

First Break Picking Using Neural Networks

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First break picks and attributes, Neural networks, Back propagation

Summary

First break picking is the essential part in the estimation of near surface velocity model building through the applications of delay time methods, refraction tomography and diving wave tomography methods etc. Being essential on one part it is quite laborious on other as it consumes a significant amount of processing time. In this study, we have demonstrated the use of neural networks in first break picking whereby we have picked first breaks picks manually for a small subset of data only and calculated certain seismic attributes in the vicinity of first breaks. Subsequently, the neural network then iteratively assigned internal weights based on the consistency of first break attributes values in correspondence to actual first break pick time. Finally, based upon these neural weights the first break pick time have been estimated for the whole seismic dataset. First break picking through neural networks have been found to achieve around 90 to 95 percent results against manual picking and thereby saved production time significantly for areas having almost linear first arrival trends. However, for areas having mixed first arrival trends (i.e. linear as well as non linear) using spatially varying neural networks have been found to serve the purpose fruitfully. Additionally, pre/post conditioning and optimum parameterization of seismic data/work flow have been found to serve the purpose to a larger extent.

Introduction

The quest of finding smaller hydrocarbon bearing structures in the subsurface gives rise to the requirement of acquiring high density seismic data followed by its processing and interpretation. No doubt the present technology is able to cop up with the increased data volume due to advancement in computing power. However, there are few processes which we still bound to perform manually as far seismic data processing is concerned. First break picking is one such process which is essential for deriving near surface velocity model and at the same time it is quite laborious as it consumes a significant amount of processing time. In seismic exploration, first break picking is the task of determining, the on

sets of the first signal arrivals as accurately as possible. In general, these arrivals are associated with the energy of refracted waves at the base of the weathering layer or to the direct wave that travels directly from the source to the receiver.

In our study we have used neural networks to pick first break picks. The basic method behind neural networks process is **back-propagation** which is also called as back-propagation of neural networks. In simple words, Back propagation is a common method for training a neural network. In order to understand the general working of any neural networks , a basic structure of back-propagation of neural networks is provided below in figure 1.

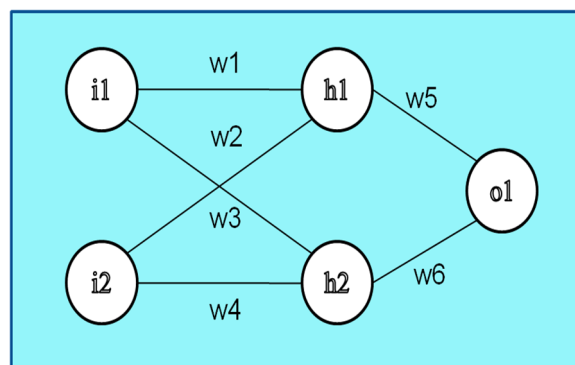


Figure 1: Basic structure of Neural Networks.

In this example, we are showing a neural network with two inputs (i1 & i2), two hidden neurons or layers (h1 & h2), one output neuron or layer (o1) along with their weights. In order to train the neural network, the input and output values should be known to the neural networks. The process of finding output from a given input is known as forward process whereas its counterpart is known as back propagation. The goal of back-propagation is to optimize the weights so that the neural network can learn how to correctly map arbitrary inputs to outputs.

The process starts by taking some initial guess about the weights. Then for a given input it calculates the output through forward process by taking into account all initial guesses about neural weights. After the first iteration, it calculates the error between

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calculated output and the actual output. Now, Our goal with back propagation is to update each of the weights in the network so that they cause the calculated output to be closer to the actual output, thereby minimizing the error for each output neuron and the network as a whole.

In the next step, we find how much a change in w_5 (say) affects the total error. This is also called as "the gradient with respect to w_5 " and is done by taking partial derivatives of the total error function w.r.t w_5 . To decrease the error, we then subtract the gradient value from the current weight and gets a new weight against w_5 . Then in the similar fashion we get updated weights against w_6 as well. In continuation of the backward process further, the weights for w_1 , w_2 , w_3 and w_4 are updated. Note that we use the original weights, not the updated weights, when we continue the back propagation further backward. Finally with the updated weights we run the 2nd iteration and usually perform around 10000 to 20000 iterations for a single project.

