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Translation of Ca II K images to construct century-old magnetograms using deep learning

Extending the record of solar activity is very important to improving our understanding of the origins and evolution of solar magnetism. To this end, we attempt to generate solar magnetograms using the valuable century-long Ca II K image database from the Kodaikanal Solar Observatory (KSO). We set up an image-to-image translation model using conditional Generative Adversarial Network (cGAN) to exploit the relationship between the chromospheric emission and the magnetic field strength to convert the KSO Ca II K images to the corresponding magnetograms observed from Michelson and Doppler Imager (MDI) onboard Solar and Heliospheric Observatory (SOHO) between 1996 - 2007. These reconstructions are found to have an accurate correspondence with the unsigned magnetograms from MDI/SOHO based on a pixel-to-pixel as well as total unsigned magnetic flux comparison. By nominally assigning polarities following Hale's law, we generate magnetograms between the past solar cycles over the period 1974 - 1993, and validate them by comparing them with the magnetograms from Kitt Peak Solar Observatory. Using the validated model, we assemble a database of the generated magnetograms between 1908 - 2008. We provide an assessment of the generated magnetograms by inspecting a derived sunspot number time series and the reconstructed butterfly diagram. We believe this century-long database can provide new insights into the long-term variability of the solar activity cycle.

Contribution Type

Theme

Solar Magnetism over Long-Time Scales

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