (1) cross-correlation based, (2) energy/amplitude-based and (3) neural network based methods that aimed to predict the onset of the FB from a plethora of attributes. For clean data with good signal-to-noise ratio, FB picking can be done reliably by any of these approaches. However, for seismic data with strong noise sources (wind, simultaneous shooting, etc.) or weak FBs due to energy dissipation (“shingling”), poor source/receiver coupling the problem remains challenging. The recent developments in computer vision have added a fourth approach to the FB picking toolbox, namely FB picking with deep learning. This technique has the promise to teach an algorithm human level first break picking quality by means of supervised learning, something which was not possible with all of the previous techniques.

As in other fields, the U-net network has been proven to work in FB picking. However, the applications are still in 2D which leads to mispicks and inconsistencies in the results between

different shot profiles As in the fields of medical imaging, where the U-net has been developed for analysis of 3D MRI scans, we want to extend the neural network based pickers to the 3D domain. We believe that this will help to ensure consistency of the picked first break, since all of the 2D shot gathers are essentially slices through a 3D wavefield.

Unlike MRI data, seismic data often suffers from poor S/N ratio, gaps, random shifts and interfering events which all complicate the picking process for an automatic picker, even though an experienced geophysicst would be able to roughly pick the signal through the noise. The objective is therefore not only to develop an algorithm that can handle 3D data, but also one that is robust in noisy data and can pick or interpret the data according to a model or expected pattern that normally only exists in the geophysicists head.
Although the U-net approach has been succesful but we are really not interested in segmentation. The first break actually is simply a line in 2D data and a cone in 3D data.. Therefore, what we really want is that line or cone. We are therefore open to alternative approaches to the segmentation route. We have both synthetic and real data with first break pick estimates.

Evaluation of Neural Network Architectures for First Break Picking, P. Zwartjes, M. Fernhout and J. Yoo. Conference Proceedings, 82nd EAGE Annual Conference & Exhibition, Dec 2020, Volume 2020, p.1 - 5. DOI: https://doi.org/10.3997/2214-4609.202010331

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.

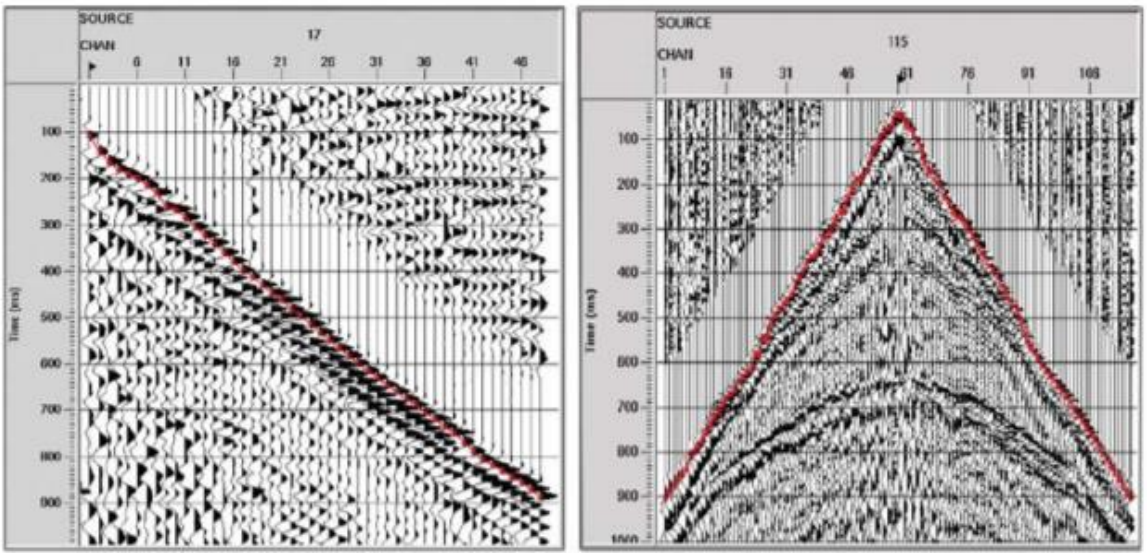

Figure 1. Examples of first break picking with conventional algorithms. Figure from https://doi.org/10.1190/sbgf2017-300, "Automatic first-breaks picking using linear moveout correction and complex seismic traces".

