Soft Computing: Potentials and Applications in Oil Exploration

Bello ShehuBello, and Isa Inuwa-Dutse

***Abstract*—**Mining and analysis of oil exploration data is becoming too complex and difficult to analyse using traditional methods. To solve this problem there is need to supplement these traditional methods with contemporary emerging techniques. Recent development in data accusation and analysis techniques begins to enhance the processes of mining and analysis of oil exploration data. Soft computing has the revolutionary effect of changing the way data is captured and utilised. It can be argued that soft computing is applicable in almost all real life problems, notably, application of soft computing in oil exploration. This paper reviews the recent applications of soft computing in oil exploration. Soft computing techniques such as artificial neural network, fuzzy logic, probabilistic reasoning, and Bayesian belief network will be highlighted. Processes that are used to enhance the efficiency of oil exploration data such as first arrival-picking, horizon picking and noise elimination will be discussed. Finally, it figures out some methods of pattern recognition, identification and prediction of oil exploration data**.**

***Keywords*—**data analysis, data mining, oil exploration, soft computing**.**

I. Introduction

Current technology and proliferation of data generating applications has made the traditional approach to solving computational problems difficult and challenging. Real life problems are associated with uncertainties, imprecision and numerous ambiguities. Traditional approach or to say hard computing limits the possibilities of solving these problems by imposing hard limits to our computational ability. Moreover, the traditional approach is faulted due to its failure to fully capture the problems solution. This motivated the adoption of soft computing approaches. Soft computing has the revolutionary effect of changing the way data is captured and utilised. Soft computing is viewed as tractable, robust, and cost effective to deploy [13].

This paper focuses on soft computing methodologies that are applicable to oil and gas industry with specific emphasis on oil exploration process. Section I serves as an introduction to the paper while section II gives brief overview of soft computing methodologies followed by section III on oil data acquisition. Section IV contained a discussion on pattern recognition, identification and prediction, section V highlighted some challenges in oil exploration process and a concluding remark is presented in section VI.

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II. Soft Computing Methodologies

Faster computer systems coupled with low cost of computing power has led to adoption of dedicated resources for huge data analysis in different organisations. Soft computing techniques pave the way for data analysis and interpretation. It has been a powerful tool for transformation of data into information and information into knowledge [13]. Oil exploration deals with large volume of data, if properly utilised, it could be turned into useful resource for decision making and locating best location for exploration [3]. Methodologies such as Artificial Neural Network, Fuzzy Logic, Probabilistic Reasoning and Bayesian Believe Network are widely in this area.

A. Artificial Neural Network

Recently, the application of Artificial Neural Network (ANN) is generating high momentum in research community to handle technological advancements and tackle emerging problems from different disciplines. As a computer model, artificial neural network, modelled after human nervous system, have high response time and provide accurate simulation of complex phenomena that are otherwise impossible to simulate. Artificial neural network models are suitable for dealing with linear and non-linear data problems. These features make ANN ideal for use in oil exploration process.

B. Fuzzy Logic

Classical logic is prone to error when dealing with complex and imprecise information. Fuzzy logic is proving to be a powerful mechanism for handling and processing of human-friendly information which is expressed in natural language. Flexibility of fuzzy logic makes it a suitable tool to manipulate symbolic information in an effective way compared with earlier mechanisms which are based on classical logic. Zadeh [6], pioneered the basic theory of fuzzy sets that distinct itself from the classical logic which is based on crisp sets of 'true and false'. From fuzzy logic point of view, problems are assign degree of truthfulness and not confine to only true or otherwise in order to obtain approximate solution. Fuzzy-based theory has been in for seismic data interpretation [10] and oil reservoir lithology identification [3].

C. Probabilistic Reasoning and Bayesian Network

The power of probability coupled with deductive logic gave rise to the powerful tool of probabilistic reasoning suitable for handling uncertainty in decision making [11]. Decision in oil exploration is full of dynamic and uncertain data that require suitable tool for effective decision and risk analysis. The

Bayesian Believe Network (BBN) is a probabilistic graphical model that represents probabilistic relationship and suitable for discovering casual rules [12]. The BBN is concerned with probabilistic models for reasoning under uncertainty. Probabilistic reasoning provides means for wise inferences from uncertain data. It allows us to reach a convincing conclusion in a situation where the picture of the situation is imprecise.

III. Oil Exploration Data Acquisition

Data acquisition is an initial stage for extracting relevant information and eventually knowledge. To extract useful knowledge, previous approach relies on human expert [5], however, with advanced information technology; intelligent system has the capability of efficiently performing excellent decision at the level of human expert [8]. The high volume of data generated in oil and gas industry is becoming difficult to analyse using previous approach. Thus, efficient automated techniques to process such massive data are required. These techniques include first arrival-picking, horizon-picking and noise elimination.

