

Dhyey Manish Rajani

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EDUCATION

University of Michigan, Ann Arbor, USA
Candidate for MS in Robotics

August 2022 - April 2024
(CGPA- 3.94/4.0)

University of Mumbai (Dwarkadas J. Sanghvi College of Engineering), Mumbai, India
Candidate for a Bachelor of Engineering in Mechanical Engineering

June 2018 - May 2022
(CGPA- 3.87/4.0)

PROFESSIONAL EXPERIENCE

Image-Guided Medical Robotics Lab, Ann Arbor, USA
Research Assistant (Computer Vision/Machine Learning)

Jan 2023 - Present

- Creating a novel Optical Coherence Tomography (OCT) imaging system based on causal motion segmentation to balance the framerate & resolution for Adaptive Scanning in Ophthalmic Microsurgery.
- Working on developing a 3D OCT system for retinal surface reconstruction to facilitate robotic forceps localization and laser guidance for minimally invasive autonomous microsurgery.
- Preparing a paper to publish this research in collaboration with the University's Medical Robotics Lab.

Mach Infinity Aerospace, Bengaluru, India
AI and Robotics Intern-Computer Vision

May 2021 - Sept 2021

- Formulated a system architecture for developing a computer vision system using Deep Reinforcement Learning for autonomous navigation of Unmanned Aerial Vehicle (UAV) through obstacle avoidance.
- Developed a multi-layered Convolutional Neural Network (CNN) pipeline in Python to process live UAV camera footage to obtain state of the agent and to rank actions from the corresponding state.
- Devised a Double Deep Q-Network architecture, in PyTorch, to enable UAV to learn an optimal policy for obstacle avoidance based on CNN input and changing metrics of reward function.
- The UAV system was simulated in a custom environment built on Microsoft's Airsim using Unreal Engine; and was successfully implemented on the company's aerial vehicle.

ZS Microtech Pvt. Ltd., Mumbai, India
Python Programming Intern

Jan 2021 – Mar 2021

- Spearheaded a team of 2 interns to create an analytics-based desktop application to discern the success parameters and launch timing for company's app launch on Google Play Store.
- Performed numerical sentiment analysis based on sentiment polarity and developed 11 distinct back-end features based on genre, size, update, upload date and android version of various apps.
- The app was successfully able to predict suitable app launch date and based upon sentiment analysis was able to approximate the customer's next purchase day for company's paid products on Google Play Store.

PROJECTS & PAPERS

Self-Supervised Multimodal Martian Terrain Classification

- Developed a self-supervised vision-based terrain classification system using unsupervised audio and contour feature processing for the Perseverance rover, based upon data provided by Jet Propulsion Laboratory.
- Created multimodal sensor fusion algorithms for augmenting audio and vision-based subsurface data obtained from the rover, for feature extraction & autonomous generation of labelled terrain data for vision-based semantic segmentation.
- Authored a paper to publish this research in collaboration with the University's Field Robotics Group.

OriCon3D: Effective 3D Object Detection using Orientation and Confidence

- Developed a novel single-view 3D Bounding Box (BBBox) estimation algorithm based on 2D geometric constraints with a light-weight neural net backbone for deployment on Android operating system.
- Extended the state-of-the-art (SOTA) 3D BBBox estimators by using only orientation & confidence score regression to achieve approximately more than 92% accuracy on the benchmark KITTI object detection datasets.
- Authored a paper on this research slated for publication this year. (DOI: <https://doi.org/10.48550/arXiv.2304.14484>).

A Contemporary Approach for Trajectory Prediction of Autonomous Surface Vessels (ASV's) Based on Long Short-Term Memory (LSTM) Neural Network

- Developed a path-prediction system for an ASV using a parallel amalgamation of particle filter based Bidirectional-LSTM and created a generalized response surface algorithm for adaptable hyper-parameter tuning using Pytorch.
- The model was able to accurately predict the vessel's trajectory 30 minutes in future with path loss of less than 0.01 km.
- Authored and presented a paper at "Smart Ship Technology" international conference organized by The Royal Institution of Naval Architects, London.

Size-based Transmogrifying Robotic Serpent for Nuclear inspection

- Developed a full monocular hybrid visual-SLAM (Simultaneous Localization and Mapping) system with keyframe based global mapping in ROS, inspired from a customized kinematic model I created after studying snake locomotion.
- Played an instrumental role in developing the motion planning and embedded control system with sensor fusion using MATLAB/Simulink; also developed computer vision algorithm for visual size-change actuations in Python.
- The robot was able to autonomously conduct regular inspection tasks in different diameters & orientations of pipelines.

