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A New View on The Processing of Seismic Data With Artificial Neural Networks

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Abstract – Artificial Intelligence, which works on the ability to learn in machines, has a widespread field of research. One of the most researched topics of artificial intelligence is artificial neural networks. Artificial neural networks are effective today with the solution of complex problems, calculation and processing of information. Seismic method, which is one of the basic applications of geophysical field, is widely used especially for the detection of oil by using seismic waves. With the literature review, it is seen that the types of artificial neural network architectures are used. It has been determined that different methods are used in the processing of seismic data. Using the convolutional neural network (CNN), one of the artificial neural network architectures, it is aimed to achieve success in oil detection by seismic waves.

Keywords – Artificial intelligence, Artificial neural networks, CNN, seismic data, Oil exploration.

I. INTRODUCTION

Rapid processing of information and making fast and accurate decisions using information is very important for the correct use of time, which is one of the most important values. Computers save us a lot of time in many areas. With the help of developing technology, learning is provided to these machines by using knowledge and then to produce new information. Machine learning, the knowledge they have learned and the ability to produce solutions to new problems is the field of artificial intelligence in computer science. One of the most commonly used technologies in the field of artificial intelligence is artificial neural networks. Artificial neural networks are an effective method for processing and calculating information [1]. Today, it can be used with almost every field. One of these areas is seismic data which is one of the basic parts of the geophysical field. In this study, studies related to seismic data of artificial neural networks or using artificial neural network architectures are examined. Based on the investigated studies, it is thought that an artificial neural network can be designed for seismic data processing by using CNN method for the determination of oil reserves. In this way, especially in the region will inform us about the oil situation and in the light of this information can be directed to the machines in the region. In addition, the profit of both time and material increases the importance of the study.

II. MATERIALS AND METHOD

A. Artificial Neural Networks

Today, with the development of computer technology, its place in human life is increasing. Because computers are designed based on human intelligence, human and computer are confronted. Intelligent machines have been started to produce successful results in predicting diseases, financial decisions, classification and image processing.

Artificial intelligence studies have been brought up with computers that perform successful operations such as these. With the machines being able to learn and use what they have learned, the studies in this field have become increasingly important. There are many methods to use the concept of artificial intelligence in machines. Artificial neural networks are one of these methods [1]. Artificial neural networks can be coded to learn by using the information entered by the user into the system [2]. Artificial neural networks are composed of processing cells called simple neurons. These cells are connected to each other in a parallel and distributed order. With the information given to the system, they can learn and store this information. In fact, neural networks are complex processors [3, 4].

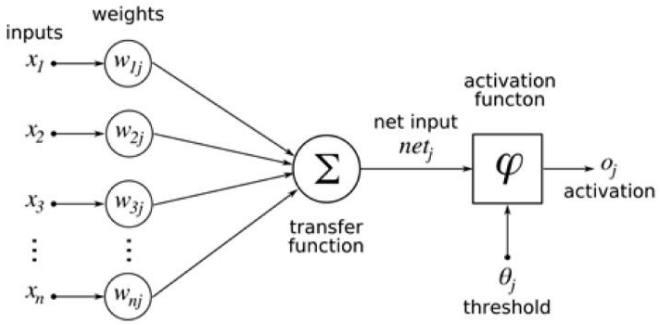

Fig. 1 Elements of artificial neural network structures [3]

Artificial neural network input data, weight value, collector, neuron and activation function consists of output units.

- Input data: This layer collects information from the external environment. They usually pass to the other layer without any action [3].
- Weight Value: The weight value indicates the importance of the incoming information and its effect on the result. It shows that when weights are positive,

the effect on the result is positive and when it is negative, the effect on the result is negative [5]. After this layer, the value of the net input is calculated by different methods. The weight values of the inputs are not constant. As new values are given to my system, artificial neural networks change the weight value until it gives the most ideal result and provides the ideal weight value.

- Aggregator (Aggregate Function): The value obtained by processing different inputs and weights is called NET (Network Abbreviation) value. There are a variety of NET value calculation formulas [6].
- Neuron and Activation Function: With the activation function, NET value determines the output that the current system will produce. There are activation functions such as sigmoid, tagsig, purelin, gaussian [3, 7]. Most commonly used is sigmoid function.
- Output: The last layer, the output layer, contains the converted data into information.

