SAI ANEESH SURYADEVARA

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Research Interests

Robot Learning, Reinforcement Learning, 3D Computer Vision, Embodied AI

Education

Indian Institute of Technology Bombay — Mumbai, India
*Bachelor of Technology in Mechanical Engineering with **Honors*** — *July 2019 – May 2023*

- Cumulative GPA: **9.02/10.0**
- Minor Degree in Artificial Intelligence and Data Science

Publications

1. R. Gondokaryono, M. Haiderbhai, **S. A. Suryadevara**, and L. A. Kahrs, **"Learning Nonprehensile Dynamic Manipulation: Sim2real Vision-based Policy with a Surgical Robot"**
IEEE Robotics and Automation Letters (RA-L), 2023

Research Experience

Control of Continuum Robots using Reinforcement Learning — *IIT Bombay*
*B.Tech Thesis, Guides: Prof. Abhishek Gupta and Prof. Kalyanakrishnan, **[Project Report]*** — *[Aug '22 - May '23]*

- Introduction: Investigated model-free reinforcement learning to train control policies for a continuum robot
- Developed a custom **OpenAI Gym** environment and integrated it with **VEGA FEM C++** middleware library and **ROS** to simulate more realistic dynamics of the mass-spring model, bridging the **sim2real** gap for RL training
- Implemented **Soft-Actor Critic** algorithm to learn optimal policy for the soft-robot to follow desired trajectories
- Engineered a **better reward function** by incorporating the **velocity** term which resulted in a **68%** improvement
- Designed a **Curriculum Learning** framework to follow complex trajectories while **minimizing the work** done

Deep Reinforcement Learning for Surgical Robot Manipulation — *University of Toronto, Canada*
*Mitacs Research Internship, Guide: Prof. Lueder Kahrs, **[Project Report]*** — *[May '22 - Jul '22]*

- Introduction: Vision-based Reinforcement Learning for autonomous manipulation of surgical robotic arm
- Implemented **Proximal Policy Optimization** (PPO) and **Generative Adversarial Imitation Learning** for training an arm of the dVRK robot in **Unity3D** to mimic human-like maneuvers with **only camera** input
- Designed **Curriculum Learning** architecture and tuned lesson parameters, enabling learning of complex tasks
- Developed **Domain Randomization** techniques and achieved **96.3% sim2real** success, enabling policies trained purely in simulation to transfer to the real dVRK robot for tasks like rolling cubes and soft-body ropes to goal

Decentralized Multi-Agent Patrolling using Q-Learning — *IIT Bombay*
*RnD Project, Guides: Prof. Arpita Sinha and Prof. Leena Vachhani, **[Code]*** — *[Dec '20 - Oct '21]*

- Introduction: Given a graph representation G(V,E) of the environment and a set of agents A, we wish to find an **optimal patrolling strategy** with minimal information sharing which minimizes average graph idleness
- Modelled the patrolling problem as a **Markov Decision Process** and designed appropriate reward functions
- Implemented **Q-Learning** and **Time Series Forecasting** (ARIMA & SES) to minimize average graph idleness
- Developed patrolling techniques and analyzed their performance using **ROS**, **TraCI** and **SUMO** simulator

Technical Skills

Programming Languages	C#, C, C++, Python, MATLAB
Machine Learning	PyTorch, TensorFlow, Keras, OpenAI Gym, Numpy, Pandas, Seaborn
Robotics & Computer Vision	ROS, Gazebo, OpenCV, CoppeliaSim
Simulation & CAD Software	Unity3D, MuJoCo, CARLA, COMSOL, SUMO, AutoCAD, SolidWorks

Key Technical Projects

Image-to-Image Translation using GAN | *GNR638: ML for Remote Sensing* | ***[Code]*** *Fall 2022*

- Implemented and compared the image generation capabilities of **Generative Adversarial Networks** (GANs) and **Variational Autoencoders** (VAEs) in PyTorch using a dataset of 17 different species of flowers.
- Increased the dataset size for GAN training for style transfer by applying position and colour **augmentation**.
- Implemented and compared the performance of **DiscoGAN** and **CycleGAN** architectures for style transfer

Statistical Solvers using Graph Neural Networks | *IE643 : Deep Learning* | ***[Report]*** *Fall 2022*

- Worked on a paper implementation to understand **Deep Graph Neural Networks** as a new class of solvers for **permutation-invariant** optimization problems that can be trained without a training set of sample solutions
- Replicated the results and obtained a correlation >**99.99%** with the state-of-the-art Newton Raphson method for a non-linear real world AC power flow computation problem, while **being 100X** faster due to GPU parallelism

Self-Driving Car | **University of Toronto** | *MOOC Project* | ***[Code]*** *Summer 2021*

- Built an **environment perception** stack, using a **Semantic Segmentation** neural network for lane estimation (**Encoder - Decoder**) and object detection to alert the car about the position and category of obstacles
- Developed a full **vehicle state estimator** using an error-state extended **Kalman filter** fuse inertial measurements from an IMU together with position measurements from a GNSS receiver and LIDAR

Stock Price Prediction: Sentiment Analysis and LSTM | **[Code]** *Spring 2022*

- Integrated CNN with **Word2Vec** (Skip-Gram) model to calculate sentiment index of the day using comments
- Implemented a **Long Short-Term Memory** (LSTM) model based on RNN architecture with **attention** mechanism and dropout, taking input : trend extracted by EMD, the historical data and the sentiment index
- Achieved **MAPE** of **1.65 %**, $R^2 >$ **0.97** with time delay of 2 days (predicted by 30-day historical data)

