

Ramkumar Natarajan

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Education

Worcester Polytechnic Institute (WPI), Worcester, MA

2015-17

Master of Science in Robotics Engineering,

GPA: 4.0/4.0

SASTRA University, IIT Madras (Transfer & Bachelor's Thesis), India

2011-15

Bachelor of Technology in Electronics and Communication Engineering,

GPA: 7.4/10 (Based on absolute grading. Ranked 38th in a class of 277)

Scholastic Achievements

2017: Ranked 1st in the Master's of Science in Robotics Engineering in a class of 48 students.

2013: Acquired a seed grant of 5000USD from the Center for Artificial Intelligence & Robotics - Defense Research and Development Organization (CAIR - DRDO) and adjudged as the Junior Research Fellow

Publications

2017: Natarajan R., Rajasekaran S.P., Taylor J.D, **Towards Planning and Control of Hybrid Systems with Limit Cycle using LQR Trees** Proceedings of the IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS) Sept 2017

2017: Natarajan R. **Efficient Factor Graph Fusion for Multi-robot Mapping** Proceedings of the IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS) Sept 2017. To appear (poster session)

2017: Natarajan R. **Efficient Factor Graph Fusion for Multi-robot Mapping** Master's Thesis, Robotics Engineering, Worcester Polytechnic Institute, WPI, (Worcester, MA, USA), June 2017

2014: Natarajan R., **Sensor Modeling, Feature Extraction, Landmark Association and EKF implementation for a Mobile Robot** Detailed Annexure, Center for Artificial Intelligence and Robotics - Defense Research and Development Organization, (CAIR-DRDO, India), June 2014

Patents

2017: Taylor J.D, Natarajan R., **Color Haar Classifier for Retail Shelf Label Detection and Recognition** U.S. Provisional Application No. 62598263. Filed by Bossa Nova Robotics

Technical Reports

2016: Sekharan S. R., Natarajan R., Rajasekaran S.P., **Transfer from Multiple Linear Predictive State Representations(PSR)** arXiv preprint arXiv:1702.02184

2015: Natarajan R., Rajasekaran S.P., Sekharan S.R., Kabilan V., **Object Recognition, Pose Estimation and Tracking of a Rigid Object with Planar Surface** Computer Vision Course Report, Robotics Engineering, Worcester Polytechnic Institute, WPI, (Worcester, MA, USA), Jan 2016

Professional Experience

Carnegie Mellon University & RobotWits LLC

POSITION: Visiting Researcher

June 2017 - Present

ADVISOR: Prof. Maxim Likhachev

Developing cost function optimization techniques for low-level planning in self-driving cars using inverse reinforcement learning. I am also working on fail-operational architecture for planning subsystem in self-driving vehicles.

Master's Thesis: Efficient Factor Graph Fusion for Multi-robot Mapping

ADVISOR: Prof. Michael A. Gennert

Aug 2016 - June 2017

- Developed a novel method to efficiently fuse the factor graphs of multiple robots for multi-robot mapping by reusing their individual variable ordering. Provided formal verification to show that it does not violate any relevant standards.
- Addressed the problem of simultaneous pose initialization in multi-robot navigation by estimating the relative robot transformations implicitly as a part of optimizing the factor graph.

Bossa Nova Robotics R&D

POSITION: Robotics Research Intern

May 2016 - Mar 2017

- Developed computer vision and robot localization algorithms. Main focus was to extend Viola Jones rapid object detection algorithm to support multi-channel (Color with depth and LIDAR intensity) images along with ranking features across different channels agnostically in Adaboost using Fischer Linear Discriminant Analysis.
- Developed a framework for performing online landmark association for factor graph based SLAM and supported standard approaches like nearest neighbor and Joint Compatibility Branch and Bound (JCBB).
- As a part of my Master's thesis I incorporated graph reductionist and tree decomposition methods to concurrently perform filtering and smoothing for SLAM as a parallel architecture.

WPI ECE 3829: Advanced Digital System Design using FPGAs.

POSITION: Teaching Assistant

Jan 2016 - May 2016

Conducted Lab sessions for this course. As a lab instructor, I tutored students based on the curriculum, evaluate their experiments and grade their assignments and exams.

