Songyuan Zhang

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Research Interests: Robotics, Human-Robot Interaction, Learning to Control, Imitation Learning, Reinforcement Learning

EDUCATIONAL BACKGROUND

Tsinghua University, Beijing, China **GPA: 3.90/4.0 (Top 2 of 140)** Aug. 2017 – Jul. 2021 (expected)

Major: Engineering Mechanics (**Tsien Excellence in Engineering Program, Qian Class**)

Core Courses: (4-point system) Fundamentals of Dynamics and Control (4.0); Data Structure (4.0); Open Research for Innovative Challenges (4.0); Foundations of Scientific and Engineering Computing (4.0); Probability and Statistics (4.0); Advanced Algebra (4.0); University Physics (4.0); Electrical Engineering and Applied Electronics (4.0); Methods of Optimization (3.6); Advanced Calculus (3.6); Quantum Mechanics (4.0); Methods of Mathematical Physics (4.0)

University of California, Berkeley Summer Exchange Researcher Jul. 2019 – Sep. 2019

Stanford University Remote Research Collaborator Jun. 2020 – Present

PUBLICATIONS

1. **Songyuan Zhang**, Zihao Wang, Chaorui Zhang, Zhongyi Huang, Hao Wu, Makoto Yamada, Bo Bai, and Gong Zhang. Gromov-Wasserstein Clustering for Combinatorial Optimization Problems with Locality and Mass Constraints. Submitted to *the 30th International Joint Conference on Artificial Intelligence, IJCAI-21*.
2. **Songyuan Zhang**, Yifeng Zhang, Hongxiang Yao, and Gangtie Zheng. Analysis and Experimental Study of the Vibration Characteristic for a Tendon-driven Continuum Manipulator. In *Proceedings of the 26th International Congress on Sound and Vibration, ICSV26*, pages 2679-2686, 2019. (**20min Oral Presentation**)

RESEARCH EXPERIENCES

Stanford's Intelligent and Interactive Autonomous Systems Group (ILIAD), with collaboration of AI Group @ National Engineering Laboratory for Neuromodulation, Tsinghua University

Advisor: Dorsa Sadigh, Assistant Professor at the Computer Science Department, Stanford University
Yanan Sui, Assistant Professor at the School of Aerospace Engineering, Tsinghua University

Topic: Imitation Learning from Sub-optimal Demonstrations Jun. 2020 – Present

The goal is to propose a novel Imitation Learning (IL) algorithm with which the agent can learn the optimal policy from a mixture of optimal and sub-optimal demonstrations, which cannot be distinguished.

- Designed a novel IL framework, Semi-confidence Imitation Learning (SIL), by introducing an outer loss in the the framework of a weighted version of AIRL. Each state-action pair in the demonstrations are labeled with a confidence score, and the occupancy measure of optimal demonstrations are approximated with a confidence-weighted occupancy measure of the mixed demonstrations. The confidence scores are updated by minimizing the outer loss, and the policy is learned by minimizing AIRL's objective.
- Experimental results showed that SIL surpasses AIRL and GAIL in some environments, and even close to the performance of AIRL/GAIL trained by optimal demonstrations. The algorithm can also deal with the scenario that insufficient optimal demonstrations are given and learn from sub-optimal demonstrations.

Department of Mathematical Sciences, Tsinghua University

Advisor: Hao Wu, Associate Professor (tenured) at the Department of Mathematical Sciences, Tsinghua University

Topic: Gromov-Wasserstein Clustering for Combinatorial Optimization Problems with Locality and Mass Constraints Nov. 2019 – Sep. 2020

The goal was to propose a novel cluster algorithm, Gromov-Wasserstein Clustering (GWC) to solve a large variety of combinatorial optimization problems with locality and mass Constraints.

- Designed GWC by introducing Gromov-Wasserstein distance in clustering. The clustering problem is modeled by matching the points in the original space with cluster centers in another high-dimensional latent cluster space through minimizing the GW distance. GWC focuses more on the structural property, which allows adding structure prior in the

clustering, including unique heuristics in solving combinatorial optimization problems.

- Proposed to adopt Radial Basis Function (RBF) kernels to impose the locality feature when clustering. Proposed a scaling law associated with the density of the points to auto-tune the radical hyperparameter in the RBF kernel. In this way, the hyperparameter can be validated at small-scale problems and generalized to large-scale problems.
- Solved Capacitated Vehicle Routing Problem (CVRP) and Capacitated Centered Clustering Problem (CCCP) using GWC. Extensive evaluations showed that GWC achieves or even surpasses state-of-the-art results on both capacitated routing and planning problems, and the computational time is reduced by one order of magnitude.

Mechanical Systems Control (MSC) Lab, University of California, Berkeley

Advisor: Masayoshi Tomizuka, Professor at the Department of Mechanical Engineering, U.C. Berkeley

Topic: Sample-based Planning for Autonomous Driving Jul. 2019 – Sep. 2019

The goal was to build up a tunable planner that can interact with other drivers and work in a complex roundabout.

- Developed a dynamic Bayesian network to predict the trajectory distribution of other vehicles.
- Developed a sample-based planner to get a smooth and collision-free trajectory. Applied edge-augmented elastic-band planner to generate a collision-free path, and bicycle-tracking model to smooth it. Applied spatial lattice to generate several trajectories and sample the velocities and applied cascaded ranking to decide the final trajectory.
- Established a ROS platform and a complex roundabout environment based on the real-world data. The algorithm showed great performance in the roundabout, generating a collision-free and smooth trajectory.
- Tested the planner on a real self-driving vehicle. The planner gave passengers a comfortable ride experience.

Future Lab, Tsinghua University

Advisor: Gangtie Zheng, Professor at the School of Aerospace Engineering, Tsinghua University

Topic: Flexible Manipulator for Minimally Invasive Surgery of Joint Aug. 2018 – Jun. 2019

The goal was to design and built up a flexible arthroscopic manipulator to reduce the dead angle of doctors' observation and alleviate the pain of patients.

- Designed and built up a two-stage four-degree-of-freedom tendon-driven flexible manipulator.
- Developed the backbone of the manipulator by slotting the thin-walled tube to enhance the flexibility of the flexible manipulator without breaking it and to maintain the isotropy of the mechanical properties of its section, inspired by the satellite dampers.
- Developed a method based on the piecewise constant curvature hypothesis while controlling.
- Proposed a practical approach to predict the manipulator's first resonant frequency combining the finite element method and the analytical method and showed how this frequency varies with the configuration.

SELECTED HONORS AND AWARDS

2020 Tsinghua Scholarship for Technological Innovation (Top **30/3500** undergraduates)
2020 Scholarship for Comprehensive Excellence (Top 17/140)
2020 Scholarship for Academic Excellence (Top 50/140)
2019 National Scholarship (Top 3/143, **highest honor** in the department)
2019 **First prize** in Excellent Student Research Training Contest (Top **15/1300** projects)
2019 **First prize** "Challenge Cup" Science and Technology Competition of Tsinghua University (The **highest-level** science and technology contest in Tsinghua University)

SOCIAL WORKS

Chairman of 13th *Spark* Innovative Talents Training Program in THU (top 1% undergraduates)	Sep. 2019 – Present
Monitor of Class	Aug. 2018 – Present
Member of The Second Team of Middle and Long Distance Running in Tsinghua University	Jun. 2018 – Present

SKILLS AND INTERESTS

Programming Languages and Software	Python / C++ / MATLAB / ROS / Pytorch / Arduino / SolidWorks / ABAQUS
Interests	long-distance running, piano, badminton, drum kit, basketball, taekwondo