In accordance with our present study, if someone wants to draw an analogy between "First Break Picking Using Neural Networks" and the process just described above then inputs and outputs above are analogous to First break attributes and first break pick time respectively whereas hidden layers are like specific internal functions against a particular algorithm. The power of any algorithm to solve a particular problem is basically connected with its own computing efficiency and the number of hidden layers involved during the process. Generally, increasing hidden layers can solve complex problems more efficiently.

Methodology

In brief, first break picking using a neural network consists of the following steps.

- Manual picking of first breaks for a small subset of the data and defining the data window in the vicinity of the first break picks for calculations of first break attributes.
- For the seismic data subset with the pick information, first break attributes are computed for the peaks (or troughs) in a data window surrounding the previously made first break picks. For our study we have included first break attributes viz. *Power Ratio*, *Geometric Ratio*,

Arithmetic Ratio, *Standard Deviation Ratio*, *Instantaneous Frequency*, *Instantaneous Amplitude*, *Enhanced Extremum*, *Values and Bounded Variation Quantity*.

- In the Neural Network, the first break attributes of the data window are examined, noting which attributes came from the first break pick and which did not. The properties of the attributes that differentiate the first break peak (or trough) from the peaks (or troughs) that are not first breaks are designed into the weights.
- The first break seismic attributes are computed for the same data window for full seismic data set.
- The neural network then decides which peak (or trough) in the window most closely matches the characteristics of the first breaks previously picked manually before by the data processing analyst. The neural network is guided by the attributes and the weights.
- Finally, Output data set with first break pick times. The whole process is depicted in the figure 2 below.

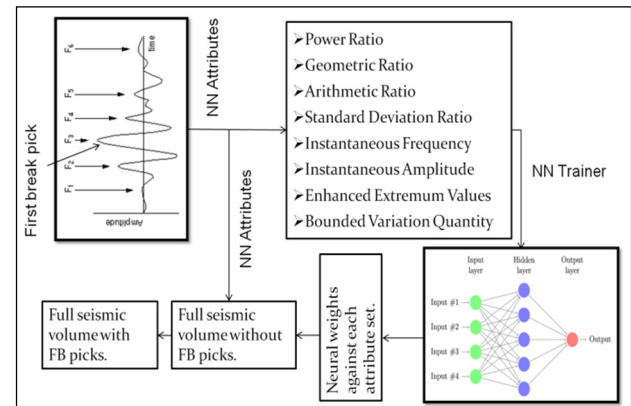


Figure 2: Workflow for first break picking using neural networks. In the Figure (2), we have shown an example waveform for first break picking for a single trace only. This waveform has two types of first break features (peaks and troughs). In our study we have considered troughs as our first break picks. In the waveform any one of the six troughs can be our first break pick. In order to ascertain which trough is associated with our first break pick, neural networks

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(NN) estimated different first break attributes for every trough.

Through the process of back propagation, neural networks assign weights in such a way that the first break attributes which are consistent and non overlapping in giving distinctive values for first break features as compared to non first break features will be considered more reliable and subsequently will be assigned more weight whereas first break attributes which are inconsistent and overlapping in giving distinctive values for first break features as compared to non first break features will be considered less reliable and subsequently will be assigned less weight. To clarify it further, probability function of two first break attributes (Arithmetic ratio and Geometric ratio) have been provided in figure 3 whereby arithmetic ratio attribute have been shown to be given more weight as compared to geometric ratio.

So, ultimately the neural networking seems to optimize neural weights based on recognitions of certain patterns and for this reason the neural networks process sometimes called as pattern recognition technique.

