Rahul Harsha Cheppally

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Work Experience

PhD Candidate at Kansas State University, Manhattan KS *Jan* 2021 -Current

- Developed an **automated pipeline** to aid in the research of seed localization system. The developed system downloads images from labelbox.com, trains **YOLOX, YOLOR** and **YOLOV4** while applying augmentations to the images. This work lead to design of seed spacing system.
- Developed an Estimator to estimate distance between seeds using **Image Detection** and a **Kalman Filter**. The Estimator was able to **reduce** the **total time** taken by researchers to collect the data from **2hrs** to a **minute.**
- Framed Multi-Robotics Pesticide spraying problem as **POMDP,** Allowing application of **Multi-Agent Reinforcement Learning.** Solved the problem almost optimally using **GNNs** to model decision making.
- Engineered and structured the software for an **autonomous** spraying robot, encompassing the precise **calibration** of **IMU**, **cameras**, and other sensors relative to **the robot's base frame**. Crafted **control algorithms** tailored to the robotic platform's requirements. Implemented these algorithms onto a **Docker** container within **the Jetson Orin platform**. Utilized **CAN** as the communication protocol between the Orin module and the motor controllers

Positioning Engineer at Caterpillar, Peoria IL Sept 2019 – Jan 2021

- Analyzing various logs to figure out the problems in the positioning aspect of autonomous trucks using **matab.**.
- **Developed** several **internal tools** to test the robustness of the code in **c++.**
- Redesign of IMU pipeline to create maintainable robust code in c++. This reduced overall time required to implement or test new IMUs by a magnitude. Further the new proposed IMU calibration technique improved the calibration to 3 milliDeg.

Robotics Engineer at Rex Robotics, Naperville Oct 2018 – Sept 2019

- **Controllers (MPC, PID, LQR, DDPG)** for multiple **robotic platforms** implemented in **C++** and prototyped in **Matlab**.
- **Dynamic Modelling** and **Analysis** of multiple **robotic Platforms** in **Maple**, **Matlab** and **Simulink.**
- Plane Segmentation using point cloud data using **PCL** the designed pipeline was able to find and segment planes with an accuracy of 75%.
- Depth estimation using struct2depth.
- Motion Planning for **legged robots** and **wheeled robots** usings RRTs and Graph based approaches.
- Designed **Core Software architecture** for **quadcopters** with focus on **performance** and **reusability**.

R&D Robotics Engineer at Swarm Robotix, Naperville May 2018 – Sept 2018

- **Localization** of Robots from **Imu**, **Visual odometry (Open CV)** and Odometry using **Sensor fusion** with an **Extended Kalman Filter**.
- Dynamic modelling of swerve drive robots (4 wheel independent steering) used **Matlab** and **Python**
- Swarm Formation **Control** and **Motion planning (A*, D*, RRT)** of multi robotic systems in **C++** and **Matlab.**

Graduate Research Assistant at Controls, Robotics and Mechatronics lab Aug 2016- Dec2017

- Dynamic modelling of robotic arm, Designing **Nonlinear controllers** to control the robots in uncertain environments. **Optimization** of the given **trajectory** of the robot to utilize the minimal control and produce energy in certain maneuvers in **Matlab** and **Simulink**.
- Helped supervisor to obtain relevant information from noisy signals , used filtering techniques (**Kalman filter**)etc.

Skills

· **OS & Programming Languages :**	*Ros, Ubuntu, Linux, Windows, C/C++, Python, Matlab, Opencv,*
· **Developer platforms:**	*Raspberry Pi, Arduino, Nvida jetson Tx2, D-space*
· **Simulation:**	*Simulink, Gazebo, 20-sim, Mathematical Modeling, Inverse and Forward Dynamics and kinematics*
· **Algorithms and Techniques:**	*Sensor Fusion, Deep Learning(CNN,RNN,GAN), Reinforcement learning, Path Planning(A*,D*,RRT,PRM)*

- **Controls Techniques:** *MPC, LQR, Space Clustering, SMC, PID, Adaptive Control, Robust Passivity based controller, Kalman Filter*
- **CAD and Finite element Analysis:** *Solidworks, Catia, Solidworks Simulation, Finite Element Techniques, Abaqus*
- **Hardware:** *IMU, Stereo Camera, Camera, lidar, Ublox GPS, Ultracapacitors, BLDC Motors, Escs, Brushed DC Motors*

Education

MASTER'S from **cleveland state university** (cleveland ohio) COURSEWORK INCLUDED ***Artificial intelligence, Robotics dynamics and Control, human motion control, Mechatronics*** **(1-12-2016-12-12-2017)**

Deep Learning nanodegree from **Udacity** Course work included ***Neural Networks, Convolution Neural Networks ,Recurrent Neural Networks, Deep Reinforcement Learning***

Bachelor's from **Jawaharlal nehru technological university**(Hyderabad, India) Course work included ***Basic Electronics, Kinematics, Numerical Methods, Dynamics, Design of Machinery, Fluid Mechanics, Data structures*** (2011-2015)

Projects

Controls and Motion Planning:

Model Predictive Controller for a quadruped : Designed a model predictive controller for a quadruped using **QPOASES** for solving the Quadratic problem in shooting method. This Included linearizing the highly non-linear model of the legged robot, modelling the legged robot, the optimized c++ solution was able to run at 200Hz enough to keep the robot stabilized.

