# An automatic seismic event identification method by sequential discounting autoregressive (SDAR) change point detecting

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In recent years, more and more reservoir evaluation studies, including CO2 sequestration, hydraulic fracturing and fracture mapping, focus on seismicity monitoring. The primary task for monitoring is the identification of seismic events in a long-term sustained time series record. Unfortunately, the time-varying characteristics of SNR (signal to noise ratio) and seismic event waveforms increase the difficulty in the automatic detection of seismic events. First, The uneven data energy distribution due to uneven data energy distribution influences the outlier identification of the targeted event, especially for weak energy earthquakes. Second, different seismic events contain different waveform properties. A fixed detecting model is inappropriate for long-term observation. Events in close propinquity of a time series also lead to a complex automatic detecting model.
The STA/LTA (short term averaging / long term averaging) method is a widely used seismic first arrival identification algorithm. This method is simple and suitable for real-time processing. It contains 2 steps: 1. set a short time window included in a long time window and calculate the time window signal amplitude (or energy) average, respectively. 2. slide the windows in the time series and calculate the two average ratios. The outlier of the ratio refers to the appearance of a seismic event. The STA/LTA method can be employed for real-time processing. However, for low SNR or related signal noise situation, STA/LTA detecting effect will be impaired. Besides, for long-term series, it is difficult to estimate an appropriate time window size for the ratio calculation. Considering seismic observed record as a stochastic time series, AR (autoregressive) process can be applied for seismic event detecting. For the event phase arrival, AR method assumes that the segments before and after the event phase is stationary as different AR models. The change point between these two models refers to the seismic event on time series. Since the AR method avoids the amplitude or energy calculation, it produces better results for low SNR signals. However, AR method needs the signal stationarity assumption, so it is not suitable for time-varying long-term records.
In this work, an improved AR method for automatic seismic event detecting is applied. This algorithm, called SDAR (sequential discounting AR learning), is widely used to represent a statistical behavior of a time series. There are 2 advantages of SDAR: 1. Real-time estimation. When new data appears in the record, the SDAR model parameters can be updated. 2. Discounting property. Comparing with AR method, the SDAR introduces the discounting parameter to decrease the statistic value on future data. Therefore, the SDAR method can handle the unstable time-varying long-term series. Comparing SDAR and STA/LTA method, the Tomakomai OBC observation test shows that SDAR can increase the seismic event detecting rate.

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