

Michael Kaess

Associate Professor
Director, Robot Perception Lab
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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

Associate Professor Carnegie Mellon University, Robotics Institute	Jul 2021–today
Associate Research Professor Carnegie Mellon University, Robotics Institute	Jul 2019–Jun 2021
Assistant Research Professor Carnegie Mellon University, Robotics Institute	Nov 2013–Jun 2019
Research Scientist Massachusetts Institute of Technology, MechE/CSAIL Marine Robotics and Persistent Mapping, Dr. John Leonard	Jul 2010–Oct 2013
Postdoctoral Associate Massachusetts Institute of Technology, MechE/CSAIL Marine Robotics and Persistent Mapping, Dr. John Leonard	Nov 2008–Jun 2010
Research Assistant Georgia Institute of Technology, College of Computing 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

Awards

ICRA: Best Multi-Robot Systems Paper Finalist (one of five) Title: Asynchronous Distributed Smoothing and Mapping Via On-Manifold Consensus ADMM	2024
IROS: Outstanding Associate Editor Award Out of 409 associate editors	2022
ICRA: Outstanding Navigation Paper Award Title: EDPLVO: Efficient Direct Point-Line Visual Odometry	2022
IROS: Best Paper and Best Student Paper Finalist (one of five) Title: Ground Encoding: Learned Factor Graph-Based Models for Localizing Ground Penetrating Radar	2021
ICRA: Best Service Robotics Paper Finalist (one of four) Title: Tactile SLAM: Real-time Inference of Shape and Pose from Planar Pushing	2021
RSS 2020 Test of Time Award (jointly with Frank Dellaert) “For pioneering an information smoothing approach to the SLAM problem via square root factorization, its interpretation as a graphical model, and the widely-used GTSAM free software repository.”	2020
IROS: Best Conference Paper Finalist (one of six) Title: Information Sparsification in Visual-Inertial Odometry	2018
ICRA: Best Vision Paper Finalist (one of five) Title: Articulated robot motion for simultaneous localization and mapping (ARM-SLAM)	2016
Google Faculty Research Award Tightly coupled visual-inertial localization and mapping	2014
ICRA: Best Student Paper Finalist (one of five) Title: Temporally scalable visual SLAM using a reduced pose graph	2013

Runner-up (top 3) for Dick Volz Best 2008 US Ph.D. Thesis in Robotics and Automation	2012
Delayed award that also considers impact of dissertation	
ICRA: Best Automation Paper Finalist (one of five)	2011
Title: Efficient AUV navigation fusing acoustic ranging and side-scan sonar	
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	

Teaching Experience

CMU Course 16-833: Robot Localization and Mapping	Spring 2017–24, Fall 2019,20,22–24
New graduate course developed and taught over 700 students	
CMU Course 16-665: Robot Mobility on Air, Land, & Sea	Fall 2018–2024
New graduate course developed and co-taught with John Dolan, Dimi Apostolopoulos, Sebastian Scherer, and Hartmut Geyer	
CMU Course 16-822: Geometry-based Methods in Vision	Fall 2021
Graduate course taught	
CMU Course 16-831, Statistical Techniques in Robotics	Fall 2015, 2016
Graduate course co-taught with Kris Kitani	
MIT Course 2.017: Design of Electro-Mechanical Robotic Systems	Spring 2013
Undergraduate course co-taught with John Leonard	

Citations

Retrieved from Google Scholar on September 28, 2024:

Citations: 15,004

h-index: 54

i10-index: 129

top cited paper in IROS (rank 27)

Publications

Journal Publications

1. S. Suresh, H. Qi, T. Wu, T. Fan, L. Pineda, M. Lambeta, J. Malik, M. Kalakrishnan, R. Candra, M. Kaess, J. Ortiz, and M. Mukadam, "Neural feels with neural fields: Visuo-tactile perception for in-hand manipulation," *AAAS Science Robotics*, vol. 9, no. 96, Nov. 2024.

2. E. Potokar and M. Kaess, "Robust preintegrated wheel odometry for off-road autonomous ground vehicles," *IEEE Robotics and Automation Letters (RA-L)*, 2024, to appear.
3. Z. Qu, O. Vengurlekar, M. Qadri, K. Zhang, M. Kaess, C. Metzler, S. Jayasuriya, and A. Pediredla, "Z-splat: Z-axis Gaussian splatting for camera-sonar fusion," *IEEE Trans. on Pattern Analysis and Machine Intelligence (PAMI)*, 2024, to appear.
4. H.-J. Huang, M. Kaess, and W. Yuan, "NormalFlow: Fast, robust, and accurate contact-based object 6DoF pose tracking with vision-based tactile sensors," *IEEE Robotics and Automation Letters (RA-L)*, 2024, to appear.
5. B. Forsgren, M. Kaess, R. Vasudevan, T. McLain, and J. Mangelson, "Group-k consistent measurement set maximization via maximum clique of k-uniform hypergraphs for robust multi-robot map merging," *Intl. J. of Robotics Research (IJRR)*, 2024, to appear.
6. E. Potokar, K. Lay, K. Norman, D. Benham, S. Ashford, R. Peirce, T. Neilsen, M. Kaess, and J. Mangelson, "HoloOcean: A full-featured marine robotics simulator for perception and autonomy," *IEEE J. of Oceanic Engineering (JOE)*, vol. 49, no. 4, pp. 1322–1336, Oct. 2024.
7. W. Dong, Y. Lao, M. Kaess, and V. Koltun, "ASH: A modern framework for parallel spatial hashing in 3D perception," *IEEE Trans. on Pattern Analysis and Machine Intelligence (PAMI)*, vol. 45, no. 5, pp. 5417–5435, May 2023.
8. S. Scherer, V. Agrawal, G. Best, C. Cao, K. Cujic, R. Darnley, R. DeBortoli, E. Dexheimer, B. Drozd, R. Garg, I. Higgins, J. Keller, D. Kohanbash, L. Nogueira, R. Pradhan, M. Tatum, V. Viswanathan, S. Willits, S. Zhao, H. Zhu, D. Abad, T. Angert, G. Armstrong, R. Boirum, A. Dongare, M. Dworman, S. Hu, J. Jaekel, R. Ji, A. Lai, Y. H. Lee, A. Luong, J. Mangelson, J. Maier, J. Picard, K. Pluckter, A. Saba, M. Saroya, E. Scheide, N. Shoemaker-Trejo, J. Spisak, J. Teza, F. Yang, A. Wilson, H. Zhang, H. Choset, M. Kaess, A. Rowe, S. Singh, J. Zhang, G. Hollinger, and M. Travers, "Resilient and modular subterranean exploration with a team of roving and flying robots," *J. of Field Robotics (JFR)*, vol. 2, pp. 678–734, May 2022.
9. L. Zhou, G. Huang, Y. Mao, J. Yu, S. Wang, and M. Kaess, "PLC-LiSLAM: LiDAR SLAM with planes, lines and cylinders," *IEEE Robotics and Automation Letters (RA-L)*, vol. 7, no. 3, pp. 7163–7170, Jul. 2022, presented at IROS 2022.
10. E. Dexheimer, P. Peluse, J. Chen, J. Pritts, and M. Kaess, "Information-theoretic online multi-camera extrinsic calibration," *IEEE Robotics and Automation Letters (RA-L)*, vol. 7, no. 2, pp. 4757–4764, Apr. 2022, presented at ICRA 2022.
11. L. Zhou, S. Wang, and M. Kaess, "DPLVO: Direct point-line monocular visual odometry," *IEEE Robotics and Automation Letters (RA-L)*, vol. 6, no. 4, pp. 7113–7120, Oct. 2021, presented at IROS 2021.
12. L. Zhou, D. Koppel, and M. Kaess, "LiDAR SLAM with plane adjustment for indoor environment," *IEEE Robotics and Automation Letters (RA-L)*, vol. 6, no. 4, pp. 7073–7080, Oct. 2021, presented at IROS 2021.
13. L. Zhou, D. Koppel, and M. Kaess, "A complete, accurate and efficient solution for the perspective-n-line problem," *IEEE Robotics and Automation Letters (RA-L)*, vol. 6, no. 2, pp. 699–706, Apr. 2021, presented at ICRA 2021.
14. E. Westman and M. Kaess, "Degeneracy-aware imaging sonar simultaneous localization and mapping," *IEEE J. of Oceanic Engineering (JOE)*, vol. 45, no. 4, pp. 1280–1294, Oct. 2020.

