

FNU Abhimanyu

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EDUCATION

Carnegie Mellon University

Masters of Robotics Research, (CGPA: 3.61/4)

Pittsburgh

May'21-Present

BITS Pilani

B.E. Mechanical Engineering (CGPA: 8.52/10)

Goa Campus

May'19

Courses Completed

Computer vision, Deep RL and control, Visual learning and recognition, 3D Vision, Robomath, Intro to machine learning, Geometric methods in vision, Robotics and Mechanism, Control Systems, Nonlinear Dynamics, Optimization, Modern Control System, Computational Physics

RESEARCH INTEREST

Computer vision, Deep Learning, Foundation Models, Robotics, Robotic manipulation, Medical Imaging

KEY SKILLS

Python, C++, Pytorch, Pytorch3D, Pybullet, OpenCV, Open3D, Mujoco, Softgym, Gazebo, Matlab, Tensorflow, Webots, SimMechanics, Solidworks

RESEARCH AND WORK EXPERIENCE

Research Assistant

Jul'19 - Present

with Profs. Howie Choset and Prof. John Galeotti at Biorobotics Lab, Robotics Institute, CMU

Three-dimensional robot-guided ultrasound scan and autonomous vessel reconstruction.

- Devised an unsupervised CNN-based non-linear registration algorithm (U-RAFT) to predict deformations and track vessels in ultrasound images under the application of different forces
- Devised an innovative deformable dynamic modeling methodology for comprehensively simulating the intricate interactions between manipulators and soft bodies
- Developed a PyTorch package using deep learning-based non-linear registration to reduce pixel movement by 78% in lung ultrasound images affected by breathing motion
- Semi-automated the process of ultrasound scanning using a Robotics Ultrasound System (RUS). Came up with an optimal way to search for the most optimal region to scan using a robotic ultrasound system using Gaussian process regression and Bayesian Optimization
- Developed a hybrid position and admittance force controller to scan flat deformable bodies. Extend this to curved surfaces by adding a SLERP controller. Accepted in ICRA'22
- Developed a 3D visualization tool to model the external surface of the scanned subject. Integrated this with robot-based scanning and multiclass segmentation with the help of ROS. Accepted paper in ICRA'23
- Working to create a generative model to produce photo-realistic ultrasound images under different force deformation. Will be using this to augment the arteries and veins segmentation pipeline
- Became the first ever group to conduct a robot-assisted Seldinger's procedure on medical pigs

E-waste classification and manipulation in collaboration with Apple Inc.

- Developed a robust object classifier for sorting e-waste items into bins. Came up with a novel iterative feature extraction attention module to solve the problem of classifying similar-looking e-waste items

Work featured on Apple Machine learning forum

- Developed a multi-modal classification paradigm by combining RGB and X-ray images of e-waste items for accurate classification. Became the first group to ever use RGB and X-ray images to classify e-waste items. Work accepted in IROS'22
- Developed a 3D reconstruction pipeline for domain randomization to create synthetic images of iPhones for RGB classification. Generated photorealistic synthetic textures/cracks on phone screens using Cycle-GAN
- Formulated a few-shot semi-supervised semantic segmentation pipeline to segment electronic components from e-waste items. Improved the performance (IoU) of existing U-Net network architecture using fewer samples using component-aware contrastive loss
- Worked on developing an object-agnostic gripping strategy for manipulating e-waste at a greater speed and accuracy in a factory setup. Modeled the manipulator with the gripper in MUJOCO simulator for training policies in the simulation

Deformable object manipulation by modeling robot-object interaction

- Used unsupervised RAFT to capture the movement of deformable objects in real-time
- Used PhyDNet to implicitly model the interaction between ropes and the robot manipulator
- Used CEM planner with the dynamics model to manipulate ropes into different configurations
- Used SoftGym to demonstrate the working of this approach in simulation

State representation learning for search-based methods.

- Developed an efficient way of encoding state space, into lower dimensional embeddings using Variational AutoEncoders such that the embeddings will be used in the ARS network
- Working on formulating a model-free learning approach for solving the Atari game environments using Augmented Random Search and Pytorch
- Secured 3rd place in OpenAI leaderboard for BipedalWalker-v2 environment [[Link](#)]

Summer Research Internship

May'18–Aug'18

with Dr. Shishir K. at Robert Bosch Centre for Cyber-Physical System, IISc Bangalore

Development of system capabilities for Sim-to-Real of Reinforcement Learning algorithms on the Stoch Robot [[Link](#)]

- Collaborated on developing lower level locomotion controller of a 12 DOF quadruped (Stoch)
- Constructed an MQTT communication protocol to deploy a neural network on the legged robot
- Developed accurate motor model using suitable toolboxes of MATLAB.

ACADEMIC PROJECTS

Improving pose and flow prediction for an ego-motion camera using epipolar constraint

- Capstone project for course work 16-822: Geometric-based Methods in Vision, CMU Fall 2022
- Improving the off-shelf flow prediction architecture by adding an extra epipolar constraint
- Proposed a new way of calculating the dynamic mask of the scene by comparing the rigid and optical flow

Predicting deformation in 3D shapes in presence of an external force

- Capstone project for course work 16-824: Visual Recognition and Learning, and 16-889 Learning for 3D, CMU Spring 2022
- Predicted the deformation of the 3D model in the form of 3D point clouds using conditional VAEs conditioned on the force applied, material property, and the point of application
- Created an automated pipeline for creating a deformed primitive shape dataset

Learning CPG parameters Hexapod through unstructured terrain using learning techniques.

