

# Muhammad Asif Rana

ROBOTICIST · ELECTRICAL ENGINEER · GRADUATE STUDENT

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## Education

### PhD in Electrical and Computer Engineering, Georgia Institute of Technology, USA

2015 - Present

- **Thesis:** Data Efficient Methods for Teaching Diverse Robot Skills: Leveraging Priors, Geometry, and Dynamics.
- **Advisor:** Sonia Chernova.
- **Core Areas:** Robot Learning from Demonstration, Motion Planning, Controls.

### MS in Electrical and Computer Engineering, Georgia Institute of Technology, USA

2013 - 2015

- **Core Areas:** Controls, Robotics, Computer Vision, Machine Learning.

### BS in Electrical Engineering, LUMS, Pakistan

2013 - 2015

- **Core Areas:** Controls.

## Research Experience

### PhD Student, Georgia Institute of Technology, Atlanta, GA

2015 - Present

- **Bayesian Inference for Skill Generalization:** Developed *CLAMP*, which learns a skill prior from demonstrations and generalizes the skill to new environments. Probabilistic inference over factor graphs is employed for efficient motion generation.
- **Reactive Policy Learning from Demonstration:** Proposed an approach towards learning stable policies from demonstrations, that can react to dynamic perturbations while guaranteeing convergence to a goal. The proposed approach is also capable of learning skills that require coordination of different robot body parts.
- **Geometric Approaches towards Learning from Demonstration:** Proposed two new approaches, namely *TLGC* and *MCCB*, which extract the important geometric features of demonstrations and uses them to generalize motions. Optimization routines and heuristics are employed for motion generation.
- **A Large-scale Benchmark of Skill Learning:** Carried out a user study for data collection, followed by a crowd-sourced evaluation to compare various approaches for skill learning on real-world robotics tasks. The dataset and evaluations are made publicly available.

### Robotics Research Intern, NVIDIA, Seattle, WA

2019 - Present

- **Human-guided Riemannian Motion Policies:** Working on learning stable motion policies and exploiting tree structures to enable coordinated and reactive motion generation. The approach has been evaluated on various tasks in a kitchen environment.

### Robotics Intern, United Technologies Research Center, East Hartford, CT

Summer 2017

- **Human-centered Robotics:** Developed an end-to-end system for learning manipulation skills from human demonstrations. The system was able to record trajectories via kinesthetic teaching, learn a skill model and reproduce the skill under perturbations.

### Graduate Research Assistant, Georgia Institute of Technology, Atlanta, GA

2014 - 2015

- **Simultaneous Path Planning and Ocean Flow Mapping:** Explored optimal control based path planning approached for long-term exploration of ocean under uncertain dynamics. Worked towards developing a recursive framework for simultaneous ocean flow estimation and exploration.
- **Control of Cell Membrane Potential:** Modeled the membrane potential trends (depolarization) seen experimentally on introduction of nanoparticles to mammalian cells. Carried out Lyapunov analysis to study the conditions which affect the resting potential.
- **Human-robot Collaboration for Car Assembly:** Implemented background subtraction, HOG+SVM based classifier and Kalman Filter on PointClouds to detect and track humans. Implemented dynamically-evolving RRT to plan paths for the robot around moving obstacles(humans).

### Research Assistant, Lahore University of Management Sciences, Lahore, Pakistan

2010 - 2012

- **Brain-Computer Interface:** Collected electrical signals from brain using Emotiv EPOC headset in response to stimulus on a computer screen. Experimented with linear classifiers (Fisher's LDA, SVM etc.) to distinguish evoked potentials from the rest.
- **Designing and Implementing Ball on Beam Control System:** Structured the control system and used Particle Swarm Optimization (PSO) to tune the PID controllers. Evaluated the performance of PSO and proposed improvements to make it more efficient.

## Publications

### Refereed Conference & Journal Publications

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| <b>2020</b> | <b>M.A. Rana</b> , A. Li, D. Fox, F. Ramos, B. Boots, & N. Ratliff, <i>Euclideanizing Flows: Diffeomorphic Reduction for Learning Stable Dynamical Systems</i> , Learning for Dynamics and Control (L4DC)  |
| <b>2020</b> | <b>M.A. Rana</b> , D. Chen, J. Williams, V. Chu, S.R. Ahmadzadeh, & S. Chernova, <i>Benchmark for Skill Learning from Demonstration: Impact of User Experience, Task Complexity, and Start Configuration on Performance</i> , International Conference on Robotics and Automation (ICRA) |
| <b>2019</b> | <b>M.A. Rana*</b> , A. Li*, H. Ravichandar, M. Mukadam, S. Chernova, D. Fox, B. Boots, & N. Ratliff, <i>Learning Reactive Motion Policies in Multiple Task Spaces from Human Demonstrations</i> , Conference on Robot Learning (CoRL)  |