Pre/Post conditioning & parameter optimization

- In order to balance the seismic amplitudes AGC (Automatic gain control) can be applied for trainer data as well as for full data volume. However, while applying AGC window length should be chosen in such a way that the first breaks remains distinctive. Generally larger window size greater than 512ms is preferable. Further, if required 'Time Function Gain' can also be applied.
- The high frequency noise can be attenuated with the application of band pass filter generally in the range of 4-70 HZ.
- For calculations of first break attributes window length should be defined very carefully mainly concentrated in the vicinity of the first breaks only. If possible larger window size should be avoided for quality picking and reducing run time.
- For reducing run time seismic data outside the first break attributes window length can be discarded before introducing it to trainer as well as picker.
- As a part of post conditioning of first breaks 'Trim Mean Filter' can be applied over the estimated pick

time by neural networks. In some cases varying filter width for near and far offset provides desirable results.

- Common parameters and conditioning should be used for trainer and picker for getting better first break picks.

Results

In order to show better accuracy of the technique, mainly two types of data sets have been considered in our study. The first seismic dataset is having linear first arrival trends and the second seismic datasets is having mixed (i.e. linear as well as non linear) first arrival trends. Further, it has been shown that for a particular area, considering spatially varying neural networks depending upon the characteristics of first arrivals can enhance picking quality. For better comparison, all the results have been compared with the results estimated from coherency picker. All results are shown from figure 4 to figure 8.

Conclusion

- First break picking with Neural Networking is able to pick first breaks picks with 90 – 95 % pick quality for areas having linear first arrival trends.
- For the area having mixed first break arrival trends, pick quality was from 75 to 85 %, which can be further enhanced by using spatially varying neural networks.
- Overall first break picking with neural networks is quite effective and time efficient.

Reference

- Michael D. McCormack, Geophysics, 1993), P. 67-78, 1995, First-break refraction event picking and seismic data trace editing using neural networks.
- Juan I. Sabbione., Automatic first-breaks picking: New strategies and algorithms; Geophysics, 2010. P. V67–V76.
- Miscellaneous sources through internet.

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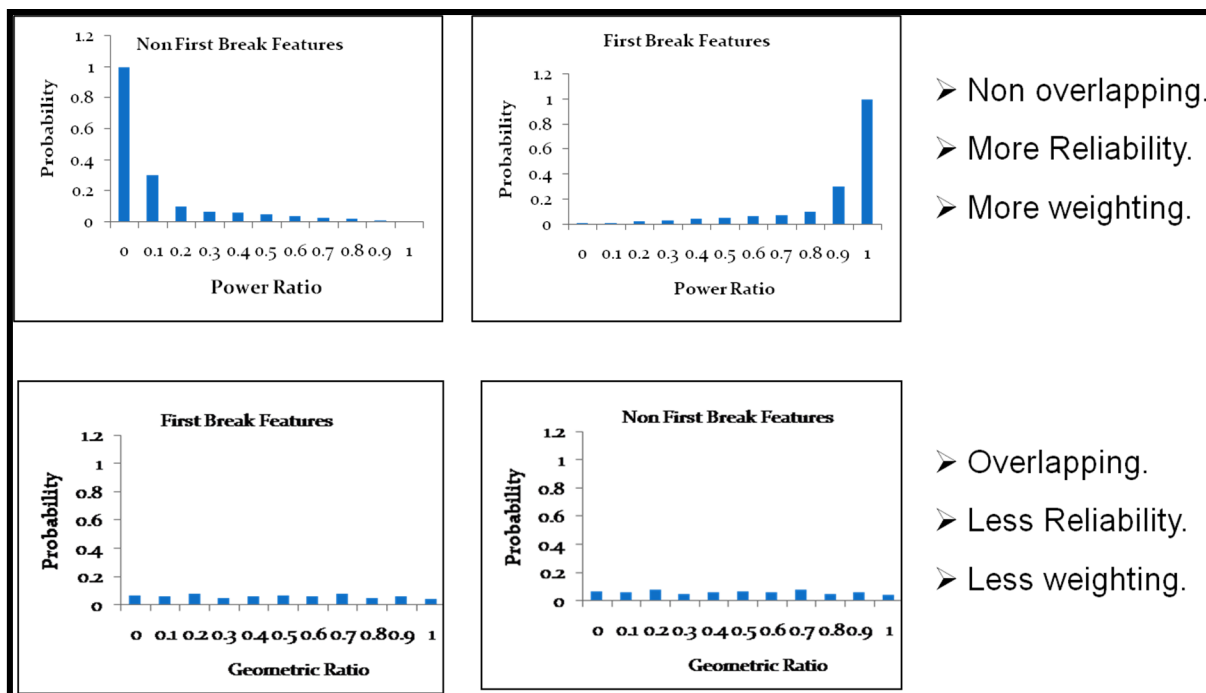