- Capstone project for course work 16-881: Deep Reinforcement Learning for Robotics, CMU Spring 2020
- Learned basic gaits for the hexapod by searching over the CPG parameter space, using Proximal Policy Optimization
- Developed a novel way of representing the terrain information for the agent in a latent space

Kinematic study of re-configurable robot and its application as snake robot [Link]

- Study of forward kinematics and workspace analysis of the re-configurable mechanism
- Manufacturing these re-configurable modules, and assembling them as a 12-DoF snake robot
- Developing central pattern generator-based controller for generating slithering and caterpillar gait of snake's locomotion

Evolving Omni-Directional Locomotion for a Quadruped Robot (Stoch2) using Physics Simulation and Real-World Verification. [Link]

- Bachelors Thesis with Dr. Shishir K. at Robert Bosch Centre for Cyber-Physical System, IISc Bangalore
- Developed lower-level controller and kinematic equations of Stoch2 robot's custom links
- Developed high-level controllers for gait transition and pose control in the Stoch2 robot.

PUBLICATIONS

- **Improving Robotic Ultrasound AI Using Optical Flow.** FNU Abhimanyu*, CMU Masters' Thesis, Pittsburgh, USA. [Thesis]
- **RGB-X Classification for Electronics Sorting.** FNU Abhimanyu*, Tejas Zodage, Umesh Thillaivasan, Xinyue Lai, Rahul Chakwate, Javier Santillan, Emma Oti, Ming Zhao, Ralph Boirum, Howie Choset, Matthew Travers Presented in IEEE International Conference on Intelligent Robots and Systems (IROS'22), Japan. [Paper]
- **Unsupervised Deformable Ultrasound Image Registration and Its Application for Vessel Segmentation.** FNU Abhimanyu, Andrew L. Orekhov, Ananya Bal, John Galeotti, Howie Choset Accepted in IEEE International Conference on Intelligent Robots and Systems (IROS'23), USA.
- **Unsupervised Deformable Image Registration for Respiratory Motion Compensation in Ultrasound Images.** FNU Abhimanyu, Andrew L. Orekhov, John Galeotti, Howie Choset Accepted in IEEE International Conference on Robotics and Automation (ICRA'23), RAMI Workshop USA.
- **Autonomous Ultrasound Scanning using Bayesian Optimization and Hybrid Force Control.** Abhimanyu*, *Raghavv Goel, Kirtan Patel, John Galeotti, Howie Choset Presented in IEEE International Conference on Robotics and Automation (ICRA'22), USA. [Paper]
- **A Curvature and Trajectory Optimization-based 3D Surface Reconstruction Pipeline for Ultrasound Trajectory Generation.** Ananya Bal, Ashutosh Gupta, Abhimanyu*, John Galeotti, Howie Choset Presented in IEEE International Conference on Robotics and Automation (Submitted in ICRA'23), Japan. [Paper]
- **Toward Robotically Automated Femoral Vascular Access.** Nico Zevallos, Evan Harber, Kenny Sladick, Abhimanyu*, Francis Guyette, Leonard Weiss, Michael R. Pinsky, Hernando Gomez, John Galeotti, Howie Choset. Submitted in IEEE International Conference on Robotics and Automation (ISMR'21).
- **3DoBot - A modular robot for wheel and chain coordinate structures.** Abhimanyu*, Tejas Rane, Rohan Godiyal, S Sankhar Reddy Ch. Presented in Advances in Robotics 2019 (AIR'19), India. [Paper]
- **2DxoPod-A Modular Robot for Mimicking Locomotion in Vertebrates.** S Shankar Reddy Ch., Abhimanyu*, Rohan Godiyal, Tejas Zodage, Tejas Rane. Accepted in Journal of Intelligent Robotic Systems.
- **Learning Active Spine Behaviors for Dynamic and Efficient Locomotion in Quadruped Robots.** Shounak Bhattacharya, Abhik Singla, Abhimanyu*, Dhaivat Dholakiya, Shalabh Bhatnagar, Bharadwaj Amrutur, Ashitava Ghosal, Shishir Kolathaya. Accepted in IEEE International Conference on Robot Human Interactive Communication (Ro-Man 2019), India. [Paper] [Video]
- **Trajectory-based Deep Policy Search for Quadrupedal Walking.** Shishir Kolathaya, Ashish Joglekar, Suhan Shetty, Dhaivat Dholakiya, Abhimanyu*, Aditya Sagi, Shounak Bhattacharya, Abhik Singla, Shalabh Bhatnagar, Ashitava Ghosal, Bharadwaj Amrutur. Accepted in IEEE International Conference on Robot Human Interactive Communication (Ro-Man 2019), India. [Paper] [Video]

MENTORSHIP AND LEADERSHIP SKILLS

- **Mentored undergrads interested in AI**, mentored a couple of enthusiast undergrads as part of the AI summer program in RI, CMU
- **President of Electronics and Robotics Club**, managed a group of around 150 robotics enthusiasts for the completion of various projects
- Instructor of **Advanced Robotics** Taught undergraduates about core concepts of control systems for robotics and its implementation in ROS
- Teaching Assistant to Prof. D. M. Kulkarni and Prof. P.M. Singru for **Computer Aided Design and Machine Design and Drawing** respectively. Designed the practical labs and taught software like MATLAB and PTC Creo. End-of-term evaluation indicated "excellent" knowledge of course material and "thorough and fair" grading