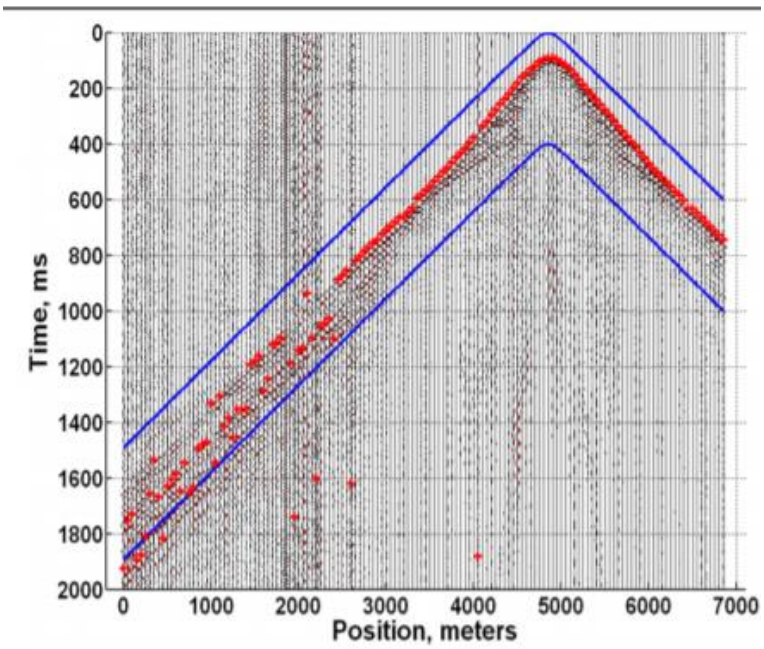

Figure 2: Example where automatic first break picking fails due to poor data quality.

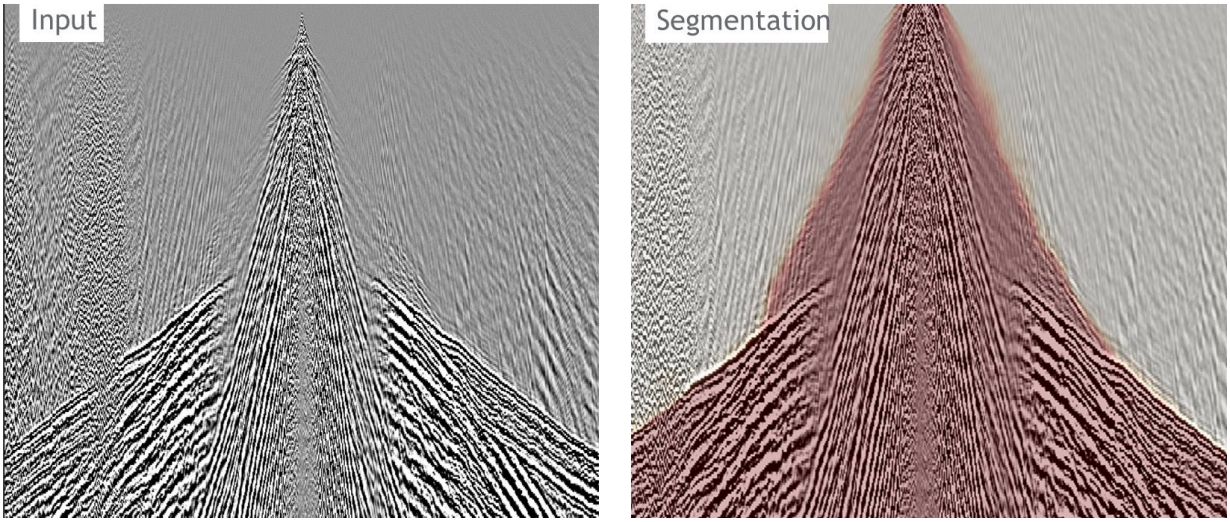

Figure 3. Example of U-net segmentation in 2D seismic.

