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Analysis of the Multi-layer Perceptrons applied to solar flares forecasting

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Abstract

Space weather phenomena, like solar flares, can affect some terrestrial activities such as satellite communications, for example. For this reason, mechanisms to predict some of these phenomena are important. In this project we improved a prediction system using the artificial neural network model called Multi-layer Perceptron. The results were a more appropriate neural network configuration and more accurate documentation for the forecasting software.

Key words:

Space weather, Solar flares prediction, Multi-layer perceptrons.

Introduction

We call the phenomena that occur in the Sun and have effects on Earth as Space Weather. Among its effects on Earth, we can mention interruptions in cable and network telecommunications, disturbances in radio waves, interruptions in navigation systems and damages to satellites.

One of the phenomena, solar flares, release large amounts of energy and electromagnetic radiation in space. We classify Solar flares into five classes, according to the intensity of their brightness. However, only the explosions of class M and X cause major effects on Earth. For this reason, the prediction of these explosions is the focus of this project.

One mechanism used to predict these solar flares are the artificial neural networks (ANN), which uses machine-learning algorithms. An ANN is a system that simulates the human brain operation, which is learning through examples and generalizations. Technically, an ANN is an oriented graph, which has nodes - or neurons - connected by edges.

One of the ANN models is the Multi-layered Perceptron (MLP), which arranges the network nodes by dividing the input layer, the intermediate layers, and the output layer.

The objective of this project was to analyze and identify the best configuration for the MLP and to verify the relevance of the input dataset of the network, aiming at the improvement of a forecasting system developed by the High Performance Intelligent Decision Systems (HighPIDS) research group.

Results and Discussion

The forecasting system receives an input file with 18 attributes related to solar flares and generates an output file with error percentages for prediction of M and X class of explosions.

In order to comply with the project objectives, we defined a test methodology, divided into three fronts. For each configuration, we ran 15 repetitions and consolidated with an average and standard deviation calculation for further analysis.

In the first front, we try to determine the best training method for the MLP network and the optimal number of nodes in the neural network hidden layer. We considered the methods (i) *backpropagation*, (ii) *resilient propagation* and (iii) *simulated annealing*. We compared the

method (i) alone, with the combination of the method (i) and the method (iii); and with the combination of the method (ii) with the method (iii). The results pointed out that *backpropagation* was the best training method for the MLP network.

To define a better range of nodes in the hidden layer of the MLP, we plotted the number of nodes in each execution in a histogram. We defined as ideal the interval that presented the highest number of occurrences, between 20 and 30 nodes in the hidden layer.

The second front of tests referred to the time series window, aiming to determine the number of days of delay for the input file. We consider the interval between 1 and 10 days. The tests showed that 5 days of delay for data entry had the best results.

The third front corresponded to the choice of the most relevant input attributes for predicting solar explosions. From the literature, we defined 13 attributes as indicators of solar flares, reducing the initial value of 18 attributes.

Conclusions

From the results, we were able to define the best configuration for the MLP neural network, which was *Backpropagation* training method, with hidden node range of 20 to 30 nodes, using 5 days delay for the input file and with a set of 13 input attributes.

In addition, we did the analysis of the software to improve its documentation and make its use simpler for the user.

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