Ran Tian

Curriculum Vitae

Phone: 734-263-4518

E-mail: tianran@umich.edu

Website: http://www-personal.umich.edu/~tianran/

Research Objective

My research goal is to build robot autonomy that perceives and interacts with the world by integrating interdisciplinary techniques from vision, planning, control, artificial intelligence and human cognition. Specifically, I am interested in:

- **Generalizable algorithms for long-horizon tasks in unstructured environments**: robot learning algorithms that exploit human cognition (prior experience, imitation, curiosity, meta-cognition); visual stochastic MPC; integrating robot learning (hierarchical RL) and symbolic planning.
- **Human-robot interaction**: reward functions learning; exploiting cognitive models of human decision-making to facilitate human-robot interaction; large-scale human-robot teaming.
- **Robot programming for all**: learning user-friendly latent languages for end-users to command robots in everyday settings.
- **Safe robot learning**: incorporating theoretically sound approaches in robot learning algorithms to promote constraints satisfaction during learning/testing in real environments.

Education

M.S.E — **University of Michigan, Ann Arbor, Robotics Institute**, 2017-2019
Advisors: Ilya Kolmanovsky and Anouck Girard
Specialization: Human-robot interaction, GPA: 3.9/4.0

B.S.E — **University of Michigan, Ann Arbor, Aerospace Engineering**, 2014-2016
Advisors: Ilya Kolmanovsky and Anouck Girard
Specialization: Control theory, Major GPA: 3.84/4.0

B.S.E — **Shanghai Jiao Tong University, China, Mechanical Engineering**, 2012-2017

Research Experience

[E6] University of California, Berkeley Sep 2019 - current

Visiting researcher with Prof. Masayoshi Tomizuka

Developing a multi-agent Inverse Reinforcement Learning algorithm that leverages game theory and optimization to recover the agents' heterogeneous reward functions from their interactions.

[E5] University of Michigan Nov 2019 - current

Research assistant with Prof. Ilya Kolmanovsky and Prof. Anouck Girard

Developing recovery strategies for autonomous systems that are confronted with unanticipated / failure situations that compromise their viability (can be applied to robot safe learning).

[E4] Honda Research Institute Jul 2019 - Oct 2019

Research intern with Dr. David Isele

Developed algorithms that enable the intelligent robots to learn and plan continuously in a human-like, curiosity-driven way.

[E3] University of Michigan Sep 2017 - May 2019

M.S. student researcher with Prof. Ilya Kolmanovsky and Prof. Anouck Girard

Worked on game-theoretic modeling of human-robot interaction, leveraged human cognitive model, model predictive control and Bayesian learning to enable an intelligent robot to cooperate with humans (autonomous driving) or compete against humans (gaming).

[E2] Qualcomm Research Self-Driving Group May 2018 - Aug 2018

Research intern with Dr. Pual Martin, Dr. Matthew Turpin and Dr. Daniel Mellinger

Worked on planning and control for self-driving cars, implemented the planning and control stacks for a Lincoln MKZ autonomous vehicle.

[E1] University of Michigan Sep 2014 - Aug 2017

B.S. student researcher with Prof. Ilya Kolmanovsky and Prof. Anouck Girard

Worked on control theory for systems with constraints and motion planning for net-worked UAVs.

Professional Services

Teaching Assistant

- Flight Dynamics and Control
- Introduction to Engineering
- Technical Communication

Journal Reviewer

- Taylor & Francis Vehicle System Dynamics
- ASME Journal of Dynamic Systems, Measurement and Control

Publications

Conference Proceedings

[**c6**] Title unavailable due to the double-blind review policy
R. Tian, L. Sun and M. Tomizuka
International Conference on Machine Learning (**ICML**), 2020, in preparation

[**c5**] **Beating humans by leveraging cognitive hierarchy theory and Bayesian learning**
R. Tian, N. Li, I. Kolmanovsky, and A. Girard
American Control Conference (**ACC**), 2020, [top conference in control theory], under review
arXiv:1909.12701

[**c4**] **Curios minded intelligent robots in uncertain and interactive environments**
R. Tian and D. Isele
IEEE International Conference on Robotics and Automation (**ICRA**), 2020, under review
Project webpage: http://www-personal.umich.edu/~tianran/curiousrobot.html

[**c3**] **Adaptive game-theoretic decision making for autonomous vehicle control at roundabouts**
R. Tian, S. Li, N. Li, I. Kolmanovsky, A. Girard and Y. Yildiz
IEEE Conference on Decision and Control (**CDC**), 2018, [top conference in control theory]

[**c2**] **Coordinated control of active steering and differential braking using extended command governor for rollover avoidance**
R. Tian, R. Bencatel, A. Girard, and I. Kolmanovsky
ASME Dynamic Systems and Control Conference (**DSCC**), 2017

[**c1**] **Path planning for information collection in contested environments using marsupial systems**
R. Tian, H. Chen, G. Frey, B. Zu, A. Girard and I. Kolmanovsky
IEEE International Conference on Unmanned Aircraft Systems (**ICUAS**), 2017

