DIGITALIZATION IN EXPLORATION AND PRODUCTION SECTOR

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The use of IT technologies in the upstream sector is becoming more and more relevant – large amounts of information and input data impose special requirements on its digitalization. One of the results of the digitalization of this sector is the Smart Field concept. According to the survey of Gazprom Neft, the main technologies that implement this concept of a Smart Field are Big Data, Augmented/Virtual Reality (AR/VR), the Internet of Things (IoT), cloud computing [1].

A Smart Field is a complex of tools that allows managing of an oil reservoir in order to increase hydrocarbon production rates. Efficiency improvement of technological processes and equipment is caused by the use of intelligent multi-parameter sensors that provide remote access to all equipment, allowing you to diagnose its condition and, if necessary, configure it. Such a field generates about 15 petabytes of information per year, which is laborious and irrational to work with without the use of big data processing methods [3]. The finance industry currently takes the largest share of the global big data market, but energy is the fastest growing sector. In the upstream sector, the collection of data on the operation of equipment allows you to remotely monitor the operation of any asset, optimize production processes, and predict possible accidents and malfunctions.

To exemplify, there is a Gazprom Neft's project searching for failures in the automatic restart system of electric submersible pumps (ESP) after the power supply system fails. The analysis was carried out on the basis of more than two hundred million records of running pumps from 15 hundred wells, as well as data on power restarts. In addition, a number of other parameters were considered: operating conditions, power supply circuits, etc. The processing of the obtained information by conventional methods is very laborious due to a significant amount of disordered data. Big Data techniques have helped to deduce causes of failures in autorun and to obtain valuable information about previously unknown dependencies in the operation of submersible equipment [3].

In addition to a Smart Field that generates a large amount of data, hydrocarbon exploration should be noted. Processing and interpretation of geological exploration data is the most time-consuming part of the work associated with the field development. The use of Big Data techniques here makes it possible to speed up information processing at the exploration stage, reservoir modeling and various correlations are taking place. All of this contributes to the discovery of promising areas, comparing new areas with already known analogues [2].

Thus, specialists of the Petroleum Learning Center (Tomsk) developed an algorithm that searches for analogous wells using one-dimensional well-logging signals. For example, PS or GR logs, being one-dimensional signals, can be represented as a time series. The search for analogues is based on two basic algorithms:

– DTW (Dynamic Time Warping) is a method for measuring similarity between two temporal sequences, which may vary in speed;

– DFT (Discrete Fourier Transform) is the most important discrete transform, used to perform Fourier analysis in many practical applications.

DTW is a method for finding the proximity between two sequences. The essence of this algorithm is to match and compare signals based on nonlinear equalization. A measure of proximity is the assessment of the distance between a pair of signals (Fig. 1).

The algorithm was written using open-source Python libraries. It compares initial signals from the field with an objective well-log, which has well-known properties, and ranges them according to the degree of similarity. Afterwards, the algorithm rejects signals from a large data set (which has up to 10,000 values), thereby making it possible to draw a conclusion about the degree of similarity of signals. Further visualization of the well logs allows to identify lithofacies.

The advantage of the method is the ability to compare time series (log curves) of different lengths. Thus, the algorithm is able to efficiently assess the similarity of two beds of different thickness of the same depositional environment. However, this feature of the DTW-algorithm is simultaneously can be seen as its drawback: log readings of beds of different thickness can be similar in shape, but not necessarily analogous (Fig. 2).

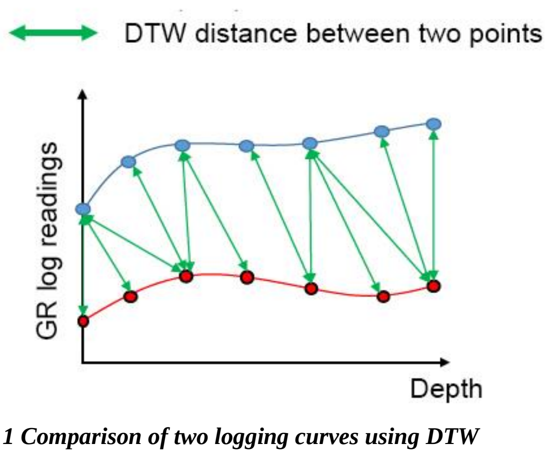

Fig. 1 Comparison of two logging curves using DTW

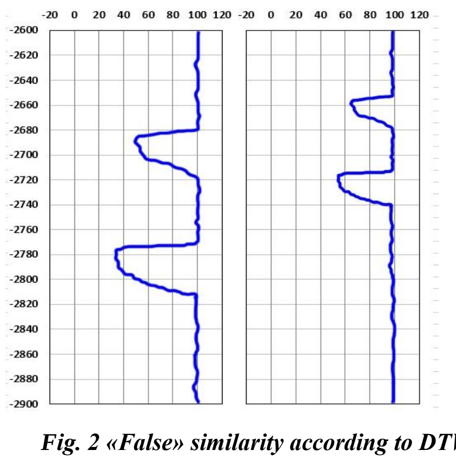

Fig. 2 «False» similarity according to DTW

Often recorded signals are noisy, i.e. contain a component that does not carry useful information (usually high-frequency and low-amplitude constituent). Comparison of such signals is difficult and impractical. To solve this problem, the discrete Fourier transform (DFT) method is used, which is a mathematical algorithm for expanding the well log signal into a Fourier series (Fig. 3).

