Kasra Eshaghi

kasra.eshaghi@mail.utoronto.ca

www.linkedin.com/in/kasra-eshaghi

416-878-8847

23 Revcoe Drive, Toronto, Canada, M2M 2B9

Education

Ph.D. – Mechanical Engineering

University of Toronto – CIMLab and ASB Lab – Sept. 2018 – Dec. 2023.

- Investigated collaborative-motion control and planning methodologies for robotic swarms with limited onboard localization capabilities.
- Collaborated on the development of swarm localization, mapping, and connectivity restoration methodologies.
- Designed, fabricated, and programmed a millimeter scale robot for algorithm verification.

B.A.Sc. – Mechanical Engineering

University of Toronto – Sept. 2013 – May 2018.

- Specialized in mechatronics and control.

Relevant Courses

- Robot motion planning, Mobile robots and perception, Intelligent robotic systems, Robotic manipulators, Introduction to machine learning.

Publications

[1] A. Rogers, **K. Eshaghi**, G. Nejat, B. Benhabib, "Occupancy grid mapping via resource-constrained robotic swarms: A collaborative exploration strategy," *Robotics*, vol. 12, no. 3, May 2023.

[2] **K. Eshaghi**, G. Nejat, and B. Benhabib, "A concurrent mission-planning methodology for robotic swarms using collaborative motion-control strategies," *J. Int. Rob. Syst.*, vol. 108, no. 2, pp. 1-26, Apr. 2023.

[3] M. Shao, M. Pham-Hung, S.F.R. Alves, M. Snyder, **K. Eshaghi**, B. Benhabib, G. Nejat, "Long-term exercise assistance: Group and one-on-one interactions between a social robot and seniors," *Robotics*, vol. 12, no. 1, Jan. 2023.

[4] **K. Eshaghi**, A. Rogers, G. Nejat, and B. Benhabib, "Closed-loop motion control of robotic swarms – A tether-based strategy," *IEEE Trans. Robot.*, vol. 38, no. 6, pp. 3564-3581, Dec. 2022.
***** Also presented at ICRA 2023.

[5] H. J. Yoon, **K. Eshaghi**, G. Nejat, and B. Benhabib, "Localization and topology estimation of robotic swarm using Kalman filter," *J. Inst. Cont., Robot., Syst.*, vol. 28. no. 6, pp. 622-631, June 2022.

[6] **K. Eshaghi**, Z. Kashino, H. J. Yoon, G. Nejat, and B. Benhabib, "An inchworm-inspired motion strategy for robotic swarms," *Robotica*, vol. 39, no. 12, pp. 2283–2305, Apr. 2021.

[7] **K. Eshaghi**, Y. Li, Z. Kashino, G. Nejat, and B. Benhabib, "mROBerTO 2.0 – An autonomous millirobot with enhanced locomotion for swarm robotics," *IEEE Robot. Autom. Let.*, vol. 5, no. 2, pp. 962–969, Apr. 2020.

Robot Autonomy Experience

Motion Control Strategies for Robotic Swarms with Localization Limitations

- Developed collaborative-motion control strategies for swarms that have localization limitations due to their short-range onboard proximity sensors.
- Optimized the developed strategies through path planning and combinatoric optimization to achieve minimum motion control errors.
- Implemented the developed strategy in simulation for swarms of up to twenty robots, and in practice on a swarm of six millimeter-scale robots (https://youtu.be/24WzlfeJWNQ).
- Achieved significant improvement in motion control compared to the state-of-the-art.

Constrained Swarm Motion Planning

- Developed a motion planning methodology for robotic swarms subject to inter-robot trajectory constraints imposed through collaborative-motion control strategies.
- Formulated and solved relevant sub-problems including the division-of-labor, task-allocation, path-planning, and movement-concurrency to minimize mission execution time.
- Implemented the developed methodology in simulation for swarms of up to 100 robots (https://youtu.be/pVl-XXai3VE).
- Improved mission execution performance by 40% compared to the state-of-the-art.

Swarm Connectivity Restoration

- Developed a strategy to restore the connectivity of a swarm that is divided into multiple disconnected subgroups.
- Optimized the developed strategy through routing and path planning for efficient area coverage using probabilistic representations of the position of the disconnected robots, obtained based on their last known positions and motion models.

Path Planning for Collision Avoidance in Multi-Robot Systems

- Completed a thorough literature review of decoupled approaches to path planning for collision avoidance in multi-robot systems, and implemented the most viable approach in simulation for teams of up to 15 robots in an Amazon distribution center scenario.

Occupancy Grid Mapping via Resource-Constrained Robotic Swarms

- Collaborated on the development of an occupancy-grid mapping methodology using robotic swarms with limited onboard computation, communication, and sensing hardware.
- Optimized the mapping strategy by planning the motion of the robots to minimize mapping time.

