Volcano-seismic signal detection and classification processing using Hidden Markov Models. Application to San Cristóbal volcano, Nicaragua.

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Abstract:

1. INTRODUCTION

We present a method for automatic seismic event detection and classification, focusing on volcanic-seismic signals by means of the validity of the hidden Markov modeling (HMM) method in active volcanoes. Nowadays, the Hidden Markov Models technique is the more effective one to implement voice recognition systems. Over the past years, Hidden Markov Models have been widely applied in several models like pattern [1, 2], pathologies [3] or speech recognition [4, 5], and DNA sequence analysis [6, 7]. On the other hand, previous works [8, 9, 10] have probed the parallelism among speech and volcano-seismic events in terms of signal complexity and real time requirements. In this sense, we recordings of different seismic event types are studied at one active volcano; San Cristóbal in Nicaragua. We use data from two field surveys carried out in February to March 2006.

2. DATA ACQUISITIONS AND BUILD MODEL TRAINING SYSTEM

More than 600 hours of data in San Cristóbal volcano were analyzed and 431 seismic events were registered at short period stations. These events were manually labelled by a single expert technicians and identified three types classes of signals; Strombolian explosions, San Cristóbal explosions, volcanic tremor and background seismic noise, with durations of 10-40 s and 20-120 s, respectively. We initially proceeded to identify the signals visually, and to segment the data to obtain a model for each event class. Once the recordings were manually segmented and labelled, the recognition system was carefully trained using the available Baum-Welch reestimation algorithms [11] using the Hidden Markov Model Toolkit (HTK) software [12].

We applied these models separately for the volcano data set, and finally mixed both data sets as a test of the portability of the system. The method analyzes the seismograms comparing the characteristics of the data to a number of event classes defined beforehand. If a signal is present, the method detects its occurrence and produces a classification. The recognition and classification system based on HMM is a powerful, effective, and successful tool [13]. From the application performed over our data set, we have demonstrated that in order to have a reliable result, a careful and adequate segmentation process is crucial. Also, each type of signals requires its own characterization. That is, each signal type must be represented by its own specific model, which would include the effects of source, path and sites.

3. CONCLUSIONS

Once we have built this model, the success level of the system is high. Extensive performance evaluation is conducted to derive the optimal configuration of the different parameters. A score of correct classification rates and accuracy in blind test of up to 85% are achieved. The high success rates obtained imply that the method is fully able to detect, isolate, and identify seismic

signals on raw seismic data. These results imply that, once an adequate training process has been used, the present method is particularly appropriate to work in real time, and in parallel to the data acquisition.

4. REFERENCES

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