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SUMMARY

I am interested in deep learning and reinforcement learning (RL), especially their application to robotics. In the past, I have applied deep RL to problems such as autonomous navigation for UAVs and multi-agent co-operation. I have a strong multidisciplinary engineering background.

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EDUCATION

- **Dual Degree (B.Tech, M.Tech), IIT Madras** Chennai, India  
*Department of Engineering Design ; CGPA: 8.30 ; Minor in Systems Engineering* *Aug 2011 - Jun 2016*

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PROFESSIONAL EXPERIENCE

- **Honeywell Technology Solutions Labs** Bengaluru, India  
*R & D Engineer/Scientist II, Aerospace Advanced Technologies* *Jun 2018 - Mar 2021*
- **Deep Reinforcement Learning**
  - Studied important publications and followed latest trends in the area.
  - **Autonomous Navigation for UAVs using Deep RL**
    - \* Designed, developed a deep RL based autonomous navigation system for unmanned aerial vehicles (UAVs), in simulation.
    - \* The overall task is to navigate to a goal position in the shortest path, without colliding with obstacles, in an unknown environment. RL agent uses it's own position, the goal position and a 360° depth sensor as inputs and outputs which direction to move. A standard flight controller then controls the UAV to move a fixed distance in that direction and the process repeats.
    - \* Trained using Double DQN algorithm. Successful in ~ 92% of scenarios used in training. On unseen scenarios, successful in ~ 72% of cases.
  - **Multi Agent Co-operation using Deep RL**
    - \* Designed, developed deep RL based multi agent systems that can co-operate and execute a given task by learning how to communicate, in simulation. Eventual business use case targeted was urban air mobility.
    - \* The representative problem considered involves a 2D environment where two agents with partial but complementary information about a target must communicate, navigate to reach it simultaneously. One agent has a 360° depth sensor and the other has a 360° color sensor. The agents can communicate using discrete symbols and can move in discrete directions.
    - \* Trained using MADDPG algorithm. Successful in ~ 99% of scenarios used in training. On unseen scenarios, successful in ~ 50% of cases.
  - Developed the required simulations from scratch using Python. Procedurally generated random environment configurations for training and testing. Briefly worked with Airsim, an open source simulator for drones based on Unreal Engine.
  - Implemented the required RL algorithms from scratch using Pytorch - Double DQN, MADDPG as well as other algorithms used in intermediate experiments such as DQN, Recurrent DQN, A2C, ACKTR etc.
  - Performed systematic research involving several stages of experimentation in order to achieve final results. Experimented with different agent inputs, agent outputs, reward functions, network architectures, algorithm specific hyperparameters and algorithms themselves.
  - Developed novel methods to interpret learnt agent behaviours.
  - Experimented with different methods to speed up training such as parallelizing experience collection across multiple workers, natural gradient descent based on kronecker factored approximate curvature (KFAC), precomputing and storing observations offline by discretizing environment.

## - Point Cloud Segmentation

- Designed, developed a deep neural network containing PointCNN layers to segment point clouds. It's main purpose was to preprocess depth data in multi agent RL experiments.
- Based on the paper "PointCNN: Convolution on  $\mathcal{X}$ -Transformed Points".
- Developed using a small, synthetic dataset of 2000 point clouds containing 3 classes. Accuracy of  $\sim 99\%$ .

## - LSTM based Speaker Verification

- Designed, developed, tested, deployed a LSTM based text-independent speaker verification model to authenticate users in a speech based building automation system.
- Based on the paper "Generalized End-to-End Loss for Speaker Verification".
- Developed using  $\sim 2000$  hours of audio from  $\sim 6000$  speakers. Accuracy of  $\sim 91\%$ .

## • Predible Health

*Deep Learning Engineer*

Bengaluru, India

Sep 2017 - Jun 2018

## - Lung Nodule Classification

- Developed CNNs to classify lung nodules detected in chest CT scans as benign or malignant. Accuracy of  $\sim 90\%$ .

