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Machine Learning for Science (ML4Sci)

Dear Mentors,

Proposal for Self-Supervised Learning for Strong Gravitational Lensing

I would like to express my ardent desire in contributing to the project Self-Supervised Learning for Strong Gravitational Lensing for Google Summer of Code (GSoC) 2023. The proposal consists of my brief introduction, and timeline with task breakdown.

I am pursuing MSc. Robotic Systems from RWTH Aachen University. I have completed multiple projects related to Computer Vision like Image Classification using Transformers, ResNets, and to Reinforcement Learning like Proximal Policy Optimization, Deep Q-Networks, and Policy Gradients, and hyperparameter tuning like Population-Based Training, ASHA using PyTorch and Ray-tune libraries. These projects along with other works can be found in the GitHub repositories: Reinforcement-Learning, Computer Vision, AutoML, and ExplainableAI.

Throughout my master's, I have gained professional experience in the domain of computer vision and software development. I worked as a student worker (part-time) in the Autonomous System Control Group at Siemens AG, Munich, Germany. I was mainly responsible for the perception of an Automated bin picking robot for different industrial parts. I improved an existing perception pipeline on 6D pose estimation, segmentation, and object detection for new parts. I automated the complete data prepossessing and training pipeline on AWS from synthetic data generation to model training using Blender, Docker, PyTorch, and Python with unit tests and CI/CD pipeline. Previously, I worked as a Robotics Software Engineering Intern at the BMW Group in the decision-making team of Logistic Robotics. I was mainly responsible for developing the behaviour design of the early-stage robot with State Machine (like Behaviour Trees) using Python, SMACH, and ROS. Our team successfully tested the state machine on simulation and deployed it on the real robot using Docker and Docker-Compose after rigorous testing.

I am a returning contributor to the organization Machine Learning for Science (ML4SCI) as I also contributed to Google Summer of Code (GSoC) 2022. I worked on the project "Transformers for Dark Matter Morphology with Strong Gravitational Lensing". The project focused on developing a framework to implement and benchmark different Vision Transformers on stimulated strong gravitational lensing images using PyTorch and Slurm on an HPC cluster with Wandb for logging. Thus, ten different Vision Transformers were selected after a thorough literature review and benchmarked to determine the best architecture for the classification of the simulated strong gravitational lensing images. Most of the vision transformers included convolutional layers in addition to the attention layers to leverage the advantages of both convolutions and attention mechanisms. Convolutional Vision Transformer (CvT) outperformed the other vision transformers based on the validation accuracy, AUC score, and confusion matrix. Code, pre-trained models, and example files are available in the DeepLense repository. It contains step-by-step instructions for installing the library, training the models from scratch, and evaluating the trained models. I also wrote a Medium Blog to explain the DeepLense project, overall work performed, results, and the lessons learned during GSoC 2022. I organized the blog in a way to inspire new contributors to the project along with some technical background on key topics such as transformers, and gravitational lensing etc. Even after GSoC 2022, I have regularly attend the weekly meetings and still maintain a professional relationships with the contributors and mentors.

What attracts me the most to GSoC and more importantly to ML4Sci organization is that the mentors and contributors are very helpful and approachable. I had learned a lot from working with them, and I want to continue developing my software development skills and sharing my ideas. The organization has a friendly and supportive culture, where everyone is welcome and valued. Moreover, I wish to join back ML4Sci because I feel passionate about their mission and vision. The organization is dedicated to leveraging modern approaches like Deep Learning for advancing scientific knowledge and solving humanity's big questions. Moreover, I would like to gain hands-on experience with Self-Supervised Learning along with transformers, hence, this project would be the right fit for my future research aspiration.

Lastly, I believe that with academic and practical knowledge in computer vision, and transformers along with open-source and professional experience, I would be able to contribute to the best of my ability at GSoC 2023. Thinking ahead, I would continue to contribute to the DeepLense repository and open-source community of ML4Sci with the lessons learned during the program.

Thank you for spending your valuable time on my letter. Please find attached the proposed timeline.

Yours sincerely,
Kartik Sachdev

Timeline

Milestones	Dates	Tasks details
Community Bonding period	May 04 - May 28	Discuss and finalize the implementation, tasks, and deliverables of the project with mentors
		Finalize the timeline of the project
Coding period (first half)	May 29 - July 03	Literature review on Self-Supervised Learning and Representation Learning e.g."Transformers in Vision: A Survey" and "A survey on Constrative Self-Supervised Learning"
		Setup of codebase in local system or cloud
		Integrate Self-Supervised Learning (SSL) using transformers with the existing codebase
		Testing SSL for image classification on the basis of accuracy, ROC curve, AUC, training time, generalizabilty etc.
		Comparing and benchmarking SSL for image classification with existing supervised learning techniques - ResNets, Transformers
Evaluation period preparation	July 04 - July 14	Incorporate feedback from mentors, Bug fixing + Performance improvements
		Preparing documentation for midterm evaluation submission
Coding period (second half)	July 14 - Aug. 06	Testing SSL for regression on the basis of MSE, training time, generalizabilty, adaptibility to new classes etc.
		Testing Representation learning on multiple tasks, datasets
		Comparing and benchmarking SSL for regression with existing supervised learning techniques - ResNets, Transformers
Evaluation period preparation	Aug. 07 - Aug. 21	Incorporate feedback from mentors, Bug fixing + Performance improvements
		Thorough testing and preparing example files
		Preparing documentation for final submission + writing blog
		Feedback from Mentors on the final codebase, documentation
Buffer period	Aug. 21 - Aug. 28	Accounting for last-minute changes in plan
		Final mentor evaluation
		Final submission