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Continuous Earthquake Detection and Classification using Hidden Markov Models

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Growing consistently, the stream of data puts emphasize on automatic event detection and classification algorithms, extracting the relevant information out of terabyte big data sets. Especially networks for registering micro-seismicity, which are gaining more and more popularity, can hardly be processed by hand. Applying common techniques such as amplitude and frequency dependent triggers to these networks will produce near continuous triggering and thus makes it apparent to migrate to more robust event detection and classification techniques.

One choice for a more robust detection and classification algorithm is to adopt Hidden Markov Models (HMM), a technique which shows major success in speech recognition. HMM provide a powerful tool to describe highly variable time series within a double stochastic model and therefore allow for broader class description than e.g. template based pattern matching techniques. In contrast to artificial neuronal networks (ANN), HMM are incorporating the time dependence explicitly in the models, thus providing a more direct representation of the seismic signal. Being based on features calculated out of the seismogram (e.g. frequency partition, envelope or the rectilinearity), HMM actually mimic the eye of a experienced seismogram analyst.

In this study HMM based detection and classification was successfully applied to earthquakes registered by the Bavarian earthquake service. The task here was to continuously classify earthquakes with distances of 0km-10km (local), 10km-100km (near), 100-600km (far). Splitting the events into different classes is crucial for further processing steps like class dependent forward-backward AR picking or frequency and thus distance dependent picking.