Proposal: Deep Regression Techniques for Decoding Dark Matter with Strong Gravitational Lensing

Background

The study of dark matter has been one of the most significant challenges in modern astrophysics. Dark matter is a form of matter that is invisible to telescopes, and its existence is inferred from its gravitational effects on visible matter. Strong gravitational lensing is a phenomenon where the gravity of a massive object, like a galaxy, bends the path of light from a background object, creating multiple images or distorted shapes. The shape of the lensed images contains information about the distribution of dark matter in the lensing galaxy. Decoding the information contained in the shapes of lensed images is a challenging problem that can be tackled with machine learning techniques.

Objectives

The objective of this project is to develop deep regression techniques to decode the shape of lensed images and infer the distribution of dark matter in the lensing galaxy. We aim to build a model that can accurately predict the mass distribution of the lensing galaxy from the observed shapes of lensed images. The project will contribute to the development of open-source code for machine learning-based searches for dark matter in astrophysics.

Technical - Components/Modules

The project will involve the following technical components/modules:

i) Data preprocessing: The first step is to preprocess the data, which involves cleaning the data, normalizing it, and dividing it into training, validation, and testing sets.

ii) Deep regression model: We will develop a deep regression model using a convolutional neural network (CNN) architecture. The model will take the observed shapes of lensed images as input and predict the mass distribution of the lensing galaxy.

iii) Model training and optimization: The model will be trained using the training set and optimized using the validation set. We will use appropriate regularization techniques to avoid overfitting.

iv) Model evaluation: The final step is to evaluate the performance of the model using the testing set. We will use appropriate metrics to evaluate the accuracy and precision of the model.

Timeline

The project will be divided into the following milestones:

i) Data preprocessing: 2 weeks ii) Model development: 6 weeks iii) Model training and optimization: 4 weeks iv) Model evaluation: 2 weeks

The total duration of the project is 14 weeks.

Evaluation

We will evaluate the success of the project based on the following criteria:

i) Accuracy: The accuracy of the model in predicting the mass distribution of the lensing galaxy from the observed shapes of lensed images.

ii) Precision: The precision of the model in estimating the uncertainties in the predicted mass distribution.

iii) Generalizability: The ability of the model to generalize to new datasets.

iv) Efficiency: The computational efficiency of the model.

v) Open-source contribution: The quality and impact of the open-source code contributed to the ML4SCI community.

In conclusion, this project aims to develop deep regression techniques to decode the distribution of dark matter in lensing galaxies using the observed shapes of lensed images. The project will contribute to the development of open-source code for machine learning-based searches for dark matter in astrophysics. We believe that this project aligns with the goals of ML4SCI, and we look forward to the opportunity to work with the ML4SCI community.