Activity Regimes Inferred from Automatic Classification of Volcanic Tremor at Mt. Etna, Italy

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Mt. Etna

Mount Etna is the largest active volcano in Europe:

- Type: Basaltic stratovolcano
- Location: Sicily, Italy (3350 m a.s.l.)
- Latest eruptions: 01, 02-03, 04-05, 06

Mount Etna's volcanic monitoring
is a
key issue

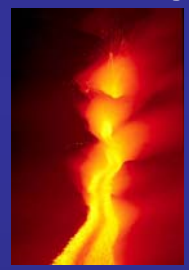
Volcanic Tremor

For basaltic volcanoes (e.g., Mount Etna)…

- Volcanic tremor is a persistent seismic signal marking different states of the volcano's activity:


Pre-eruptive


Lava fountain


Eruptive


Post-eruptive

- Volcanic tremor provides reliable information for alerting governmental authorities during a crisis and permits surveillance even when direct access to the eruptive theatre is not possible

Automatic Classification

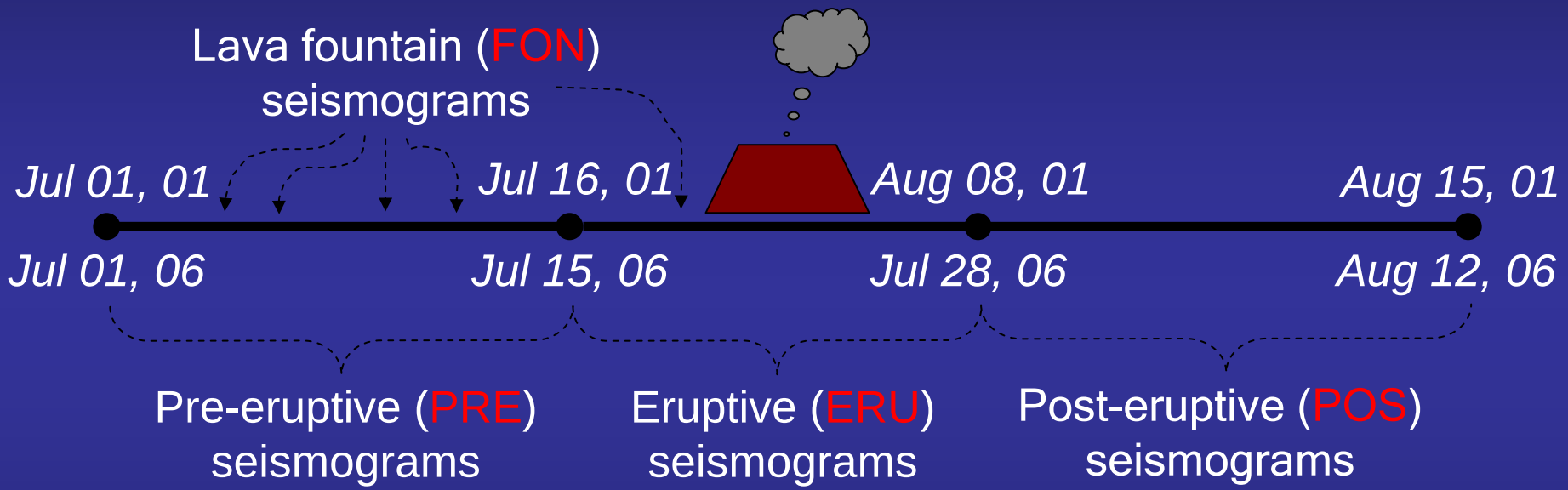
In [*Masotti, Geo. Res. Lett., 33 (20) (2006)*], a system able to automatically classify different states of the volcano's activity from the analysis of its volcanic tremor was proposed:

Here, what if:

- Support Vector Machine is optimized (e.g., using Genetic Algorithm)?
- A different (optimized) classifier is used (e.g., Artificial Neural Networks or Cluster Analysis)?
- A different eruption is considered (e.g., 2006)?

