APPLICATION OF DEEP LEARNING TECHNIQUES IN SOLAR PHOTOSPHERE MODELING

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This proceedings paper summarizes the research on the application of deep learning techniques in modeling the solar photosphere. The study explores the challenges of precisely modeling the complex and variable photosphere and introduces generative adversarial networks as an innovative approach to capture physical structures without direct reliance on MHD equations.

Recent leaps in observational technology, catalyzed by milestones like cutting-edge space telescopes, have propelled our understanding of the universe. Confronted with atmospheric constraints, modern astronomical instrumentation and projects have tackled the challenge, despite significant expenses and intricate construction. In pursuit of nimble alternatives, current investigations delve into the fusion of artificial intelligence (AI), specifically leveraging deep learning techniques. Neural networks have demonstrated potency in diverse domains, from medical diagnostics and smart marketing to autonomous driving and secure data encryption.

Our work provides a comprehensive overview of research focused on applying deep learning techniques to model the solar photosphere, emphasizing the use of generative adversarial networks (GANs). We delve into the challenges associated with accurately representing the intricate and dynamic nature of the Sun's surface, introducing GANs as an innovative solution that doesn't rely directly on MHD equations. In particular, we are interested in exploring the use of deep learning techniques for generating solar photospheric structures based on numerical simulations from the MURaM code. With a specific use of Convolutional Neural Networks (CNNs) and GANs, the study aims to efficiently produce realistic images of complex solar phenomena. The primary objective is to develop GANs tailored for solar photosphere modeling. The methodology encompasses data collection from various solar instruments, with a detailed exploration of the proposed DCGAN (Deep Convolutional Generative Adversarial Network). This includes the 3D structure, training process, and physical implications, such as incorporating magnetic field divergence into the loss function. Multiple experimental runs are conducted to validate the proposed configurations and explore various physical conditions, resulting in visually appealing and physically accurate outcomes (Fig.1). The obtained results showcase remarkable performance, surpassing traditional methods and underscoring the potential of GANs in capturing intricate patterns within the solar photosphere. Quantitative validation metrics, visual representations, and comparisons with traditional methods further substantiate the robustness and superiority of the deep learning approach. The results highlight the computational efficiency of the models, suggesting practical implications for real-time solar observation and modeling.

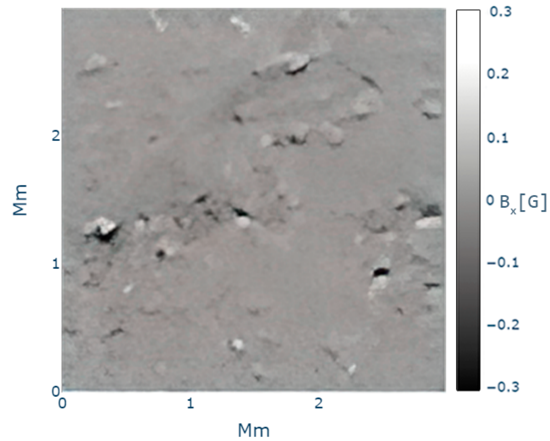

Fig. 1. Magnetogram of a magnetic field cube generated by the DCGAN, the activation functions of the network generate normalized magnetic field magnitudes ranging from -1 to 1 Gauss (rescaled to -0.3 to 0.3 Gauss in the figure).

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