15. L. Zhou and M. Kaess, "Windowed bundle adjustment framework for unsupervised learning of monocular depth estimation with u-net extension and clip loss," *IEEE Robotics and Automation Letters (RA-L)*, vol. 5, no. 2, pp. 3283–3290, Apr. 2020, presented at ICRA 2020.
16. S. Mukherjee, M. Kaess, J. Martel, and C. Riviere, "EyeSAM: Graph-based localization and mapping of retinal vasculature during intraocular microsurgery," *Intl. J. of Computer Assisted Radiology and Surgery (JCARS)*, vol. 14, no. 5, pp. 819–828, May 2019.
17. S. Suresh, E. Westman, and M. Kaess, "Through-water stereo SLAM with refraction correction for AUV localization," *IEEE Robotics and Automation Letters (RA-L)*, vol. 4, no. 2, pp. 692–699, Apr. 2019, presented at ICRA 2019.
18. J. Li, M. Kaess, R. Eustice, and M. Johnson-Roberson, "Pose-graph SLAM using forward-looking sonar," *IEEE Robotics and Automation Letters (RA-L)*, vol. 3, no. 3, pp. 2330–2337, Jul. 2018, presented at ICRA 2018.
19. F. Dellaert and M. Kaess, "Factor graphs for robot perception," *Foundations and Trends in Robotics (FNT)*, vol. 6, no. 1-2, pp. 1–139, Aug. 2017.
20. H. Alismail, M. Kaess, B. Browning, and S. Lucey, "Direct visual odometry in low light using binary descriptors," *IEEE Robotics and Automation Letters (RA-L)*, vol. 2, no. 2, pp. 444–451, Apr. 2017, presented at ICRA 2017.
21. J. Zhang, M. Kaess, and S. Singh, "A real-time method for depth enhanced monocular odometry," *Autonomous Robots (AURO)*, vol. 41, no. 1, pp. 31–43, Jan. 2017.
22. M. Klingensmith, S. Srinivasa, and M. Kaess, "Articulated robot motion for simultaneous localization and mapping (ARM-SLAM)," *IEEE Robotics and Automation Letters (RA-L)*, vol. 1, no. 2, pp. 1156–1163, Jul. 2016, presented at ICRA 2016. **Best vision paper finalist (one of five).**
23. T. Whelan, M. Kaess, H. Johannsson, M. Fallon, J. Leonard, and J. McDonald, "Real-time large scale dense RGB-D SLAM with volumetric fusion," *Intl. J. of Robotics Research (IJRR)*, vol. 34, no. 4-5, pp. 598–626, Apr. 2015.
24. G. Huang, M. Kaess, and J. Leonard, "Consistent unscented incremental smoothing for multi-robot cooperative target tracking," *J. of Robotics and Autonomous Systems (RAS)*, vol. 69, pp. 52–67, Jul. 2015.
25. N. Carlevaris-Bianco, M. Kaess, and R. Eustice, "Generic factor-based node removal: Enabling long-term SLAM," *IEEE Trans. on Robotics (TRO)*, vol. 30, no. 6, pp. 1371–1385, Dec. 2014.
26. D. Rosen, M. Kaess, and J. Leonard, "RISE: An incremental trust-region method for robust online sparse least-squares estimation," *IEEE Trans. on Robotics (TRO)*, vol. 30, no. 5, pp. 1091–1108, Oct. 2014.
27. S. Williams, V. Indelman, M. Kaess, R. Roberts, J. Leonard, and F. Dellaert, "Concurrent filtering and smoothing: A parallel architecture for real-time navigation and full smoothing," *Intl. J. of Robotics Research (IJRR)*, vol. 33, no. 12, pp. 1544–1568, Oct. 2014.
28. M. Fallon, H. Johannsson, M. Kaess, and J. Leonard, "The MIT Stata Center dataset," *Intl. J. of Robotics Research (IJRR)*, vol. 32, no. 14, pp. 1695–1699, Dec. 2013.
29. V. Indelman, S. Williams, M. Kaess, and F. Dellaert, "Information fusion in navigation systems via factor graph based incremental smoothing," *J. of Robotics and Autonomous Systems (RAS)*, vol. 61, no. 8, pp. 721–738, Aug. 2013.

30. J. McDonald, M. Kaess, C. Cadena, J. Neira, and J. Leonard, "Real-time 6-DOF multi-session visual SLAM over large scale environments," *J. of Robotics and Autonomous Systems (RAS)*, vol. 61, no. 10, pp. 1144–1158, Oct. 2013.
31. A. Wu, E. Johnson, M. Kaess, F. Dellaert, and G. Chowdhary, "Autonomous flight in GPS-denied environments using monocular vision and inertial sensors," *AIAA J. of Aerospace Information Systems (JAIS)*, vol. 10, no. 4, pp. 172–186, Apr. 2013.
32. F. Hover, R. Eustice, A. Kim, B. Englot, H. Johannsson, M. Kaess, and J. Leonard, "Advanced perception, navigation and planning for autonomous in-water ship hull inspection," *Intl. J. of Robotics Research (IJRR)*, vol. 31, no. 12, pp. 1445–1464, Oct. 2012.
33. 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, no. 2, pp. 216–235, Feb. 2012.
34. M. Kaess and F. Dellaert, "Probabilistic structure matching for visual SLAM with a multi-camera rig," *Computer Vision and Image Understanding (CVIU)*, vol. 114, no. 2, pp. 286–296, Feb. 2010.
35. M. Kaess and F. Dellaert, "Covariance recovery from a square root information matrix for data association," *J. of Robotics and Autonomous Systems (RAS)*, vol. 57, no. 12, pp. 1198–1210, Dec. 2009.
36. M. Kaess, A. Ranganathan, and F. Dellaert, "iSAM: Incremental smoothing and mapping," *IEEE Trans. on Robotics (TRO)*, vol. 24, no. 6, pp. 1365–1378, Dec. 2008.
37. 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, no. 12, pp. 1181–1204, Dec. 2006, **Inaugural RSS 2020 Test of Time Award.**

Book Chapter

38. M. Fallon, H. Johannsson, M. Kaess, J. Folkesson, H. McClelland, B. Englot, F. Hover, and J. J. Leonard, "Simultaneous localization and mapping in marine environments," in *Marine Robot Autonomy*, M. L. Seto, Ed. Springer, 2013, pp. 329–372.

Peer-reviewed Publications

39. C. Higuera, A. Sharma, C. Bodduluri, T. Fan, P. Lancaster, M. Kalakrishnan, M. Kaess, B. Boots, M. Lambeta, T. Wu, and M. Mukadam, "Sparsh: Self-supervised touch representations for vision-based tactile sensing," in *Proc. Conf. on Robot Learning (CoRL)*, Munich, Germany, Nov. 2024, to appear.
40. C. Klammer and M. Kaess, "BEVLoc: Cross-view localization and matching via birds-eye-view synthesis," in *Proc. IEEE/RSJ Intl. Conf. on Intelligent Robots and Systems (IROS)*, Abu Dhabi, UAE, Oct. 2024.
41. L. Jin, W. Dong, W. Wang, and M. Kaess, "BEVRender: Vision-based cross-view vehicle registration in off-road GNSS-denied environment," in *Proc. IEEE/RSJ Intl. Conf. on Intelligent Robots and Systems (IROS)*, Abu Dhabi, UAE, Oct. 2024.
42. M. Shienman, O. Levy-Or, M. Kaess, and V. Indelman, "A slices perspective for incremental nonparametric inference in high dimensional state spaces," in *Proc. IEEE/RSJ Intl. Conf. on Intelligent Robots and Systems (IROS)*, Abu Dhabi, UAE, Oct. 2024.

