

Michael Kaess

Computer Science and Artificial Intelligence Laboratory (CSAIL)
Massachusetts Institute of Technology (MIT)
32 Vassar St, Room 32-230, Cambridge, MA 02139
(678)365-1243, kaess@mit.edu
<http://people.csail.mit.edu/kaess>

Research Interests

Mobile Robotics (simultaneous localization and mapping)
Computer Vision (SFM, calibration, multi-camera rigs, large-scale 3D reconstruction)
Probabilistic Methods (Bayesian inference, graphical models)
Optimization (sparse non-linear systems)

Education

Ph.D. Computer Science <i>Georgia Institute of Technology, Atlanta, GA</i>	Dec 2008
M.S. Computer Science <i>Georgia Institute of Technology, Atlanta, GA</i>	Dec 2002
B.S. Computer Science (Vordiplom Informatik) <i>University of Karlsruhe, Germany</i>	Sep 1998

Employment

Research Scientist Massachusetts Institute of Technology, MechE/CSAIL Marine Robotics, Dr. John Leonard	Jul 2010–today
Postdoctoral Associate Massachusetts Institute of Technology, MechE/CSAIL Marine Robotics, Dr. John Leonard	Nov 2008–Jun 2010
Research Assistant Georgia Institute of Technology, BORG Lab DARPA LAGR Program and NSF Career Award, Dr. Frank Dellaert	May 2003–Oct 2008
Research Intern Microsoft Research, Interactive Visual Media Group Virtual Earth, Dr. Richard Szeliski and Dr. Drew Steedly	Sep 2005–Dec 2005
Research Assistant (Wissenschaftlicher Angestellter) University of Freiburg, Autonomous Intelligent Systems, Germany Closing the Loop, Dr. Wolfram Burgard	Sep 2004–Dec 2004

Teaching Assistant Georgia Institute of Technology, College of Computing Machine Learning, Dr. Frank Dellaert	Jan 2003–May 2003
Research Assistant Georgia Institute of Technology, Mobile Robot Lab DARPA MARS Program, Dr. Ronald C. Arkin	May 2001–Dec 2002
Undergraduate Research Assistant Research Center for Information Technologies (FZI), Karlsruhe, Germany Electronic Systems and Microsystems, Dr. Stefan Schmerler	Aug 1998–Jul 2000

Publications

Journal Publications

- [1] M. Kaess, H. Johannsson, R. Roberts, V. Ila, J. Leonard, and F. Dellaert, “iSAM2: Incremental smoothing and mapping using the Bayes tree,” *Intl. J. of Robotics Research, IJRR*, vol. 31, pp. 217–236, Feb 2012.
- [2] M. Kaess and F. Dellaert, “Probabilistic structure matching for visual SLAM with a multi-camera rig,” *Computer Vision and Image Understanding, CVIU*, vol. 114, pp. 286–296, Feb 2010.
- [3] M. Kaess and F. Dellaert, “Covariance recovery from a square root information matrix for data association,” *Journal of Robotics and Autonomous Systems, RAS*, vol. 57, pp. 1198–1210, Dec 2009.
- [4] M. Kaess, A. Ranganathan, and F. Dellaert, “iSAM: Incremental smoothing and mapping,” *IEEE Trans. on Robotics, TRO*, vol. 24, pp. 1365–1378, Dec 2008.
- [5] F. Dellaert and M. Kaess, “Square Root SAM: Simultaneous localization and mapping via square root information smoothing,” *Intl. J. of Robotics Research, IJRR*, vol. 25, pp. 1181–1204, Dec 2006.

Book Chapter

- [6] M. Fallon, H. Johannsson, M. Kaess, J. Folkesson, B. Englot, F. Hover, and J. J. Leonard, “Simultaneous localization and mapping in marine environments,” in *Autonomy for Marine Robots* (M. L. Seta, ed.), Springer, 2012. To appear.