Data

Seismograms are labeled according to their recording date…

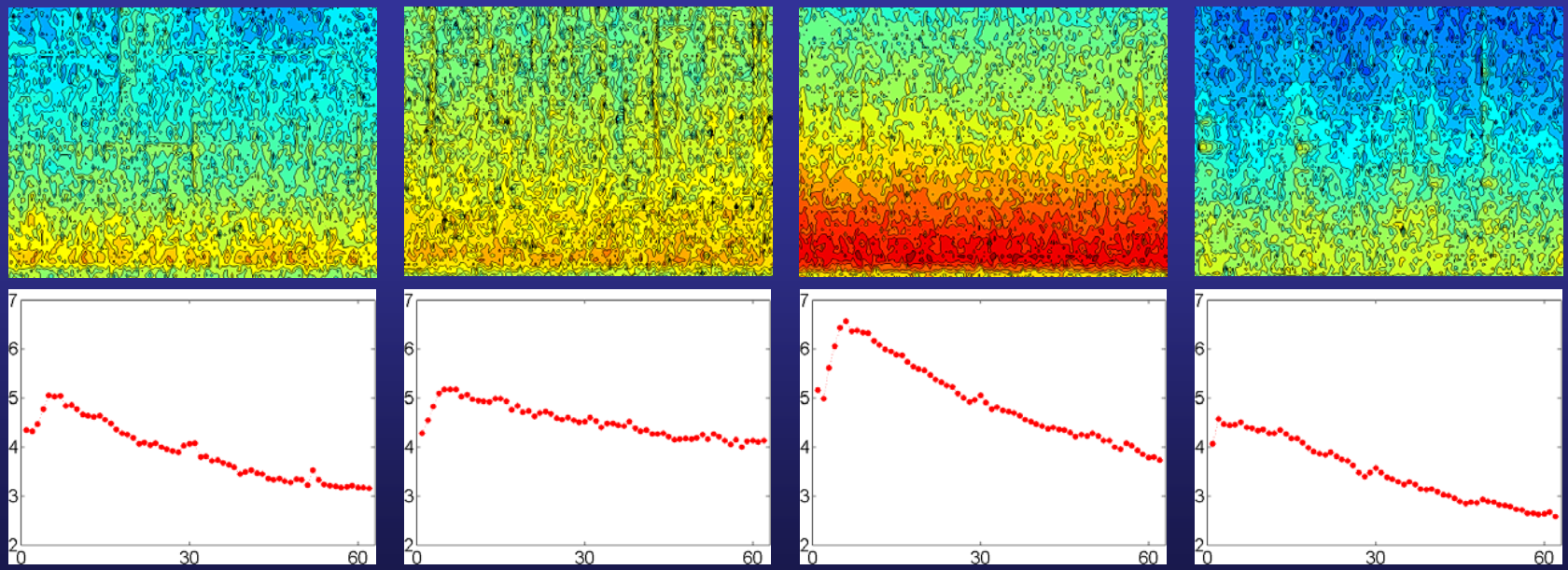


	Number of patterns for each class			
	PRE	FON	ERU	POS
2001	153	55	180	37
2006	84	0	168	84

Feature Extraction

Features are computed by…

1. Calculating the spectrogram of each seismogram (10 min., 0-15 Hz)
2. Averaging the rows of each spectrogram (62-dimensional feature vector)



Pre-eruptive Lava fountain Eruptive Post-eruptive

Classification

A comparison is performed among:

Supervised classification based on
Support Vector Machine (SVM) + Genetic Algorithm (GA)

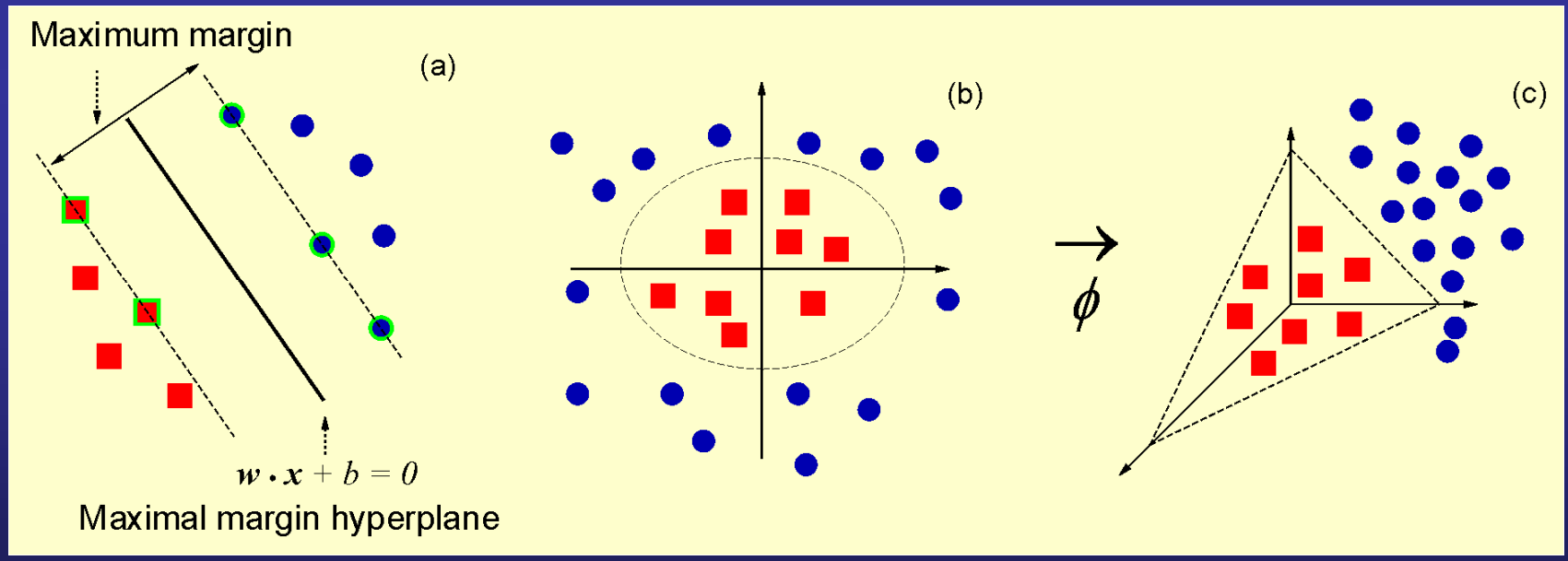
VS

Supervised classification based on
Artificial Neural Network (ANN) + GA

Unsupervised classification based on
Cluster Analysis (CA)

