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Fast and robust microseismic event detection using very fast simulated annealing

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The study of microseismic data has become an essential tool in many geoscience fields, including oil reservoir geophysics, mining and CO_2 sequestration. In hydraulic fracturing, microseismicity studies permit the characterization and monitoring of the reservoir dynamics in order to optimize the production and the fluid injection process itself. As the number of events is usually large and the signal-to-noise ratio is in general very low, fast, automated, and robust detection algorithms are required for most applications. Also, real-time functionality is commonly needed to control the fluid injection in the field. Generally, events are located by means of grid search algorithms that rely on some approximate velocity model. These techniques are very effective and accurate, but computationally intensive when dealing with large three or four-dimensional grids. Here, we present a fast and robust method that allows to automatically detect and pick an event in 3C microseismic data without any input information about the velocity model. The detection is carried out by means of a very fast simulated annealing (VFSA) algorithm. To this end, we define an objective function that measures the energy of a potential microseismic event along the multichannel signal. This objective function is based on the stacked energy of the envelope of the signals calculated within a predefined narrow time window that depends on the source position, receivers geometry and velocity. Once an event has been detected, the source location can be estimated, in a second stage, by inverting the corresponding traveltimes using a standard technique, which would naturally require some knowledge of the velocity model. Since the proposed technique focuses on the detection of the microseismic events only, the velocity model is not required, leading to a fast algorithm that carries out the detection in real-time. Besides, the strategy is applicable to data with very low signal-to-noise ratios, for it relies on the stacked energy of the 3C signal envelopes centered on the time window that contains the event. Results using synthetic and field data show the reliability and effectiveness of the proposed method for the accurate detection of multichannel microseismic events under noisy conditions.