B. Seismic Data

Seismic methods are used to determine the positions of the elastic waves emitted from the energy source and the geological strata formed underground. The waves used in seismic methods are spread in a certain order and it is a geophysical method used to record the amplitudes of the waves reaching the receptors over time. In the seismic refraction, there are signal transmitters (source), receivers (geophans), data transfer and registrar [8]. Seismic reflection is carried out in many fields. Seismic reflections are used in explorations such as oil, gas, coal, submarine ground dredging, large constructions such as ports, dams, roads, and tectonic surveys of the earth's crust. Sources are obtained from tools such as sledgehammer, weight reduction, mini-vibro, dynamite, vibro [9]. The basic data processing sequence in seismic reflection is as follows;

- Data acquisition and format conversion
- Trace removal, cleaning
- Amplitude gain
- Noise filtering
- deconvolution
- Speed analysis
- Static correction
- Seismic migration [10]

Seismic reflection methods are known as 2D seismic used to obtain the seismic profile of underground velocity fields, and 3D seismic used in hydrocarbon explorations.

C. Some Studies

Artificial neural networks are used in many areas today. With the data obtained, it can realize the learning and test stages and make predictions. Examples of an artificial neural network found in the literature are given below.

In his study of Zhang G. et al., he developed a new architecture based on deep learning technique for seismic reservoir characterization [11]. Studies have also used convolutional neural networks (CNN) to estimate lithology and achieve better results compared to conventional methods. Researchers have proposed to use continuous wavelet transforms (CWT) to obtain a time-frequency spectrum in neural networks. CWTs were used to fully utilize the frequency content of the post-stack seismic data. 4 deep learning architecture is recommended for seismic lithology estimation according to input data and difference of access layer.

1. Deep neural network (DNN)
2. The convolutional Neural Network (CNN)
3. The continuous wavelet transform deep neural network (CWT-DNN)
4. The continuous wavelet transform convolutional neural network (CWT-CNN)

All of these architectures were applied in the study. As a result of the study, it was observed that the CWT-CNN algorithm gave the best performance in predicting the layer. It was also emphasized that the CNN algorithm was effective for the results seismic estimation.

Yuan S. et al. investigated the application of CNNs in order to classify the data in the seismic collectors and also to select the first breaks of the direct or broken wave [12]. Similar samples of two types of labeled waveform classification were used to test CNN training. The aim here was to minimize the error and obtain the ideal weight of the CNNs. The study showed that they could use trained CNNs to extract certain time interval features from any image. These obtained properties were added to the layer of CNNs trained to produce two values from 0 to 1. The first break was calculated from the calculated score maps. In the study, CNN-based waveform classification is also used to collect the first break synthetic and real shot data samples. As a result of the study, it is stated that CNN algorithm is an efficient automatic data-oriented classifier collector.

Abdel-Hamid O. et al. conducted speech recognition with the help of CNN in his study. The speech signals are very high, because of the high number of speakers, the vague external voices, the speech becomes difficult to transfer to words [13]. Speech recognition can occur like hidden Markov models (HMM), Gaussian blend models (GMM). With the emergence of artificial neural networks in this area has been seen. Compared to traditional GMM-HMMs, it was stated that ANNs acoustic frameworks can be easily exploited from highly correlated features such as those found in the wider temporal contexts of generally 9-15 frameworks. In the study, a new architecture was created on convolutional neural networks. In this study, the application of CNNs to ASR is shown in detail. As a result of the study, it was concluded that more error rate can be reduced by CNN.

Huang H. et al. his work has also been identified seismic event in underground mines using CNN and deep learning [14]. It is stated that micro seismic events are used to predict mine disasters. In the study, it is emphasized that deep learning is the greatest advantage of traditional method without the need for human intervention. Convolutional Neural Networks (CNN) and deep learning were used in the study. With these

technologies, the location determination of micro seismic events has been tried to be realized.

The power and phase spectrum of the diagonal wavelet transform were calculated from seismic waves and added to the CNN. It has been shown that the source position of the field explosion tests can be determined because the experimental approach and the proposed approach may indicate time delay of arrival.

The work done by Iturrarán-Viveros U. et al. is using artificial neural networks to estimate permeability, porosity and internal weakness in the reservoir [15]. Permeability and porosity are two main features of fluidity in the reservoir. The study also stated that these terms are related to petro and gas saturation and significantly affect seismic signature. The study was conducted in southeastern Flori and in northeastern Texas. In order to estimate k and gam, gamma test in artificial neural networks was applied. In this way, it is aimed to save the mean square error to a minimum limit by avoiding excessive training. With this method, he was able to successfully predict the highly permeable region.