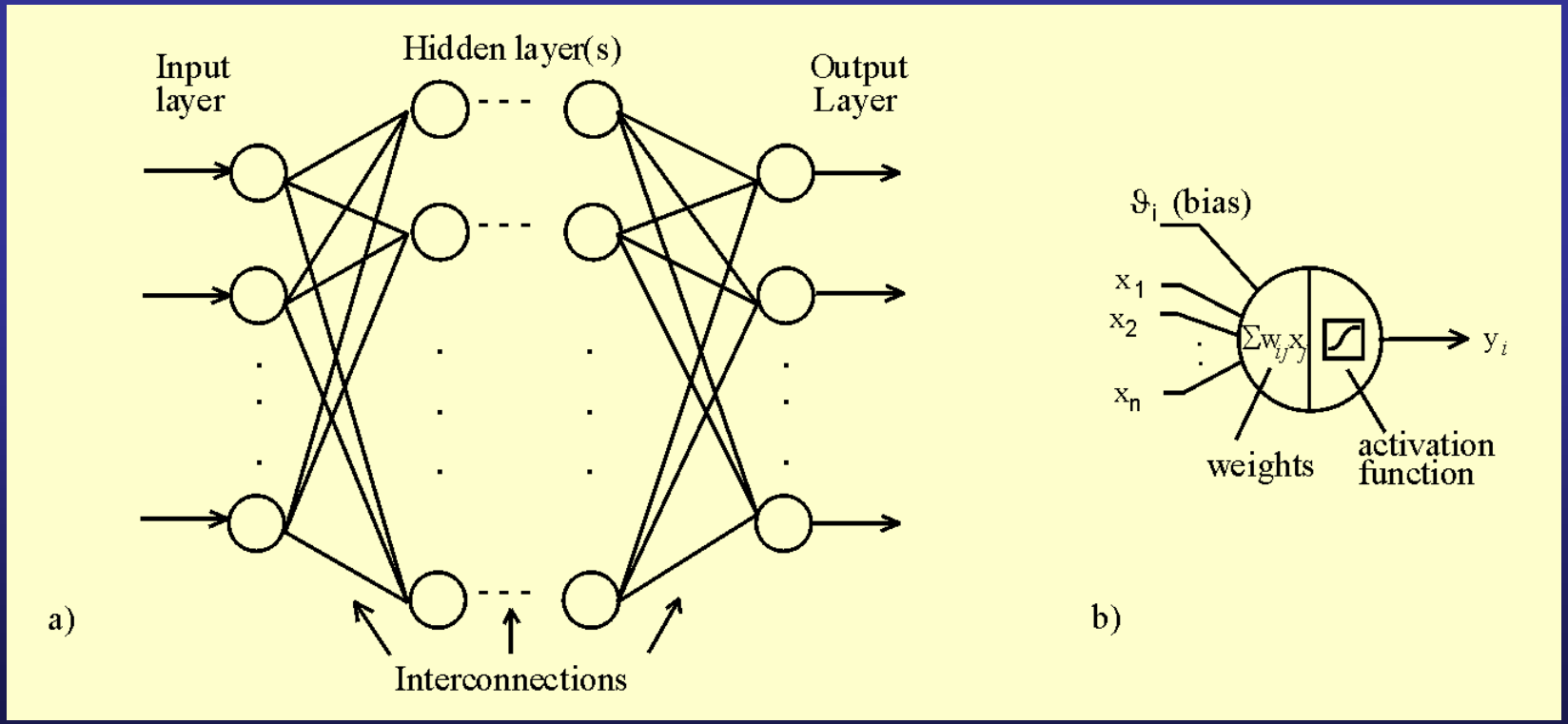
Classification :: SVM

Supervised classification



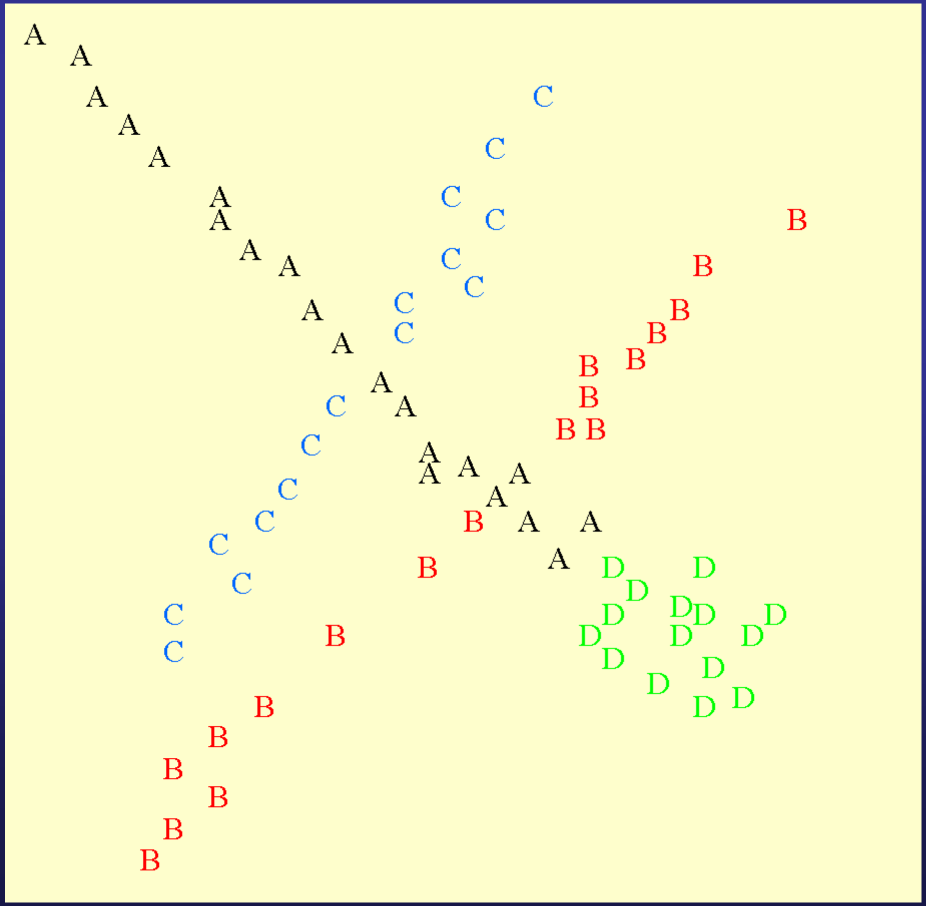
Classification :: ANN

Supervised classification



