JOURNAL OF RESEARCH ON APPLIED GEOPHYSICS

(JRAG)

Shahrood University of Technology

2022, VOL 8, NO 3

(DOI): 10.22044/JRAG.2023.13124.1351

Improvement of seismic attributes based on gray level co-occurrence matrix using non-linear transform to gray scale for identification of salt dome geobody

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Received: 14 May 2023 ; Accepted: 2 December 2023

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Keywords

Salt dome
Seismic interpretation
Textural attributes
Nonlinear transform to gray scale
Gray level co-occurrence matrix (GLCM)

Extended Abstract

Summary

Geophysical methods, especially reflection seismology, are one of the methods of identification the subsurface structures of the earth, and are widely used in the exploration of hydrocarbon resources. Salt domes are one of the most important geological structures. Determination of their geobody in seismic data is of great importance for various reasons. Due to different texture of salt domes compared to the surrounding sediments, texture seismic attributes are a useful tool for identifying and distinguishing these structures in seismic data. The gray level co-occurrence matrix (GLCM) has been used as a tool to generate multiple textural attributes in seismic data that includes two main steps: 1. rescaling of the seismic domain to user-defined gray levels, and 2. calculation of GLCM and extraction of texture features from it. Traditionally, linear transform is simply used to scale the seismic data domain to gray levels. The most important feature of this approach is to preserve the maximum of the distribution histogram of the original seismic data domains. However, the seismic features of interest to interpreters often cover only a small part of the amplitude histogram, and to display them more effectively, it is better to display them with more gray levels. The non-linear transform to gray scale provides the possibility of emphasizing the part of the amplitude distribution histogram in which the seismic feature is of interest, and it causes the enhancement of that feature in the gray scale image and improves the resulting textural attributes. In this paper, the classification of texture attributes based on the improved GLCM is used to determine the geobody of the salt dome in the two-dimensional marine seismic data of the bay of Hormuz. The obtained results show that the accuracy of identifying the salt dome using the improved attributes has an acceptable increase compared to the conventional ones. Furthermore, in this paper, to improve the salt dome geobody detection, nonlinear transform is used with the help of sigmoid transform function in the calculation of textural attributes based on GLCM, and its results are compared with the conventional linear transform. Finally, the geobody of the salt dome is determined using the classification of seismic attributes and its result is compared with the result of manual interpretation.

Introduction

Reflection seismic methods are considered as the most important geophysical methods used for the exploration of hydrocarbon resources or their host structures. A salt dome is a mass of salt that behaves as a fluid due to the high pressure of the overburden and due to its lower density compared to the surrounding rocks, it moves upwards and penetrates the upper layers. The insoluble property of salt also plays the role of covering the rocks underneath. On the other hand, salt domes are one of the hazards in deep excavations. Today, seismic attributes are used as one of the main tools in the quantitative interpretation of seismic data. By revealing the hidden information in the seismic data, they can help the interpreter in identifying and determining the structural and layered characteristics of the data. Considering the difference in the texture of the salt dome and the surrounding environment, texture seismic attributes can be useful in identifying this geological phenomenon in the seismic data.

GLCM is the most common texture analysis tool in image processing that is widely used in the production of texture attributes for seismic interpretation of salt domes, buried channels and seismic facies analysis. The values of this matrix

express the spatial relationship of different gray levels of an image in distance and direction. The quadratic statistics parameters extracted from the GLCM can be used in the texture analysis of the image. The calculation of texture seismic attributes based on GLCM includes two steps. In the first step, the seismic data should be converted into a gray scale image using linear transformation. The main advantage of using linear transformation is to preserve the maximum histogram distribution of the original domain among different seismic features, which preserves the appearance of the seismic section in gray scale conversion.

Methodology and Approaches

Considering the explanations stated earlier, seismic data or images in this study are supposed to be classified into salt and non-salt textures, and for this, nonlinear transform of the domains to gray scale has been performed, and support vector machine has been used as the classification algorithm. Moreover, the analysis of variance (ANOVA) method has been used to select attributes that reveal the dependence between the attributes and the target variable. The textural attributes based on GLCM are selected that are strongly dependent on the target variable.

Results and Conclusions

Determination of salt dome geobody in seismic data has always been considered as an issue for investigation due to the structures related to oil traps, underground gas storage and drilling risks. The aim of this research work has been to improve the textural attributes based on the GLCM using non-linear sigmoid transform to gray scale and its effect in determination of salt dome geobody, and finally, achieving the separation of salt and non-salt structures. Due to the negative impact of salt dome on seismic interpretation and the creation of low-amplitude reflections on the borders of the salt dome, a non-linear algorithm has been used to convert the seismic data into gray scale that enhances the low-amplitude reflections. This transform has improved the results significantly. The sigmoid transform expands the distribution of weak reflection, and the textural features causes to determine the geometry of the salt dome closer to that of the manual interpretation.