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Shivam Thukral

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EDUCATION

Master of Science in Computer Science — September 2019 – Present
University of British Columbia (UBC), Vancouver, Canada — **GPA:** 88.8 / 100
Thesis: Real-time Perception of Potential Docking Locations for Smart Wheelchairs (Presentation) [In progress]

Bachelor of Technology in Computer Science and Engineering. — August 2017
Indraprastha Institute of Information Technology (IIIT), Delhi, India — **GPA:** 9.4 / 10.0
Thesis: Resolving Message Logic Dependencies in Robotic Systems (Poster)

SKILLS

Languages: C/C++, Python, Julia, CUDA, MATLAB, Java, Bash, SQL, R, Haskell.
Technologies: Robotics Operating System (ROS), Pytorch, Tensorflow, PCL, Open3d, OpenCV, OMPL, Git
Tools: PyCharm, CLion, Atom, VSCode, Eclipse, Qt-Creator, Andriod SDK, Soot, Google Test.
Platform: Linux, Windows, Universal Robots, Android

ACADEMIC EXPERIENCE

Graduate Research Assistant, UBC Vancouver — May 2020 – Present
- Developed vision-based algorithm, ApproachFinder-CV, to find docking locations for a wheelchair in indoor scenes.
  - Each location is accompanied by a desirability weight based on visibility, relative position and heading.
- Proposed a real-time deep network, ApproachFinder-NN, that predicts docking spots using just geometric information.
  - Our end-to-end differentiable Hough voting based architecture is 15x faster than computer vision pipeline.
- Evaluated the performance of ApproachFinder-NN on a large state-of-the-art indoor dataset (SUNRGB-D).
- Proposed a way to integrate network output as 3D temporal desirability cost map for wheelchair navigation.
  - Used Model Predictive Controller with efficiently designed task-driven cost functions to share human intent.

University of British Columbia, Vancouver, Canada
- **Graduate Teaching Assistant (Advanced Relation Databases)** — August 2020 – December 2020
- **Graduate Teaching Assistant (Introduction to Relation Databases)** — May 2020 – June 2020
- **Graduate Teaching Assistant (Advanced Relation Databases)** — August 2019 – April 2020
  - Designed and graded questions for homework assignments, quizzes and examinations.
  - Conducted weekly office hours and attended classes in 2019 to assist students during in-class doubts.
  - Assisted instructor to have a smooth transition from offline to online classes during Covid-19.

Undergraduate Researcher, IIIT Delhi — June 2016 – December 2016
- Developed an optimal path planning algorithm (BugFlood) in an obstacle rich environment.
- Bugflood delivers lower cost paths compared to other planners with lower computational time.
  - It is 11x and 18x times faster than BFMT* and FMT* respectively.
  - It generates paths that are only 5% sub-optimal than the Visibility Graphs (the most optimal path planner).
- Bugflood rapidly indicates if a path does not exist.
  - Planner can detect a no path scenario in 0.4 seconds.

INDUSTRY EXPERIENCE

Researcher (Software Engineer), Innovation Labs, TATA Consultancy Services — August 2017 – August 2019

Calibration: Robot and Camera
- Developed a package for autonomous calibration of stereo camera with Universal Robots.
- Automated transformation detection that helps with both Eye-to-Hand and Eye-in-Hand setup of the robot.
- Added testing support feature to verify the generated robot to camera frame transformation matrix.
- Dropped calibration time from 20 to 9 minutes, and resource requirement from 2 to a 1 person.

Palletizer - Automated Truck Loading System
- Designed GUI based system, with motion planning, that can optimally load heterogeneous boxes on a pallet.
- Increased system throughput by directly publishing poses and joints to the robot by surpassing ROS-MoveIt.
- Successfully achieved target output of 12 seconds per pick and place of the box.

Long Distance Container (LDC) Packing (Video)
- Designed new industrial level system to automatically load parcels in LDC's.

- To help improve parcel transfer between large warehouses.
- Developed pose estimation and motion planning for placing parcels in LDC's using Universal Robots.
- Achieved target filling rate of 12 seconds per LDC.