Indian Institute of Technology(IIT), Madras

POSITION: Research Intern

Dec 2014 - May 2015

High dimensional planning and Reliability map for a mobile robot in dynamic, cluttered & unknown environment.

Investigator: Prof. Dr. Balaraman Ravindran

- Implemented Rapidly exploring Random Tree * (RRT*) algorithm with a local online re-planner for a Pioneer mobile robot in a unstructured dynamic environment.
- Computed a reliability map of the unstructured environment for a mobile robot (Pioneer P3-DX) based on the "Kalman Filter" beliefs of each sensor at every state.
- Used policy evaluation techniques from Reinforcement Learning to find the most energy efficient path strategy.
- Tools:** ROS, Gazebo,PCL. **Programming:** Python and C++.

Research Projects

Planning and Control of Hybrid Dynamical System with Limit Cycles using LQR Trees

Jan – May 2016

- To extend the existing capability of LQR tree to a hybrid system exhibiting limit cycle behaviour.
- Stabilize the controller across a goal trajectory as opposed to goal limit cycle in the previous methods.
- Results are tested in simulation using a Knead Compass Gait.
- Tools:** DRAKE

Transfer from Multiple Linear Predictive State Representation.

Sept – Dec 2015

- Formulated a framework to transfer knowledge from learnt source tasks to new target task with 'different' state and action parametrization.
- Modelled a controlled dynamical system as PSR using reset algorithm and planned using approximate Q learning.
- Devised a novel similarity metric-check called 'Validation Test Projection Algorithm' to estimate the closeness of two PSRs.
- The similarity in the model is exploited to reduce the lead time by transferring the prediction probabilities of future observations.

Recognition, Pose Estimation and Tracking of a Rigid Object with Planar Surface Oct 2015 – Jan 2016

- Formulated a method to solve the problem of object detection given the 3D model of the object and sufficient non co-planar 2D points in the image.
- The Opponent SURF features of the model are matched with scene descriptors using FLANN Matcher.
- My role was to formulate the task as Perspection-n-Point problem to estimate the pose and do online tracking using kalman filter to eliminate the bad poses.
- **Tools:** OpenCV **Programming:** C++, Python.

Design of Ground Control Station for Unmanned Air Vehicle July – Oct 2013

- Developed Virtual Ground Control Station (GCS) to interface with the on-board hardware of the Unmanned Aerial Vehicles.
- GCS is used to control an UAV beyond visual range and to monitor the data sent by the UAV(sensor, images, video feed, etc.).
- Analyzed the performance and dynamics to improve the design of the vehicle using data logger designed within the GCS.
- **Tool:** LabVIEW

Prof. N. S. Manigandan, SASTRA

Intelligent control and fault detection using sensor fusion techniques Jan 2013 – Oct 2014

- Designed a framework for the data association of extracted features from the robot environment.
- An incremental setup was designed to overcome the computational complexities and sensitivities to non linearity.
- It is formulated in terms of the posterior distribution by exploiting the probabilistic structure present in feature cloud matching.
- **Sensors used:** Hokuyo LIDAR, Optical encoders, 9 axis IMU, Kinect, Visual feed from camera.

Computer skills

Programming: C/C++, Python, Matlab, Verilog, \LaTeX .

Software: ROS, OpenCV, Gazebo, OpenNI, Eclipse, Valgrind, GDB, PlayerStage, PCL.

Robot Platforms: Pioneer P3-DX, Corobot CL2/CL4 (Differential/Skid Drive), Boston Dynamics Atlas, Atlas(BNR).

OS: Linux, Microsoft Windows

Activities

Dec 2015: Scoring Assistant, FIRST LEGO League (State Level)

Nov 2015: Speaker Minder, North Eastern Robotics Colloquium (NERC).

Apr 2015: Selected Participant, Recent Advances in Reinforcement Learning (RARL), IIT-Madras.

Feb 2015: Organizer, DAKSH 2015, SASTRA University, India.

Dec 2014: Teaching Volunteer, Public higher secondary school, Chennai, India.

Oct 2013: Mentor, Workshop on 'Programming MSP430 LaunchPad-The Wonder Chip'.

2013–15: Clowning Coordinator, Seb's Project, India.

2012–15: Student President, Robotics Club @ SASTRA (RCS), SASTRA University, India.