Discovering Gravitationally Lensed Galaxies Using a Vision Transformer Image Classification Model Trained on Synthetic and Real Data

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Gravitational lenses are rare but significant phenomena in astronomy, where a foreground galaxy magnifies and distorts the light of a distant galaxy. Each lens enables the study of dark matter and early galaxies, and collectively they are an independent method of calculating the Hubble Constant. Yet only a fraction of lenses that are estimated to exist have been found. My goal is to build an image classification model to find lenses in archival telescope data. Unlike conventional searches that use Convolutional Neural Networks operating on supercomputer GPU clusters, I use a Vision Transformer model trained on both real and simulated lenses and non-lenses, requiring forty minutes on one Nvidia GPU. Taking advantage of the characteristic that lenses have an image of both the source and lensing galaxies, I predicted self-attention would optimize the ability of the model to distinguish true lenses from artifacts. To train the model, I developed astrophysical parameter distributions that generate synthetic lens images of different configuration/distortion types. The training set consists of lenses and non-lenses from the Dark Energy Survey, Sloan Digital Sky Survey(SDSS), and synthetic images. Training with only real images resulted in an F1 accuracy score of ~96% on a control test set. Adding synthetic images to the training set increased the accuracy to ~98%. Finally, I applied the trained model on 60,000 images from the SDSS and identified thirteen undiscovered lens candidates. I created a website for researchers to use my model and find lenses in their image data.

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