Classification strategy in machine learning predicting seasons duration in the chaotic Lorenz system

Eduardo L Brugnago[1*], Tony A Hild[1], Daniel Weingaertner[12], Marcus W Beims[12]
[1]Federal University of Paraná, [2]Max Planck Institute for the Physics of Complex System
*e-mail: elb@fisica.ufpr.br

1st Perspectives on Oscillation Control

Introduction

The chaotic Lorenz system [1], Eq. (1), has two regimes according to the variable x [2], as shown in Figure 1. We are interested in predicting seasons duration. Our goal is to turn a typical regression problem into a classification case. We label the seasons according to the amount of local extremes in the time series of the first variable, the relation between labels and durations is shown in Figure 2(a).

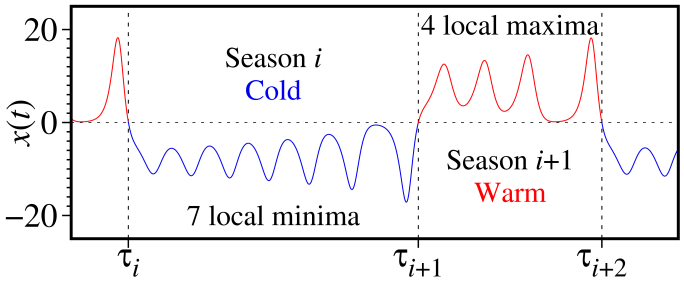

Figure 1: Time series of x in Lorenz system. Colors differentiate the seasons in Cold and Warm.

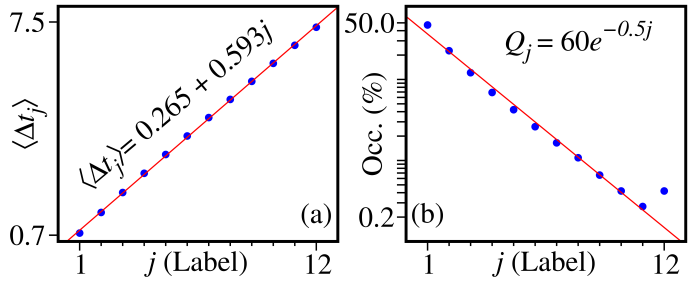

Figure 2: Statistical data on seasons. (a) Relationship between labels and average length of seasons. (b) Occurrence of each class. Label 12 gathers all seasons with more than 11 local extremes.

The chaotic Lorenz system:

$$\dot{x}=10(y-x);\quad \dot{y}=x(28-z)-y;\quad \dot{z}=xy-\frac{8}{3}z.\quad Eq.(1)$$

Methodology

We use artificial neural networks as classifiers [3]. Multilayer Perceptron (MLP) networks have been grouped into working ensembles [4]. MLPs with two hidden layers were made.

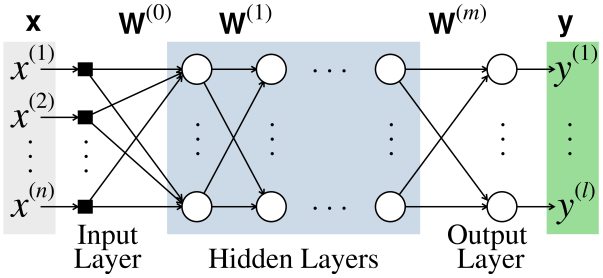

Figure 3: Scheme of a generic MLP.

The classifiable information is the pair:

$$\left(y(\tau_i), z(\tau_i)\right) \;\blacktriangleright\; j_{i+1}$$

The networks were trained with sets of 2500 examples randomly chosen, containing at least one representative from each class.

Results

To test the method, data were generated over 10^5 seasons and repeated 50 times the training and prediction cycle. The results in the Figure 4(a) are the ensemble averages.

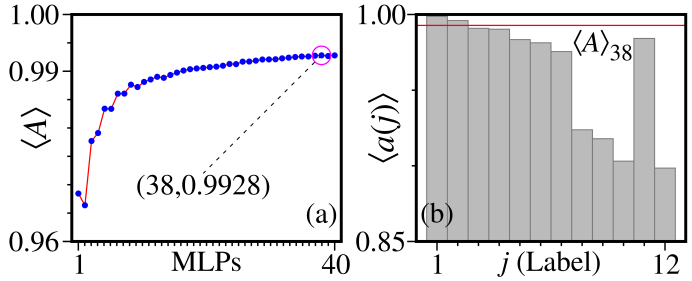

Figure 4: Classification success rate: (a) By amount of MLPs in ensemble; (b) For each class in the most successful ensemble (with 38 networks).

Best:

38 MLPs ⟶ 99.28%

Conclusions

Turning the regression problem into a classification case proved to be effective for predicting seasons duration.
The method is easy to apply and returns high level of accuracy in all classes, see Figure 4(b)

References

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[3] SB Kotsiantis et al. Emerging artificial intelligence applications in computer engineering (2007).
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Acknowledgment:

CNPq