Figure 3: First break attributes plot for arithmetic and geometric ratio.

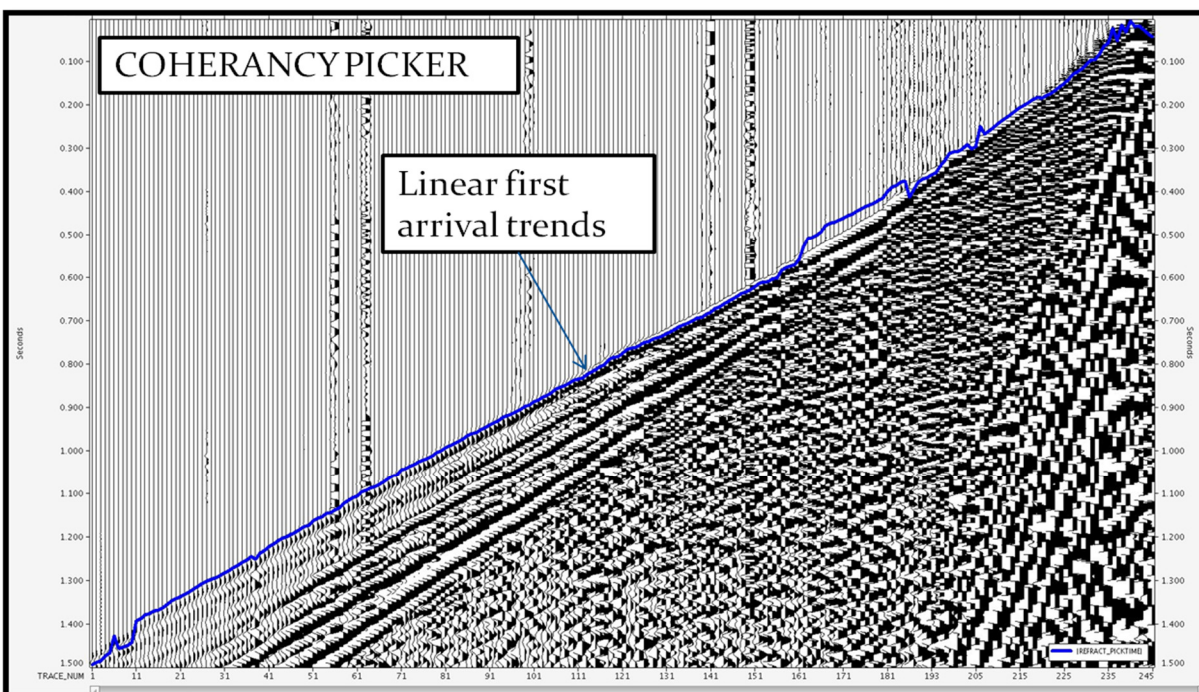


Figure 4: Seismic Shot record with First break picks by coherency picker (shown by blue line)

