Deep Learning-Based Denoising Autoencoders for Real-Time Wavefront Reconstruction in Adaptive Optics

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Adaptive Optics (AO) systems for large telescopes face significant wavefront measurement degradation due to noise, particularly when observing high-magnitude (faint) stars. To enhance wavefront reconstruction, we investigate the application of deep learning-based denoising autoencoders to suppress noise in AO sensor images.
We evaluate two autoencoder architectures: one based on convolutional layers and another using fully connected layers. Synthetic datasets were generated through AO simulations to assess model robustness under various turbulence conditions. Preliminary results indicate a significant improvement in the Strehl Ratio in simulations, attributed to enhanced noise filtering and more accurate wavefront estimation.
Performance optimization has also been a key focus, with GPU acceleration in a ROCm environment ensuring real-time execution. Future work will explore U-Net-based models and alternative architectures to further enhance the robustness and generalization of these methods to real-world observation conditions.

In the field of physics, relativity improved the science of elementary particles and their fundamental interactions, along with ushering in the nuclear age. With relativity, cosmology and astrophysics predicted extraordinary astronomical phenomena such as neutron stars, black holes, and gravitational waves……