Nirmal Raj

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EDUCATION

University of Minnesota   Twin Cities, Minnesota
Master of Science - Robotics (GPA: 3.7/ 4)   *September 2021 - Present*

Relevant Courses: Computer Vision, Advanced Machine Learning, Deep Learning, Artificial Intelligence, Sensing and Estimation in Robotics, Natural Language Processing

College of Engineering Trivandrum(Kerala Technological University)   Kerala, India
Bachelor of Technology - Electrical and Electronics Engineering   *August 2015 - July 2019*

Relevant Courses: Linear Control Systems, Non-linear Control System, Microcontrollers and Microprocessors, Digital Electronics, Analog Electronics

SKILLS

- **Languages**: Python, C, C++, JAVA, SQL, MATLAB, HTML, CSS, JavaScript, Latex
- **Tools and Libraries**: PyTorch, ROS, Scikit-Learn, OpenCV, NumPy, Pandas, Git, Linux Bash, Tensorflow, Intel Realsense, NLTK, Docker, Informatica PowerCenter, CVAT, Arduino, HuggingFace, WandB
- **Techniques**: Neural Networks, Statistical Modeling, Feature Engineering, Regression, Classification, Clustering, Segmentation, Model Evaluation, Predictive Modeling, Generative Models, Transformer Models, Image Processing

RESEARCH EXPERIENCE

Graduate Student Researcher - Robotics: Perception and Manipulation Lab (link)
University of Minnesota   *Nov 2022 - Present*

Project 1: Tactile Perception for Robot Grasping and Manipulation (link)

- Collaborated with the research team in developing the control algorithms for UR5e robot arm and integrating the GelSight visuo-tactile sensors with the arm for enhanced gripper control
- Generated data for the classification model using gelsight sensor and Tacto simulator
- Fine tuned and trained model for classification of chess pieces using ResNet-50 as feature extractor. Model achieved an accuracy of 96% on gelsight images

Project 2: Localization using Neural Radiance Field (NeRF) [Master's Capstone]

- Developed pipeline for data extraction and sensor fusion using ROS for Boston Dynamics Spot
- Designed and implemented an algorithm that estimates the position and orientation of a camera in 3D space given a camera image. The model accurately detected the pose of a novel camera image within an error margin of 2 cm and 1 degree

Project 3: Task learning using NOCS (Normalized Object Coordinate Space) descriptors

- Generated Ground-Truth NOCS feature maps using Blender for additional object classes
- Modified and retrained NOCS model for pose estimation with chair as an additional class. The model was able to accurately detect the 3D pose of the chair in real time

Graduate Research Assistant
University of Minnesota   *June 2022 - Jan 2023*

Project : High Fidelity Quantification of Social Distancing Behaviours in Public Recreational Areas (link)

- Ground-Truth labeling of pedestrian datasets acquired from ZED 2 Stereo Camera using CVAT and SiamMask segmentation model
- Implemented various computer vision, image processing, and visualization techniques for detection and tracking of pedestrians to analyze public behavior
- Analyzed the performance of face mask detection models, identified failure cases, and recommended improvements, resulting in enhanced model accuracy and reliability

WORK EXPERIENCE

Wipro Ltd, Chennai
Project Engineer (Software Development)   *July 2019 - May 2021*

- Designed and implemented advanced ETL (Extract, Transform, Load) mappings in Informatica to streamline data extraction, transformation, and loading processes into the data warehouse, enhancing data accuracy and availability
- Developed and optimized SQL queries for analysis of customer data, providing valuable insights to clients

Bosch Rexroth CET- Center for Excellence
Internship in Industrial Automation   *July 2018*

- Hands-on training in Industrial Automation comprising of operating pneumatic and hydraulic drives with PLC control system
- Designed and implemented control system using ladder diagram for hydraulic actuation in industrial setting

Teaching Experience

University of Minnesota
Graduate Teaching Assistant   *June 2022 - Aug 2022, June 2023 - Aug 2023*
- MSBA 6311: Python for Data Science

Course Projects

- **Pose Estimation using RGB images**: Reimplemented PoseCNN for object detection and pose estimation on PROPS dataset

- **Localization of Robots in Webots**: Simulation of localization of robot in an unknown environment using Webots. Using the landmarks in the environment and Extended Kalman Filter, the robot is programmed to avoid obstacles and move towards a goal while simultaneously trying to determine its position in the environment

- **Facemask detection from camera images**: Developed a deep learning network using RCNN to detect facemasks on people. The model was able to accurately detect facemask on test images extracted from the internet with 94% accuracy

- **Predicting Water Potability using Machine Learning**: Cleaned data and applied feature engineering to extract significant features. Tested various models including XGBoost, Random Forest, Decision Trees, etc to find best model. The best performance of over 65% accuracy was acquired with Random Forest and SMOTE

- **Semantic Segmentation on SemanticKITTI dataset**: Experimented with various state of the art deep learning models for semantic segmentation on LiDAR data for autonomous driving

- **Pneumonia detection from X-rays**: Developed a deep learning network using ResNet to detect pneumonia from chest X-rays images. The model was able to achieve an accuracy of over 90%

- **Open Monkey Challenge**: Designed and developed a machine learning pipeline for detection and estimation of landmarks and pose of non-human primates using DeepLabCut and U-Net and tested it's performance against baseline

- **Sentiment Analysis of Tweets**: Developed a deep learning pipeline using NLTK toolkit and RNN for sentiment analysis of tweets. The model was able to achieve an accuracy of over 80%

- **Generative models on Fashion-MNIST dataset**: Reimplemented and trained GAN, conditional-GAN and VAE on Fashion-MNIST dataset

- **Stereo Reconstruction**: Using SIFT extracted and matched keypoints from two image views. Determined the fundamental matrix to establish the geometric relationship between the two images and employed triangulation to derive a stereo disparity map

- **N-gram model for classification**: Designed and implemented n-gram language model to accurately identify the author of a new piece of text

- **Single Point Driving Mechanism**: Designed a system with a ball as ground contact to achieve better agility and maneuverability. With design based on inverted pendulum theory, the robot navigates narrow spaces efficiently with zero turning radius. Programmed using Arduino Uno, the system utilizes a simple motion planning algorithm

- **Image Registration and tracking**: Developed an image registration system using Python and OpenCV, implementing SIFT feature extraction and matching, affine transformation using RANSAC, inverse compositional image alignment, and multi-frame tracking

Honors and Awards

- **Best Project Award at the Innov Expo IEDC CET,2019**: Project 'Single Point Driving Mechanism' was chosen as Best Project from the Department of Electrical Engineering (Undergraduate level)

- **Project funding awarded by the Kerala State Council for Science, Technology and Education,2019**: 'Single Point Driving Mechanism' awarded government funding for the undergraduate technical project (State level)

Volunteer Experience

- **Event Coordinator, ROBOCET**: Conducted a competition as part of robotics club that challenged students to build their own line-following robots and to set the best time on the track

- **Committee Member, ROBOCET**: Organized events, conducted workshops, and delivered talks in local high schools for robotics enthusiasts

- **Event Coordinator, College of Engineering Trivandrum**: Organized a hands-on quadcopter workshop during the College Technical Festival

- **Event Coordinator, Department of Electrical Engineering**: Conducted workshop on Machine Learning using Python