Automatic Detection and Classification of Seismic Signals for Monitoring Purposes

Ohrnberger M.[1], Wassermann J.[2], and Richter, G.[1]

1) Institut für Geowissenschaften, Universität Potsdam; contact: mao@geo.uni-potsdam.de
2) Department für Geo- und Umweltwissenschaften, LMU München

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.

Mt. Merapi's seismic network

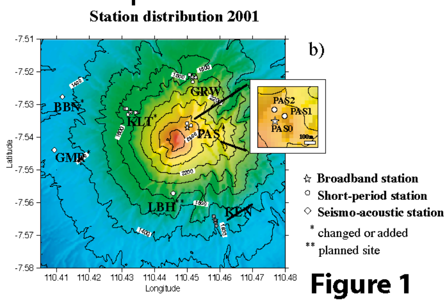

Figure 1

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).

Parametrization of continuously recorded seismic wavefield

broadband frequency wavenumber analysis = short term estimates 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 wavefield

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

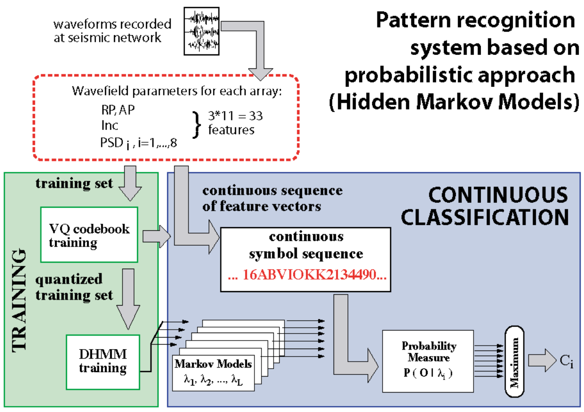

Figure 2

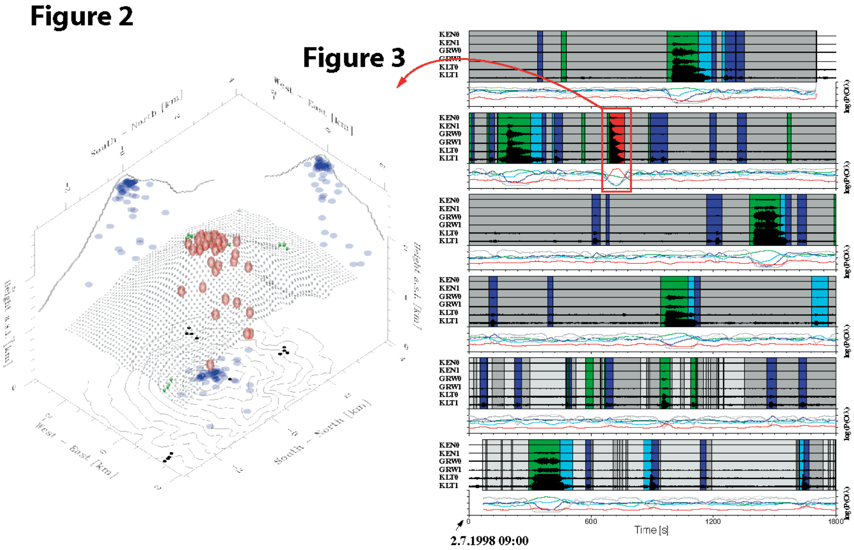

Figure 3

Classification results

Figure 3 shows a typical classification result. The waveforms are auto-matically 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 (Ohrnberger, 2001). The system was implemented as realtime component of an data acquisition system. Special event types were directly transfered to a location module (left part of Figure 3).