## - Liver Tumour Segmentation

- Developed CNNs to segment liver, tumour and background in abdominal CT scans.

## • Self Employed

*Machine Learning Enthusiast*

Chennai, India

Jun 2016 - Sep 2017

- Learnt fundamentals of deep learning, reinforcement learning. Worked on representative problems in image classification (CIFAR-10), tabular RL (Grid World, Random Walk) and deep RL (Open AI Gym environments such as CartPole, Breakout etc) to gain an in-depth understanding of concepts.
- As a side project, conducted a robotics and hobby electronics course for high school students.

## • Airwood Pvt Ltd

*Intern*

Chennai, India

Dec 2014 - May 2015

## - Flight Controller for UAVs

- Worked towards developing a flight controller for quadrotors. Worked on state estimation algorithms to estimate quadrotor's state from noisy IMU data and PID based control algorithms to fly it.

## PROJECTS

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### - Mixed State Entanglement in Quantized Chaotic Systems (Master's Thesis)

Advisors : Dr. Arul Lakshminarayan, Department of Physics, IIT Madras

Dr. Sandipan Bandyopadhyay, Department of Engineering Design, IIT Madras

- Studied the entanglement of the quantum coupled standard map under time evolution for initial states that are mixed, for different interaction strengths between the standard maps and different dimensions of the surrounding environment.
- Most previous work on entanglement in quantized chaotic systems had dealt only with pure states. However, in reality, even a carefully prepared and isolated system tends to interact with it's environment, which has the effect of leaving the system in a mixed state. Thus the study of mixed state entanglement in quantized chaotic systems forms an important and unexplored problem. It could have an important role to play in how quantum chaos affects quantum computing.
- We found that for a given interaction strength, as we increase the environment dimension, the tendency to get entangled reduces and there exists a critical environment 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.

## - 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. Calculated Lyapunov exponents and plotted phase space plots to identify chaotic dynamics.

## - Mechatronics

Built several projects combining mechanical and/or electronic elements, mainly as a hobby.

- **Wheeled Robot** : Developed different variants of a four-wheeled ground robot - line follower, remote controlled car, WiFi controlled car, simple collision avoider.
- **Automatic Transmission for a Bicycle** : Designed, developed an automatic transmission system for a geared bicycle that picks the optimal gear combination to reduce user fatigue (physical and cognitive) and improve performance. Measured important parameters during real time operation of the bicycle using sensors. Effected gear change using a servo motor based actuation mechanism.
- **Dimmer circuit for incandescent light bulbs** : Developed an Arduino based dimmer circuit to control intensity of incandescent light bulbs.
- **Home Automation** : Experimented with WiFi based control of DC, AC appliances.
- **Miscellaneous** : Homemade speaker, IR remote.

## SKILLS

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| • <b>Operating Systems</b> - Linux, Windows                | • <b>Version Control</b> - Git           |
| • <b>Programming Languages</b> - Python, C, C++            | • <b>Container Technologies</b> - Docker |
| • <b>Deep Learning Frameworks</b> - Pytorch                | • <b>Microcontrollers</b> - Arduino      |
| • <b>Scientific Computing</b> - Numpy, Mathematica, Matlab | • <b>CAD</b> - Autodesk Inventor         |

## AWARDS AND SCHOLASTIC ACHIEVEMENTS

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- Awarded the NTSE scholarship by NCERT, Government of India in 2007.
- Awarded the KVPY fellowship by Department of Science and Technology, Government of India in 2011.
- Secured All India Rank 2264 in IIT-JEE 2011.
- Secured All India Rank 642, Tamil Nadu State Rank 20 in AIEEE 2011.
- 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 and the Indian National Olympiad in Informatics in 2010.

## RELEVANT COURSE WORK

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|--------------------------|-------------------------|--------------------------------|
| • Deep Learning          | • Optimization          | • Design, Analysis, Control of |
| • Reinforcement Learning | • Classical Physics     | Robotic Manipulators           |
| • Linear Algebra         | • Modern Control Theory | • Mechatronic System Design    |

## TEACHING

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