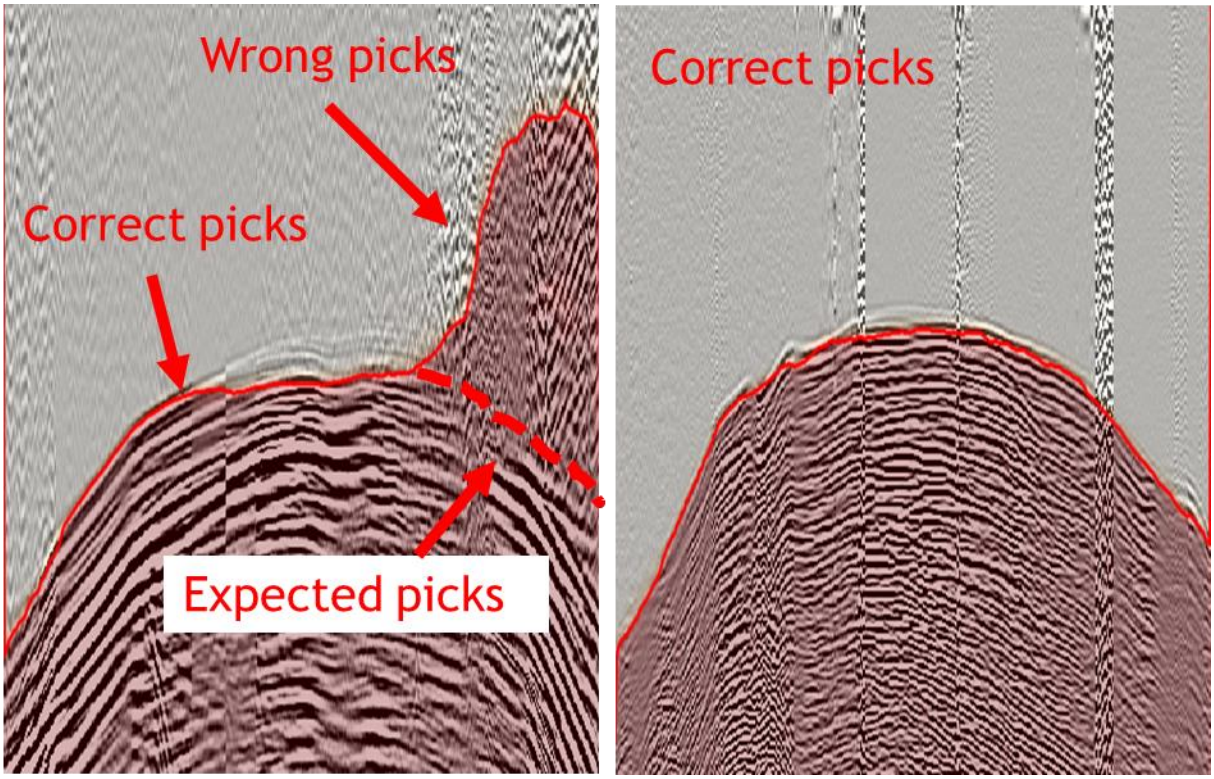

Figure 3: Example of the problem with 2D FB picking. The U-net algorithm has incorrectly picked the first break on part of the shot gather (labelled as "wrong picks"), whereas on the next 2D shot gather it has picked the first break much better. By combining all these 2D shot gathers and ensuring consistency in 3D we hope to improve the picking results .

References

Evaluation of Neural Network Architectures for First Break Picking , P. Zwartjes, M. Fernhout and J. Yoo, European Association of Geoscientists & Engineers, Conference Proceedings, 82nd EAGE Annual Conference & Exhibition, Dec 2020, Volume 2020, p.1 – 5. DOI: https://doi.org/10.3997/2214-4609.202010331