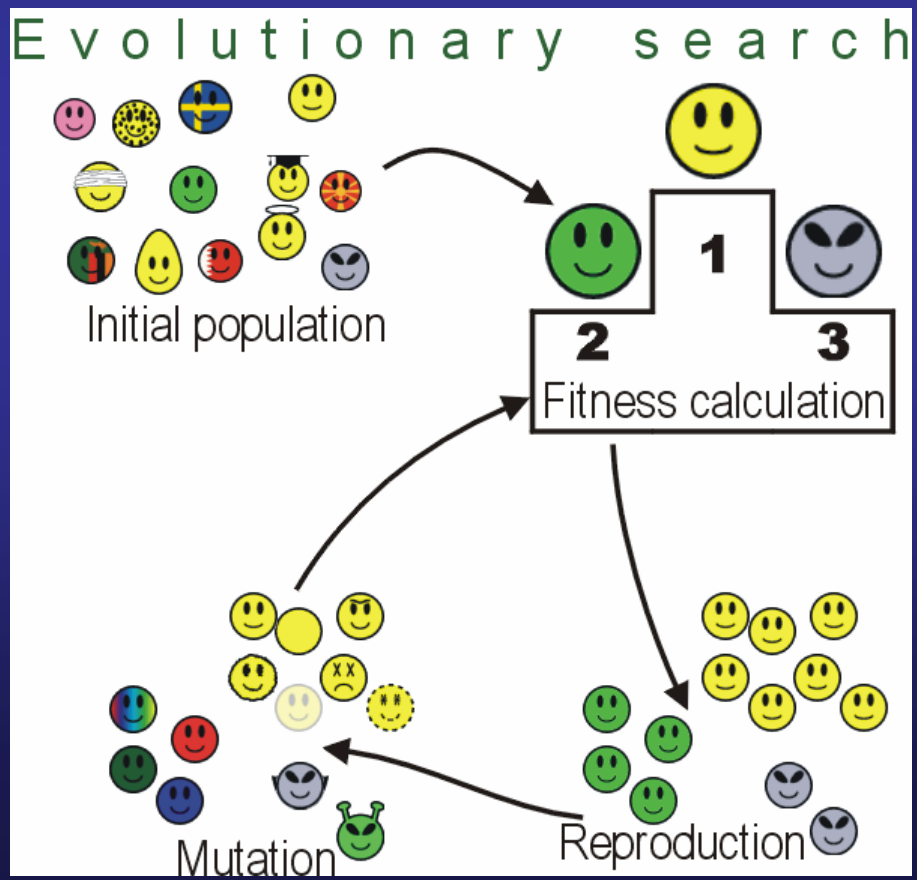
Classification :: CA

Unsupervised classification



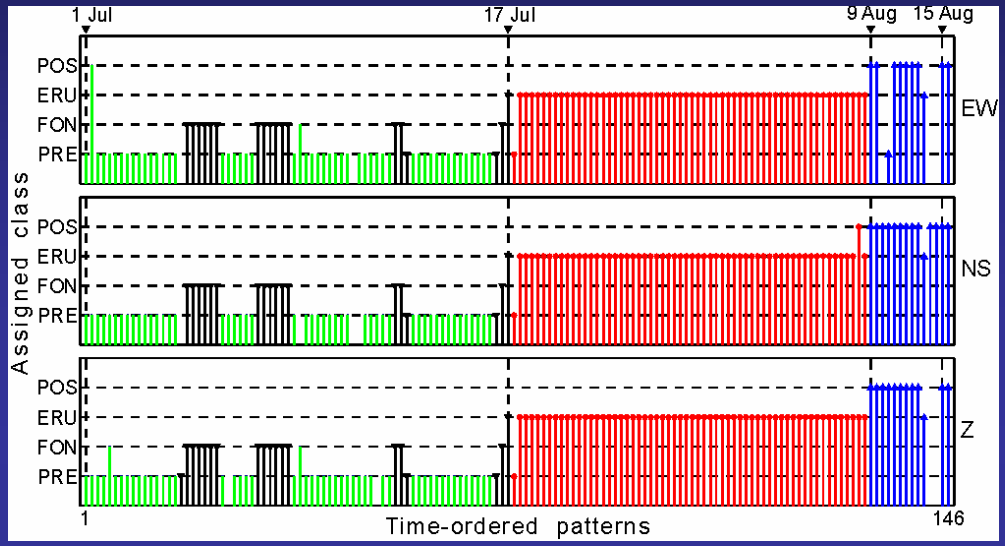
Classification :: GA

Some of the SVM and ANN parameters are tuned using GA:



