Updating the DeepLense Pipeline

Google Summer of Code 2022

➔ PERSONAL INFORMATION

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- Batch: 2019-2023
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➔ PROJECT DESCRIPTION

Strong gravitational lensing is a promising probe of the substructure of dark matter to better understand its underlying nature. Deep learning methods have the potential to accurately identify images containing substructure, and differentiate WIMP particle dark matter from other well motivated models, including vortex substructure of dark matter condensates and superfluids.

This project will focus on further development of the DeepLense pipeline that combines state-of-the-art deep learning models with strong lensing simulations based on lenstronomy. The focus of this project will be updating the previous results of DeepLense with our new dark matter simulations (e.g. WDM and SIDM).

➔ PRIMARY GOALS FOR THE PROJECT

- Understanding and getting familiar with already existing models in DeepLense pipeline like Deep Convolutional Autoencoder, Restricted Boltzmann Machine, etc.
- Planning and implementing features to update the existing models and improve their performance.

- Documenting the increase in performance on training and testing sets then monitor their usage on problems.

➔ TIMELINE

This project has a mentioned time of 175 hours over 12 weeks. But I am willing to provide as much time required beyond the given timeline.

17 May - 12 June: During the community bonding period I aim to familiarize myself with the mentors and their related works and engage with the community as well. I would also go through the existing DeepLense pipeline and PyAutoLens codebase to better understand them. I would also brush up on Dark Matter related research and read up on related theories and concepts again.

Week 1 - Week 3: During this period I will research the existing architectures in the pipeline and figure out points to improve them. Discuss these points with the mentors and get their opinion on them. Also research on the WDM and SIDM simulations in lenstronomy.

Week 3 - Week 6: During this period I will start coding on the improvements and implementing the upgraded features as discussed with the mentors. I will work closely with mentors and get their input and reviews on different stages of coding and development.

Week 6 - Week 9: During this period I will work on documenting the process of development and check the training and testing results of these upgraded models.

Week 9 - Week 12: During this period I will finalize my work and work closely with my mentors to review and improve the project to my best capabilities. Prepare for the final submission and do bug and error fixes if required.

Extended Period (20 September - 21 November): During the extended period I plan to monitor the performance of the model integrated in DeepLense and get feedback from the community on it. Keep communicating with the mentors to contribute to the model according to the feedback and be on the lookout for further avenues of contributions.

➔ POST GSOC

After the completion of my project I want to stay invested in this field and related research as my goal is to research and contribute something meaningful for advancement in Astrophysics and CS research. My dream is to help in the discovery of the Theory of Everything and if the results of research on dark matter prove to be in accordance with predictions of String theory then it can be a proof of concept and make its candidature for the Theory of Everything stronger. Even if I don't get selected for this project in GSOC I will keep working to find a way to contribute to Astrophysics research with CS through other avenues. And if I do then I will try to make the most of this opportunity to help advance my career towards my goal and be invested in it.

➔ REASON FOR MY INTEREST IN THIS PROJECT

I have been a fan of Physics since high school and have sustained that interest into my CS undergrad. I have been keeping up with it and have studied works of Brian Greene, Michio Kaku, Stephen Hawking, Roger Penrose, Kip Thorne, PJE Peebles and many more. I have a good understanding of the Standard Model, QED, QCD, CMB, Relativity which all are important for understanding what Dark Matter is. I can understand the physics behind the problem and can help model my deep learning solution around it. I can combine my knowledge in both fields to produce the optimal solution to this problem. Dark Matter and Dark Energy are two areas where advancement in research can help us further the gaps in the Standard Model and lead us one step closer towards the Theory of Everything.

➔ ABOUT ME

I am a third year student of Computer Science Engineering in Jadavpur University. I am passionate about Physics as well. I have experience in Machine Learning and Deep Learning focusing on computer vision. Recently I have been working on a research project for IEEE with a professor of my university to create a DL model to detect medical accidents and emergencies. Physics was my favorite subject since high school and I have kept up with studying it. I have in-depth knowledge about Standard Model, String Theory, Relativity and many more related astrophysics topics. I aim to contribute to Physics Research using my CS knowledge. I was motivated a lot by the EHT project and the CHIRP algorithm and hope to do something significant like that in my career.

➔ RELEVANT PAST EXPERIENCES

- Deep Learning model for Detecting Higgs Boson with the help of TPUs
- Vision Transformer for classification on the CIFAR-100 dataset
- Comparing performance of different CNN models like ResNet, VGG on MNIST dataset
- Deep Learning model to detect anomaly in regular behavior of people in medical accidents

➔ REFERENCES

- DeepLense_Slides_Pranath.pdf (cern.ch)
- GSoC 2020 with CERN-HSF | Dark Matter and Deep Learning | by Pranath Reddy | Towards Data Science
- [2112.12121] Domain Adaptation for Simulation-Based Dark Matter Searches Using Strong Gravitational Lensing (arxiv.org)