# Qiangqiang (Chad) Huang

Ph.D. Candidate · Robotics · MIT

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## Engineering Background

State estimation · Computer vision · SLAM · Visual localization · Probabilistic modeling and inference

## Education

**Massachusetts Institute of Technology**                                                                                      *Cambridge, MA*

PH.D. IN ROBOTICS, DEPARTMENT OF MECHANICAL ENGINEERING                                                    *2018 – 2023 (expected)*

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

Advisor: Prof. John Leonard

**Tsinghua University**                                                                                                                *Beijing, China*

M.S. IN POWER ENGINEERING AND ENGINEERING THERMOPHYSICS, SCHOOL OF VEHICLE AND MOBILITY                     *2014 – 2017*

B.E. IN VEHICLE ENGINEERING, SCHOOL OF VEHICLE AND MOBILITY                                                     *2010 - 2014*

Minor: Computer Science

## Experience

**Computer Science and Artificial Intelligence Lab**                                                                                      *MIT*

RESEARCH ASSISTANT @ MARINE ROBOTICS GROUP LED BY PROF. JOHN LEONARD                                          *2018 - present*

- *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)

**Microsoft**                                                                                                                        *Redmond, WA*

RESEARCH INTERN                                                                                                               *Jun. - Aug. 2022*

- *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)

## Research Projects

GAPSLAM: Blending **G**aussian **A**pproximation and **P**article 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

### 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, accepted by *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[+],  Alan Papalia,  John J. Leonard
 *IEEE Robotics and Automation Letters & 2022 IEEE/RSJ IROS*, 7, 4, pp. 9232–9239, 2022

### CONFERENCE PROCEEDINGS ( [*]EQUAL CONTRIBUTORS, [+]CONFERENCE PRESENTER)

[C1]  **A Multi-Hypothesis Approach to Pose Ambiguity in Object-Based SLAM**
 Jiahui Fu[+],  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[*,+],  Qiangqiang Huang[*],  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[*,+],  Can Pu[*],  Dehann Fourie,  Kasra Khosoussi,  Jonathan P. How,  John J. Leonard
 *2021 IEEE Intl. Conf. on Robotics and Automation (ICRA)*

## Selected Class Projects

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