Remarks on the micro-earthquake detection problem: Refining the outcome using stochastic modeling

Athanasios Lois¹, Fotis Kopsaftopoulos², Dimitrios Giannopoulos¹,³, Katerina Polychronopoulou¹, and Nikos Martakis¹

¹Seismotech S.A., Research and Development, Marousi, Greece (lois@seismotech.gr)
²Rensselaer Polytechnic Institute, Department of Mechanical, Aerospace, and Nuclear Engineering, Troy, NY, USA
³Laboratory of Geophysics & Seismology, Department of Natural Resources & Environment, Hellenic Mediterranean University, Chania, Greece

Methodologies dealing with the detection of micro-earthquakes and the accurate estimation of body waves’ arrival time constitute, during the last decades, a topic of ongoing research. The extraction and efficient analysis of the useful information from the continuous recordings is of great importance, since it is a prerequisite for reliable interpretations. Small magnitude seismic events, either naturally-occuring or induced, have been increasingly used in a wide range of industrial fields, with applications ranging from hydrocarbon and geothermal reservoir exploration, to passive seismic tomography surveys.

A great number of algorithms have been proposed and applied up to now for seismic event detection, exploiting specific properties of the seismic signals both in time and in frequency domain, with the energy-based detectors (STA/LTA) to be the most commonly used, due to their simplicity and the low computational cost they require. A significant obstacle emerging at seismological identification problems lies on the fact that such processes usually suffer from a number of false alarms, which is significantly increased in extremely noisy environments.

For that scope, we propose a “Decision-Making” mechanism, independent of the applied detection algorithm, which controls the results obtained during the detection process by minimizing false detections and providing the best possible outcome for further analysis. The specific scenario is based on the comparison among autoregressive models estimated on isolated seismic noise recordings, as well as on the detected intervals that resulted during the event identification procedure. A number of examples, associated with the implementation of the proposed scenario on real data, is presented with the scope of evaluating its performance. Several issues concerning the isolation of the seismic noise from the raw data, the estimation of the autoregressive models, the choice of the orders of the stochastic models etc., are discussed.