Automatic Detection and Classification of Seismic Signals for Monitoring Purposes

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Motivation

Detection and classification (identification) of seismic signals is one of the fundamental processing steps in seismic or seismological applications in order to pre-select seismic waveform data or meta-data derived from those for certain investigations. Typical detection and classification examples in seismology are: i) automatic picking of arrival times (active seismics, earthquakes, man made events) for locating the source of seismic energy release in space and time; ii) discrimination between natural and man-made seismic events (nuclear explosion recognition - comprehensive test ban treaty verification); iii) recognition of critical events or seismicity evolution for alert systems (tsunamigenic earthquakes, volcanic seismicity, early warning systems).

The example demonstrates the use of pattern recognition techniques for monitoring low-energetic seismic events at the high-risk volcano Mt. Merapi in Indonesia.

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**Figures**

**Figure 2**

- **Parametrization of continuously recorded seismic wavefield**
  - broadband frequency wavenumber analysis = short term estimate of coherence, strength and direction of wavefield
  - Sonogram = short term estimate of spectral content of seismic wavefield
  - Polarization Analysis = short term estimate of polarization state of waveform

**Figure 3**

- **Pattern recognition system based on probabilistic approach (Hidden Markov Models)**

**Figure 1**

**Approach**

At Merapi, a dense network of seismic sensors provide continuous seismic data streams (Figure 1). The information content of the recorded seismic wavefield is characterised by a set of short term signal features. The sequence of feature vectors is classified using a discrete hidden Markov model approach. Supervised learning from a small set of training data is required for calibrating the classifier function in this multi-class detection problem (Figure 2).

**Classification results**

Figure 3 shows a typical classification result. The waveforms are automatically attributed to one of the trained seismic event classes including one special (absorbing) class which indicates the absence of any significant transient seismic energy. Overall a classification accuracy of around 65% could be achieved (Ohnberger, 2001). The system was implemented as real-time component of an data acquisition system. Special event types were directly transferred to a location module (left part of Figure 3).