Peer-reviewed Conference Publications

- [7] D. Rosen, M. Kaess, and J. Leonard, “An incremental trust-region method for robust online sparse least-squares estimation,” in *IEEE Intl. Conf. on Robotics and Automation, ICRA*, (St. Paul, MN), May 2012. To appear.
- [8] J. McDonald, M. Kaess, C. Cadena, J. Neira, and J. Leonard, “6-DOF multi-session visual SLAM using anchor nodes,” in *European Conference on Mobile Robots, ECMR*, (Orebro, Sweden), pp. 69–76, Sep. 2011.
- [9] M. Kaess, H. Johannsson, R. Roberts, V. Ila, J. Leonard, and F. Dellaert, “iSAM2: Incremental smoothing and mapping with fluid relinearization and incremental variable reordering,” in *IEEE Intl. Conf. on Robotics and Automation, ICRA*, (Shanghai, China), pp. 3281–3288, May 2011.

- [10] M. Fallon, M. Kaess, H. Johannsson, and J. Leonard, "Efficient AUV navigation fusing acoustic ranging and side-scan sonar," in *IEEE Intl. Conf. on Robotics and Automation, ICRA*, (Shanghai, China), pp. 2398–2405, May 2011. Nominated for best automation paper.
- [11] M. Kaess, V. Ila, R. Roberts, and F. Dellaert, "The Bayes tree: An algorithmic foundation for probabilistic robot mapping," in *Intl. Workshop on the Algorithmic Foundations of Robotics, WAFR*, (Singapore), Dec 2010.
- [12] H. Johannsson, M. Kaess, B. Englot, F. Hover, and J. Leonard, "Imaging sonar-aided navigation for autonomous underwater harbor surveillance," in *IEEE/RSJ Intl. Conf. on Intelligent Robots and Systems, IROS*, (Taipei, Taiwan), Oct 2010.
- [13] B. Kim, M. Kaess, L. Fletcher, J. Leonard, A. Bachrach, N. Roy, and S. Teller, "Multiple relative pose graphs for robust cooperative mapping," in *IEEE Intl. Conf. on Robotics and Automation, ICRA*, (Anchorage, Alaska), pp. 3185–3192, May 2010.
- [14] M. Kaess, K. Ni, and F. Dellaert, "Flow separation for fast and robust stereo odometry," in *IEEE Intl. Conf. on Robotics and Automation, ICRA*, (Kobe, Japan), May 2009.
- [15] R. Mottaghi, M. Kaess, A. Ranganathan, R. Roberts, and F. Dellaert, "Place recognition-based fixed-lag smoothing for environments with unreliable GPS," in *IEEE Intl. Conf. on Robotics and Automation, ICRA*, (Pasadena, CA), May 2008.
- [16] A. Ranganathan, M. Kaess, and F. Dellaert, "Fast 3D pose estimation with out-of-sequence measurements," in *IEEE/RSJ Intl. Conf. on Intelligent Robots and Systems, IROS*, (San Diego, CA), pp. 2486–2493, Oct 2007.
- [17] M. Kaess, A. Ranganathan, and F. Dellaert, "iSAM: Fast incremental smoothing and mapping with efficient data association," in *IEEE Intl. Conf. on Robotics and Automation, ICRA*, (Rome, Italy), pp. 1670–1677, Apr 2007.
- [18] M. Kaess, A. Ranganathan, and F. Dellaert, "Fast incremental square root information smoothing," in *Intl. Joint Conf. on Artificial Intelligence, IJCAI*, (Hyderabad, India), pp. 2129–2134, Jan 2007. Oral presentation acceptance ratio 15.7% (212 of 1353).
- [19] A. Ranganathan, M. Kaess, and F. Dellaert, "Loopy SAM," in *Intl. Joint Conf. on Artificial Intelligence, IJCAI*, (Hyderabad, India), pp. 2191–2196, Jan 2007. Oral presentation acceptance ratio 15.7% (212 of 1353).
- [20] M. Kaess and F. Dellaert, "A Markov chain Monte Carlo approach to closing the loop in SLAM," in *IEEE Intl. Conf. on Robotics and Automation, ICRA*, (Barcelona, Spain), pp. 645–650, Apr 2005.
- [21] M. Kaess, R. Zboinski, and F. Dellaert, "MCMC-based multiview reconstruction of piecewise smooth subdivision curves with a variable number of control points," in *Eur. Conf. on Computer Vision, ECCV*, vol. 3023 of *Lecture Notes in Computer Science*, (Prague, Czech Republic), pp. 329–341, Springer, May 2004. Acceptance ratio 34.2% (190 of 555).
- [22] M. Kaess and F. Dellaert, "Reconstruction of objects with jagged edges through Rao-Blackwellized fitting of piecewise smooth subdivision curves," in *Proceedings of the IEEE 1st International Workshop on Higher-Level Knowledge in 3D Modeling and Motion Analysis*, (Nice, France), pp. 39–47, IEEE Computer Society, Oct 2003.

