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 Unviersity, IIT Madras (Transfer & Bachelor's Thesis), India *2011-15*
Bachelor of Technology in Electronics and Communication Engineering

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) 2017.

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

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., **Sensor Modeling and Reliability Map, 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 2015

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 involved in 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 as a part of optimizing the factor graph by introducing a new type of error function.

BossaNova Robotics R&D
POSITION: Robotics 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.
- 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.

Center for Artificial Intelligence of Robotics, Defense Research & Development Organization (CAIR-DRDO)
POSITION: Junior Research Fellow — Dec 2012 - May 2015
Innovative signal processing algorithms for probabilistic unmanned vehicles — *Investigator: Dr. K. Ramkumar*

- The main objectives of this research work were to promote technologies for the automation of a mobile robot in the areas of localization, navigation and control.
- My duty was to solve the Simultaneous Localization and Mapping (SLAM) problem in a mobile robot with the motivation that human perception is a confluence of simple geometric figures.

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 an online re-planner that scales depending on the structure of a dynamic environment for Pioneer robot with Kinect, LIDAR and Odometer.
- Formulated a Reliability map of the stochastic 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 2016 – May 2015*

- 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 method.
- Results are tested in simulation using a Kneed Compass Gait.
- **Tools:** DRAKE

Transfer from Multiple Linear Predictive State Representation. *Sept 2015 – 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 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 methodology 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 situation 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 2013 – Oct 2013*

- Developed Virtual Ground Control Station (GCS) to interface with the hardware on board 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).
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.