Aravind Venugopal

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EDUCATION

Carnegie Mellon University Pittsburgh, PA, USA
M.S. in Machine Learning *Grad. Dec. 2023, CGPA: 4.11/4*

BITS Pilani K. K. Birla Goa Campus Goa, India
B.E. (Hons) in C.S. and M.Sc. (Hons) in Economics *Grad. Aug. 2020, CGPA : 8.53/10 (85.3%)*

Loyola School Trivandrum, India
Indian School Certificate (ISC), 12th Grade *Grad. May 2015, 97.2%*

EXPERIENCE

Graduate Researcher Aug. 2022 - Present
Carnegie Mellon University | Advisors: Prof. Fei Fang, Prof. Jeff Schneider *Pittsburgh, PA*
- Developed a hierarchical latent variable model, Multi-Agent Bi-Level Model (MABL) for multi-agent RL.
- Extended MABL to learn temporally abstracted action and state sequence representations for RL.
- Working on Denoising Probabilistic Diffusion Models to learn stochastic dynamics from real-world, offline RL data.

Machine Learning Intern May. 2023 - Aug. 2023
Blue River Technology, L.L.C, Manager: Ben Cline *Santa Clara, CA*
- Designed a real-time 3D Transformer framework for object detection on autonomous tractors in the field.
- Constructed large-scale pseudo-label datasets and pipelines applying classical computer vision.

Post Baccalaureate Research Fellow Aug. 2020 - June 2022
RBCDSAI, Indian Institute of Technology | Advisor: Prof. Balaraman Ravindran *Madras, India*
- Developed, CombSGPO, which uses game theory and RL to combat wildlife poaching.
- Developed an RL approach for empirical comparison with evolutionary algorithms in Green Security Games (GSGs), collaborating with Prof. Jacek Mańdziuk.
- Developed an optimization framework to achieve robust equilibrium performance in Markov games.

Research Intern Feb. 2020 - Aug. 2020
RBCDSAI, Indian Institute of Technology | Advisor: Prof. Balaraman Ravindran *Madras, India*
- Develop an RL algorithm for resource allocation in GSGs using contextual, combinatorial multi-armed bandits.
- Worked on optimizing defender patrolling strategies in GSGs, using Neural Fictitious Self Play.

Research Intern (Thesis) Sept. 2019 - Feb. 2020
Robotics Insitute, Carnegie Mellon University | Advisor: Prof. Cameron Riviere *Pittsburgh, PA*
- Developed a real-time virtual fixture strategy for Micron, a handheld surgical robotic tool, to avoid blood vessels during neurosurgery and conducted real-world trials.

Research Intern July 2019 - Sept. 2019
NearLab, Politecnico di Milano | Advisor: Prof. Elena De Momi *Milan, Italy*
- Worked towards vessel avoidance using Micron by implementing accurate and fast deep-learning algorithms for real-time, intra-operative blood vessel segmentation.

RESEARCH PROJECTS

Diffusion Models for RL-based Tokamak Control
Advisor: Prof. Jeff Schneider
- Developing approaches based on diffusion models accurately learn noisy and stochastic plasma dynamics from real offline Tokamak data.
- Exploring the use of diffusion models as generalizable planners to create robust policies capable of out-of-distribution generalization.

Latent Variable Models for Multi-Agent Reinforcement Learning
Advisors: Prof. Fei Fang, Prof. Balaraman Ravindran
- Developed a latent variable world model for MARL, LaVa, in collaboration with Prof. Elizabeth Bondi, with potential applications to real-world scenarios (**paper**).
- Developed a scalable hierarchical latent-variable model, MABL, that disentangles agent-centric and global information, respectively, from multi-agent trajectories (**paper**).
- Exploring temporally abstract hierarchical models to use as representation learners for hierarchical RL.

Optimization for N-player Games
Advisor: Prof. Balaraman Ravindran
- Developed and implemented an actor-critic algorithm that provably converges to SSE, collaborating with Prof. Elizabeth Bondi and Prof. Fei Fang.
- Evaluated the algorithm empirically on Stackelberg games and showed improved sample efficiency and rate of convergence.
- Derived and implemented a framework that uses pair-wise bilinear approximations of objectives to solve for NE in fully cooperative Markov games.

Reinforcement Learning for Unified Allocation and Patrolling in Green Security Games
Advisor: Prof. Balaraman Ravindran
- Developed Combined Security Game Policy Optimization (CombSGPO), combining defender strategies for resource allocation and patrolling in GSGs, collaborating with Elizabeth Bondi and Prof. Milind Tambe (**paper**).
- Achieved **3x** better utility and **2.5x** better scalability than state-of-the-art RL and MILP-based approaches.
- CombSGPO uses action representation learning, competitive optimization and MARL. It has applications to combat wildlife poaching, illegal logging, illegal fishing etc. (**code**)

Real-time 3D Object Detection with Visual Transformers
Advisor: Ben Cline
- Developed a transformer-based 3D object detection model to detect stopclass objects for autonomous tractors.
- Developed all stages of the 3D model pipeline from 3D dataset creation, camera calibration and 3D labelling workflows to model training, modification and evaluation.
- Achieved 3D bounding box prediction with a median error of **40 cm** at **25 fps**.