- [23] M. Kaess, R. Arkin, and J. Rossignac, "Compact encoding of robot-generated 3D maps for efficient wireless transmission," in *IEEE Intl. Conf. on Advanced Robotics, ICAR*, (Coimbra, Portugal), pp. 324–331, Jun 2003.
- [24] M. Likhachev, M. Kaess, and R. Arkin, "Learning behavioral parameterization using spatio-temporal case-based reasoning," in *IEEE Intl. Conf. on Robotics and Automation, ICRA*, vol. 2, (Washington, DC), pp. 1282–1289, May 2002.

Other Publications

- [25] M. Kaess, H. Johannsson, B. Englot, F. Hover, and J. Leonard, "Towards autonomous ship hull inspection using the Bluefin HAUV," in *Ninth International Symposium on Technology and the Mine Problem*, (Naval Postgraduate School, Monterey, CA), May 2010.
- [26] M. Kaess, V. Ila, R. Roberts, and F. Dellaert, "The Bayes tree: Enabling incremental reordering and fluid relinearization for online mapping," Tech. Rep. MIT-CSAIL-TR-2010-021, Computer Science and Artificial Intelligence Laboratory, MIT, Jan 2010.
- [27] E. Olson and M. Kaess, "Evaluating the performance of robot mapping systems," in *Workshop on Good Experimental Methodology in Robotics*, 2009.
- [28] M. Kaess, *Incremental Smoothing and Mapping*. PhD thesis, Georgia Institute of Technology, Dec 2008.
- [29] M. Kaess and F. Dellaert, "Visual SLAM with a multi-camera rig," Tech. Rep. GIT-GVU-06-06, Georgia Institute of Technology, Feb 2006.
- [30] F. Dellaert, T. Balch, M. Kaess, R. Ravichandran, F. Alegre, M. Berhault, R. McGuire, E. Merrill, L. Moshkina, and D. Walker, "The Georgia Tech Yellow Jackets: A marsupial team for urban search and rescue," in *AAAI Mobile Robot Competition*, (Edmonton, Alberta, Canada), pp. 44–49, AAAI Press, 2002.

Invited Talks

Incremental Smoothing and Mapping, Sarnoff/SRI International, Princeton, NJ, 2012

Towards Life-long Mapping and Navigation, ICRA Workshop on Long-term Autonomy, Shanghai, China, 2011

Incremental Smoothing and Mapping and Applications to Ship Hull Inspection, SMART Center, National University of Singapore, Singapore, 2010

iSAM and the Bayes Tree, IROS Workshop on Probabilistic Graphical Models in Robotics (Graph-Bot), Taipei, Taiwan, 2010

iSAM: Incremental Smoothing and Mapping, German Research Center for Artificial Intelligence (DFKI), Bremen, Germany, 2007

Research Experience

Marine Robotics

Supervisor: Dr. John Leonard

Ship Hull Inspection funded by the Office of Naval Research, involving mapping and localization with robotic underwater vehicles using multiple sensors including imaging sonar. Also, mentoring M.S. and Ph.D. students in the areas of persistent and multi-robot mapping. See [8], [1], [9], [10], [11], [12], [25], [26], [13], [27].

