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

Machine Learning Intern — May. 2023 - Present
Blue River Technology, L.L.C, Manager: Ben Cline — *Santa Clara, CA*

- Designed a transformer-based 3D deep learning framework from scratch for Bird's Eye View (BEV) detection of objects of interests from multi-view images.
- Developed all stages of the 3D model pipeline from 3D dataset creation, camera calibration and 3D labelling workflows to model training, modification and evaluation.

Graduate Researcher — Aug. 2022 - Present
Carnegie Mellon University | Advisor: Prof. Fei Fang — *Pittsburgh, PA*

- Developed a hierarchical world model for Multi-Agent Reinforcement Learning (MARL) which is currently the state-of-the-art MARL algorithm in sample efficiency.
- Currently developing an action representation learning framework for MARL with the eventual aim of real-world deployment. Initial results show improvements over the state-of-the-art.

Post Baccalaureate Research Fellow — Aug. 2020 - June 2022
RBCDSAI, Indian Institute of Technology | Advisor: Prof. Balaraman Ravindran — *Madras, India*

- Developed an optimization framework to solve for Strong Stackelberg Equilibria (SSE) and Nash Equilibria (NE) in Markov games.
- Developed a RL approach for empirical comparison with evolutionary algorithms in Green Security Games (GSGs) with signaling, collaborating with Prof. Jacek Mańdziuk.
- Developed an algorithm, CombSGPO, which uses game theory and RL to combat wildlife poaching.

Research Intern — Feb. 2020 - Aug. 2020
RBCDSAI, Indian Institute of Technology | Advisor: Prof. Balaraman Ravindran — *Madras, India*

- Worked on RL for resource allocation in GSGs using contextual, combinatorial multi-armed bandits.
- Worked on optimizing defender patrolling strategies in GSGs, exploring game-theoretic MARL algorithms such as NFSP, PSRO etc.

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.

Projects

Generative Models for Reinforcement Learning
Advisors: Prof. Fei Fang, Prof. Balaraman Ravindran

- Developed a latent variable world model for MARL, in collaboration with Prof. Elizabeth Bondi, with potential applications to real-world scenarios (**paper**).
- Developed a scalable hierarchical latent-variable model that disentangles agent-centric and global information, respectively, from multi-agent trajectories (**paper**).
- Currently exploring approaches to improve robustness and generalizability of world models, experimenting with successor representations and hierarchical RL .

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 using PyTorch, LibTorch and C++ (**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**)

Multi-Agent 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**).
- CombSGPO uses action representation learning, competitive optimization and MARL. It has applications to combat wildlife poaching, illegal logging, illegal fishing etc. (**code**)

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**. (**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**)

Aravind Venugopal, 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)

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, Design and Analysis of Algorithms, Object Oriented Programming

Teaching and Others

Teaching Assistant Aug. 2022 - Present
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.

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