43. M. Qadri, K. Zhang, A. Hinduja, M. Kaess, A. Pediredla, and C. Metzler, “AONeuS: A neural rendering framework for acoustic-optical sensor fusion,” in *Proc. ACM SIGGRAPH*, Denver, CO, USA, Jul. 2024.
44. D. McGann and M. Kaess, “iMESA: Incremental distributed optimization for collaborative simultaneous localization and mapping,” in *Proc. Robotics: Science and Systems (RSS)*, Delft, Netherlands, Jul. 2024.
45. S. Gode, A. Hinduja, and M. Kaess, “SONIC: Sonar image correspondence using pose supervised learning for imaging sonars,” in *Proc. IEEE Intl. Conf. on Robotics and Automation (ICRA)*, Yokohama, Japan, May 2024, pp. 3766–3772.
46. J.-T. Huang, R. Xu, A. Hinduja, and M. Kaess, “Multi-radar inertial odometry for 3D state estimation using mmWave imaging radar,” in *Proc. IEEE Intl. Conf. on Robotics and Automation (ICRA)*, Yokohama, Japan, May 2024, pp. 12 006–12 012.
47. D. McGann, K. Lassak, and M. Kaess, “Asynchronous distributed smoothing and mapping via on-manifold consensus ADMM,” in *Proc. IEEE Intl. Conf. on Robotics and Automation (ICRA)*, Yokohama, Japan, May 2024, pp. 4577–4583, **Best multi-robot systems paper finalist (one of five)**.
48. M. Qadri, Z. Manchester, and M. Kaess, “Learning covariances for estimation with constrained bilevel optimization,” in *Proc. IEEE Intl. Conf. on Robotics and Automation (ICRA)*, Yokohama, Japan, May 2024, pp. 15 951–15 957.
49. M.-F. Chang, A. Sharma, M. Kaess, and S. Lucey, “Neural radiance field with lidar maps,” in *Proc. Intl. Conf. on Computer Vision (ICCV)*, Paris, France, Oct. 2023.
50. T. Lin, A. Hinduja, M. Qadri, and M. Kaess, “Conditional GANs for sonar image filtering with applications to underwater occupancy mapping,” in *Proc. IEEE Intl. Conf. on Robotics and Automation (ICRA)*, London, UK, May 2023, pp. 1048–1054.
51. D. McGann, J. Rogers III, and M. Kaess, “Robust incremental smoothing and mapping (riSAM),” in *Proc. IEEE Intl. Conf. on Robotics and Automation (ICRA)*, London, UK, May 2023, pp. 4157–4163.
52. M. Qadri, M. Kaess, and I. Gkioulekas, “Neural implicit surface reconstruction using imaging sonar,” in *Proc. IEEE Intl. Conf. on Robotics and Automation (ICRA)*, London, UK, May 2023, pp. 1040–1047.
53. L. Zhou, J. Liu, P. Ai, F. Zhai, K. Ren, Z. Meng, and M. Kaess, “Efficient bundle adjustment for coplanar points and lines,” in *Proc. IEEE Intl. Conf. on Robotics and Automation (ICRA)*, London, UK, May 2023, pp. 8356–8363.
54. S. Suresh, Z. Si, S. Anderson, M. Kaess, and M. Mukadam, “MidasTouch: Monte-Carlo inference over distributions across sliding touch,” in *Proc. Conf. on Robot Learning (CoRL)*, Auckland, New Zealand, Dec. 2022.
55. B. Forsgren, R. Vasudevan, M. Kaess, T. McLain, and J. Mangelson, “Group-k consistent measurement set maximization for robust outlier detection,” in *Proc. IEEE/RSJ Intl. Conf. on Intelligent Robots and Systems (IROS)*, Kyoto, Japan, Oct. 2022, pp. 4849–4856.
56. A. Hinduja, Y. Ohm, J. Liao, C. Majidi, and M. Kaess, “Acoustic localization and communication using a MEMS microphone for low-cost and low-power bio-inspired underwater robots,” in *Proc. IEEE/RSJ Intl. Conf. on Intelligent Robots and Systems (IROS)*, Kyoto, Japan, Oct. 2022, pp. 5470–5477.

57. E. Potokar, K. Lay, K. Norman, D. Benham, T. Neilsen, M. Kaess, and J. Mangelson, "HoloOcean: Realistic sonar simulation," in *Proc. IEEE/RSJ Intl. Conf. on Intelligent Robots and Systems (IROS)*, Kyoto, Japan, Oct. 2022, pp. 8450–8456.
58. M. Qadri, P. Sodhi, J. Mangelson, F. Dellaert, and M. Kaess, "InCOpt: Incremental constrained optimization using the Bayes tree," in *Proc. IEEE/RSJ Intl. Conf. on Intelligent Robots and Systems (IROS)*, Kyoto, Japan, Oct. 2022, pp. 6381–6388.
59. R. Xu, W. Dong, A. Sharma, and M. Kaess, "Learned depth estimation of 3D imaging radar for indoor mapping," in *Proc. IEEE/RSJ Intl. Conf. on Intelligent Robots and Systems (IROS)*, Kyoto, Japan, Oct. 2022, pp. 13 260–13 267.
60. M.-F. Chang, Y. Zhao, R. Shah, J. Engel, M. Kaess, and S. Lucey, "Long-term visual map sparsification with heterogeneous GNN," in *Proc. IEEE Conf. on Computer Vision and Pattern Recognition (CVPR)*, New Orleans, LA, USA, Jun. 2022, pp. 2406–2415.
61. Y. Litman, D. McGann, E. Dexheimer, and M. Kaess, "Global visual-inertial ground vehicle state estimation via image registration," in *Proc. IEEE Intl. Conf. on Robotics and Automation (ICRA)*, Philadelphia, PA, USA, May 2022, pp. 8178–8184.
62. E. Potokar, S. Ashford, M. Kaess, and J. Mangelson, "HoloOcean: An underwater robotics simulator," in *Proc. IEEE Intl. Conf. on Robotics and Automation (ICRA)*, Philadelphia, PA, USA, May 2022, pp. 3040–3046.
63. P. Sodhi, M. Kaess, M. Mukadam, and S. Anderson, "PatchGraph: In-hand tactile tracking with learned surface normals," in *Proc. IEEE Intl. Conf. on Robotics and Automation (ICRA)*, Philadelphia, PA, USA, May 2022, pp. 2164–2170.
64. S. Suresh, Z. Si, J. Mangelson, W. Yuan, and M. Kaess, "ShapeMap 3-D: Efficient shape mapping through dense touch and vision," in *Proc. IEEE Intl. Conf. on Robotics and Automation (ICRA)*, Philadelphia, PA, USA, May 2022, pp. 7073–7080.
65. L. Zhou, G. Huang, Y. Mao, S. Wang, and M. Kaess, "EDPLVO: Efficient direct point-line visual odometry," in *Proc. IEEE Intl. Conf. on Robotics and Automation (ICRA)*, Philadelphia, PA, USA, May 2022, pp. 7559–7565, **Outstanding navigation paper award**.
66. P. Sodhi, M. Mukadam, S. Anderson, and M. Kaess, "LEO: Learning energy-based models in factor graph optimization," in *Proc. Conf. on Robot Learning (CoRL)*, London, UK, Nov. 2021.
67. A. Baikovitz, P. Sodhi, M. Dille, and M. Kaess, "Ground encoding: Learned factor graph-based models for localizing ground penetrating radar," in *Proc. IEEE/RSJ Intl. Conf. on Intelligent Robots and Systems (IROS)*, Prague, Czech Republic, Sep. 2021, pp. 5476–5483, **Best paper and best student paper finalist (one of five)**.
68. M.-F. Chang, W. Dong, J. Mangelson, M. Kaess, and S. Lucey, "Map compressibility assessment for LiDAR registration," in *Proc. IEEE/RSJ Intl. Conf. on Intelligent Robots and Systems (IROS)*, Prague, Czech Republic, Sep. 2021, pp. 5560–5567.
69. M. Abello, J. Mangelson, and M. Kaess, "A graph-based method for joint instance segmentation of point clouds and image sequences," in *Proc. IEEE Intl. Conf. on Robotics and Automation (ICRA)*, Xi'an, China, May 2021, pp. 9565–9571.
70. M.-F. Chang, J. Mangelson, M. Kaess, and S. Lucey, "HyperMap: Compressed 3D map for monocular camera registration," in *Proc. IEEE Intl. Conf. on Robotics and Automation (ICRA)*, Xi'an, China, May 2021, pp. 11 739–11 745.
71. A. Sharma, W. Dong, and M. Kaess, "Compositional and scalable object SLAM," in *Proc. IEEE Intl. Conf. on Robotics and Automation (ICRA)*, Xi'an, China, May 2021, pp. 11 626–11 632.

