Extreme Learning Machines for Dst forecasting

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Abstract: A globally averaged measure of the magnetic storm induced by the solar wind-magnetosphere coupling intensification, is usually characterized by the Dst index, constructed from mid-latitude ground stations. Intense storms, defined by Dst values below -100 nT, have been identified as the cause of extensive damage to many ground and space-based systems, and as such, their understanding is crucial to space weather studies [1]. Such effects include fluctuating
magnetic fields generated on the ground, which can destabilize electric power transmission systems. In space, changes in the magnetosphere can produce energetic particle fluxes that affect satellites, sometimes causing irreparable damage to the electronics on board. Here, we develop a forecasting approach based on an Extreme Learning Machine (ELM), testing different objective functions as well as direct and iterated schemes to forecast the Dst index, from Dst itself and Dst and solar wind parameters. Comparisons are made between iterated and multi-step model predictions. Particular importance is given to the error propagation with the length of the prediction with and without the use of solar wind parameters. The methods also provides an out-of-sample error estimation by following an ensemble of ELM fitted from the same and different training sets.

ELM approach

We take a sequential model, which is a linear stack of layers, containing densely-connected nodes equipped with a nonlinear activation function. We use data provided by OMNIWeb [2], from 1963 to the present day. What makes this approach interesting is that it does not need training, obtaining results comparable to deep dense neural networks.
In the figure we show a typical result, where we plot the expected versus the forecasted results.

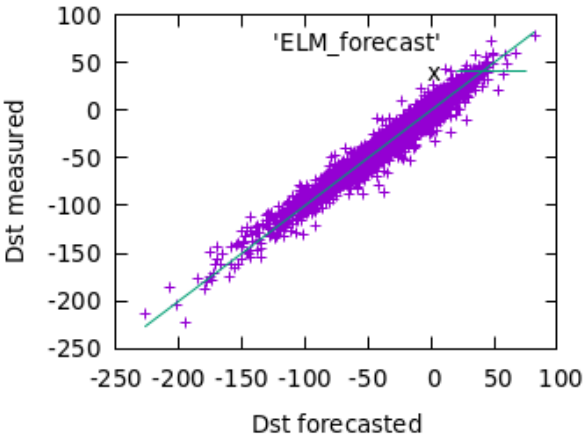

Figure: Dst forecast by an Extreme Learning Machine

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References:

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Session: The Solar wind

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