Adithya Ramesh

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Website | Github | LinkedIn

Education

- **Indian Institute of Technology Madras** Chennai, India
  Dual Degree (B.Tech, M.Tech) in Engineering Design *Aug 2011 - Jun 2016*
  Major in Automotive Engineering, Minor in Systems Engineering
  CGPA (Cumulative Grade Point Average) : 8.30/10.0

Professional Experience

- **Robert Bosch Centre for Data Science and Artificial Intelligence, IIT Madras** Chennai, India
  Research Fellow *Oct 2021 - Present*

  - Physics-Informed Model-Based Reinforcement Learning for Robotics

  Research Guide : Prof. Balaraman Ravindran, Department of Computer Science and Engineering, IIT Madras

  - Improved the performance of model-based RL in robotics tasks through inductive biases based on the underlying physics.

  - Considered robotic systems undergoing rigid body motion without contacts. Utilized the structure of rigid body dynamics to learn a Lagrangian / Hamiltonian Neural Network. Used the learnt dynamics model to generate imaginary trajectories. Backpropagated through the imaginary trajectories to update the policy.

  - Our physics-informed model-based RL approach achieves better average-return and sample efficiency than standard model-based RL, as well as state-of-the-art model-free RL approaches, in challenging robotics environments with underactuation and high inherent sensitivity to initial conditions.

  - Our work has resulted in a few publications so far,
    * Adithya Ramesh and Balaraman Ravindran. Lagrangian Model Based Reinforcement Learning. Deep Reinforcement Learning Workshop, NeurIPS 2022. Accepted.
    * Adithya Ramesh and Balaraman Ravindran. Hamiltonian Model Based Reinforcement Learning for Robotics. The Multi-disciplinary Conference on Reinforcement Learning and Decision Making (RLDM), 2022. Accepted.
    * Adithya Ramesh and Balaraman Ravindran. Hamiltonian Model Based Reinforcement Learning for Robotics. The RBCDSAI-FCAI conference on Deployable AI, 2022. Won the best paper award.

- **Honeywell** Bengaluru, India
  R &D Engineer/Scientist II, Advanced Technologies Division, Honeywell Aerospace *Jun 2018 - Mar 2021*

  - Multi-Agent Co-operation using Deep Reinforcement Learning

  - Considered multi-agent problems where the agents must learn an efficient communication protocol to co-operate and execute a task.

  - The representative problem considered involves two agents with complementary sensing modalities (depth and color), who have partial information about a target and must communicate, navigate to reach it simultaneously.

  - Trained the multi-agent system using the MADDPG algorithm. Success rate on 4800 training environment configurations $\sim 99\%$. Success rate on 1200 test environment configurations $\sim 49\%$.

  - Autonomous Navigation for UAVs using Deep Reinforcement Learning

  - Developed a deep RL based autonomous navigation system for unmanned aerial vehicles (UAVs), in simulation.

  - The task is to navigate to a goal position in the shortest path, without colliding with stationary obstacles, in an unknown environment. The deep RL agent uses the UAV position, goal position and $360°$ depth information to determine the instantaneous direction of motion. A control algorithm then controls the UAV to move a small distance in that direction and the process repeats.

  - Trained using the DQN algorithm. Success rate on 4800 training environment configurations $\sim 92\%$. Success rate on 1200 test environment configurations $\sim 72\%$.

  - Point Cloud Processing

  - Developed PointCNNs to process point cloud / depth data in RL experiments.

  - LSTM based Speaker Recognition

  - Developed a LSTM based text-independent speaker recognition system. Trained on ~ 2000 hours of audio from 5994 speakers. Achieved accuracy of $\sim 91.8\%$ on a test dataset containing 1251 speakers.

  - Explored use cases such as authentication of users in a speech based building automation system and enhancing automatic transcription of aircraft-ATC communication.

  - Drove collaboration with Microsoft Research, India in development of light-weight recurrent neural networks for deployment on resource constrained edge devices.

- **Predible Health** — Bengaluru, India
  Deep Learning Engineer — *Sep 2017 - May 2018*
  - **- Biomedical Image Processing**
    - ○ Developed CNNs to classify lung nodules as benign or malignant. Achieved sensitivity of $\sim 90\%$, specificity of $\sim 81\%$ after performing 5-fold cross-validation on a dataset of $\sim 40k$ images.
    - ○ Experimented with CNNs for liver segmentation, prostate segmentation.

- **Self Employed** — Chennai, India
  Entrepreneur — *Jun 2016 - Sep 2017*
  - **- Cooking Robot**
    - ○ Envisioned a system with two robotic arms and a camera, which can perceive the kitchen environment and dexterously manipulate objects to autonomously prepare food, using deep RL.
    - ○ Learnt the fundamentals of deep learning, with a focus on vision related architectures such as CNNs. Worked on representative problems such as training a CNN to classify images in the CIFAR-10 dataset.
    - ○ Learnt the fundamentals of RL. Worked on representative problems in tabular RL such as grid world, random walk and implemented algorithms such as TD(λ), value-iteration, SARSA, Q-learning etc. Worked on representative problems in deep RL such as Cartpole, Mountain Car and implemented DQN.
    - ○ Explored literature in deep learning based computer vision and deep RL based robotic manipulation.
    - ○ Due to the complexity of the cooking robot problem and the low maturity of technologies such as deep learning and RL at the time, decided to not pursue the project further.