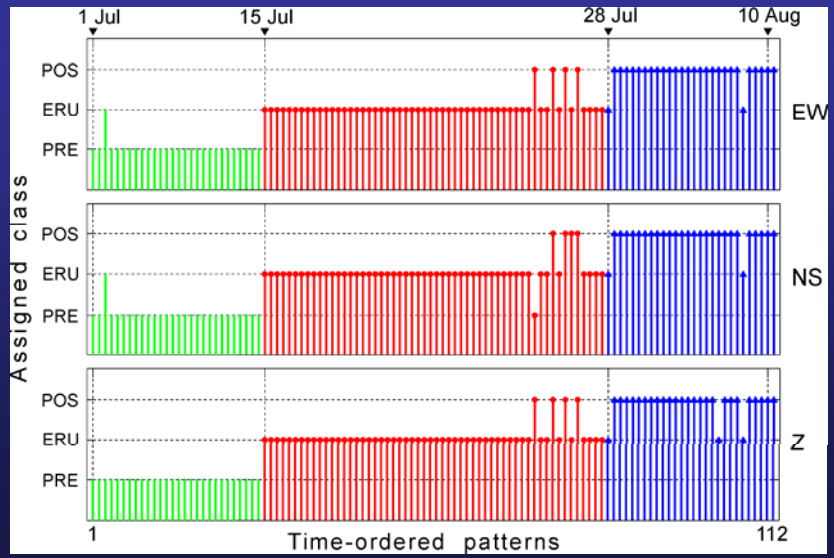
Results :: SVM + GA

2001



Overall classification error:
22/425 = 5% patterns

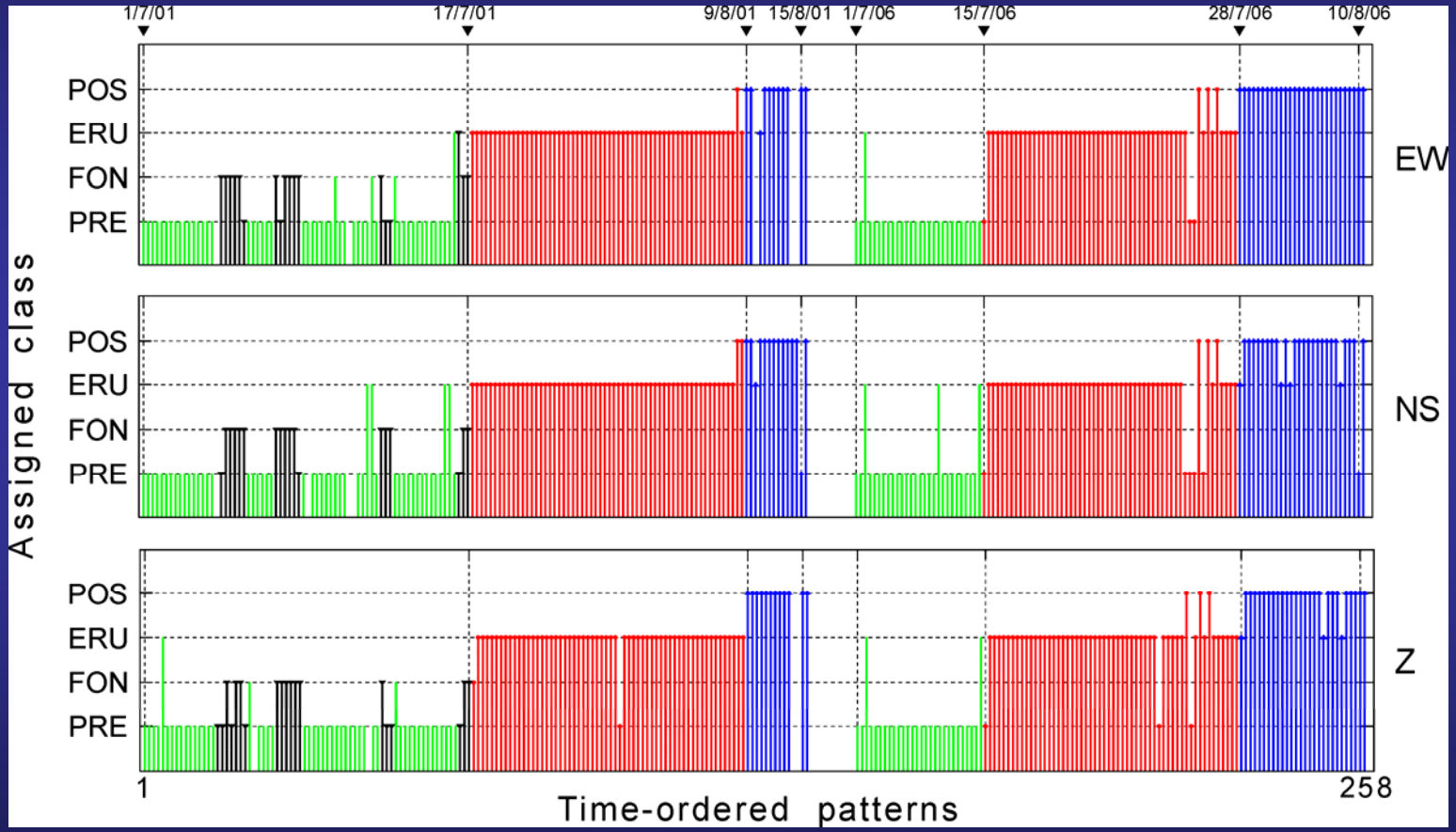
2006



Overall classification error:
22/336 = 7% patterns

Results :: SVM + GA

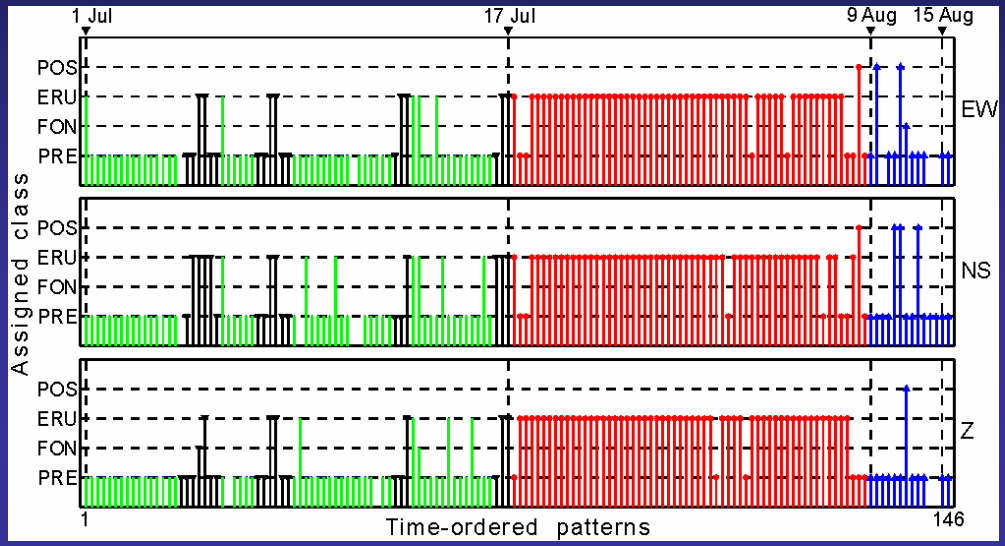
2001
+
2006



Overall classification error:
68/761 = 9% patterns

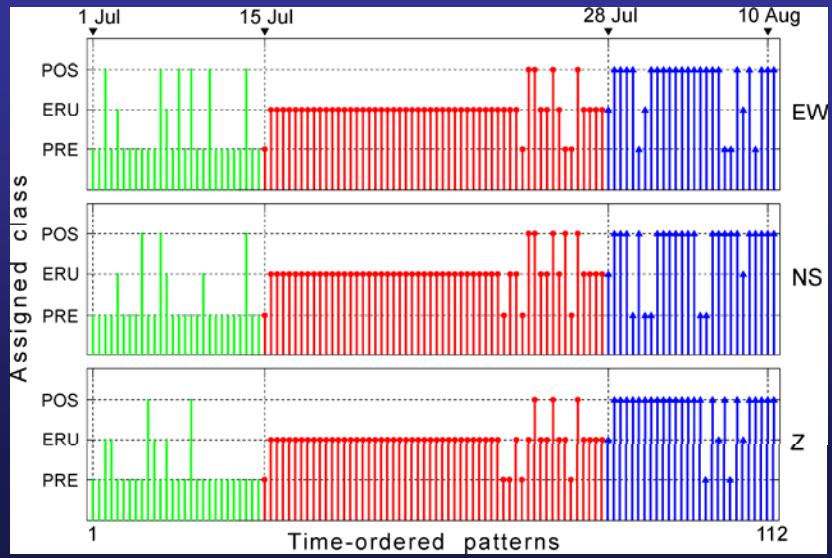
Results :: ANN + GA

2001