This algorithm is applied as follows: the signal is decomposed into an amplitude-frequency domain, after which the harmonics are sorted with their sequential and sufficient addition. As a result, the original logging curve is restored to a state in which noise is suppressed, and the regenerated signal remains similar to the original. Therefore, spectrograms are plotted for each of the regenerated signals for comparison with an objective well-log. Thus, one can determine the degree of similarity of two signals (Fig. 4).

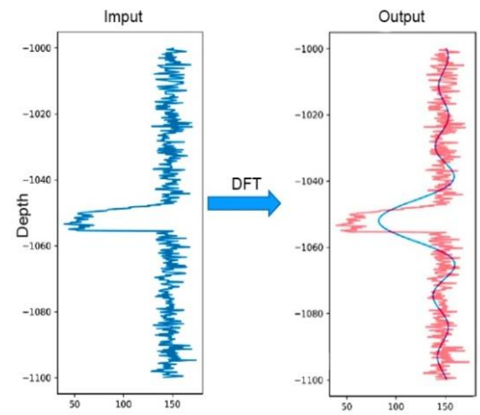

Fig. 3 Noisy and regenerated signals using DFT

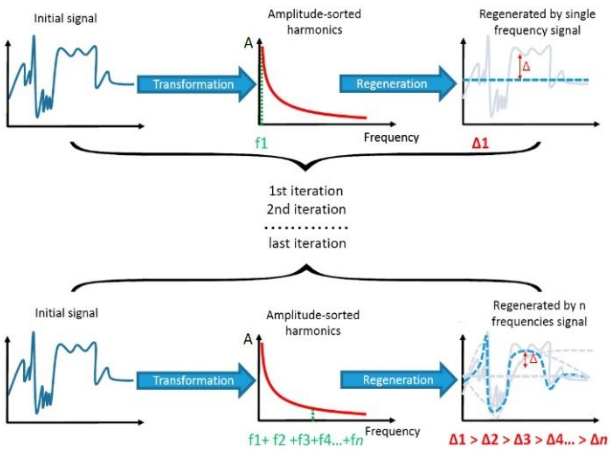

Fig. 4 Filtration process

However, if the signals are similar in shape, but are in different phases, the discrete Fourier transform will conclude that the signals are similar, although this is not completely true (Fig. 5).

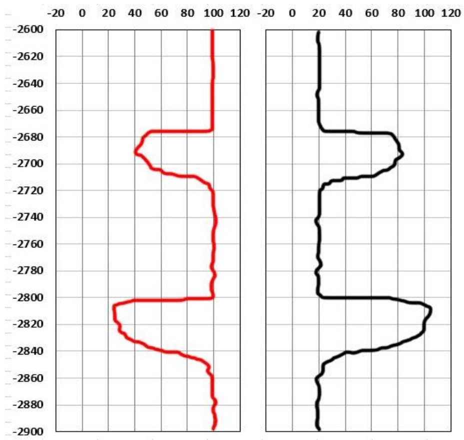

Fig. 5 «False» similarity according to DFT

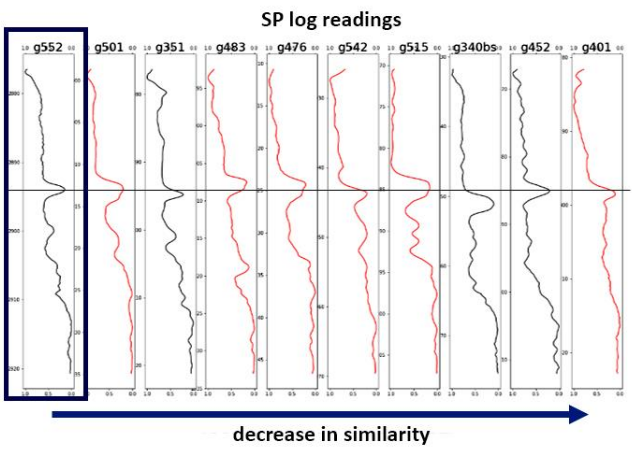

Fig. 6 Output of «MEGA» algorithm

In order to unite the advantages and simultaneously get rid of the disadvantages of both DTW and DFT algorithms, the comparison metric named «MEGA» was developed. «MEGA» can be used in several applications, such as: the search for well analogues, the designing of a new drilling point, and the assessment of the initial flow rate and its further decline. Having a geological model, it is possible to extract SP-logging from any cell of grid and predict the reservoir parameters. As a result, it is possible to predict various technological parameters within the identified clusters. The metric was tested on a real oil field in Western Siberia (Fig. 6).

Thus, various digitalization methods can significantly increase the efficiency of analytical work on predicting well parameters and they can assist in implementing the aspects of the Smart Field in the upstream sector.

References

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