72. P. Sodhi, M. Kaess, M. Mukadam, and S. Anderson, "Learning tactile models for factor graph-based estimation," in *Proc. IEEE Intl. Conf. on Robotics and Automation (ICRA)*, Xi'an, China, May 2021, pp. 13 686–13 692.
73. S. Suresh, M. Bauza, K.-T. Yu, J. Mangelson, A. Rodriguez, and M. Kaess, "Tactile SLAM: Real-time inference of shape and pose from planar pushing," in *Proc. IEEE Intl. Conf. on Robotics and Automation (ICRA)*, Xi'an, China, May 2021, pp. 11 322–11 328, **Best service robotics paper finalist (one of four)**.
74. L. Zhou, S. Wang, and M. Kaess, " π -LSAM: LiDAR smoothing and mapping with planes," in *Proc. IEEE Intl. Conf. on Robotics and Automation (ICRA)*, Xi'an, China, May 2021, pp. 5751–5757.
75. L. Zhou, D. Koppel, H. Ju, F. Steinbruecker, and M. Kaess, "An efficient planar bundle adjustment algorithm," in *Proc. IEEE Intl. Symp. on Mixed and Augmented Reality (ISMAR)*, Porto de Galinhas, Brazil, Nov. 2020, pp. 136–145.
76. E. Dexheimer, J. Mangelson, S. Scherer, and M. Kaess, "Efficient multiresolution scrolling grid for stereo vision-based MAV obstacle avoidance," in *Proc. IEEE/RSJ Intl. Conf. on Intelligent Robots and Systems (IROS)*, Oct. 2020, pp. 4758–4765.
77. M. Hsiao, J. Mangelson, C. Debrunner, and M. Kaess, "ARAS: Ambiguity-aware robust active SLAM based on multi-hypothesis state and map estimations," in *Proc. IEEE/RSJ Intl. Conf. on Intelligent Robots and Systems (IROS)*, Oct. 2020, pp. 5037–5044.
78. J. Jaekel, J. Mangelson, S. Scherer, and M. Kaess, "A robust multi-stereo visual-inertial odometry pipeline," in *Proc. IEEE/RSJ Intl. Conf. on Intelligent Robots and Systems (IROS)*, Oct. 2020, pp. 4623–4630.
79. V. Viswanathan, E. Dexheimer, G. Li, G. Loianno, M. Kaess, and S. Scherer, "Efficient trajectory library filtering for quadrotor flight in unknown environments," in *Proc. IEEE/RSJ Intl. Conf. on Intelligent Robots and Systems (IROS)*, Oct. 2020, pp. 2510–2517.
80. E. Westman, I. Gkioulekas, and M. Kaess, "A theory of Fermat paths for 3D imaging sonar reconstruction," in *Proc. IEEE/RSJ Intl. Conf. on Intelligent Robots and Systems (IROS)*, Oct. 2020, pp. 5082–5088.
81. D. Fourie, A. Espinoza, M. Kaess, and J. Leonard, "Characterizing marginalization and incremental operations on the Bayes tree," in *Proc. Intl. Workshop on the Algorithmic Foundations of Robotics (WAFR)*, Oulu, Finland, Jun. 2020.
82. P. Sodhi, S. Choudhury, J. Mangelson, and M. Kaess, "ICS: Incremental constrained smoothing for state estimation," in *Proc. IEEE Intl. Conf. on Robotics and Automation (ICRA)*, May 2020, pp. 279–285.
83. S. Suresh, P. Sodhi, J. Mangelson, D. Wettergreen, and M. Kaess, "Active SLAM using 3D submap saliency for underwater volumetric exploration," in *Proc. IEEE Intl. Conf. on Robotics and Automation (ICRA)*, May 2020, pp. 3132–3138.
84. E. Westman, I. Gkioulekas, and M. Kaess, "A volumetric albedo framework for 3D imaging sonar reconstruction," in *Proc. IEEE Intl. Conf. on Robotics and Automation (ICRA)*, May 2020, pp. 9645–9651.
85. L. Zhou, S. Wang, and M. Kaess, "A fast and accurate solution for pose estimation from 3D correspondences," in *Proc. IEEE Intl. Conf. on Robotics and Automation (ICRA)*, May 2020, pp. 1308–1314.

86. W. Dong, J. Park, Y. Yang, and M. Kaess, "GPU accelerated robust scene reconstruction," in *Proc. IEEE/RSJ Intl. Conf. on Intelligent Robots and Systems (IROS)*, Macao, Nov. 2019, pp. 7863–7870.
87. A. Hinduja, B. Ho, and M. Kaess, "Degeneracy-aware factors with applications to underwater SLAM," in *Proc. IEEE/RSJ Intl. Conf. on Intelligent Robots and Systems (IROS)*, Macao, Nov. 2019, pp. 1293–1299.
88. P. Sodhi, B. Ho, and M. Kaess, "Online and consistent occupancy grid mapping for planning in unknown environments," in *Proc. IEEE/RSJ Intl. Conf. on Intelligent Robots and Systems (IROS)*, Macao, Nov. 2019, pp. 7879–7886.
89. P. Teixeira, D. Fourie, M. Kaess, and J. Leonard, "Dense sonar-based reconstruction of underwater scenes," in *Proc. IEEE/RSJ Intl. Conf. on Intelligent Robots and Systems (IROS)*, Macao, Nov. 2019, pp. 8060–8066.
90. E. Westman and M. Kaess, "Wide aperture imaging sonar reconstruction using generative models," in *Proc. IEEE/RSJ Intl. Conf. on Intelligent Robots and Systems (IROS)*, Macao, Nov. 2019, pp. 8067–8074.
91. L. Zhou and M. Kaess, "An efficient and accurate algorithm for the perspective-n-point problem," in *Proc. IEEE/RSJ Intl. Conf. on Intelligent Robots and Systems (IROS)*, Macao, Nov. 2019, pp. 6245–6252.
92. M. Hsiao and M. Kaess, "MH-iSAM2: Multi-hypothesis iSAM using Bayes tree and hypotree," in *Proc. IEEE Intl. Conf. on Robotics and Automation (ICRA)*, Montreal, Canada, May 2019, pp. 1274–1280.
93. Z. Li, P. Gogia, and M. Kaess, "Dense surface reconstruction from monocular vision and LiDAR," in *Proc. IEEE Intl. Conf. on Robotics and Automation (ICRA)*, Montreal, Canada, May 2019, pp. 6905–6911.
94. R. Madaan, M. Kaess, and S. Scherer, "Multi-view reconstruction of wires using a catenary model," in *Proc. IEEE Intl. Conf. on Robotics and Automation (ICRA)*, Montreal, Canada, May 2019, pp. 5657–5664.
95. Y. Yang, W. Dong, and M. Kaess, "Surfel-based dense RGB-D reconstruction with global and local consistency," in *Proc. IEEE Intl. Conf. on Robotics and Automation (ICRA)*, Montreal, Canada, May 2019, pp. 5238–5244.
96. L. Zhou, Y. Yang, M. Abello, and M. Kaess, "A robust and efficient algorithm for the PnL problem using algebraic distance to approximate the reprojection distance," in *Proc. AAAI Conference on Artificial Intelligence (AAAI)*, Honolulu, Hawaii, USA, Jan. 2019, pp. 9307–9315.
97. L. Zhou, J. Ye, and M. Kaess, "A stable algebraic camera pose estimation for minimal configurations of 2D/3D point and line correspondences," in *Proc. Asian Conf. on Computer Vision (ACCV)*, Perth, Australia, Dec. 2018, pp. 273–288.
98. B. Ho, P. Sodhi, P. Teixeira, M. Hsiao, T. Kusnur, and M. Kaess, "Virtual occupancy grid map for submap-based pose graph SLAM and planning in 3D environments," in *Proc. IEEE/RSJ Intl. Conf. on Intelligent Robots and Systems (IROS)*, Madrid, Spain, Oct. 2018, pp. 2175–2182.
99. J. Hsiung, M. Hsiao, E. Westman, R. Valencia, and M. Kaess, "Information sparsification in visual-inertial odometry," in *Proc. IEEE/RSJ Intl. Conf. on Intelligent Robots and Systems (IROS)*, Madrid, Spain, Oct. 2018, pp. 1146–1153, **Best conference paper finalist (one of six)**.

