Prediction of sunspot behavior using machine learning techniques

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***Abstract*—The prediction of solar activity allows the study and pattern recognition of future solar and terrestrial events. In this work, we applied Machine Learning techniques to predict sunspot numbers based on solar activity. Results show a high potential of this processing that become a competitive approach for the sunspots prediction.**

***Index Terms*—Sunspot series, prediction, machine learning**

I. Background, Motivation and Objective

The Sun presents a complete cycle of 22 years, when the magnetic polarity changes affect the behavior and solar activity. Currently, most benchmarks to measure solar activity are based on the number of sunspots present on the sun at any time.

According to the literature, number of sunspots and solar activity are observed since the middle of XVII, and is highly correlated with life and activities on Earth, for example in areas such as Agriculture, Nature Systems and Telecommunications.

In this paper was proposed an approach do deal with the prediction of the number of sunspots using artificial intelligence. For this, were used machine learning techniques and different neural networks with neuron number variation, analyzing, in total, 73565 days registered by Solar Influences Data analysis Center (SIDC).

II. Statement of Contribution/Methods

Sunspots are recurrent, one way to analyze for to find possible patterns is by using a large database demanding higher computational time. For faster results, some computing and machine learning tools can be used, such as Radial Basis Function (RBF) and Extreme Learning Machine (ELM).

Radial Basis Function network (RBFN) is a neural network based on supervised learning a type of machine learning technique applied when the data set has defined labels, the inputs and outputs are known. In this type of architecture, there is only one intermediate layer, where the activation functions present higher dimensions.

Extreme learning machine network (ELMN) is a multilayer perceptron (MLP) with an intermediate layer with random weights. Thus, only weights in the output layer are tuned, demanding lower computational training time.

A hybrid approach using RBF and ELM techniques are implemented, with the objective to overcome their individual tests. The tool Matlab was used to developed, training and test in all the networks.

III. Results, Discussion and Conclusions

The neural network prediction performance was measured computing the root mean square error (RMSE) over ELM, RBF and the hybrid approach, and its best performance among all days is presented in the Table 1. The results from the hybrid model overcomes the others,the best RMSE of [**? ?**] using SIDC data without adaptation is 1.5900 compared with this approach 0.0883, adapted of 0.0078 MSE value, from ELM with RBF method.

TABLE I
ELM - RBF RMSE.

Neuron Quantity	Best
500	0.1459
1000	0.1044
1500	0.0979
2000	0.0883

References

[1] Safiullin, N., et al. Monthly sunspot numbers forecast with artificial neural network combined with dynamo model:comparison with modern methods. USBEREIT; pp. 199–202. IEEE. (2018).