

# Qiangqiang (Chad) Huang

PH.D. CANDIDATE · ROBOTICS · MIT

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## Research interests

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SLAM · Visual localization · Probabilistic modeling and inference · Uncertainty-aware autonomous systems

## Education

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### Massachusetts Institute of Technology

PH.D. IN ROBOTICS, DEPARTMENT OF MECHANICAL ENGINEERING

Proposed thesis title: Towards Scalable Full Posterior Inference for Uncertainty-Aware Robot Perception

Advisor: Prof. John Leonard

Cambridge, MA

2018 – 2023 (expected)

### Tsinghua University

M.S. IN POWER ENGINEERING AND ENGINEERING THERMOPHYSICS, SCHOOL OF VEHICLE AND MOBILITY

B.E. IN VEHICLE ENGINEERING, SCHOOL OF VEHICLE AND MOBILITY

Minor: Computer Science

Beijing, China

2014 – 2017

2010 – 2014

## Experience

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### Computer Science and Artificial Intelligence Lab

RESEARCH ASSISTANT @ [MARINE ROBOTICS GROUP](#) LED BY PROF. JOHN LEONARD

- *Algorithm development* for full posterior inference in SLAM (code: [NF-iSAM](#), [NSFG](#), [GAPSLAM](#))
- *Object-based SLAM* in indoor environments and *range-only SLAM* in outdoor environments ([video](#))

MIT

2018 - present

### Microsoft

RESEARCH INTERN

- *Algorithmic solution* to the automatic placement of fiducial markers in visual localization using features (code: [OMP](#))
- Visual localization experiments in both *photo-realistic simulation* and *real-world* environments ([video](#))

Redmond, WA

Jun. - Aug. 2022

## Research Projects

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GAPSLAM: Blending Gaussian Approximation and Particle Filters for Real-Time Non-Gaussian SLAM

Mar. 2022 - Present

- Inferring marginal posteriors of robot poses and landmark locations encountered in SLAM via *real-time operation*
- Paper [\[P1\]](#), [code](#), and [demo video](#)

OMP: Optimizing Marker Placement for Improved Visual Localization

Jun. 2022 - Mar. 2023

- *First work* that optimizes marker placement for visual localization based on scene features and fiducial markers.
- Paper [\[J1\]](#), [code](#), and [demo video](#)

NF-iSAM: Incremental Smoothing and Mapping via Normalizing Flows

Nov. 2019 - Oct. 2022

- Exploiting the expressive power of *neural networks*, and training normalizing flows to model and sample the joint posterior encountered in SLAM.
- Paper [\[C3, J2\]](#), [code](#), and [talk](#)

NSFG: Nested Sampling for Factor Graphs

Jun. 2020 - Oct. 2022

- Leveraging nested sampling to generate high-quality samples of posterior distributions at the expense of computation.
- These samples serve as *reference solutions* for validating other inference methods.
- Paper [\[J3\]](#), [code](#), and [demo video](#)

Mixture Models for Representing Pose Ambiguity in Object-Based SLAM Systems

Mar. 2020 - Oct. 2021

- Modeling multi-hypothesis object poses that are incurred by perceptual aliasing in images.
- Fusing these multi-hypothesis models in object-based SLAM systems.
- Paper [\[C2, C1\]](#), [talk1](#), and [talk 2](#)

## Recent Publications

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### PREPRINTS

- [P1] **GAPSLAM: Blending Gaussian Approximation and Particle Filters for Real-Time Non-Gaussian SLAM**  
Qiangqiang Huang, John J. Leonard  
arXiv preprint arXiv:2303.14283, submitted to the *IEEE/RSJ IROS* 2023.

### JOURNAL ARTICLES

- [J1] **Optimizing Fiducial Marker Placement for Improved Visual Localization**  
Qiangqiang Huang, Joseph DeGol, Victor Fragoso, Sudipta N. Sinha, John J. Leonard  
*IEEE Robotics and Automation Letters*, 8, 5, pp. 2756–2763, 2023
- [J2] **Incremental Non-Gaussian Inference for SLAM Using Normalizing Flows**  
Qiangqiang Huang, Can Pu, Kasra Khosoussi, David M. Rosen, Dehann Fourie, Jonathan P. How, John J. Leonard  
*IEEE Transactions on Robotics*, 2022
- [J3] **Nested Sampling for Non-Gaussian Inference in SLAM Factor Graphs**  
Qiangqiang Huang<sup>+</sup>, Alan Papalia, John J. Leonard  
*IEEE Robotics and Automation Letters & 2022 IEEE/RSJ IROS*, 7, 4, pp. 9232–9239, 2022

### CONFERENCE PROCEEDINGS ( \* EQUAL CONTRIBUTORS, <sup>+</sup> CONFERENCE PRESENTER)

- [C1] **A Multi-Hypothesis Approach to Pose Ambiguity in Object-Based SLAM**  
Jiahui Fu<sup>+</sup>, Qiangqiang Huang, Kevin Doherty, Yue Wang, John J. Leonard  
2021 *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*
- [C2] **Consensus-Informed Optimization Over Mixtures for Ambiguity-Aware Object SLAM**  
Ziqi Lu<sup>\*,+</sup>, Qiangqiang Huang<sup>\*</sup>, Kevin Doherty, John J. Leonard  
2021 *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*
- [C3] **NF-iSAM: Incremental Smoothing and Mapping via Normalizing Flows**  
Qiangqiang Huang<sup>\*,+</sup>, Can Pu<sup>\*</sup>, Dehann Fourie, Kasra Khosoussi, Jonathan P. How, John J. Leonard  
2021 *IEEE Intl. Conf. on Robotics and Automation (ICRA)*

## Selected Class Projects

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### Teddy Bear Finder: Real-Time Exploration in Unknown Environments Using MIT RACECAR

MIT

CLASS: VISUAL NAVIGATION FOR AUTONOMOUS VEHICLES

Dec. 2019

- Integrating SLAM, the frontier-based exploration approach, and a learned object detector to find teddy bears in unknown environments
- Demonstration: [video](#) in a small environment and [video](#) in a relatively larger environment.

### Optimal Racing Line Control for Race Cars

MIT

CLASS: PRINCIPLE OF OPTIMAL CONTROL AND STATE ESTIMATION

May 2019

- Using optimal control techniques to solve for optimal racing lines of an F1 race car and MIT RACECAR
- Demonstration: [video](#) for the F1 race car and [video](#) for MIT RACECAR.

## Skills

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**Programming** Python, C/C++, MATLAB, Julia, Fortran, LaTeX

**Software Libraries** PyTorch, OpenCV, Open3D, PyMC3, Unreal Engine, Robot Operating System, GTSAM

## Honors & Awards

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|------------|--|------------------------------|
| 2016       | <b>Student Advisory Committee Travel Awards</b> , \$2000 travel grant        | ASME IGTI                    |
| 2015, 2016 | <b>China National Scholarship</b> , annual selection for academic excellence | Ministry of Education, China |
| 2014       | <b>Outstanding Diploma Thesis</b> , 5% among diploma projects                | Tsinghua University          |
| 2011       | <b>1st Prize</b> , 28th National Physics Olympiad (college)                  | Ministry of Education, China |
| 2009       | <b>1st Prize</b> , 26th National Physics Olympiad (high school)              | Ministry of Education, China |