100. P. Teixeira, M. Kaess, F. Hover, and J. Leonard, "Multibeam data processing for underwater mapping," in *Proc. IEEE/RSJ Intl. Conf. on Intelligent Robots and Systems (IROS)*, Madrid, Spain, Oct. 2018, pp. 1877–1884.
101. L. Zhou, Z. Li, and M. Kaess, "Automatic extrinsic calibration of a camera and a 3D LiDAR using line and plane correspondences," in *Proc. IEEE/RSJ Intl. Conf. on Intelligent Robots and Systems (IROS)*, Madrid, Spain, Oct. 2018, pp. 5562–5569.
102. M. Hsiao, E. Westman, and M. Kaess, "Dense planar-inertial SLAM with structural constraints," in *Proc. IEEE Intl. Conf. on Robotics and Automation (ICRA)*, Brisbane, Australia, May 2018, pp. 6521–6528.
103. E. Westman, A. Hinduja, and M. Kaess, "Feature-based SLAM for imaging sonar with under-constrained landmarks," in *Proc. IEEE Intl. Conf. on Robotics and Automation (ICRA)*, Brisbane, Australia, May 2018, pp. 3629–3636.
104. P. Puri, D. Jia, and M. Kaess, "GravityFusion: Real-time dense mapping without pose graph using deformation and orientation," in *Proc. IEEE/RSJ Intl. Conf. on Intelligent Robots and Systems (IROS)*, Vancouver, Canada, Sep. 2017, pp. 6506–6513.
105. M. Hsiao, E. Westman, G. Zhang, and M. Kaess, "Keyframe-based dense planar SLAM," in *Proc. IEEE Intl. Conf. on Robotics and Automation (ICRA)*, Singapore, May 2017, pp. 5110–5117.
106. M. C. Koval, M. Klingensmith, S. S. Srinivasa, N. S. Pollard, and M. Kaess, "The manifold particle filter for state estimation on high-dimensional implicit manifolds," in *Proc. IEEE Intl. Conf. on Robotics and Automation (ICRA)*, Singapore, May 2017, pp. 4673–4680.
107. S. Zhang, W. Xie, G. Zhang, H. Bao, and M. Kaess, "Robust stereo matching with surface normal prediction," in *Proc. IEEE Intl. Conf. on Robotics and Automation (ICRA)*, Singapore, May 2017, pp. 2540–2547.
108. D. Fourie, J. Leonard, and M. Kaess, "A nonparametric belief solution to the Bayes tree," in *Proc. IEEE/RSJ Intl. Conf. on Intelligent Robots and Systems (IROS)*, Daejeon, Korea, Oct. 2016, pp. 2189–2196.
109. G. Hemann, S. Singh, and M. Kaess, "Long-range GPS-denied aerial inertial navigation with LIDAR localization," in *Proc. IEEE/RSJ Intl. Conf. on Intelligent Robots and Systems (IROS)*, Daejeon, Korea, Oct. 2016, pp. 1659–1666.
110. T. Huang and M. Kaess, "Incremental data association for acoustic structure from motion," in *Proc. IEEE/RSJ Intl. Conf. on Intelligent Robots and Systems (IROS)*, Daejeon, Korea, Oct. 2016, pp. 1334–1341.
111. P. Teixeira, M. Kaess, F. Hover, and J. Leonard, "Underwater inspection using sonar-based volumetric submaps," in *Proc. IEEE/RSJ Intl. Conf. on Intelligent Robots and Systems (IROS)*, Daejeon, Korea, Oct. 2016, pp. 4288–4295.
112. S. Yang, Y. Song, M. Kaess, and S. Scherer, "Pop-up SLAM: Semantic monocular plane SLAM for low-texture environments," in *Proc. IEEE/RSJ Intl. Conf. on Intelligent Robots and Systems (IROS)*, Daejeon, Korea, Oct. 2016, pp. 1222–1229.
113. J. Zhang, M. Kaess, and S. Singh, "On degeneracy of optimization-based state estimation problems," in *Proc. IEEE Intl. Conf. on Robotics and Automation (ICRA)*, Stockholm, Sweden, May 2016, pp. 809–816.
114. T. Huang and M. Kaess, "Towards acoustic structure from motion for imaging sonar," in *Proc. IEEE/RSJ Intl. Conf. on Intelligent Robots and Systems (IROS)*, Hamburg, Germany, Sep. 2015, pp. 758–765.

115. H.-C. Wang, C. Finn, L. Paull, M. Kaess, R. Rosenholtz, S. Teller, and J. Leonard, "Bridging text spotting and SLAM with junction features," in *Proc. IEEE/RSJ Intl. Conf. on Intelligent Robots and Systems (IROS)*, Hamburg, Germany, Sep. 2015, pp. 3701–3708.
116. M. Kaess, "Simultaneous localization and mapping with infinite planes," in *Proc. IEEE Intl. Conf. on Robotics and Automation (ICRA)*, Seattle, WA, USA, May 2015, pp. 4605–4611.
117. P. Ozog, G. Troni, M. Kaess, R. Eustice, and M. Johnson-Roberson, "Building 3D mosaics from an autonomous underwater vehicle and 2D imaging sonar," in *Proc. IEEE Intl. Conf. on Robotics and Automation (ICRA)*, Seattle, WA, USA, May 2015, pp. 1137–1143.
118. J. Zhang, M. Kaess, and S. Singh, "Real-time depth enhanced monocular odometry," in *Proc. IEEE/RSJ Intl. Conf. on Intelligent Robots and Systems (IROS)*, Chicago, IL, USA, Sep. 2014, pp. 4973–4980.
119. T. Whelan, M. Kaess, R. Finman, M. Fallon, H. Johannsson, J. Leonard, and J. McDonald, "3D mapping, localisation and object retrieval using low cost robotic platforms: A robotic search engine for the real-world," in *RSS Workshop on RGB-D: Advanced Reasoning with Depth Cameras*, Berkeley, CA, USA, Jul. 2014.
120. R. Finman, T. Whelan, M. Kaess, and J. Leonard, "Efficient incremental map segmentation in dense RGB-D maps," in *Proc. IEEE Intl. Conf. on Robotics and Automation (ICRA)*, Hong Kong, Jun. 2014, pp. 5488–5494.
121. G. Huang, M. Kaess, and J. Leonard, "Towards consistent visual-inertial navigation," in *Proc. IEEE Intl. Conf. on Robotics and Automation (ICRA)*, Hong Kong, Jun. 2014, pp. 4926–4933.
122. M. VanMiddlesworth, M. Kaess, F. Hover, and J. Leonard, "Mapping 3D underwater environments with smoothed submaps," in *Proc. Conf. on Field and Service Robotics (FSR)*, Brisbane, Australia, Dec. 2013, pp. 17–30.
123. T. Whelan, M. Kaess, J. Leonard, and J. McDonald, "Deformation-based loop closure for large scale dense RGB-D SLAM," in *Proc. IEEE/RSJ Intl. Conf. on Intelligent Robots and Systems (IROS)*, Tokyo, Japan, Nov. 2013, pp. 548–555.
124. G. Huang, R. Truax, M. Kaess, and J. Leonard, "Unscented iSAM: A consistent incremental solution to cooperative localization and target tracking," in *Proc. European Conf. on Mobile Robots (ECMR)*, Barcelona, Spain, Sep. 2013, pp. 248–254.
125. G. Huang, M. Kaess, and J. Leonard, "Consistent sparsification for graph optimization," in *Proc. European Conf. on Mobile Robots (ECMR)*, Barcelona, Spain, Sep. 2013, pp. 150–157.
126. R. Finman, T. Whelan, M. Kaess, and J. Leonard, "Toward lifelong object segmentation from change detection in dense RGB-D maps," in *Proc. European Conf. on Mobile Robots (ECMR)*, Barcelona, Spain, Sep. 2013, pp. 178–185.
127. G. Huang, M. Kaess, J. Leonard, and S. Roumeliotis, "Analytically-selected multi-hypothesis incremental MAP estimation," in *Proc. Intl. Conf. on Acoustics, Speech, and Signal Processing (ICASSP)*, Vancouver, Canada, May 2013, pp. 6481–6485.
128. H. Johannsson, M. Kaess, M. Fallon, and J. Leonard, "Temporally scalable visual SLAM using a reduced pose graph," in *Proc. IEEE Intl. Conf. on Robotics and Automation (ICRA)*, Karlsruhe, Germany, May 2013, pp. 54–61, **Best student paper finalist (one of five)**.
129. D. Rosen, M. Kaess, and J. Leonard, "Robust incremental online inference over sparse factor graphs: Beyond the Gaussian case," in *Proc. IEEE Intl. Conf. on Robotics and Automation (ICRA)*, Karlsruhe, Germany, May 2013, pp. 1025–1032.