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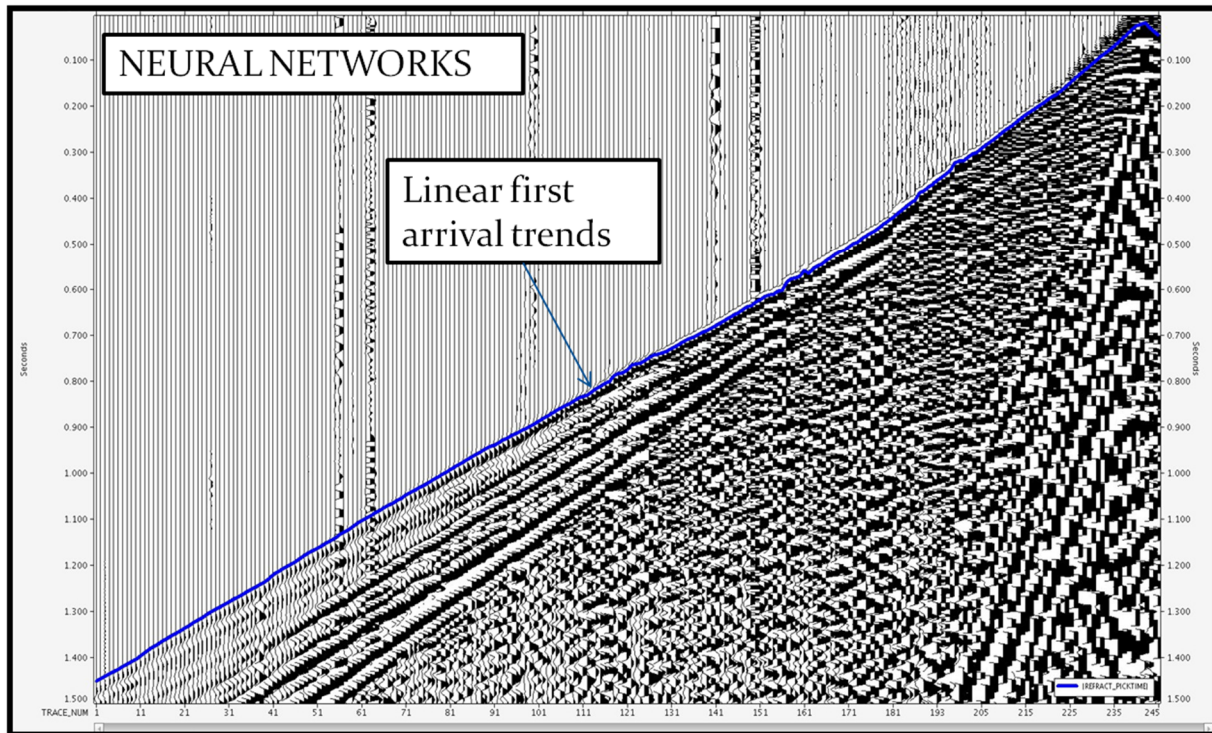


Figure 5: Seismic Shot record with First break picks by Neural Networks (shown by blue line)

