Thivyanth M V

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Research Projects

Improving Image-Text Alignment in Diffusion Models with Reinforcement Learning May 2024 - Jul 2024

Guide: Prof. Biplab Banerjee, Centre of Studies in Resources Engineering (CSRE)

- Conducted a detailed **literature review** on the use of **reinforcement learning (RL) for optimizing diffusion models**, specifically implementing the Denoising Diffusion Policy Optimization (DDPO) from *Training Diffusion Models with Reinforcement Learning*, enhancing image-text alignment using CLIP scores from *Fine-grained Image Captioning with CLIP Reward*.
- Developed and integrated the **DDPO algorithm** in PyTorch, **treating the sequence of denoising steps as a Markov Decision Process (MDP)**. Implemented **CLIP reward**, leveraging **image-text similarity scores** from a pretrained CLIP model to optimize image generation towards specific textual descriptions. Enabled **LoRA finetuning** for lesser memory usage.
- Employed Hugging Face's `transformers` for efficient model training; tailored the CLIP reward function to dynamically adjust training objectives, ensuring the **generation of images closely aligned with textual prompts**.
- Considering potential follow-up research to further explore and extend this methodology in the future. GitHub Repository: `thivyanth/ddpo`

Key Projects

The RoboDrive Challenge (ICRA 2024) Feb 2024 - Apr 2024

Competition Project — International Conference on Robotics and Automation (ICRA)

- Participated in the RoboDrive Challenge, focusing on **advanced multi-modal BEV 3D object detection**, addressing challenges posed by **corrupted sensor data** from cameras and LiDAR on the NuScenes dataset.
- Developed a **robust detection model** using a Modality-Agnostic Feature Sampler (MAFS) for unified multi-scale feature processing from cameras and LiDAR & a transformer-based decoder for precise iterative refinement of 3D detection outputs.
- **Secured 4th place** with scores of **42.8 (NDS)** and **26.4 (mAP)**, demonstrating the model's robustness to corruptions.
- **Got invited to present the team's findings and methodologies** at ICRA 2024, underscoring our innovative approach that integrates concepts from FUTR3D and BEVFusion, leading to advancements in sensor fusion and 3D detection.

Generalist Robotics Policy (GRP) Implementation Oct 2024

Self-Project — ML Implementation Project

- Implemented a **Generalist Robotics Policy (GRP) model** using **Vision Transformers** for multi-modal robotic control, integrating image, text, and goal image inputs to generate continuous action outputs. Programmed key components including **patch embedding**, **positional encoding**, and **multi-head attention mechanisms**, adapting Transformer architectures for robotics applications.
- Implemented a comprehensive training pipeline with **AdamW optimizer** and **MSE loss**, along with simulation-based testing. GitHub Repository: `thivyanth/grp`

Proximal Policy Optimization for Cart-Pole Balancing Jun 2024

Self-Project — ML Implementation Project

- Developed a robust reinforcement learning model using **Proximal Policy Optimization** (PPO) tailored for the **CartPole balancing problem**, focusing on advanced policy learning strategies.
- Engineered an agent using Python and PyTorch, integrating techniques such as **Generalized Advantage Estimation** (GAE) and **clip loss** to optimize performance and stability.
- Configured a vectorized training environment using **Gym** to facilitate **efficient and parallel simulations**, significantly improving the model's performance metrics.

Implementation of Kolmogorov-Arnold Neural Networks Jun 2024

Self-Project — ML Paper Implementation Project

- Implemented the Kolmogorov-Arnold Network (KAN) from a recent paper using PyTorch, enhancing model interpretability and computational efficiency on the **MNIST** dataset through advanced **spline functions for precise function approximation**.
- Optimized network training and convergence using the **AdamW optimizer and exponential learning rate decay**; visualized results through **confusion matrices** to demonstrate accuracy and effectiveness. GitHub Repository: `thivyanth/kan`

Ray Tune Optimization for DeepLabV3 Semantic Segmentation Jun 2024

Self-Project — ML Implementation Project

- Led the optimization of the **DeepLabV3 model** using **Ray Tune**, achieving significant accuracy and efficiency improvements by tuning hyperparameters such as learning rates, epochs, and class counts.
- Employed ASHAScheduler for **dynamic trial pruning** and **HyperOptSearch** for **guided Bayesian optimization**, resulting in a **40% reduction in computational resources** and documented performance gains, contributing to a robust and scalable semantic segmentation solution. GitHub Repository: `thivyanth/deeplabv3-raytune`

Smart Appliance IR Controller Mar 2024 - Apr 2024

Course Project: Digital Electronics and Microprocessor — Guide: Prof. Maniraj Malingam

- Developed a **Smart Appliance Infrared-Remote Controller** using Arduino and Arduino-based components.
- **Integrated 2 Arduino units** via Serial Communication protocol, enabling the storage of signals for over 5 different devices.
- Utilized the **HC-05 Bluetooth module** to enhance functionality by enabling **remote control** via a Bluetooth device.

Obstacle Removing Line Follower Robot Nov 2022 - Feb 2023

MS 101 Course Project — Guide: Prof(s). D.K. Sharma and Joseph John (Department of Electrical Engineering)

- **Designed and developed** a line follower robot using **Arduino**, **Fusion 360** for 3D modeling, **LaserCAD** for laser-cutting templates, and **Fractory** for 3D printing, integrating these with circuit design to enhance reliability.
- Achieved recognition as a top-performing team, placing among the **top 24 out of 120** and presenting our project.

Positions of Responsibility

Senior Engineer (Machine Learning & Localization Subsystem) Apr 2024 - Jul 2024
Unmesh Mashruwala Innovation Cell, IIT Bombay

- **Team Participation:** Part of AeRoVe, which competes in UAV competitions worldwide.
- **Technical Leadership:** Responsible for technical challenges in the ML subsystem, participating in ML challenges like RoboDrive (ICRA), Autonomous Grand Challenge (CVPR), Stranger Sections, Field Area Segmentation and more projects.
- **Recruitment Panel:** Served on a panel interviewing 20 students, selecting 2 for team membership in the subsystem.
- **Mentorship:** Guided 2 students through 5-week beginner projects, covering technical and non-technical aspects.

Education

2022 - 2026 Bachelor's Degree of Engineering Physics at **IIT Bombay**

Skills

Machine Learning	PyTorch, NumPy, TensorFlow, HuggingFace, WandB, Tensorboard, Transformers
Reinforcement Learning	TorchRL, Stable Baselines 3, OpenAI Gym, TRL - Transformer Reinforcement Learning
Computer Vision	TorchVision, MMCV, MMDet, MMSegmentation, MMDet3d, PCDet
Programming Languages	Python, HTML, CSS, JS, Bash
Tools and Platforms	Conda, Poetry, LaTeX, Git, Fusion 360, Linux, WSL, Docker, SSH

Key Courses Undertaken

CS & Robotics: Computer Programming and Utilisation, Makerspace, Artificial Intelligence and Data Science

Physics and Electronics: Quantum Physics I & II, Classical Mechanics, Analog Electronics, Digital Electronics & Microprocessors, Statistical Physics, Electromagnetic Theory, Non-linear Dynamics

Math: Calculus, Linear Algebra, Differential Equations, Complex Analysis and Integral Transform, Estimation on Lie Groups, Numerical Analysis, Analytical and Geometric Dynamics

Miscellaneous: Physical, Organic & Inorganic Chemistry, Biology, Economics, Environmental Studies, Physics of Biological Systems

Extracurriculars

- Participated in the National Sports Organization for **Weightlifting** for a year, showcasing my grit and fitness passion.