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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   **Current GPA:** 90.2%
   Thesis: Visual Goal Identification

Bachelor of Technology in Computer Science and Engineering.   August 2017
   Indraprastha Institute of Information Technology (IIIT), Delhi, India   **CGPA:** 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

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
  • 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.

ACADEMIC EXPERIENCE

Graduate Research Assistant, UBC Vancouver   May 2020 – Present
  • Working on a real-time algorithm to find salient locations for a wheelchair in an indoor environment.
  • Segmented indoor objects using votenet, an end-to-end 3D object detection network, trained on SUNRGB-D dataset.
    • Average inference time of 0.25 seconds with only 20,000 XYZ points.
  • Designed a real-time pipeline to find parking spots at these salient locations under 2 secs form pointcloud data.
  • Used log-odds formulation to get a temporal desirability costmap for these parking spots in a room.
  • Formulated cost functions for shared control using Model Predictive Path Integral (MPPI) for wheelchair path planning.
    • This controller uses both desirability costmap and user joystick commands for in-sync path planning.

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.

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.

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 (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

- Received *International Tuition Award* to assist my tuition fees for the year 2019, 2020 and 2021 (Amount: 6400$).
- Received *St John's College Sir Quo-Wei Lee Fellowship* for Summer Session 2021 of amount 2000$.
- *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.

Autonomous multi-bin parcel loading system, A. Singhal, H. Kahdilkar, V. Raju, D. Raina, V.S. Prasad, S. Thukral, R. Sinha, Patent filed on July 14, 2019