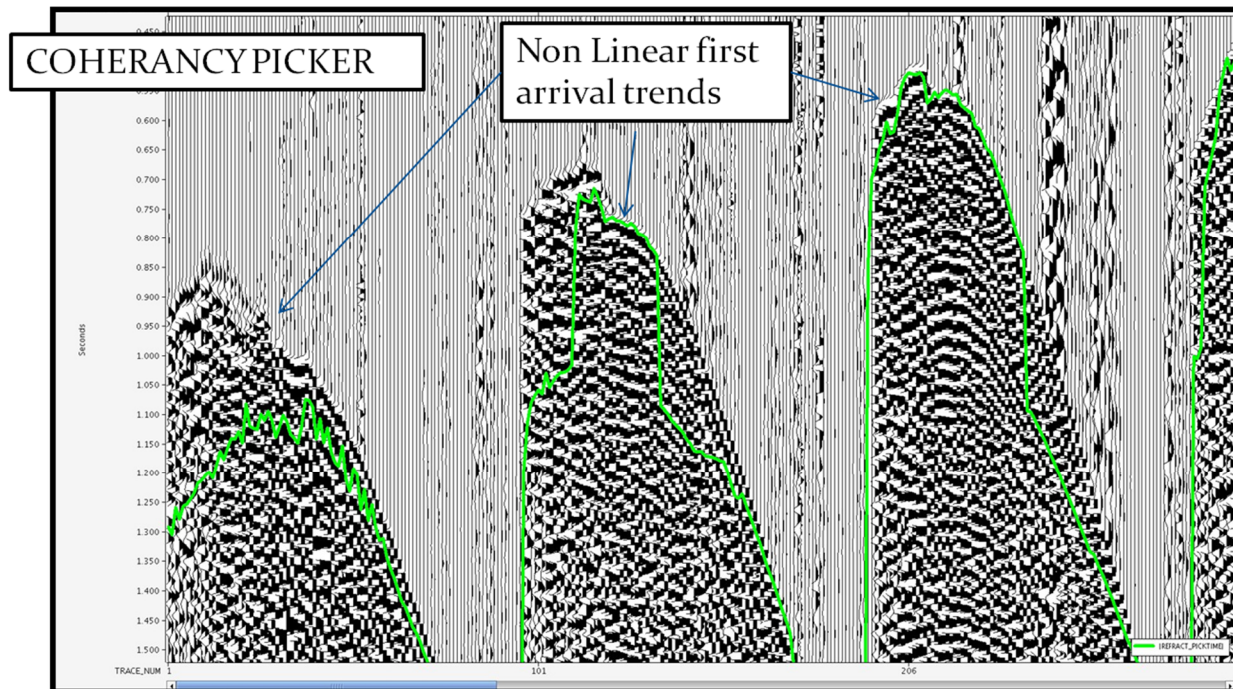


Figure 6: Seismic Shot record with First break picks by coherency picker (shown by green line)

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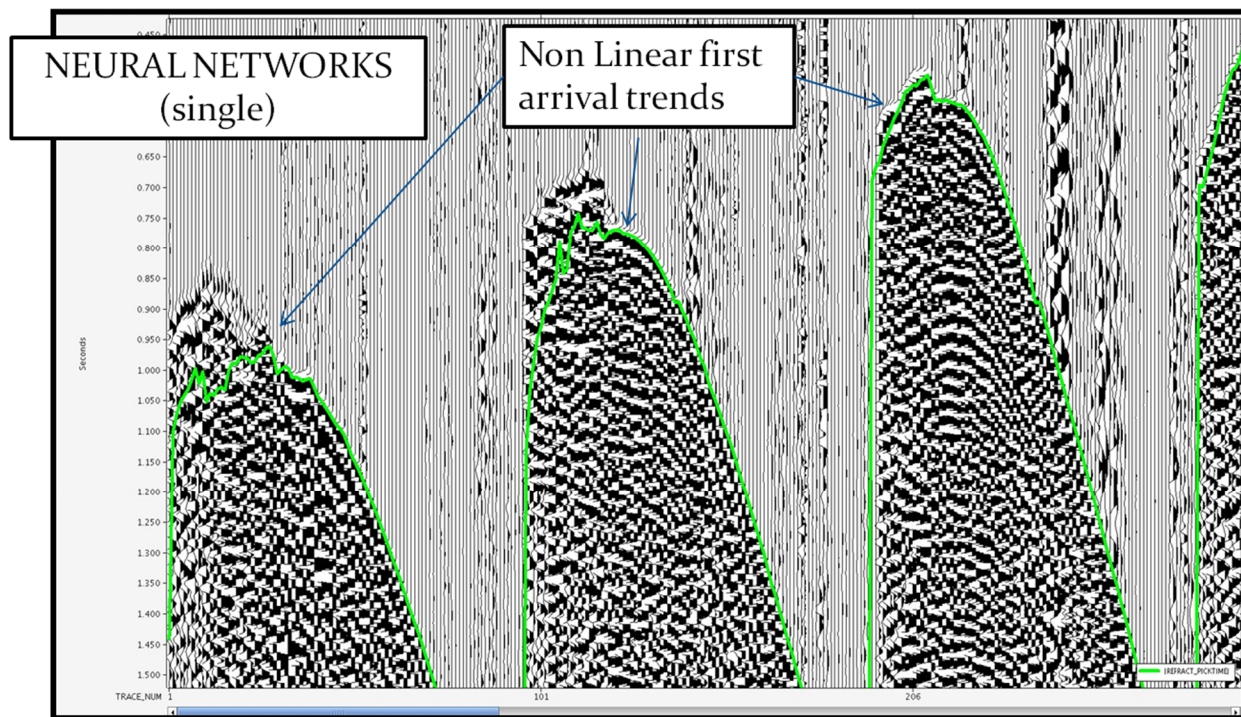


