DeepFlare: Solar Flare Forecasting and Active Region Monitoring Using Multi-Modal Machine Learning

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Solar flares are a major component of understanding solar weather. Geomagnetic storms resulting from solar flares can cause catastrophic damage to man-made satellites in space, disruption to GPS and radio signals, power grid issues, and significant damage to sensitive technologies on earth, particularly in regions closer to the poles. Solar flares originate from active regions, which are temporary areas on the surface of the sun that have much stronger magnetic fields than surrounding areas. Forecasting solar flares and understanding the characteristics of the sun's active regions is critical for anticipating such storms so that sensitive infrastructure can be protected, and for a greater understanding of solar flares to be developed. In this research, various multimodal machine learning architectures were constructed and then trained, validated, and tested for forecasting solar flares and predicting active region characteristics using both magnetograms and numerical active region features. After being trained, validated, tested, and compared, we identified the strongest model for solar flare forecasting and the strongest model for active region characteristic prediction, with both models achieving strong performance. This research helps earth to anticipate solar flares earlier, helping minimize damage to satellites and ground infrastructure. It also introduces the use of machine learning for active region monitoring through numerical characteristics, allowing for more research into the transition of active regions into solar flares to be conducted by astronomers.

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