AN APPLICATION OF SYNTACTIC PATTERN RECOGNITION TO SEISMIC INTERPRETATION

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ABSTRACT

Seismic exploration data can be used to image the acoustic impedance variations in the earth. In order to convert such data to an image that more closely matches the vision of geology image enhancement techniques, including pattern recognition methods, must be applied. A syntax-dependent approach employing a string-to-string matching algorithm matches peaks between traces on a seismic record. A filtering process then enforces matching coherence by correcting matches that deviate seriously from the general trend around anomalous pairs. Connected pairs form lateral coherent events which have a confidence measure. These events are objects of any seismic investigation. Clustering techniques can be used to associate the objects with geologic zones. The algorithm performs well in a test run and detects most of the strong reflections.

KEYWORDS: string-to-string matching, seismic records, trace, events, parallel analysis, clustering analysis, zone.

INTRODUCTION

Geophysical exploration of the earth's crust aims to develop an image of the distribution of physical properties within the earth by remote sensing methods of various kinds. Among the many methods used seismic reflection studies are by far the most productive and it is to seismic data that we apply some novel, for geophysicists, approaches. These approaches have merit in other geophysical techniques, but we do not discuss them here.

During the past ten years, substantial achievement has been made in the area of geophysical data acquisition, processing and inversion. The reliability and resolution of information available to geophysical interpreters have increased. In spite of such a large data base of good quality, computer software is not sophisticated enough to help geophysicists make even simple judgement or monitor the data processing flow. Even though computer usage is more pervasive than ever, the nature of the computer program is virtually the same. Geophysical data processing programs are by and large compute intensive processing tools that depend extensively for their control on expert judgment. Very few decision-making aids exist in the lexicon of geophysical image processing systems.

Seismic data contain records of signals that are echoed from acoustic impedance contrasts within the earth. Seismic interpretation is the identification of these contrasts and could be done with expert systems. The final goal of interpretation is to obtain the image of the subsurface structure in terms of physical quantities such as densities and velocities. This requires recognition of the major seismic events on a seismic record and translation of these events to yield the desired quantities.

A seismic record is the response of geophones to a source of mechanical energy. The record of response with time of any single geophone is called a trace. The elastic waves generated by the source are perceived to travel into the earth and be reflected at the impedance discontinuities. Such reflections appear on a seismic record as wavelets of strong amplitudes and form seismic events.

Picking the events is an important and elementary step in any seismic interpretation process and is usually done manually. Statistical picking algorithms have been proposed (Paulson and Merdler, 1968; Schneider, 1971) but pattern recognition (Fu, 1974; Lu, 1982) provides an attractive alternative.

AN AUTOMATED SEISMIC EVENT-PICKING PROCEDURE

A seismic trace can be considered a pattern or string of primitives with features such as amplitude, location and duration. A comparison between two traces can be made on their corresponding strings by the string-to-string matching algorithm which examines all possible mapping between the two strings and determines the optimal mapping which derives one string from the other with the least effort.

Consider a seismic trace as a sequence of cycles (Figure 1) each of which is bounded by two consecutive local minima. The primitives are defined as an upslope followed by a downslope. The amplitude, $y'(t_p)$ is

$$y'(t_p) = \frac{y(t_p) - y^*(t_p)}{2} \qquad (1)$$

The duration is the time difference between A^* and B^* and the location is time, t_p. The time gap between two adjacent transformed peaks is the duration of the corresponding null primitive which has a location in the middle of this gap.