Using Artificial Neural Networks and Kolmogorov-Zurbenko Filtering to Predict Future Sunspot Numbers and Temperatures

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Coronal Mass Ejections alter space weather, causing geomagnetic storms, atmospheric density disruptions, and ionospheric turbulence, damaging over 2 trillion dollars of satellites and power grids. Predicting space weather through sunspot numbers (SNs) and temperatures can help mitigate risks posed by atmospheric fluctuations. Present predictive models require weeks and thousands of dollars to train on complex data sets, demanding the need for efficient and accurate deep learning models. This study closes the gap using univariate and multivariate Artificial Neural Networks (ANNs) trained on SN and temperature data sets. The training data went through Kolmogorov-Zurbenko (KZ) Filtering and was then passed into multivariate ANNs; comparing model efficiency based on step convergence indicated increased average ANN training efficiency (71.062%) while maintaining accuracy for SN (MSE = 0.003805) and temperature (MSE = 0.003854) predictions. Additionally, both SN (100 days) and temperature (200 days) models yielded reliable future predictions of atmospheric conditions. KZ Filtering, combined with Wavelet Analysis for optimal SN (3,281.7 days) and temperature (362 days) period detection, revealed hidden patterns in both data sets – consistent with literature regarding the Gleissberg Centennial Cycle and global warming. Subsequent ANN training using these hidden patterns resulted in accurate prediction of SNs (MSE = 0.002145) and temperatures (MSE = 0.008438) while demonstrating further average training efficiency increases (66.837%). This study novelly establishes that KZ filtering significantly reduces training data complexity, increasing average efficiency while maintaining high accuracy for a wide range of predictive models to understand and anticipate environmental trends.

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