Swarm Localization Using Partial Location Data

- Developed a swarm localization methodology that estimates the position of the robots based on the proximity measurements that robots make of each other and of the environment.
- Devised a clustering function to estimate the swarm's topology based on the obtained proximity measurements while considering scalability.
- Formulated a weighted least-squares objective to combine the estimated swarm topology with the robots' executed motion commands and the known map of the environment.

Machine Learning Experience

Product Rating Prediction – Amazon Dataset

- Developed and trained a neural network to predict Amazon product ratings based on reviewer data.
- Pre-processed the data through case-folding, tokenization, lemmatization, stop-word removal, and one-hot encoding.
- Conducted an exploratory analysis to evaluate the dependence of the available textual and contextual data on product ratings.
- Achieved a prediction error 30% better than the competing baseline using a network that considered the reviewers' comments and summary, and the product review times and categories, and included dense, recurrent, and embedding layers.

Heart Rate Profile Prediction – FitRec Dataset

- Collaborated on the developed a neural network to predict the heart rate profile of exercising individuals based on data obtained through wearable technology.
- Conducted an exploratory analysis to evaluate the dependence of the users' speed, altitude, workout history, gender, and sport on their heart rate profiles.
- Achieved a prediction error 30% better than then competing baseline using a network that included multiple recurrent and embedding layers.
- Proposed a custom loss function that is less sensitive to time-shifts for future work.

Improvement in Mission Execution Performance Prediction

- Engineered a tool for selecting between a computationally intensive *optimal* swarm mission planning methodology and a computationally efficient *sub-optimal* planning methodology.
- Developed a neural network to predict the improvement in mission execution performance that may be achieved by the optimal planning methodology versus its sub-optimal counterpart.
- Generated a dataset of 10,000 samples through a custom simulation environment.
- Achieved an estimation error of 5% using a feedforward neural network that was tuned through a grid search and validated through a k-fold cross validation process.

Robot Hardware Experience

mROBerTO 2.0

- Designed, fabricated, and debugged the mechatronic system of a 20*mm* x 20*mm* robot for swarm studies. This included PCB design for the locomotion (stepper motors), computation (ARM Cortex-M0), wireless communication (BLE & ANT), sensing (IR), and power management modules.
- Programmed the libraries for interfacing with the various modules.
- Developed the robot control architecture (perception, communication, localization, and control) for conducting swarm experiments and algorithm verification.

Mobile Robot for Autonomous Pickup and Delivery

- Led a team of four students in designing the mechatronic systems of a differential drive mobile robot equipped with brushed DC motors, ultrasonic proximity sensors, an Arduino microcontroller, and grippers. Robot was used for autonomous pickup and delivery in a maze.

Professional Engineering Experience

Mechanical Engineering Assistant

SciCan Ltd. Department of Research and Development, Toronto, Canada – May 2016 – July 2017.

- Collaborated with engineers, service personnel, and manufacturing staff on the development of a steam autoclave sterilizer for dental applications.
- Studied the venturi vacuum pump initiation problem and designed a fluid distortion mechanism to ensure initiation under all working conditions.
- Designed and fabricated multiple mechatronic systems dedicated to evaluating the vacuum pump, functionality of thermal switches, and hydro-pressure testing the pressure vessels.

Mechanical Engineering Co-op Student

HH Angus & Associates Ltd., Toronto, Canada – May 2015 – September 2015.

- Revised control sequences and prepared schematics for the ventilation, heating, cooling, and plumbing systems of a hospital (Centre Hospitalier de l'Université de Montréal).

Leadership Experience

Head Teacher Assistant

University of Toronto, Probability & Statistics / Manufacturing Engineering – Sept. 2020 – May 2023.

- Organized course material, managed up to eight teacher assistants, and communicated with instructors to ensure smooth operations of course lectures, tutorials, and laboratories.
- Oversaw the transition of the course to online learning during the Covid-19 pandemic.
- Taught classes of up to forty students, covering assigned homework problems, reviewing course material, and answering course-related questions.

Lab Manager

CIMLab, University of Toronto – Sept. 2020 – Dec. 2023.

- Interviewed prospective students and provided recommendations to my supervisors.
- Supervised undergraduate students and collaborated with graduate students for the completion of their degree requirements and paper publication.

Technical Skills

Programming Languages

Python, C, C++, Matlab, Simulink.

Programming Tools

TensorFlow, scikit-learn, Pandas, NumPy, Matplotlib, Git, ROS.

Mechatronics and Design

PCB design and development, Autodesk EAGLE, SolidWorks.