Overall classification error:
124/425 = 29% patterns

2006



Overall classification error:
64/336 = 19% patterns

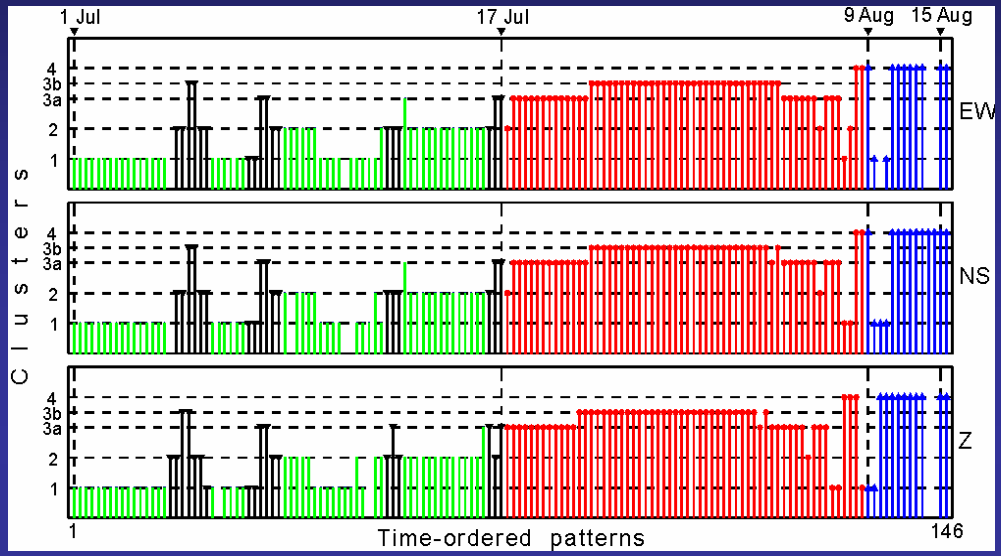
Results :: ANN + GA

2001
+
2006

Overall classification error:
196/761 = 26% patterns

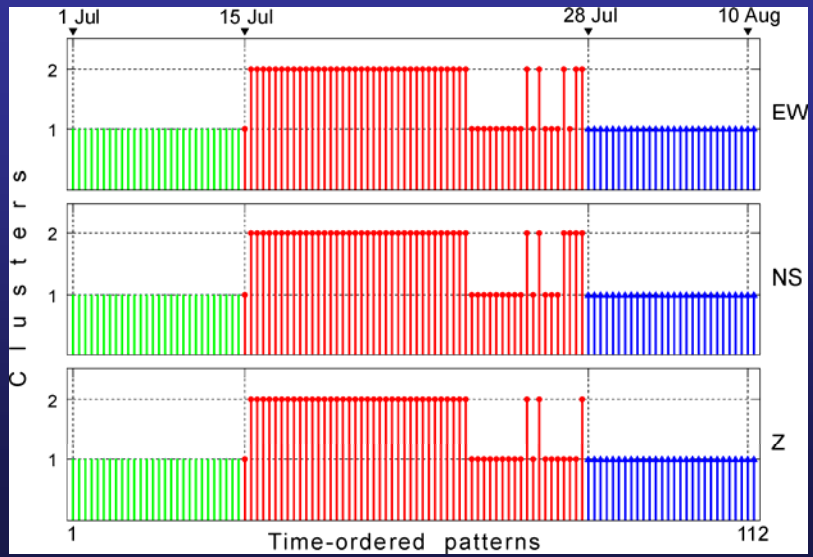
Results :: CA

2001



Number of clusters: 5

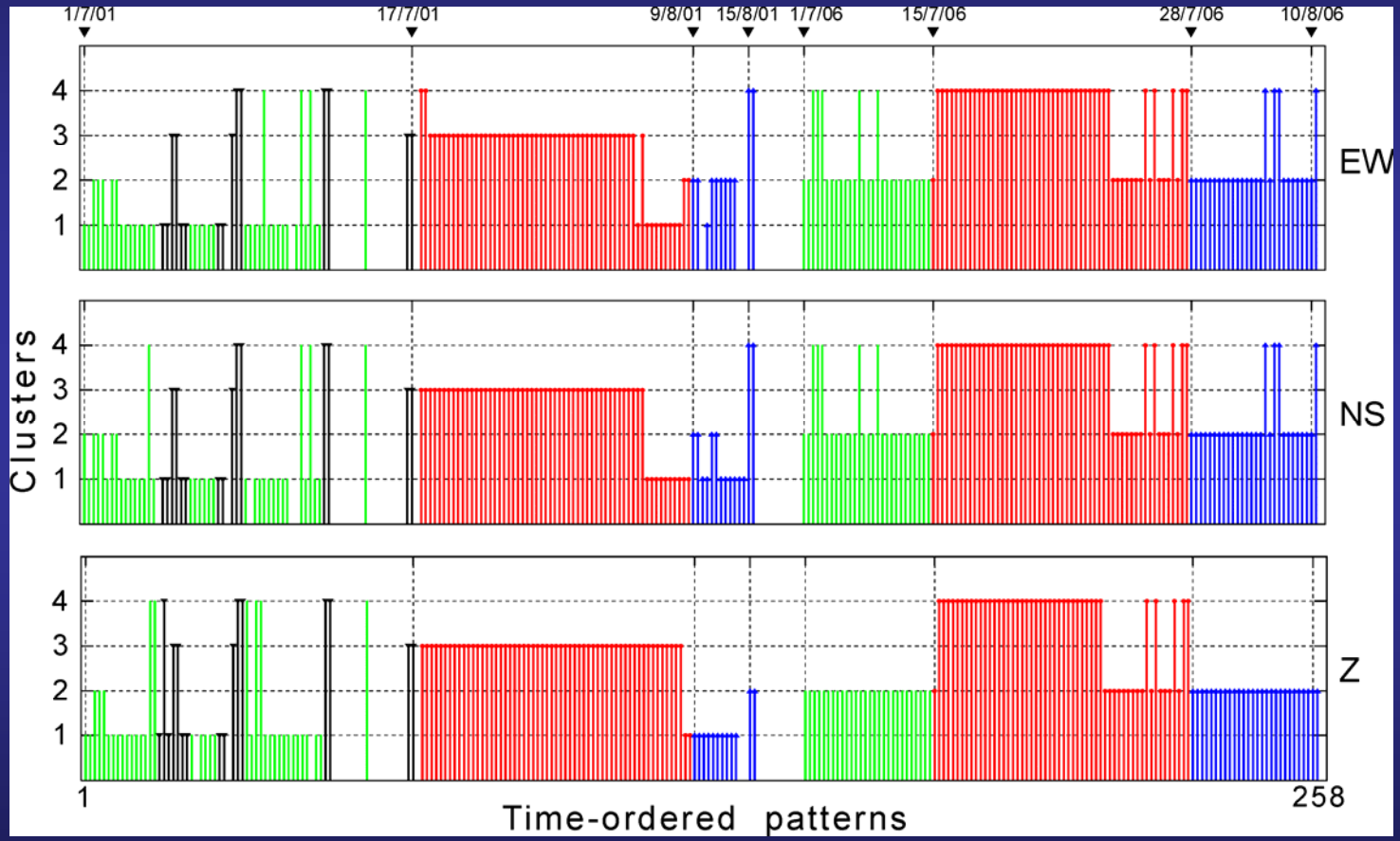
2006



Number of clusters: 2

Results :: CA

2001