- **Airwood Pvt Ltd** — Chennai, India
  Intern — *Dec 2014 - May 2015*
  - **- Flight Controller for UAVs**
    - ○ Worked towards developing a flight controller for unmanned aerial vehicles (UAVs), mainly quadrotors. Worked on state estimation algorithms to estimate the quadrotor's state from noisy IMU data and PID based control algorithms to fly it.
    - ○ Owned all aspects of development - software and hardware. Extensively performed flight tests.

PROJECTS

- Mixed State Entanglement in Quantum Chaos (Master's Thesis) Link

Research Guides : Prof. Arul Lakshminarayan, Department of Physics, IIT Madras
Prof. Sandipan Bandyopadhyay, Department of Engineering Design, IIT Madras

- Studied the connections between chaos and quantum entanglement. In particular, studied mixed state entanglement in quantized chaotic systems, which forms an important and unexplored problem, with possible implications for quantum computing.

- Considered a prototypical system, the quantum coupled standard map. Studied its entanglement under time evolution, for initial states that are mixed, for different interaction strengths between the sub-systems and different dimensions of the surrounding environment.

- Found that, for a given interaction strength, as we increase the environment dimension, the tendency to get entangled reduces and there exists a critical dimension in most cases beyond which the state remains separable at all times. Such a phenomenon is potentially a problem in situations where entanglement is desirable, such as in quantum computing.

- Implementation of Deep RL Algorithms (Hobby Project) Link
- Implemented deep RL algorithms such as DQN, A3C, DDPG, MADDPG, PPO, SAC etc, from scratch, in Pytorch. Tested them on sample tasks from OpenAI Gym, Deepmind Control Suite. Open sourced the code on Github.

- Chaotic Dynamics in Robotic Manipulation (Course Project)
- Studied chaotic dynamics in robotic manipulation that can occur for certain values of controller gains and model mismatch. Simulated a parallel manipulator - a planar 5-bar, to track a periodic trajectory. Numerically estimated Lyapunov exponents and plotted phase space plots to identify chaotic dynamics.

- Mechatronics / Embedded Systems (Hobby Projects)
- Ground Robot : Developed different variants of a four-wheeled ground robot - remote controlled robot, line follower and simple collision avoider.

- Automatic Transmission for a Bicycle : Experimentally developed an automatic transmission system for a geared bicycle that determines the optimal gear during operation and automatically switches to it.

- Electric Assisted Bicycle : Connected a motor to the bicycle sprocket, to share the driving effort.

- Home Automation : Experimented with WiFi based control of home appliances.

- Light Dimmer : Developed a dimmer circuit to control intensity of incandescent light bulbs.

Skills

- **Operating Systems** - Linux, Windows
- **Programming Languages** - Python, C, C++
- **Deep Learning Frameworks** - Pytorch
- **Scientific Computing** - Numpy, Scipy, Mathematica, Matlab
- **Visualization Tools** - Matplotlib, Tensorboard
- **Robotic Frameworks** - ROS
- **Robotic Simulators** - Mujoco, Deepmind Control Suite, OpenAI Gym, Airsim, Gazebo
- **Development Tools** - SSH, Docker, Git
- **Microcontrollers** - Arduino, NodeMCU
- **CAD** - Autodesk Inventor
- **Document Preparation** - Latex, Microsoft Office

Awards and Scholastic Achievements

- Awarded the NTSE (National Talent Search Exam) scholarship by NCERT, Government of India in 2007.

- Awarded the KVPY fellowship by Department of Science and Technology, Government of India in 2011.

- All India Rank 2264 in IIT-JEE (IIT Joint Entrance Examination) 2011 (total 0.5 million candidates).

- All India Rank 642, Tamil Nadu State Rank 20 in AIEEE (All India Engineering Entrance Examination) 2011 (total 1 million candidates).

- Featured in the top 300 in the National Standard Examination in Physics and subsequently participated in the Indian National Physics Olympiad in 2011.

- Cleared qualifying stages and participated in the Indian National Mathematics Olympiad in 2010 and the Indian National Olympiad in Informatics in 2009, 2010.

Relevant Course Work

- Deep Learning
- Reinforcement Learning
- Data Structures and Algorithms
- Mathematics - Calculus, Linear Algebra, Probability, Optimization, Numerical Methods etc
- Physics - Mechanics, Electromagnetism, Optics etc
- Kinematics and Dynamics of Machinery
- Analog and Digital Circuits
- Mechatronic System Design
- Modern Control Theory
- Mechanics and Control of Serial, Parallel Robotic Manipulators
- Vehicle Dynamics

Teaching

- Teaching Assistant for Reinforcement Learning course at Department of Computer Science and Engineering, IIT Madras in 2022.

- Teaching Assistant for Electronics Lab, CAD Lab courses at Department of Engineering Design, IIT Madras in 2015-16.