Review on the "Joint Detection, Location and Source Mechanism Determination of Microseismic Events" - a PhD thesis by Denis Anikiev

The thesis describes development of a technique for a fully automated detection and processing of microseismic events. Microseismic events are usually a very small seismic events generated within the hydraulic fracturing of a reservoir. A real-time processing of such events (a reliable detection, precise location and moment tensor computation) allows operators to monitor opening of fractures within the reservoir and adjust fracturing pressure and other parameters according to current situation. In addition, also potential large seismic events could be mitigated by real-time monitoring of seismic activity and timely decrease of fracturing pressure when large events start to emerge.

The PhD thesis consists of four parts - Introduction, Methodology, Experimental Results and Conclusions. The core of the thesis is the Methodology section, where author describes basic principles of the detection technique and his own contributions to state-of-the-art techniques.

The microseismic events are seismic events with a very low SNR from which only the strongest could be visible on the raw data without any further processing. Hence, the author selects a simple and effective, but computationally expensive approach of testing all possible locations on a grid and testing whether synthetics for a potential event agrees with measured data. If successful, then a moment tensor inversion is run and synthetics are corrected for a radiation pattern and geophones close to the nodal lines (where there is no or only a negligible signal is predicted) are removed from further processing. Such fine-tuned synthetics are then compared with measured data once more leading to a much more reliable differentiation between real and false events.

The Experimental Results chapter tests the proposed methodology on a real dataset obtained during a hydraulic fracturing of gas wells in the Arkoma basin, Oklahoma. The dataset consist of approximately five days of continuous data from almost a thousand of vertical high-frequency geophones. The geophones were planted on the surface in a star-like pattern around the production wells. After a several trial runs on a subset of the data appropriate algorithm settings were estimated and a complete dataset was processed as a whole. The obtained results look realistic and unexpectedly large number of events enables interpretation of processes during the fracturing.

The inevitable down side of such complex processing is a high computational load. However, on a 64-processors computer the results were reported almost in a real time. Five days of continuous data were processed in a slightly more than five days. Therefore, it can be stated that it is achievable to get the results in a real time during the fracturing. This is, in my opinion, really important. After some initial set up, even an inexperienced operator can run the code and see on-line what are the consequences of a current fracturing stage and, if necessary, adjust the fracturing pressure and other parameters instantly.

Therefore, I highly appreciate this thesis and *recommend it for acceptance*.

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