130. T. Whelan, H. Johannsson, M. Kaess, J. Leonard, and J. McDonald, "Robust real-time visual odometry for dense RGB-D mapping," in *Proc. IEEE Intl. Conf. on Robotics and Automation (ICRA)*, Karlsruhe, Germany, May 2013, pp. 5724–5731.
131. A. Walcott-Bryant, M. Kaess, H. Johannsson, and J. Leonard, "Dynamic pose graph SLAM: Long-term mapping in low dynamic environments," in *Proc. IEEE/RSJ Intl. Conf. on Intelligent Robots and Systems (IROS)*, Vilamoura, Portugal, Oct. 2012, pp. 1871–1878.
132. T. Whelan, J. McDonald, M. Kaess, M. Fallon, H. Johannsson, and J. Leonard, "Kintinuous: Spatially extended KinectFusion," in *RSS Workshop on RGB-D: Advanced Reasoning with Depth Cameras*, Sydney, Australia, Jul. 2012.
133. H. Johannsson, M. Kaess, M. Fallon, and J. Leonard, "Temporally scalable visual SLAM using a reduced pose graph," in *RSS Workshop on Long-term Operation of Autonomous Robotic Systems in Changing Environments*, Sydney, Australia, Jul. 2012.
134. V. Indelman, S. Williams, M. Kaess, and F. Dellaert, "Factor graph based incremental smoothing in inertial navigation systems," in *Proc. Intl. Conf. on Information Fusion (FUSION)*, Singapore, Jul. 2012, pp. 2154–2161.
135. M. Kaess, S. Williams, V. Indelman, R. Roberts, J. Leonard, and F. Dellaert, "Concurrent filtering and smoothing," in *Proc. Intl. Conf. on Information Fusion (FUSION)*, Singapore, Jul. 2012, pp. 1300–1307.
136. D. Rosen, M. Kaess, and J. Leonard, "An incremental trust-region method for robust online sparse least-squares estimation," in *Proc. IEEE Intl. Conf. on Robotics and Automation (ICRA)*, St. Paul, MN, USA, May 2012, pp. 1262–1269.
137. J. McDonald, M. Kaess, C. Cadena, J. Neira, and J. Leonard, "6-DOF multi-session visual SLAM using anchor nodes," in *Proc. European Conf. on Mobile Robots (ECMR)*, Orebro, Sweden, Sep. 2011, pp. 69–76.
138. 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 *Proc. IEEE Intl. Conf. on Robotics and Automation (ICRA)*, Shanghai, China, May 2011, pp. 3281–3288.
139. M. Fallon, M. Kaess, H. Johannsson, and J. Leonard, "Efficient AUV navigation fusing acoustic ranging and side-scan sonar," in *Proc. IEEE Intl. Conf. on Robotics and Automation (ICRA)*, Shanghai, China, May 2011, pp. 2398–2405, **Best automation paper finalist (one of five)**.
140. M. Kaess, V. Ila, R. Roberts, and F. Dellaert, "The Bayes tree: An algorithmic foundation for probabilistic robot mapping," in *Proc. Intl. Workshop on the Algorithmic Foundations of Robotics (WAFR)*, Singapore, Dec. 2010, pp. 157–173.
141. H. Johannsson, M. Kaess, B. Englot, F. Hover, and J. Leonard, "Imaging sonar-aided navigation for autonomous underwater harbor surveillance," in *Proc. IEEE/RSJ Intl. Conf. on Intelligent Robots and Systems (IROS)*, Taipei, Taiwan, Oct. 2010, pp. 4396–4403.
142. B. Kim, M. Kaess, L. Fletcher, J. Leonard, A. Bachrach, N. Roy, and S. Teller, "Multiple relative pose graphs for robust cooperative mapping," in *Proc. IEEE Intl. Conf. on Robotics and Automation (ICRA)*, Anchorage, Alaska, USA, May 2010, pp. 3185–3192.
143. M. Kaess, K. Ni, and F. Dellaert, "Flow separation for fast and robust stereo odometry," in *Proc. IEEE Intl. Conf. on Robotics and Automation (ICRA)*, Kobe, Japan, May 2009, pp. 3539–3544.

144. R. Mottaghi, M. Kaess, A. Ranganathan, R. Roberts, and F. Dellaert, "Place recognition-based fixed-lag smoothing for environments with unreliable GPS," in *Proc. IEEE Intl. Conf. on Robotics and Automation (ICRA)*, Pasadena, CA, USA, May 2008, pp. 1862–1867.
145. A. Ranganathan, M. Kaess, and F. Dellaert, "Fast 3D pose estimation with out-of-sequence measurements," in *Proc. IEEE/RSJ Intl. Conf. on Intelligent Robots and Systems (IROS)*, San Diego, CA, USA, Oct. 2007, pp. 2486–2493.
146. M. Kaess, A. Ranganathan, and F. Dellaert, "iSAM: Fast incremental smoothing and mapping with efficient data association," in *Proc. IEEE Intl. Conf. on Robotics and Automation (ICRA)*, Rome, Italy, Apr. 2007, pp. 1670–1677.
147. M. Kaess, A. Ranganathan, and F. Dellaert, "Fast incremental square root information smoothing," in *Proc. Intl. Joint Conf. on Artificial Intelligence (IJCAI)*, Hyderabad, India, Jan. 2007, pp. 2129–2134, **Oral presentation acceptance ratio 15.7% (212 of 1353)**.
148. A. Ranganathan, M. Kaess, and F. Dellaert, "Loopy SAM," in *Proc. Intl. Joint Conf. on Artificial Intelligence (IJCAI)*, Hyderabad, India, Jan. 2007, pp. 2191–2196, **Oral presentation acceptance ratio 15.7% (212 of 1353)**.
149. M. Kaess and F. Dellaert, "A Markov chain Monte Carlo approach to closing the loop in SLAM," in *Proc. IEEE Intl. Conf. on Robotics and Automation (ICRA)*, Barcelona, Spain, Apr. 2005, pp. 645–650.
150. M. Kaess, R. Zboinski, and F. Dellaert, "MCMC-based multiview reconstruction of piecewise smooth subdivision curves with a variable number of control points," in *Proc. European Conf. on Computer Vision (ECCV)*, ser. Lecture Notes in Computer Science, vol. 3023. Prague, Czech Republic: Springer, May 2004, pp. 329–341, acceptance ratio 34.2% (190 of 555).
151. 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: IEEE Computer Society, Oct. 2003, pp. 39–47.
152. M. Kaess, R. Arkin, and J. Rossignac, "Compact encoding of robot-generated 3D maps for efficient wireless transmission," in *Proc. IEEE Intl. Conf. on Advanced Robotics (ICAR)*, Coimbra, Portugal, Jun. 2003, pp. 324–331.
153. M. Likhachev, M. Kaess, and R. Arkin, "Learning behavioral parameterization using spatio-temporal case-based reasoning," in *Proc. IEEE Intl. Conf. on Robotics and Automation (ICRA)*, vol. 2, Washington, DC, USA, May 2002, pp. 1282–1289.