Amazon Robotic Challenge (Video)
- Built robot hardware and software that can attempt the task of picking and stowing items on shelves.
- Replicated this system in a lab environment that was designed in-house by TCS Robotics.
- Worked on complete pipeline including object recognition, pose recognition, grasp planning, and motion planning.

Chitrakar: Robot Artist (Video, Paper)
- Programmed a robotic arm to draw a human face as a recognizable non-self-intersecting loop (jordan curve).
- Designed automated image processing pipeline and motion planning module to complete the drawing within 30 minutes.
- This work demonstrates use of robotics to augment humans in executing difficult craft-work instead of replacing them.

SELECTED PROJECTS

Image-based Visual Servoing using Industrial Manipulator (Report, Code)
- Proposed a framework to track moving visual features with occlusion using a 6-DoF robotic arm in 3D.
- Features are tracked using CAMShift and Kalman filter is used to predict target's motion in cases of occlusion.
- End-effector velocity is estimated from feature jacobian and it is used to generate joint velocities from robot jacobian.
- Dexterous manipulation capability is shown by using the robot to play ping-pong at a ball speed of 15 cm/s.

Verifying Deep Neural Networks (Report, Code)
- Literature Survey: summarized 10 research papers on state-of-the-art approaches to verify deep neural networks.
- Used ReLUplex, an SMT solver for verifying deep neural networks, to verify properties of:
  - A prototype DNN for airborne collision avoidance system for unmanned aircraft (ACAS Xu).
  - A simplified network trained on MNIST Digit Recognition dataset
- Extended ReLUplex to run on piece-wise linear max-pooling functions with no significant delay.

Modelling Human Behaviour in Chess (Report, Code)
- Developed a predictive model of human chess moves through supervised learning.
  - Predicting human moves is a multi-class classification problem, but with a different set of classes for each position.
- Trained three models: linear, neural net and transformer model, on Lichess dataset.
- Transformer based model performed best with an accuracy of 76.4% on top-5 accuracy.

3D Pose Estimation from Single RGB Camera (Report, Code)
- Developed a method to estimate 3D kinematic pose of human using a RGB camera video stream at 15 Hz.
- Fully-connected CNN's yields 2D and 3D joint positions simultaneously and eliminates expensive BB computation.
- Real-time model based kinematic fitting is used against 2D/3D predictions to produce joint positions of 3D skeleton.

Optimizing Network Usage in Robotic Systems (Undergrad Thesis) (Report, Poster)
- Developed static analysis tool for ROS to optimize network usage.
- Automatically generated ROS messages contain shared information between publishers and subscribers.
  - Reduced network usage by 10% by pruning unused fields from messages.
  - Decreased network bandwidth usage that helped drop message latency by 4%.

Swarath - Autonomous Car (Website)
- Designed a test bench template using Google Test and ROS for testing perception module of an autonomous car.
- Used predetermined ground truth for verification and validation of the module outputs.
- Helped improve iteration time on module development in simulation environment.
  - Selected among the top 13 teams (out of 153) to enter the hardware round.

SCHOLARSHIPS AND ACHIEVEMENTS

- Received International Tuition Award to assist my tuition fees for my graduate program (Amount: 7400$).
- Received St John's College Sir Quo-Wei Lee Fellowship for Summer Session 2021 (Amount: 2000$).
- Graduate Teaching Assistant Award for earning outstanding scores and feedback from students on teaching evaluations.
- Chancellor's Gold Medal for best academic record amongst the entire B.Tech program.
- Acknowledged in Dean's Merit List for excellent academic performance amid computer science undergraduates.

PUBLICATIONS, WORKSHOPS AND PATENTS

N. Sharma, S. Thukral, S. Aine, and P.B. Sujit, "A virtual bug planning technique for 2D robot path planning," in *IEEE American Control Conference*, ACC , Milwaukee, June 2018.

A. Singhal, A. Kumar, S. Thukral, D. Raina, S. Kumar,"Chitrakar: Robotic System for Drawing Jordan Curve of Facial Portrait," Workshop on Creativity and Robotics, *International Conference on Social Robotics*, ICSR, November 2020.

A. Singhal, H. Kahdilkar, V. Raju, D. Raina, V.S. Prasad, S. Thukral, R. Sinha, "System and method for autonomous multi-bin parcel loading system", U.S. Patent Application No. 17/167,999.