Music Genre Classification System | *DS303: Introduction to Machine Learning* | ***[Code]*** *Spring 2022*

- Extracted Mel-frequency Cepstral Coefficients **(MFCC)** from audio samples belonging to **10** music genres
- Compared the performance of K-Nearest Neighbors **(KNN)**, Random Forest, Support Vector Machine **(SVM)**, Convolutional Neural Network **(CNN)**, Long Short-Term Memory **(LSTM)** network for classification
- Achieved test accuracy of **90.1%** and **88.2%** using CNN and LSTM respectively using ADAM and CE loss

Modelling and Control of a Robotic Arm | *ME604: Robotics* | ***[Code]*** *Spring 2021*

- Modelled a **6-axis robot arm** using **DH** parameters in **MATLAB** and solved for position kinematics
- Designed a **motion planner** that generates a **joint-space trajectory** to move the end-effector to the goal

Technical Competitions

Autonomous Multi-Agent Package Sorting System | **[Code]** *[Aug '21 - Feb '22]*

Team Lead of 10 Membered team | *National Semi-Finalists* | *Flipkart GRiD 3.0 - Robotics Challenge*

- Developed a system of mobile bots capable of autonomous package sorting using **ROS** and **OpenCV** framework
- Built a navigation system using a central image processing unit, tracking each bot's pose through **ArUco** markers
- Engineered a **multi-robot** collision-free **path planner** implementing Conflict-Based Search **(CBS)** algorithm
- Implemented **Space-Time A*** search algorithm with an additional time dimension to deal with dynamic obstacles

Autonomous Delivery Drone System | **[Code]** *[Sep '20 - Mar '21]*

Team Lead | *Vitarana Drone* | *e -Yantra Robotics Competition*

- Simulated a working prototype of an autonomous drone delivery system for package delivery during Covid-19
- Designed **attitude and position** (PID) controllers in **ROS** to control the drone's pose in **Gazebo** simulator
- Implemented **A* algorithm** for path planning and obstacle avoidance in an unknown environment
- Built a Local Binary Pattern (LBP) **Cascade classifier** to detect the landing markers for package delivery

Image to Speech Converter for Visually Impaired | **[Code]** *[Apr '20 - Jun '20]*

- Implemented **MSER** algorithm to extract text from an image in an **unstructured** environment
- Built a **Convolutional Neural Network** using **TensorFlow**, trained it to identify the text extracted
- Included a **Tesseract OCR** model for structured environment and used a **Text-to-Speech** module to read aloud

Scholastic Achievements

- Selected for the **MITACS Globalink** Internship Program at **University of Toronto**, Canada (2022)
- Awarded **AP grade** for exceptional performance in Introduction to **Machine Learning** (top 2%) (2022)
- Secured **All India Rank 949** in **IIT-JEE Advanced** entrance exam out of **160,000** candidates (2019)
- Achieved a percentile of **99.91** in **JEE Main** entrance exam out of **1.1 million** students (2019)
- Admitted to pursue **B.E** in **Aerospace Engineering** from **NTU Singapore** (QS Rank 12) (2019)

Positions of Responsibility

Convener | Electronics and Robotics Club | Institute Technical Council *[Jun '20 - May '21]*

15-member team promoting tech culture amongst 1000+ freshmen

- Organized and spoke at numerous workshops and bootcamps ranging from **Robot Design**, **Arduino**, **Image Processing**, Forward & Inverse Kinematics, and **Control Theory** attended by **150**+ students
- Planned and executed an **institute level technical championship**, in a virtual world modelling the campus
- Contributed to **ERC Wiki** and authored articles on **Path Planning Algorithms :** A*, RRTs, APFs & PRMs

Junior Propulsion Engineer | Team Veloce Hyperloop IITB *[Jan '20 - May '21]*

A student technical team developing a working Hyperloop pod prototype

- Worked on the development of **Linear Induction Motor** as the principal propulsion mechanism
- Optimized the thrust as well as lift production using **COMSOL** simulator over a large range of speeds
- Finalists (**Top 5** teams internationally) in Desert Hyperloop competition organized by the Arizona State University

Key Coursework

AI & ML	Introduction to Machine Learning, Programming for Data Science, Statistical Machine Learning and Data Mining, Deep Learning: Theory and Practice, Deep Learning for Remote Sensing, Data Processing in Remote Sensing, Multiscale Materials Informatics, Distributed Optimization and Machine Learning
CS & Math	Computer Programming and Utilization, Calculus, Linear Algebra, Introduction to Numerical Analysis, Statistics and Probability for Materials Engineers
Robotics & Control	Robotics, Microprocessor and Automatic Controls, Linear and Nonlinear systems, Signals and Feedback Systems, Mathematical Structures for Control, Kinematics & Dynamics of Machines, Machine Design
Certifications (MOOCs)	ROS: Localization, Navigation and SLAM, Mastering Data Structures & Algorithms using C and C++ (Udemy), Algorithmic Toolbox (UC San Diego), Neural Networks and Deep Learning (Deeplearning.ai), Introduction to TensorFlow (Deeplearning.ai), Fundamentals of Reinforcement Learning (University of Alberta), Deep Reinforcement Learning, Self Driving Car Specialization (University of Toronto)

References

Prof. Lueder Kahrs
Assistant Professor
University of Toronto, Canada

Prof. Arpita Sinha
Professor
IIT Bombay, India

Prof. Biplab Banerjee
Associate Professor
IIT Bombay, India

Prof. Leena Vachhani
Professor
IIT Bombay, India

Prof. Abhishek Gupta
Assistant Professor
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