Thivyanth M V

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Research Projects

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

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**.
- Planning future research to apply this method for generating satellite images from text prompts, targeting advancements in geospatial analysis and environmental monitoring. Intent on publishing the outcomes. 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.

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`

Implementing Low-Rank Adaptation (LoRA) on Simple Neural Networks Apr 2024

Self-Project — ML Implementation Project

- Implemented the Low-Rank Adaptation (LoRA) technique, which strategically uses low-rank matrices to adjust the weights of neural networks, **significantly reducing the number of trainable parameters** and thus computational requirements.
- Demonstrated the technique's effectiveness on a neural network model for **the MNIST digit classification task**, showcasing its potential to maintain model performance with minimal computational resources. GitHub Repository: `thivyanth/lora`

Academic Assistance Chatbot Oct 2023

Machine Learning Project

- Developed a chatbot using the **Llama-2-7b-chat model** with an NLP pipeline for **data parsing, embedding, and retrieval, leveraging Hugging Face and Pinecone**.
- Conducted extensive testing and debugging to ensure accuracy and relevance of responses, integrating advanced model configurations and callback mechanisms.

University Network Auto-Login Browser Extension Feb 2024
Self-Project — Web Development Project
- Engineered and deployed a **Chrome extension** using JavaScript to **automate login** for the university's network, mitigating disconnections due to inactivity timeouts and enhancing user experience during idle or boot-up phases.
- Implemented **real-time monitoring and event-driven authentication scripts**, rigorously tested across various operating systems, **ensuring robust network connectivity and reducing user intervention**.
- GitHub Repository: `thivyanth/Auto-IITB-internet-login`

Created a Personal Website Hosted @ GitHub Apr 2024
Self-Project — Web Development Project
- Developed and managing a **Jekyll-based academic website**, integrating **GitHub Actions** for automated content updates and deployment, leveraging Jekyll collections for organized content management.
- Enhanced website interface and performance by customizing Jekyll themes and layouts, **improving site SEO** and user experience through optimized design and structured data. GitHub Repository: `thivyanth/thivyanth.github.io`

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.

SC651 Paper Review: LieGG Apr 2024
Academic Project under Prof(s). Ravi N Banavar
- Analyzed the paper "LieGG: Studying Learned Lie Group Generators" by Moskalev et al., focusing on the **methodology for extracting symmetries as generators of Lie groups**, and discussed the theoretical foundations and practical implications.
- Evaluated the robustness of neural networks and assessed the computational efficiency of the proposed method, providing critical insights into its strengths and limitations.

Comprehensive Business Analysis of Havells India Apr 2023 - May 2023
Strategic Management Insights — Guide: Prof. Ashish Pandey (Department of Shailesh J. Mehta School of Management)
- Analyzed Havells India's products and services placement in the **GE 3x3 matrix**, focusing on industry attractiveness and profit margin, with insights into organizational design, including stakeholder interactions with dealers, and vendors.
- Conducted a **SWOT analysis** to identify strengths, weaknesses, opportunities, and threats, complemented by a **TOWS matrix** to propose strategic actions, emphasizing Havells' differentiation strategy alongside cost leadership.

Positions of Responsibility

Senior Engineer (Machine Learning & Localization Subsystem) Apr 2024 - Present
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, Classical Mechanics, Analog Electronics, Digital Electronics & Microprocessors, Statistical Mechanics, Numerical Analysis

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

Miscellaneous: Physical, Organic & Inorganic Chemistry, Biology

Extracurriculars

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