- 2019** H. Ravichandar\*, S.R. Ahmadzadeh\*, **M.A. Rana**, & S. Chernova, *Skill Acquisition via Automated Multi-Coordinate Cost Balancing*, International Conference on Robotics and Automation (ICRA)
- 2019** S. Banerjee, A. Daruna, D. Kent, W. Liu, J. Balloch, A. Jain, A. Krishnan, **M.A. Rana**, H. Ravichandar, B. Shah, N. Shrivatsav, & S. Chernova, *Taking Recoveries to Task: Recovery-Driven Development for Recipe-based Robot Tasks*, International Symposium on Robotics Research (ISRR)
- 2018** **M.A. Rana**, M. Mukadam, S.R. Ahmadzadeh, S. Chernova & B. Boots, *Learning Generalizable Robot Skills from Demonstrations in Cluttered Environments*, International Conference on Intelligent Robots (IROS)
- 2017** **M.A. Rana**, M. Mukadam, S.R. Ahmadzadeh, S. Chernova & B. Boots, *Towards Robust Skill Generalization: Unifying Learning from Demonstration and Motion Planning*, Conference on Robot Learning (CoRL) - **Selected for long talk (8% acceptance rate)**
- 2017** S.R. Ahmadzadeh, **M.A. Rana** & S. Chernova, *Generalized Cylinders for Learning, Reproduction, Generalization & Refinement of Robot Skills*, Robotics: Science & Systems (RSS)
- 2016** **M.A. Rana**, N. Zao, S. Mukhopadhyay, F. Zhang, E. Warren & C. Payne, *Modeling the effect of nanoparticles & the bistability of transmembrane potential in non-excitable cells*, American Control Conference (ACC)
- 2014** Z. Sharif, Z. Usman & **M.A. Rana**, *Optimization of Static and Full Order Anti-Windup Compensator (AWC) using Improved Particle Swarm Optimization Algorithm*, 14th IEEE International Symposium on Computational Intelligence and Informatics (CINTI)
- 2011** **M. A. Rana**, Z. Usman & Z. Sharif, *Automatic Control of Ball and Beam System Using Particle Swarm Optimization*, 12th IEEE International Symposium on Computational Intelligence and Informatics (CINTI)

### Refereed Workshop Publications

- 2018** **M.A. Rana**, M. Mukadam, S.R. Ahmadzadeh, S. Chernova & B. Boots, *Robot Skill Learning from Demonstrations in Cluttered Environments*, RSS Workshop on Learning and Inference in Robotics: Integrating Structure, Priors and Models
- 2017** **M.A. Rana**, M. Mukadam, S.R. Ahmadzadeh, S. Chernova & B. Boots, *Skill Generalization via Inference-based Planning*, RSS Workshop on Mathematical Models, Algorithms, and Human-Robot Interaction
- 2017** **M.A. Rana**, M. Mukadam, S.R. Ahmadzadeh, S. Chernova & B. Boots, *Skill Generalization via Inference-based Planning*, RSS Workshop on (Empirically) Data-driven Manipulation

## Professional and Teaching Experience

### Assistant Engineer, Descon Engineering Ltd, Lahore, Pakistan

2012-2013

- **Barzan Gas Project:** Earned intensive training on different aspects of a plant and its documentation. Worked on P&ID and line diagram development.

### Field Applications Intern, National Instruments, Islamabad, Pakistan

Summer 2011

- **High-frequency Source Localization:** Setup the receiver hardware, developed LabVIEW VIs to triangulate the source and interfaced it with NI PXI/DAQ. Conducted a training workshop on LabVIEW for lab engineers.

### Intern, Suraj Foundation, Lahore, Pakistan

Summer 2010

- **Alternative Energy Solutions:** Modeled solar-powered systems for homes and small businesses. Conducted a feasibility study and price estimates for various solar-powered systems. Contacted various vendors to and designed various system layouts to design a low-cost end-to-end system

### Teaching Assistant, Lahore University of Management Sciences, Lahore, Pakistan

2010-2012

- Feedback Control Systems
- Electromechanical Systems
- Intro to Differential Equations

## Skills

**Programming** Python, C++, MATLAB, LaTeX

**Tools** ROS (Robot Operating System), PyTorch, MATLAB, LabVIEW

**Languages** English, Urdu, Punjabi

## Honors, Awards, & Services

- 2017-  
2013 **Reviewer**, for CoRL, ICRA, RAL, and IROS
- 2012 **Recipient**, Fulbright scholarship for Masters at Georgia Tech
- 2012 **Winner**, Dean's Honor List award for 4 consecutive years in college
- 2012 **2nd Place**, IEEE Senior Design competition
- 2008 **Recipient**, Baber Ali Foundation scholarship for 4 years in college
- 2006 **Recipient**, Merit scholarship for 2 years in high school