+
2006



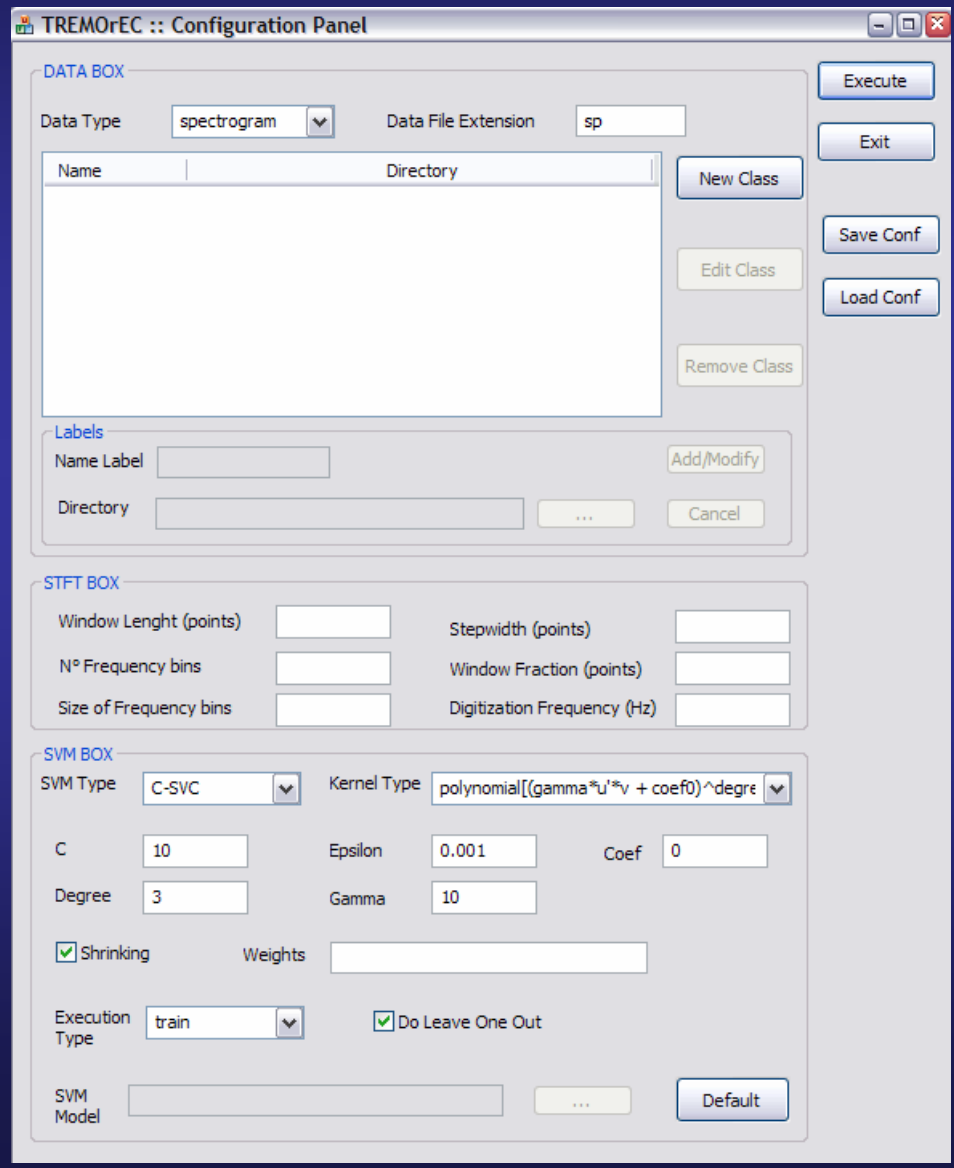
Number of clusters:
4

Conclusions

- The improvement achieved using SVM+GA rather than SVM is not significant, i.e., < 1%
- SVM+GA performs significantly better than ANN+GA, i.e., overall classification error is equal to 5% on 2001 and 7% on 2006, versus 29% on 2001 and 19% on 2006, respectively
- Individually, SVM+GA and ANN+GA achieve quite similar classification results regardless of the data considered, i.e., 2001, 2006, or 2001+2006
- CA: separation of data is quite close to what expected

Advertisement…

The translation of the SVM-based system (TREMOrEC) from Matlab to Visual C++, to make it available to our collaboration and scientific community for validation, is completed



For more information, and to see a demo of TREMOrEC, join us today at poster A-05120!

Thank you