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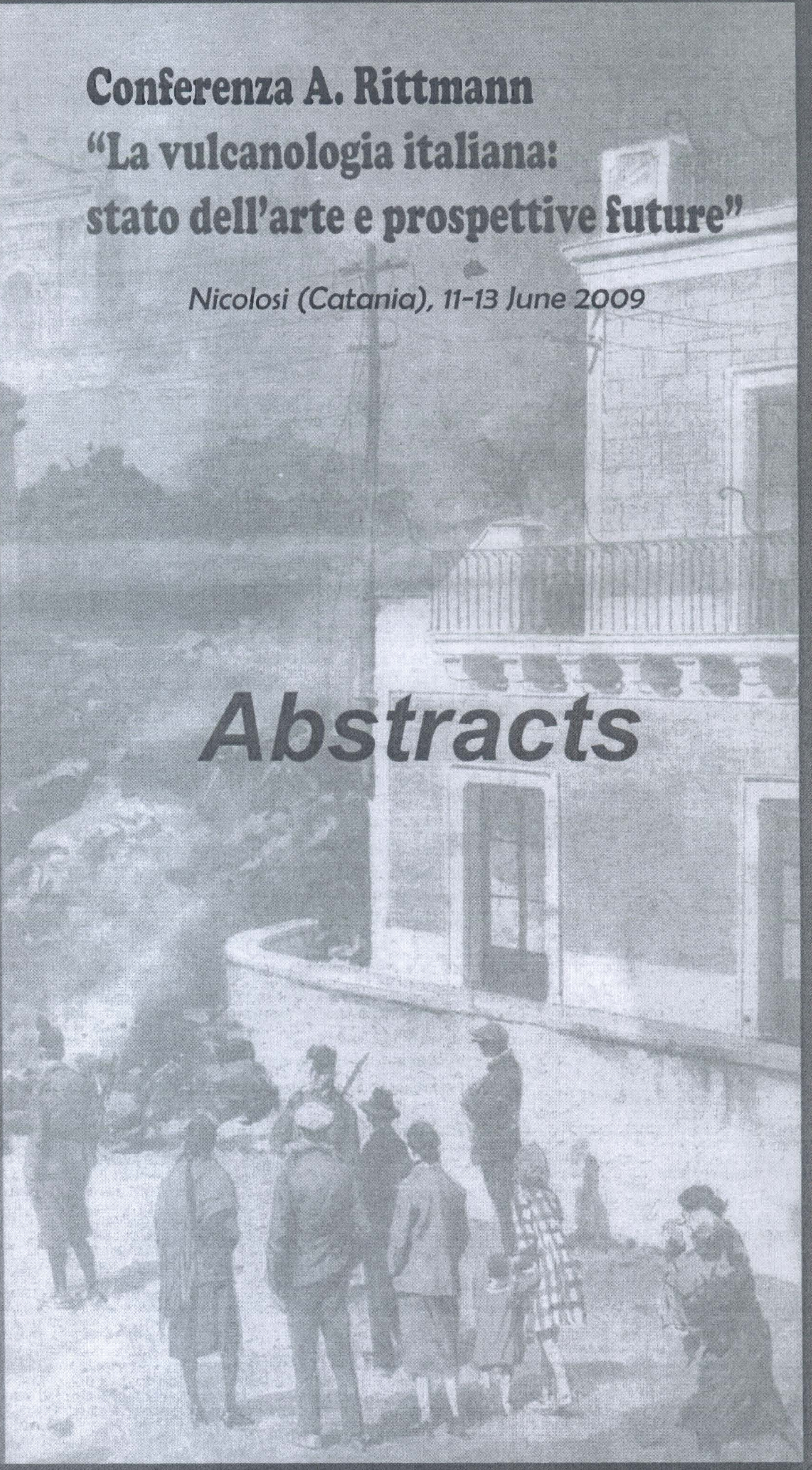
Abstracts



Automatic detection of landslides at Stromboli using neural network analysis of seismic signals

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Landslides along the Sciara del Fuoco flank of Stromboli volcano are generally accompanied by distinctive seismic signals which can be used for studying this phenomenon. These signals are characterized by a spectral content with higher frequencies and a wider band than the typical explosion quakes and volcanic tremor signals which are continuously recorded at Stromboli. Furthermore their amplitude envelope usually shows a cigar-like shape. These two features make the detection of such signals quite easy. The detection of landslides at Stromboli has shown to be an important short-term precursor of effusive eruptions. Before the Feb. 27th 2007 eruption, the opening of the effusive vents was preceded by few hours of increased occurrence of landslide signals (Martini et al., 2007). Furthermore since the Sciara del Fuoco has shown significant instabilities during the 2002-2003 eruption, the automatic detection of landslide signals is an important monitoring tool for notifying variations in the stability of this flank. We propose a technique based on a Multi Layer Perceptron (MLP) neural network which has shown excellent performances. The network is composed of two layer of neurons, the hidden and the output. The hidden layer is composed of 4 neurons while the output layer is composed by a single neuron whose output value ranges between 0 and 1, with values higher than a given threshold (e.g. 0.5) meaning positive detection. The continuous seismic signals are analysed using moving windows of 24 s, with an overlap of 12 s. For each of these windows the neural output is computed. The waveforms of each time window are parametrized using both their spectrogram and their amplitude envelope. The spectrogram is described using the Linear Predictive Coding (LPC) technique which allows to represent the spectral content using a limited number of coefficients. The whole signal is divided into 8 sub-windows of 5.12 s length, with an overlapping of 2.56 s. For each sub-window we compute 6 LPC coefficients, so each spectrogram is described by only 48 coefficients. The amplitude envelope is defined by computing the difference between the maximum and minimum value over 1 s sub-windows obtaining 24 coefficients. In conclusion we use an input vector composed of 72 elements (48+24). This vector has shown to be an efficient and compact representation of the raw signal (composed of 1200 samples) (Esposito et al. 2006). The dataset used for determining the network parameters is composed of 537 signals, divided in two classes: 267 landslide signals and 270 other signals (explosions and tremor). The classification of these signals has been performed by analysts. The training is carried out using subsets of 5/8 of the total dataset. The testing subsets are composed by the remaining 3/8. The network has shown a performance of about 98.7%. This value is an average over 6 random permutations of the dataset. A preliminary real-time automatic system has already been implemented. This system performs continuous analysis of the seismic signals, publishing them on internal web pages. It allows a detection of the landslides and a comparison with the past activity on arbitrary time intervals.

References

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