Journal Articles

[**J2**] **Game-theoretic modeling of traffic in unsignalized intersection network for autonomous vehicle control verification and validation**
R. Tian, N. Li, I. Kolmanovsky, and A. Girard
IEEE Transactions on Intelligent Transportation Systems, 2019, under review, arXiv:1910.07141

[**J1**] **Reference governor strategies for vehicle rollover avoidance**
R. Bencatel, **R. Tian**, A. R. Girard and I. Kolmanovsky
IEEE Transactions on Control Systems Technology, 2017

Workshops

[**w1**] **Game-theoretic modeling of interactive traffic for autonomous vehicle control**
N. Li, **R. Tian**, I. Kolmanovsky, and A. Girard
In 3rd IAVSD Workshop on Dynamics of Road Vehicles: Connected and Automated Vehicles, 2019

Selected Research Projects

Multi-agent Inverse Reinforcement Learning, *UC Berkeley* `09/2019 - current`

- Developed an Inverse Reinforcement Learning algorithm that recovers the reward functions of the multiple agents that act in an interactive and uncertain environment
- Leveraged game theory, optimal control and deep network to recover the heterogeneous reward functions from the demonstrations of the interactive agents

Curious minded intelligent robots, *Honda Research Institute* `07/2019 - 10/2019`

- Developed an algorithm that enables the robots to learn and plan with a human-like sense of curiosity
- Leveraged partially observable MDP, model predictive control, Monte Carlo tree search and information theory to continually evolve a planning strategy that adaptively balances the explore-exploit trade-off
- Applied the proposed algorithm to a visual navigation under pose uncertainty scenario; the proposed algorithm outperforms the state-of-the-art RL-based base lines (publication [**c4**])

Mind reading AI: exploiting human cognitive model to beat humans, *University of Michigan*
`04/2019 - present`

- Developed a novel Artificial Intelligence that beats human players in a two-player zero-sum game
- Exploited cognitive hierarchy theory and Bayesian learning techniques to continually evolve a model for predicting human player decisions
- The proposed AI makes decisions according to the model predictions to pursue the best chance of winning
- The proposed AI beats 90% of the real human players in a simulated gambling game (publication [**c5**])

Planing and control for a self-driving car, *Qualcomm Research* `05/2018 - 08/2018`

- Developed and implemented the planning and control stacks for a Lincoln MKZ autonomous vehicle and successfully validated the developed algorithms in real traffic

Game-theoretic modeling of driver interactions for autonomous driving, ***University of Michigan***
04/2018 - 06/2019

- Proposed a game-theoretic approach to modeling human driver interactions in urban traffic environments
- Leveraged level-k game theory and receding-horizon optimization to define the heterogeneous human decision-making models, and exploited imitation learning techniques to achieve scalable computation of the human decision-making models
- Exploited the proposed human decision-making models to develop an interaction-aware planning algorithm for autonomous vehicles ([**c3**])
- Exploited the proposed human decision-making models to build a virtual simulation tool (able to model large scale interactions) for verification and validation of autonomous vehicle control systems ([**J2**])

Safety enforcement under unsafe reference commands, ***University of Michigan*** 09/2015 - 10/2017

- Proposed a safety controller for the safety-critical agents that operate under potential unsafe commands
- Exploited Reference Governor strategy in the controller design to guard the unsafe reference commands and compute the command corrections to enforce the safety constraints
- Applied the developed controller to vehicle rollover avoidance; the developed controller utilizes active steering and differential braking to maintain vehicle stability under the unsafe commands from the driver
- The developed controller can effectively enforce the vehicle's safety constraints under the unsafe commands and is shown to be robust to state estimation error ([**J2**], [**c2**])

Motion planning for networked UAVs, ***University of Michigan*** 03/2015 - 09/2015

- Developed a motion planning algorithm for a marsupial system (a team of heterogeneous UAVs with distinct capabilities) assigned to gather information in adversarial environments
- Formulated the Optimal Control Problem that solves for the optimal path of each agent in the marsupial system, utilized the maximum principle to prove the necessary conditions for optimality and validated them through the numerical simulations
- The developed motion planning algorithm leverages the distinct capabilities of the agents in the marsupial system to plan the optimal paths that minimize the likelihood of detection by an adversarial radar ([**c1**])

Awards

Conference Travel Award, University of Michigan, 2017-2018
University Honors, University of Michigan, 2014-2016
The Distinguished Student Scholarship, Shanghai Jiao Tong University, 2012-2014
China Mathematics Olympiad, First Price, 2012

Talks & Presentations

1. Game-theoretic decision-making for autonomous vehicles, 2018 Conference on Decision and Control, December 2018
2. Decision-making for autonomous vehicles in urban environments, Robotics Institute, University of Michigan, April 2018
3. Reference governor strategy for vehicle rollover avoidance, 2017 Dynamic Systems and Control Conference, October 2017

Activities

Hobby Rescue Diver, Single Engine Aircraft Pilot, Photography