Other Publications

154. E. Westman and M. Kaess, "Underwater AprilTag SLAM and calibration for high precision robot localization," Robotics Institute, Carnegie Mellon University, Tech. Rep. CMU-RI-TR-18-43, Oct. 2018.
155. J. Hsiung, A. Tallaksen, L. Papincak, S. Suresh, H. Jones, W. Whittaker, and M. Kaess, "Localized imaging and mapping for underwater fuel storage basins," in *Proc. of the Symposium on Waste Management*, Phoenix, Arizona, Mar. 2018.
156. H. Liu, C. Li, G. Chen, G. Zhang, M. Kaess, and H. Bao, "Robust keyframe-based dense SLAM with an RGB-D camera," arXiv, Tech. Rep. arXiv:1711.05166, Nov. 2017.

157. M. Klingensmith, M. Koval, S. Srinivasa, N. Pollard, and M. Kaess, "The manifold particle filter for state estimation on high-dimensional implicit manifolds," arXiv, Tech. Rep. arXiv:1604.07224, Apr. 2016.
158. S. Singh, H. Cover, A. Stambler, B. Grocholsky, J. Mishler, B. Hamner, K. Strabala, G. Sherwin, M. Kaess, G. Hemann, M. Bergerman, and S. Spiker, "Perception for safe autonomous helicopter flight and landing," in *72nd Annual Forum and Technology Display, American Helicopter Society (AHS)*, May 2016.
159. T. Whelan, M. Kaess, M. Fallon, H. Johannsson, J. Leonard, and J. McDonald, "Kintinuous: Spatially extended KinectFusion," Computer Science and Artificial Intelligence Laboratory, MIT, Tech. Rep. MIT-CSAIL-TR-2012-020, Jul. 2012.
160. M. Fallon, H. Johannsson, M. Kaess, D. Rosen, E. Muggler, and J. Leonard, "Mapping the MIT Stata Center: Large-scale integrated visual and RGB-D SLAM," in *RSS Workshop on RGB-D: Advanced Reasoning with Depth Cameras*, Jul. 2012.
161. M. Kaess, H. Johannsson, B. Englot, F. Hover, and J. Leonard, "Towards autonomous ship hull inspection using the Bluefin HAUV," in *Ninth Intl. Symposium on Technology and the Mine Problem*, Naval Postgraduate School, Monterey, CA, May 2010.
162. M. Kaess, V. Ila, R. Roberts, and F. Dellaert, "The Bayes tree: Enabling incremental reordering and fluid relinearization for online mapping," Computer Science and Artificial Intelligence Laboratory, MIT, Tech. Rep. MIT-CSAIL-TR-2010-021, Jan. 2010.
163. E. Olson and M. Kaess, "Evaluating the performance of robot mapping systems," in *Workshop on Good Experimental Methodology in Robotics*, 2009.
164. M. Kaess, "Incremental smoothing and mapping," Ph.D. dissertation, Georgia Institute of Technology, Dec. 2008.
165. M. Kaess and F. Dellaert, "Visual SLAM with a multi-camera rig," Georgia Institute of Technology, Tech. Rep. GIT-GVU-06-06, Feb. 2006.
166. 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: AAAI Press, 2002, pp. 44–49, **Award for best mapping**.

Invited Talks and Seminars

Learning for Sonar and Radar SLAM, IROS Workshop on Robotic Perception and Mapping: Frontier Vision & Learning Techniques, Detroit, MI, 2023

Learning for Sonar and Radar SLAM, ICCV Workshop on Robot Learning and SLAM, remote, 2023

Factor Graphs and Robust Perception, Brigham Young University, 2023

Factor Graphs and Robust Perception, Technion, 2021

Factor Graphs and Robust Perception, Tartan SLAM Series, 2021

Factor Graphs for Robot Perception, University of Zurich, Switzerland, 2020

Localization and Mapping with Imaging Sonar, Schlumberger Robotics Symposium, MIT, Cambridge, MA, 2019

Factor Graphs for Robot Perception, West Virginia University, Morgantown, WV, 2019

Localization and Mapping with Imaging Sonar, ICRA Workshop on Underwater Robotics Perception, Montreal, Canada, 2019

Factor Graphs for Robot Perception, Carnegie Mellon University, Pittsburgh, PA, 2018

Efficient Incremental Smoothing, ICRA SLAM Tutorial, Stockholm, Sweden, 2016

Localization and Mapping in Confined Areas with a Hovering AUV, ICRA Workshop on Marine Robot Localization, Stockholm, Sweden, 2016

Robust and Efficient Real-time Mapping for Autonomous Robots, University of Michigan, Ann Arbor, MI and Duke University, Durham, NC, 2015

Real-Time Dense 3D Mapping, Reality Computing Pittsburgh, Pittsburgh, PA, 2014

Robust and Efficient Real-time Mapping for Autonomous Robots, George Washington University, Washington, DC, 2013

Towards Persistent Mapping for Long-Term Autonomy, ICRA Workshop on Long-Term Autonomy, Karlsruhe, Germany, 2013

Incremental Inference and Applications, ICRA Workshop on Robust and Incremental Inference in Factor Graphs, Karlsruhe, Germany, 2013

Robust and Efficient Real-time Mapping for Autonomous Robots, Univ. of Texas, Austin, TX and Carnegie Mellon Univ., Pittsburgh, PA and Univ. of Southern California, CA, 2013

Incremental Smoothing and Mapping, Brown University, Providence, RI, 2012

Temporally Scalable Visual SLAM using the Reduced Pose Graph, University of Technology, Sydney, Australia, 2012

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 (GraphBot), Taipei, Taiwan, 2010

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

Student Advising

Ph.D. Students

Tushaar Jain (co-advisor David Wettergreen), 2024–
 Hung-Jui (Joe) Huang (co-advisor Wenzhen Yuan), 2023–
 Easton Potokar, 2022–
 Akash Sharma, 2021–
 Mohamad Qadri, 2021–

Dan McGann, 2020–
Sudharshan Suresh, 2019–2024, now Boston Dynamics
Akshay Hinduya, 2018–2024, now MBARI
Wei Dong, 2018–2023, now Apple
Allie Chang (co-advisor Simon Lucey), 2018–2023, now Rivian
Montiel Abello, 2017–2024
Paloma Sodhi, 2017–2022, now ASAPP
Ming Hsiao, 2014–2020, now Facebook Reality Labs
Eric Westman, 2014–2019, now Latitude AI
Matthew Klingensmith (co-advisor Siddhartha Srinivasa), 2015–2016, now Boston Dynamics