Twilight SLAM

- Devised an algorithmic extension to the SOTA low-light image enhancement module Dark-GAN (Generative Adversarial Network) to enhance the efficiency of ORB-SLAM3 and SuperPoint-SLAM framework.
- Built SuperPoint and ORB-SLAM pipelines from scratch and created custom plugins for augmenting them with various GAN-assisted image enhancers for a comparative study. (DOI: <https://doi.org/10.48550/arXiv.2304.11310>).
- Developed an unpaired image-to-image translation module for day-night image data generation and scene adaptation.

Monocular Video-based Odometry Using KITTI Dataset

- Undistorted selected input images from KITTI dataset, and pre-processed raw camera's footage with OpenCV.
- Implemented FAST corner detector for feature detection and Kanade-Lucas-Tomasi (KLT) feature tracker.
- Applied Nister's 5-point algorithm and RANSAC to deduce the essential matrix for finding Rotation matrix and translation vector and the results were obtained within reasonable error limits when compared to ground truth.

Autonomous RC Aircraft Navigation

- Designed and developed an aircraft self-stabilization system and monocular vision-based autonomous landing system.
- Developed a visual-inertial self-supervised landing site selection system using Structure from Motion and Depth maps.
- Secured 2nd position and government funding at state-level aero-design competition, to compete at 2020 SAE Aero Design.

Labor Safety using Computer Vision

- Developed and trained, on web-scraped labelled image dataset, first deep CNN model to identify the construction site scene of image given and second one to indicate the probability of hazardous scenario in each scene.
- Analyzed three model architectures - RESNET50, VGG16, and Inception V3, and shortlisted RESNET50 as the most suitable one for domain adaptation and transfer learning to generalize similar scenes.
- The model successfully screened numerous images, with an accuracy of 93.6%, indicating unsafe conditions.

Sparse Optical Flow for Motion Continuity Detection/Tracking

- Developed a video based sparse optical flow implementation from scratch by leveraging Lucas-Kanade algorithm.
- Devised an image pyramid based multi-scaling method to avenge the abrupt motion the optical flow suffered due to the algorithm's limitations and rapid video frame rate.
- Calculated the base parameters and analyzed various corner detector methodologies for path continuity generation, and shortlisted Shi-Tomasi corner detector to probabilistically estimate the object's corners in dynamic video scenes.
- The optical flow system was successfully able to track local and global motion constancy irrespective of the frame rate.

A Review on Carbon Nanotubes as Novel Drug Carriers in Cancer Therapy

- Researched upon various carbon nanotube-based drug targeting methods and proposed a generalized carbon nanotube-based malignancy targeting method which can replace conventional chemotherapy.
- Authored and presented a paper on the same at International Conference on Intelligent Manufacturing and Automation (ICIMA) 2020 and published in Springer Nature Singapore (DOI: https://doi.org/10.1007/978-981-15-4485-9_47).

TECHNICAL SKILLS AND COURSES

- Programming Languages & Database: Python, C/C++ ; MySQL
- Robotics Tools: ROS Melodic, Gazebo, Microsoft Airsim, MATLAB/ Simulink, V-REP/ CoppeliaSim
- Packages: Tensorflow, Keras, PyTorch, NumPy, Scikit-Learn, Matplotlib, Pandas, OpenCV, Pybullet, Open3D, OMPL
- Courses: Transfer Learning and Domain Adaptation, Navigation and Guidance of Aerospace Vehicles, Model-based Optimization for Robotics, Self-Driving Cars, Vision-based Motion & Path Planning, Advanced Computer Vision, Fuzzy logic and Neural Networks, Machine Learning, TensorFlow & Deep Learning, AWS Deep racer

EXTRA CURRICULAR ACTIVITIES

- Led a group of 12 engineering students to develop 2 major RC aircrafts to compete at 2020 SAE Aero Design East, securing 3rd position worldwide in system design presentation.
- Secured gold and silver medal in national level NPTEL Robotics and Fuzzy logic exams respectively.
- Secured 1st place in a national debate competition organized by the American Chemical Society in April 2021.
- Served as city's committee vice-president for SAE India and Indian Society of Manufacturing Engineers (2020-2022)
- Secured 1st place in an 18-mile annual marathon organized by TATA Consultancy Services in May 2021.