A. First Arrival-Picking

Seismic data is obtained by sending sound waves into the ground using energy sources such as vibrator, air guns or dynamite. These waves pass through the earth surface and receivers are used to collect the data reflected off of the rock layers [15]. This data can be processed and analysed to develop a clear understanding of the rock surface and other geological properties of the earth. It is essential to improve and increase the efficiency of this data; automated methods which are mainly based on first arrival picking of seismic data are used.These methods include clustering and discernment analysis technique [13]. Fabio [16], proposed a method of picking first arrival seismic in noise data set based on the change in fractal dimension of the trace. The first arrival is located and then more accurate search with shorter step is carried out in that area. The whole process depends on the signal to noise ratio and the simpler the trace the faster the algorithm.

B. Horizon-Picking

Horizon-picking is an important process in seismic data interpretation as it allows for structural analysis and feature recognition. Interpretation of Seismic data is incomplete without effective analysis of horizon. Manual process of horizon-picking is viewed as inadequate and inefficient considering the dynamic and complexity of the process involved. Suitable algorithms are still been sought to automate the process. Horizon refers to a layer in the earth and its manifestation in seismic data. It is very difficult to exactly locate in the earth subsurface, thus make such a process a difficult and challenging seismic data interpretation process [9].

C. Noise Elimination

Seismic data is usually associated with noise which hampers correct analysis and interpretation of the data. In order to improve the quality of the data, it is essential to identify part of the data with non seismic origin and remove it to increase the signal to noise ratio (SNR). The whole noisy trace can be edited out from the trace by initiating a network with supervised learning phase, unsupervised learning phase and recognizing phase [17]. The whole data is scanned to assign a distinguishing factors between good and bad traces, any part of the output of the network that is less than or greater than a given threshold level is edited out as a bad trace [13].

IV. Pattern Recognition, Identification And Prediction

Pattern recognition refers to the ability to infer useful information from data using appropriate tools. Interpreting large volume of seismic data is becoming more challenging problem. Recent advance in computing technology has induced numerous methods of pattern recognition, identification and prediction. Soft computing techniques such Artificial Neural Network, Fuzzy Logic models are widely used in character recognition, interpolation and extrapolation of specific pattern. Seismic data pattern can be recognised and interpreted using structural methods such as syntactic pattern recognition. Simpler models such as self organizing network and fuzzy c- means techniques can be used to recognise seismic data objects and their distribution in a specific set of information [13].

Fig. 1 presents a block diagram of syntactic pattern recognition system. Upon given input pattern, primitives are generated by decomposing the input pattern into simpler sub-pattern at the segmentation phase. Primitives are set of strings, symbols and terminals. Training and recognition are the two major part of the system. Segmentation, primitives recognition, reconstruction, and syntactic analysis are carried out at the recognition part. The training part of the system deals with the primitive selection, grammatical inference and automata construction [14].

Pattern Recognition, Identification and Prediction of Oil Exploration data are best achieved using Artificial Neural Network. Models based on the ANN are used to recognise patterns and predict outcome of processed oil data.

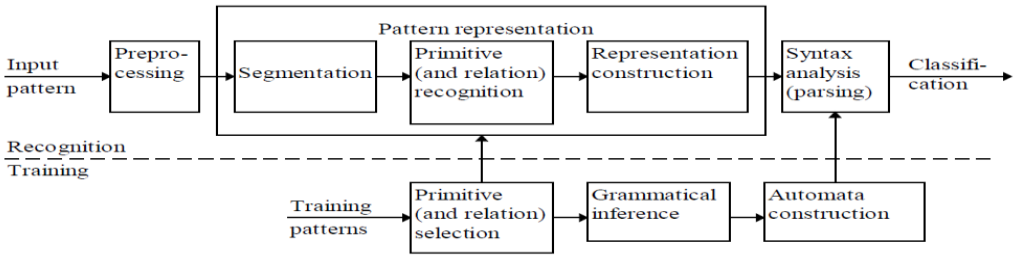

Fig. 1.Block diagram of Syntactic pattern recognition system [14].

V. Challenges In Oil Exploration Process

As the quest for productive well and improve well performance grow, several challenges lay ahead that requires urgent response. The most challenging problems of oil exploration require application of advanced technology of soft computing. Some identified challenges in oil exploration and production include accurate positioning of complex structures (such as salt, over-thrust), deep exploration and accurate depth imaging, distinguishing commercial gas from non-commercial gas, fractures: type, orientation, frequency and connectivity, prediction and evaluation of over-pressured reservoir [1]. Soft computing has a promising prospect to tackle these challenges. A study by [1] establishes that soft computing is the most patronise technique in comparison to techniques such as Kalman Filtering and Expert Systems.

VI. Concluding Remark

The paper presents the state of the art in soft computing applications in oil exploration and highlighted key areas where soft computing plays crucial role in oil exploration process. Application of soft computing techniques in data acquisition, processing, analysis and interpretation will bring a quick revolution in oil industry. It was shown that application of soft computing techniques offers a promising benefit in oil exploration process. Having identified and reviewed relevant soft computing techniques from oil exploration perspective, future work will focus on optimising algorithms for pattern recognition, identification and prediction of seismic data.

It is evident that soft computing has much to offer in the oil and gas industry. Successful application of soft computing techniques and identifying proper way of fusing soft computing techniques will drastically reduce cost of data acquisition & analysis, exploration risk, and improve general production cycle.

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