Incremental Smoothing and Mapping

Advisor: Dr. Frank Dellaert

Thesis research: Devised and implemented a fast incremental SLAM algorithm, that performs full optimization and provides efficient access to the exact covariances needed for data association. The algorithm has been used with both cameras and laser-range sensors on multiple platforms. See [3], [4], [5], [9], [11], [26], [17], [18], [19], [28].

Visual Odometry

Advisor: Dr. Frank Dellaert

Developed a real-time system and demonstrated it live at the DARPA LAGR final demo in San Antonio, Texas. Devised an algorithm to robustly handle degenerate data. See [14], [16], [28].

Multi-planar Stereo

Supervisor: Dr. Drew Steedly

Implemented a graph-cut based multi-planar stereo reconstruction to synthesize oblique urban views from multiple images and laser-range data.

Probabilistic Data Association for SLAM

Advisor: Dr. Frank Dellaert

Deployed the probabilistic framework of Dr. Dellaert's thesis work to the incremental correspondence problem of SLAM for both laser-range sensors and a multi-camera rig. See [2], [20].

Multi-view Subdivision Curve Fitting

Advisor: Dr. Frank Dellaert

Developed a Markov chain Monte Carlo approach to fit a 3D subdivision curve to multiple images of an object with both jagged and round edges. See [21], [22].

3D Mapping and Compression

Advisor: Dr. Ronald C. Arkin, Dr. Jarek Rossignac

Implemented 3D laser-based mapping of a building with a focus on data compression for efficient wireless transmission. See [23].

Awards

Marshall D. Williamson Fellowship	2001
College of Computing, Georgia Institute of Technology	
Exchange Student Scholarship	2000
Federation of German-American Clubs	
Robert Mayer Jugendpreis	1995
City of Heilbronn, Germany	

Service

Associate Editor

IROS (International Conference on Intelligent Robots and Systems) 2010, 2012

Workshop Organizer

Automated SLAM Evaluation Workshop at RSS 2011

Program Committee Member

RSS (Robotics: Science and Systems) 2011, 2012

AAAI Robotics Track 2012

DARS (International Symposium on Distributed Autonomous Robotic Systems) 2010

RSS Workshop: Inside Data Association 2008

Session Chair

IROS (International Conference on Intelligent Robots and Systems) 2010

ICRA (International Conference on Robotics and Automation) 2009

Student Volunteer

3DPVT (International Symposium on 3D Data Processing, Visualization and Transmission) 2008

RSS (Robotics Science and Systems) 2007

Journal reviewer

TRO (IEEE Trans. on Robotics) 2004, 2007–2009, 2011, 2012

IJRR (International Journal of Robotics Research) 2010

PAMI (IEEE Trans. on Pattern Analysis and Machine Intelligence) 2008

RAS (Journal of Robotics and Autonomous Systems) 2009

JFR (Journal of Field Robotics) 2006, 2009–2010

AURO (Autonomous Robots) 2009, 2011

FTR (Foundations and Trends in Robotics) 2011

IVC (Image and Vision Computing) 2010

IEEE Pervasive Computing 2010

Conference reviewer

RSS (Robotics Science and Systems) 2005, 2006, 2010–2012

ICRA (International Conference on Robotics and Automation) 2005, 2007–2012

IROS (International Conference on Intelligent Robots and Systems) 2007, 2009–2011

AAAI (Conference on Artificial Intelligence) 2012

ICCV (International Conference on Computer Vision) 2005, 2007

ECCV (European Conference on Computer Vision) 2004, 2006

CVPR (Computer Vision and Pattern Recognition) 2004–2008

Professional Memberships

IEEE

IEEE Computer Society

IEEE Robotics and Automation Society

References

References are available upon request.