M.S. Students

Tianxiang Lin, 2023–
Jui-Te Huang, 2022–2023, now CMU RI staff
Taylor Pool, 2022–2023, now CMU RI staff
Lihong Jin, 2021–2023, now CMU RI staff
Talha Faiz (co-advisor Christoph Mertz, MSME), 2021–2023, Samsung Research
Samiran Gode, 2021–2023 (MSME), now Aethon
Tianxiang Lin, 2021–2023 (MSIN), now CMU RI MSR student
Yehonathan Litman, 2020–2022, now CMU RI Ph.D. student
Andrew VanOsten, 2020–2022, now US Air Force
Ruoyang Xu, 2020–2022, now ArgoAI
Alexander Baikovitz, 2020–2021, now Mach9 Robotics
Akash Sharma, 2019–2021, now CMU RI Ph.D. student
Allison Wong, 2019–2021 (MSME), now Martin Defense Group
Chenfeng Tu, 2018–2020, now Apple
Eric Dexheimer, 2018–2020, now CMU software engineer
Joshua Jaekel, 2018–2020, now ArgoAI
Yi Yang, 2017–2019, now Phiar
Zimo Li, 2017–2019, now AutoNavi
Sudharshan Suresh, 2017–2019, now CMU RI Ph.D. student
Bing-Jui Ho, 2016–2018, now Aptiv
Jerry Hsiung, 2016–2018, now Dusty Robotics
Puneet Puri, 2015–2017, now Stanford Business School
Garrett Hemann (co-advisor Sanjiv Singh), 2014–2016, now AirWorks
Tiffany Huang, 2014–2016, now Nuro

Ph.D. Thesis Committee

Srinivasan Vijayarangan, 2024
Mengwen He (ECE), 2023
Brian Jackson, 2022
Mengwen He (ECE), 2022
Weikun Zhen, 2021
John Yao, 2020
Eugene Fang, 2020
Kumar Shaurya Shankar, 2020

Shichao Yang, 2018
Abhijeet Tallavajhula, 2018
Arun Srivatsan, 2018
Ji Zhang, 2017
Hatem Alismail, 2016
Heather Jones, 2016

Ph.D. Quals Committee

Shibo Zhao, 2024
Bardienus Duisterhof, 2023
Dominic Guri, 2023
Maggie Hansen, 2023
Ceci Morales Garza, 2023
Chase Noren, 2022
Suhail Saleem, 2022
Srinivasan Vijayarangan, 2020
Shohin Mukherjee, 2019
Cormac O'Meadhra, 2018
Eugene Fang, 2017
Minh Vo, 2017
Nick Rhinehart, 2016
Kristen Holtz, 2015
Humphrey Hu, 2015

M.S. Thesis Committee

Jay Karhade, 2024
Fausto Vega, 2023
Harry Freeman, 2023
Josh Spisak, 2023
Lucas Nogueira, 2023
Benjamin Jensen, 2022
Nikhil Angad Bakshi, 2022
Manash Pratim Das, 2022
Vivek Roy, 2022
Mohamad Qadri, 2021
Daqian Cheng, 2021
Hengrui (Henry) Zhang, 2021
Dennis Melamed, 2021
Hans Kumar, 2021
Haidar Jamal, 2021
Scott Sun, 2020
Harsh Agarwal, 2020
Vaibhav Viswanathan, 2020
Aditya Dhawale, 2020
Naman Gupta, 2019
Cong Li, 2019

Kevin Pluckter, 2019
 Weizhao Shao, 2019
 Hunter Goforth, 2019
 Jack Buffington, 2018
 Michael Sukyung Lee, 2018
 Ratnesh Madaan, 2018
 Allie Chang, 2018
 Hadi Salman, 2018
 Wei-Hsin Chou, 2017
 Sarah Tan, 2017
 Debidatta Dwibedi, 2017
 Shehzaman Khatib, 2016
 Samuel Yim, 2016
 Shiyuan Chen, 2016
 Ben Holden, 2016
 Adam Werries, 2016
 Daniel Lu, 2016
 Wennie Tabib, 2014

External

Young-Hee Lee, Technical University of Munich (external examiner), 2023
 Kevin Doherty, MIT (external reader), 2022
 Krishna Murthy Jatavallabhula, University of Montreal (external examiner), 2022
 Mina Heinen, Australian National University (external examiner), 2020
 Antonio Teran Espinoza, MIT (external reader), 2020
 Zichao Zhang, University of Zurich (external examiner), 2020
 Chen Zhu, Technical University of Munich (external examiner), 2019
 Pedro Nuno Vaz Teixeira, MIT (mentor, external Ph.D. committee member), 2013–2019
 Renaud Dubee, ETH Zurich (external examiner), 2018
 Dehann Fourie, MIT (mentor, external Ph.D. committee member), 2012–2017
 Jie Li, University of Michigan (external Ph.D. committee member), 2017
 Stephen M. Chaves, University of Michigan (external Ph.D. committee member), 2016
 Raul Mur Artal, University of Zaragoza (external reader), 2016
 John Vial, University of Sydney (external reader), 2013

Service

University Service and Committee Work

MSCV Program Director, 2022–today
 MSCV Admissions Committee, Chair 2022–today
 Robotics Institute Program Committee 2015–today
 Robotics Institute Ph.D. Admissions Committee 2018, 2021, Chair 2020
 Field Robotics Center Seminar Committee 2014–2020
 Faculty Senate 2016–2018
 Robotics Institute Undergraduate Major Committee 2015, 2017

School of Computer Science Fellowship Committee 2014

Senior Program Committee Member

IROS (International Conference on Intelligent Robots and Systems) 2023

Associate Editor

RA-L (IEEE Robotics and Automation Letters) 2020–2023

TRO (IEEE Transactions on Robotics) 2015–2019

IROS (International Conference on Intelligent Robots and Systems) 2010, 2012–2015, 2020–2022

ICRA (International Conference on Robotics and Automation) 2013–2015, 2017–2020

NSF Panel

Proposal Review Panel 2016, 2020, 2021

Workshop Organizer

Workshop on Visual-Inertial Navigation Systems, ICRA 2021

Workshop on Visual-Inertial Navigation: Challenges and Applications, IROS 2019

International Workshop on Lines, Planes and Manhattan Models for 3-D Mapping, IROS 2017, ICRA 2019

Automated SLAM Evaluation Workshop, RSS (Robotics: Science and Systems) 2011

Tutorial Organizer

Visual Simultaneous Localization and Mapping Tutorial at CVPR (Computer Vision and Pattern Recognition) 2014

Journal Reviewer

RAL (IEEE Robotics Automation Letters) 2017, 2018, 2023

T-ASE (IEEE Transactions on Automation Science and Engineering) 2022

TRO (IEEE Transactions on Robotics) 2004, 2007–2009, 2011–2019

JOE (IEEE Journal of Oceanic Engineering) 2017, 2018

JFR (Journal of Field Robotics) 2006, 2009, 2010, 2017

RAS (Journal of Robotics and Autonomous Systems) 2009, 2012, 2016

IJRR (International Journal of Robotics Research) 2010, 2012–2014

IJCV (International Journal of Computer Vision) 2015

MVAP (Machine Vision and Applications) 2015

PAMI (IEEE Transactions on Pattern Analysis and Machine Intelligence) 2008, 2014

TAES (IEEE Transactions on Aerospace and Electronic Systems) 2014

AURO (Autonomous Robots) 2009, 2011, 2013

FTR (Foundations and Trends in Robotics) 2011

IVC (Image and Vision Computing) 2010

IEEE Pervasive Computing 2010

Conference Reviewer

ICRA (International Conference on Robotics and Automation) 2005, 2007–2016, 2022, 2024

IROS (International Conference on Intelligent Robots and Systems) 2007, 2009–2017, 2019

IJCAI (International Joint Conference on Artificial Intelligence) 2003, 2017

RSS (Robotics Science and Systems) 2005, 2006, 2010–2016

SIGGRAPH Asia 2016

AAAI (AAAI Conference on Artificial Intelligence) 2012

RSS Workshop: Long-term Operation of Autonomous Robotic Systems 2012

DARS (International Symposium on Distributed Autonomous Robotic Systems) 2010

RSS Workshop: Inside Data Association 2008

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 Senior Member (Computer Society, Robotics and Automation Society)

AAAI

ACM