Real-time Segmentation for Vessel Avoidance with Surgical Robot
Advisors: Prof. Cameron Riviere and Prof. Elena De Momi
- Developed an algorithm integrating real-time segmentation and real-time 3D reconstruction of a blood vessel with a virtual-fixture-based control strategy. (**paper**)
- Built segmentation datasets of intra-operative neurosurgery images for training and evaluation.
- Used the control strategy for real-time vessel avoidance by interfacing with Micron, a surgical robot, and conducted real-world trials.
- Achieved vessel avoidance at **33.3 fps** enabling safe operation at up to **400 μm** near a vessel. (**code** | **data**)

Undergraduate Projects
- Visual Question Answering on CLEVR dataset using Stacked Attention Networks (SANs). (**code**)
- Locomotion tasks with Turtlebot3 robots using ROS. (**code**)
- Predicting Party Behavior in 2019 Indian Parliamentary Elections from electoral data using game theory and machine learning. (**report**)

PUBLICATIONS

Aravind Venugopal, Stephanie Milani, Fei Fang and Balaraman Ravindran. **Bi-level Latent Variable Model for Sample-Efficient Multi-Agent Reinforcement Learning.** (*under review, AAMAS 2024*). (**paper**)

Aravind Venugopal, Elizabeth Bondi, Fei Fang and Balaraman Ravindran. **LaVa: Latent Variable Models for Sample Efficient Multi-Agent Reinforcement Learning**. In *RLDM*, June 2022. (**paper**)

Adam Zychowski, Jacek Mańdziuk, Elizabeth Bondi, Aravind Venugopal, Milind Tambe and Balaraman Ravindran. **Evolutionary Approach to Security Games with Signaling**. In *IJCAI-ECAI*, July 2022. (**paper**)

Aravind Venugopal, Sara Moccia, Arpita Routray, Simone Foti, Elena De Momi and Cameron N. Riviere. **Real-time vessel segmentation and reconstruction for virtual fixtures for an active handheld microneurosurgical instrument**. In *International Journal of Computer Assisted Radiology and Surgery*, 2022. (**paper**)

Aravind Venugopal, Elizabeth Bondi, Harshavardhan Kamarthi, Keval Dholakia, Balaraman Ravindran and Milind Tambe. **Reinforcement Learning for Unified Allocation and Patrolling in Signaling Games with Uncertainty**. In *AAMAS*, May 2021. (**paper**, **media**)

<u>Aravind Venugopal</u>, Sara Moccia, Arpita Routray, Simone Foti, Elena De Momi and Cameron N. Riviere. **Real-time Compensation of Handheld Surgical Robotic Tool for Safer Neurosurgery**. In *Workshop on "Integrating Sensor Fusion and Perception for Human-robot Interaction" at IEEE RO-MAN*, September 2020. (**paper**)

Technical Skills

Languages: Python, C++

Tools and Frameworks: PyTorch, Tensorflow, ROS, Visual Studio, Git

Relevant Coursework (Masters) Reinforcement Learning (10703), Probabilistic Graphical Models (10708), Computer Vision (16720), Convex Optimization (10725), Probability and Mathematical Statistics (36700), Advanced Introduction to Machine Learning (10715), Machine Learning in Practice (10718)

Relevant Coursework (Undergrad): Probability and Statistics, Econometrics, Machine Learning, Neural Networks and Fuzzy Logic, Logic in Computer Science, Artifical Intelligence, Reinforcement Learning, Data Structures and Algorithms, Object Oriented Programming

Teaching and Extra-Curriculars

Teaching Assistant   Aug. 2022 - Dec 2022
Carnegie Mellon University   *Pittsburgh, PA*
- Teaching Assistant for Exec. Education, 17759: Advanced Topics in ML and Game Theory, taught by Prof. Fei Fang

Teaching Assistant   Jan. 2022 - May 2022
Indian Institute of Technology   *Madras, India*
- Teaching Assistant for CS 6700: Reinforcement Learning, taught by Prof. Balaraman Ravindran

Operations Head   Oct. 2017
Waves   *Goa, India*
- Led a 3-tier team of 50+ volunteers to organize 25+ events at Waves, a national level inter-collegiate competition organized by BITS Pilani, Goa.

Registered Player, Division I League   Sept.2016 - Sept. 2020
Goa Football Association   *Goa, India*
- Registered player contract in Division I Goa Football League under the purview of GFA - Goa Football Association.

Academic Services

Subreviewer: AAMAS 2024

Merits

2011: National Talent Search Scholar (0.5% acceptance out of over 1,000,000)

2015: Innovation in Science Pursuit for Inspired Research Scholar(top 1% nationally in ISC, 12th grade)

Test Scores

GRE: 337 (Q: 169, V:168, W: 5.0)

IELTS: 8.5/9