The study of Raeesi M. et al. is related to the classification and identification of hydrocarbon reservoir lighting and their heterogeneity using seismic features log data and artificial neural networks [16]. It is stated that 3D seismic interpretation of reservoir discovery is an important factor for side variables. It is stated that it provides superiority for the use of seismic data thanks to artificial neural networks.

The study was carried out in the Persian Gulf using the ANN model. The classification is also indicated to be geological importance, statistical analysis is important cases to choose the right seismic properties. As a result of the study, warm and sandy areas in the reservoir range are shown. In addition, attempts were made to find oil reserves in the northeast and southwest regions.

Na.imi, S.R. and his friends' support vector regression approach based on seismic properties based on reservoir porosity and water saturation is estimated [17]. Among the important properties of hydrocarbon reservoirs are porosity and liquid saturation. In the study, these features were used in almost all reservoir estimates. The real values of these parameters are expensive and time consuming. These elements are taken into consideration in the study should be used in the study of cheaper and simpler methodologies. Support Vector Regression approach regression problems with the principle of structural risk minimization is a new method that minimizes the expected risk. In the study, firstly the seismic features with porosity and water saturation were removed. A nonlinear support vector regression algorithm was then used to obtain a quantitative formulation. As a result of this study, it was concluded that it is possible to characterize hydrocarbon bed formation with this method.

Chen, Y. 's work is carried out on the automatic micro-branchic event collection through uncontrolled machine learning [18]. Earthquake and gathering the arrival of microsismic data processing are also stated to have a significant impact. short-term-average long-term-average ratio (STA / LTA) based arrival algorithms are affected up to ambient noise. In the study, he firstly emphasized the need to make arrival collection approaches effective by processing microseismic data. In order to solve the noise problem, machine learning techniques have been used to help to recognize the seismic waveforms in microcyclical or earthquake data. In the study, an unsupervised machine learning algorithm was used to cluster as waveform points and non-waveform points. For this reason, fuzzy clustering algorithm is effective. As a result of the study, it was concluded that the actual microsismic and earthquake data set is much stronger than the STA / LTA method which has the latest technology in collecting microseismic events even in moderately strong cases.

Fattahi H. et al in his study by comparing the methods of bayesian reversal and computational intelligence to determine porosity and water saturation by using seismic features before stacking were investigated [19]. The mechanical properties of hydrocarbon reservoir rocks have been shown to have significant physical properties such as porosity and water saturation. The estimation of these physical properties by seismic data is essential for reservoir characterization. The study showed that clustering method (ANFIS-SCM) that draws the modified particle regression (SVR) and adaptive network based fuzzy inference systems using the particle swarm optimization (PSO) predicts porosity and water saturation. The synthetic data used in the study were obtained from gas carbonate reservoirs in Iran. In these models, pre-seismic data and attributes were used. Estimation models were compared in terms of performance. The results of the study showed that the ANFIS-SCM model has a strong potential for predicting indirect porosity and water saturation by the high degree of accuracy and robustness resulting from the seismic data in both synthetic and real states.

Alpaslan N. and his friend's work with the geophysical methods used in the exploration of oil were collected in a single source [20]. It was stated that the first stage of petroleum exploration was to determine the location of hydrocarbons, and that land photographs were generally used for this phase. In this study, seismic and gravity etures which are used in oil exploration are emphasized. In each method, the physical properties of the Earth's crust were measured and then processed by computer programs and interpreted.

Çelik E. et al. also used seismic pulses with artificial neural networks and support vector machines for earthquake prediction [21]. Firstly, the classification phase was used by using classification algorithms. In this stage, some statistical features were used to increase accuracy. Data provided by DEMETER satellite and feedback neural network were used. Then, electron density, electron temperature, ion temperature, oxygen ion density and sample sets were formed. GONFIS (Genetic optimization neural network inference system) has been proposed. The study is also included in the artificial neural network training procedure to leave-one-out into the fuzzy tool. Reasenberg is aimed at removing aftershocks using the clustering technique. 170 of the University of California

seismic impulse data set, including the dangerous 2414 non-hazardous state were used. At the end of the study, 96% of the training was completed. In the test phase, the study was completed with a rate of 17%.