Robust Passivity Controller with Regeneration*:** Developed regressor for a puma **(R-R-R)**robot by using kinematics and ***lagrange dynamic formulation method using ***DH-convection***; Designed *the **Robust passivity-based controller***, modified it to suit energy regeneration from the robot; Simulated the robot and the controller in ***Simulink and Matlab***; Implemented it in real time on the robot by using *D-space and control desk*.

***Sliding Mode controller with Regeneration*:** Started by building a better model for a manipulator**(R-R-R-R)** by estimating the model parameters; Then Created a **sliding mode controller** for the robot and tested it by implementing it on Simulink; Applied it to the Robot through **Dspace**.

Optimization of Trajectory followed by the Robot with energy regeneration: Applied *inverse kinematics for a couple arbitrary points to convert* them into joint co-ordinates for a pick and place robot and *optimized the trajectory* using a Non-linear solver. It was concluded the trajectory followed by the robot with regeneration was 20% more efficient than a conventional trajectory followed by the same robot without energy regeneration in **IPOPT** and **Simulink**.

Self-Playing Pac-man Game: Applied several AI algorithms like ***BFS, DFS, A**** for path planning , **Mini max, expecti-max** for decision making, ***reinforcement learning***, Behavior Planning to improve the average score of the pacman agent over 1000 games in **Python.**

Deep Deterministic Policy Gradient*:** Implemented ***DDPG to teach a quadcopter how to fly through reinforcement learning agent learn to fly in a matter of **134 episodes**. Designed the ***reward function carefully*** that the agent does not find in appropriate ways to attain more rewards. Both the networks actor and the critic where written in Keras.

Skid Steer Controller with Radius Constraints: Implemented a skid steer controller with constraints on max velocity, turning radius on an **STM32** board as well as arm based **Nvidia- Orin** platform in **microRos** and **Ros2**. The implemented controller with constraints was optimized to run at 100 Hz by converting the **minimization** problem into a **geometric** one.

MPCC controller for a Ackerman Car Around a Track: Implemented a Model predictive contouring controller with various constraints on max velocity, etc to track a given set of way points in **gazebo** and **ros1** this was preliminary study to test if the mpcc controller can be utilized for a skid steer vehicle in agricultural setting. This was tested in **python 3.8**, optimization equations were implemented in **casadi** and solved in the same using **ipopt** backend.

Perception:

Ground Reaction Force Predictor: Wrote a script in *Python* using ***OpenCv*** to determine the maximum radius of curvature of a shoe while walking from an *image*. The predicted radius of curvature was used to select ***piezo-electric sensors***; The sensor reading where read through the D-space while Walking; A Neural Network was trained on the data attained; The sensor was able to predict the Ground reaction force with an ***accuracy of 80%.***

Image Classifier (Convolution Neural Network): A CNN was created in **Tensorflow(python)** by transferring the feature detection parameters form ***Resnet-50*;** It was trained with several Dog images to predict the dog breed; The Network attained an accuracy of 84.52% with **133 Classes.**

***TV script generation(LSTM)*:** Created a **LSTM** recurrent neural Network to generate tv script for a scene in the Simpsons TV show by training the recurrent network to predict the probability of the next word given the script of the whole season and using a custom word as the first input for the trained network to predict the whole sequence of words.

Face Generation (GAN)*:** *Implemented **DCGAN** to **generate faces from a random noise given as input to the network. Both the networks where tuned such that they won't overfit or underfit.

Extend Kalman Filter for fusing the data from lidar and radar: Implemented an ***Extended Kalman filter*** for fusing the data from the Lidar(cartesian coordinates) and radar (polar coordinates) to attain a rmse error over ground truth of less than 1 in ***C++.*** Started from deriving the Jacobian for the radar readings and implementing extended version considering the non-linearities in radar.

Depth Prediction Network: Modified **Struct2Depth** to predict depth indoors and trained it on a custom dataset.

Publications:

***Seed Localization System Suite with CNNs for Seed Spacing Estimation, Population Estimation and Doubles Identification*:** Seed placement information for evaluating planters is obtained by tedious manual methods like using a pogostick or a ruler. To obtain more information and reduce the time required. There is a need for an automated system. The goal of this study is to design such a system with the use of GPS and seed detection.

***A Deep Architecture using Multiple TabNets for Environmental Prediction and Control in Smart Home*:** A deep neural network model is proposed in this research for indoor environmental prediction and control in the smart home. It attempts to benefit directly from human experience by making use of imitation learning, a paradigm that is closely related to reinforcement learning. In imitation learning, the agent learns from real human experience. The research uses the state-of-the-art deep attentive tabular network architecture, which is an extension of deep neural networks. The tabular network, which is designed specifically to handle tabular data, is able to outperform all other machine learning algorithms in current use. The proposed model incorporates four such tabular networks. Promising results described here demonstrate how current developments in machine learning can be adopted effectively in HEMS related applications.

Presentations:

Seed Localization System Suite with CNNs for Seed Spacing Estimation, Population Estimation and Doubles Identification
ASABE 2023