Figure 7: Seismic Shot record with First break picks by NN (single) (shown by green line)

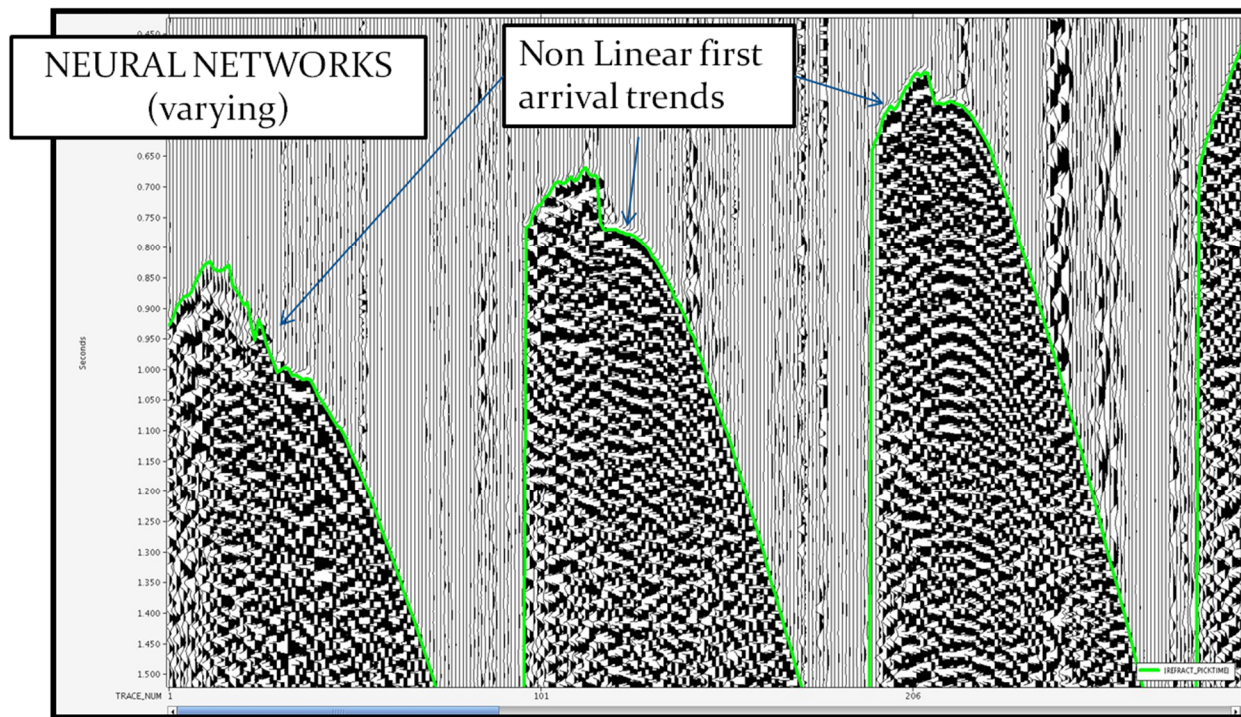


Figure 8: Seismic Shot record with First break picks by NN (spatially varying) (shown by green line)