

## EDUCATION

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### Master of Science in Computer Science

University of British Columbia (UBC), Vancouver, Canada

September 2019 – Present

**GPA:** 88.8 / 100

Thesis: Real-time Perception of Potential Docking Locations for Smart Wheelchairs

### Bachelor of Technology in Computer Science and Engineering.

Indraprastha Institute of Information Technology (IIIT), Delhi, India

August 2017

**GPA:** 9.4 / 10.0

Thesis: Resolving Message Logic Dependencies in Robotic Systems ([Poster](#))

## SKILLS

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**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

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### 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 Path Integral to develop a shared control strategy for wheelchairs.

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

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### 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

- 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

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### 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 ReLUpex, 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 ReLUpex 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 (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

- 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

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- 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

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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.