Anirudh Vemula

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RESEARCH STATEMENT

I am passionate about making robots work in the wild. This involves bringing robots from structured lab environments out into homes, offices, and disaster sites. To achieve this, we need to tackle issues of robustness and reliability in current planning and control methods. My research focuses on developing algorithms with provable guarantees on the robot completing the task without assuming extensive knowledge about the environment it is operating in. These algorithms have the unique capability of quickly adapting to new scenarios by learning from experience, while using structured priors in the form of inaccurate models to reduce the amount of experience needed. I am particularly interested in robotic applications that involve articulated manipulation and agile locomotion, for which we can obtain at best partial models that are informative but not accurate enough to reflect the complexity of the real world.

EXPERIENCE

Apr 2022 - Present   **Aurora Innovation, Pittsburgh, USA**
Senior Software Engineer
Manager: Arun Venkatraman
Description: Building the motion planning and machine learning software stack for the autonomous vehicle

May 2021 - August 2021   **Special Projects Group, Apple, Cupertino, USA**
PhD Intern
Manager: Martin Levihn
Description: Developed advanced robot motion planning algorithms for problems with complex constraints. Conceptualized a novel algorithmic solution that was deployed on a hardware system

May 2019 - August 2019   **Intelligent Systems Lab, Intel, Santa Clara, USA**
PhD Research Intern
Advisors: Vladlen Koltun, Ozan Sener
Description: Worked on scaling derivative-free optimization techniques to high dimensions for model-free reinforcement learning

August 2017 - March 2019   **National Robotics Engineering Center, Pittsburgh, USA**
Graduate Research Assistant
Advisor: Oren Salzman
Description: Developed motion planning and sequential decision making software for a large scale truck unloading robot

EDUCATION

September 2017 - Feb 2022   **Carnegie Mellon University, Pittsburgh, USA**
PhD in Robotics
Advisors: Maxim Likhachev, Drew Bagnell
Thesis: Planning and Execution using Inaccurate Models with Provable Guarantees on Task Completeness

August 2015 - August 2017   **Carnegie Mellon University, Pittsburgh, USA**
M.S in Robotics
Advisors: Jean Oh, Katharina Muelling
Thesis: Safe and Efficient Navigation in Dynamic Environments

July 2011 - May 2015   **IIT Bombay, Mumbai, India**
B.Tech in Computer Science and Engineering (*with honors*)

AWARDS AND FELLOWSHIPS

- Received the **CMU Presidential Fellowship 2019** to support tuition and stipend for one year of graduate education
- Received the **Best Paper Award in Cognitive Robotics** at the International Conference on Robotics and Automation (ICRA) 2018
- Received the **Centre for Learning Systems PhD fellowship 2017** for doctoral studies at ETH Zurich
- **Gold Medal** in the selection camp of the *International Physics Olympiad* for being ranked in the Top 35 of India
- **Gold Medal** in the selection camp of the *International Chemistry Olympiad* for being ranked in the Top 35 of India
- **Best Independent Research Project** for my undergraduate research on genetic algorithms for stochastic optimization

- **KVPY Scholarship**, instituted by Department of Science and Technology, Govt. of India
- **MCM Scholarship**, awarded by IIT Bombay to fund undergraduate tuition

PROJECTS AND PUBLICATIONS

- **Planning and Execution using Inaccurate Models with Provable Guarantees** *(PhD Thesis)*

  ⋆ Developed algorithms for robotic planning that provably guarantee that the robot completes the task despite using an inaccurate model

  ⋆ PUBLICATIONS:

  ∗ On the Effectiveness of Iterative Learning Control. Anirudh Vemula, Wen Sun, Maxim Likhachev, J. Andrew Bagnell. *Proceedings of the 4th annual conference on Learning for Dynamics and Control (L4DC).* 2022

  ∗ CMAX++ : Leveraging Experience in Planning and Execution using Inaccurate Models. Anirudh Vemula, J. Andrew Bagnell, Maxim Likhachev. *Proceedings of the AAAI conference on Artificial Intelligence (AAAI).* 2021

  ∗ Planning and Execution using Inaccurate Models with Provable Guarantees. Anirudh Vemula, Yash Oza, J. Andrew Bagnell, Maxim Likhachev. *Proceedings of Robotics: Science and Systems (RSS).* 2020

- **Fast Trajectory Optimization for Optimal Control in Complex Robotic Tasks**

  ⋆ Formulate trajectory optimization as a dynamic game and use game-theoretic techniques to obtain fast convergence

  ⋆ PUBLICATIONS:

  ∗ TRON: A Fast Solver for Trajectory Optimization with Non-Smooth Cost Functions. Anirudh Vemula, J. Andrew Bagnell. *Proceedings of the IEEE Conference on Decision and Control (CDC).* 2020

- **Planning and Sequential Decision Making for a Large Scale Truck Unloading Robot**

  ⋆ Improve throughput of a truck unloading robot by learning a high-level policy to switch between planned strategies

  ⋆ PUBLICATIONS:

  ∗ Planning, Learning and Reasoning Framework for Robot Truck Unloading. Fahad Islam*, Anirudh Vemula*, Sung-Kyun Kim, Andrew Dornbush, Oren Salzman, Maxim Likhachev. *Proceedings of the International Conference on Robotics and Automation (ICRA).* 2020

- **Imitation Learning from Observations Alone**

  ⋆ Enable robots to imitate experts purely from observation with no access to expert's actions

  ⋆ PUBLICATIONS:

  ∗ Provably Efficient Imitation Learning from Observation Alone. Wen Sun, Anirudh Vemula, Byron Boots, J. Andrew Bagnell. *Proceedings of the International Conference on Machine Learning (ICML).* 2019 (**Oral Presentation**)

- **Sample Complexity of Exploration in Model-Free Reinforcement Learning**

  ⋆ Establish upper bounds on the sample complexity required to obtain near-optimal policy using model-free techniques

  ⋆ PUBLICATIONS:

  ∗ Contrasting Exploration in Parameter and Action Space: A Zeroth-order Optimization Perspective. Anirudh Vemula, Wen Sun, J. Andrew Bagnell. *Proceedings of the International Conference on Artificial Intelligence and Statistics (AISTATS).* 2019

- **Social Robot Navigation in Dense Human Crowds** *(Masters Thesis)*

  ⋆ Develop algorithms to enable mobile robots to safely, efficiently, and socially navigate in dense human crowds

  ⋆ PUBLICATIONS:

  ∗ Social Attention: Modeling Attention in Human Crowds. Anirudh Vemula, Katharina Muelling, Jean Oh. *Proceedings of the International Conference on Robotics and Automation (ICRA).* 2018 (**Best Paper Award Winner in Cognitive Robotics**)

  ∗ Modeling Cooperative Navigation in Dense Human Crowds. Anirudh Vemula, Katharina Muelling, Jean Oh. *Proceedings of the International Conference on Robotics and Automation (ICRA).* 2017

  ∗ Path Planning in Dynamic Environments with Adaptive Dimensionality. Anirudh Vemula, Katharina Muelling, Jean Oh. *Proceedings of the International Symposium on Combinatorial Search (SoCS).* 2016

SCHOLASTIC ACHIEVEMENTS

- Secured **All India Rank 78** in IIT-JEE 2011, among 500,000 candidates
- Secured **All India Rank 42** (**State Rank 9**) in AIEEE 2011, among 1.1 million candidates
- Certified as among **Top 1%** (300 students) in India, to appear for the **Indian National Astronomy Olympiad**
- Graduated with **Honors** in Computer Science, IIT Bombay