Kuar K. et al. in his work by using artificial neural networks to identify and detect the seismic p wave [22]. They also stated the importance of seismic p-wave in the detection and detection of crime scene. The study also used a neural network that propagated backward from neural networks. 4 properties were determined as introduction to the designed neural network. These; Polarization Degree (DOP), Automatic Regression Factor (ARC), Short term average to Long term average (STA / LTA) and Rate Total power (RV2T) for Vertical power. These four properties were calculated in the frequency band 1-8 Hz. Test and training results using the existing earthquake recordings were determined correctly in 95% of the artificial neural network. At the end of the study, 90% of the P-Waves were determined with a maximum deviation of 0.1 s from the correct manual intake.

Diersen S. et al. also studied the improvement of the structural model using the Artificial Neural Network (ANN) and a Significantly Supported Neural Network (IANN) [23]. In the study, it is stated that the seismograms are acceptable and acceptable if there is an intuitive observation which is made by a specialist. Thanks to the ANN and IANN used, it is aimed to eliminate the cost of the expert used in the classification process. Data from the study were obtained from Southern California. As a result of our experiments on seismic data, promising results were obtained for the classification accuracy and maximization of the time elapsed during this pairing.

Dai H. and his friend's work using the local earthquake data to determine the type of arrival artificial neural networks were used [24]. A part of the three-component time series as an ANN input was used to determine the type of arrival using the degree of polarization (DOP). Artificial neural networks are divided into 3 groups of incoming noise corresponding to the maximum output of the P-arrays, S-arrivals and output nodes. In the study, 327 records, which had already been started from a station in a local earthquake network, were first processed by an ANN selector for all possible P and S arrivals and the start times were measured. DOP sections were selected according to this situation and fed in the artificial neural network. As a result of the study, the trained ANN can accurately identify the 84% P-destination and 63% S-destination. The limit of design is stated as the complexity of DOP models which cannot be improved by adding new training data sets. This limitation of the study also showed that the selection of input information is critical. As a result, ANN has the potential to automatically detect arrivals but must be associated with other information [25].

The study of Zamani A.S. et al. with the artificial neural networks by using the study of the reaction of earthquake behavior was studied [26]. In the study, it was mentioned that the earthquakes will cause damage to the waste areas and cause them to interfere with groundwater. It focuses on the identification and analysis of return on potential earthquake scenarios in the future. Artificial Neural Network (ANN) models were used to calculate the structural response of a structural system by training the model for a particular earthquake.

Benbrahim M. et al. study on the classification of seismic signals using artificial intelligence. Two seismic signal classes, routinely recorded in the geophysical laboratory of the Moroccan National Scientific and Technical Research Center, have been studied [27]. These are local earthquakes and chemical explosions. The system is composed of blocks including representation, dimensional reduction and classification. In the study, a new wavelet called a wave of modified mexican hats was used. As a result, a new algorithm based on random projection and basic component analysis is proposed to reduce dimensionality. Source [28, 29] shows similar studies. Other interesting studies employing deep neural networks can be seen in [25, 30].

III. RESULTS

In this study, using artificial neural networks, especially in the field of geophysics studies are examined. According to the study, it is aimed to decide the method to be used in artificial neural networks that will be designed by using seismic data. In many studies, it has been observed that the success of artificial neural networks has been achieved. Especially, studies using CNN method have been shown to give successful results.

Table 1. Some of the studies

Work	Method	Result
Seismic reservoir characterization	CWT-CNN	Successful
To classify data in seismic collectors	CNN	Efficient
Speech recognition	CNN	Method proposed
Seismic event detected in underground mines	CNN	Successful
Permeability in reservoir, porosity estimation	ANN	Accurately predicted specific region
Classification and description of hydrocarbon reservoir illuminations and their heterogeneities	ANN	Warm and sandy areas have been identified
Estimation of reservoir porosity and water saturation based on seismic properties	Support vector regression algorithm	Moderate
Automatic microseismic event collection	(STA/LTA) based arrival algorithms	Efficient
Estimation of porosity and water saturation using pre-	ANFIS-SCM	High accuracy

agglomeration seismic properties		
Earthquake prediction	Support vector	%17

According to the results of this study, it is aimed to estimate the location of oil reserves in the system to be designed by using seismic data. It has been decided to use CNN as the method in the system to be designed. Thus, the success of the system is expected to be high.

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