JOEL A. HESCH

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EDUCATION

University of Minnesota, Minneapolis, MN   *expected* 2011
Ph.D. in Computer Science
- Thesis: "Towards Consistent Vision-aided Inertial Navigation"
- Committee: Professors Stergios I. Roumeliotis (advisor), Yousef Saad, Volkan Isler, and
  Georgios B. Giannakis (ECE)

University of Minnesota, Minneapolis, MN   Dec. 2008
M.Sc. in Computer Science

University of Minnesota, Minneapolis, MN   Dec. 2004
B.Eng. in Computer Engineering
- Senior Project: "Autonomous Parallel Parking of a Non-holonomic Vehicle"

RESEARCH INTERESTS

- Autonomous vehicle navigation, 2D/3D simultaneous localization and mapping (SLAM) using odometry, inertial measurements, laser range data, and vision information
- Indoor localization systems for human position and orientation tracking in GPS denied scenarios
- Extrinsic camera calibration, multiple-view geometry, catadioptric vision systems, and 3D scene reconstruction
- State estimation for static and dynamical systems using Kalman filter (KF), particle filter, maximum-likelihood estimator (MLE), and maximum a posteriori (MAP) estimator

RESEARCH EXPERIENCE

University of Minnesota, Department of Computer Science   Jan. 2005 – Present
Research Assistant
- Developed an indoor Laser-aided Inertial Navigation System (L-INS), capable of tracking a person's 3D trajectory with 5 cm position accuracy and sub-degree orientation accuracy, while concurrently constructing a 3D map of the building
- Designed a high-precision mirror-based extrinsic camera calibration technique to estimate the transformation between a camera reference frame and a base reference frame
- Formulated a 2D simultaneous localization and mapping (SLAM) algorithm utilizing bearing-only measurements from a paracatadioptric camera
- Created a system to identify and read numerical door signs based on scale-invariant feature transform (SIFT) image features and support vector machine (SVM) classification
- Aided in preparation of a proposal for collaborative localization of unmanned areal vehicles in partially- and fully-GPS-denied scenarios, submitted to the Air Force Research Laboratory (AFRL)
- Aided in preparation of a proposal for person tracking from a moving vehicle in day- and night-time conditions, submitted to the Robotics Technology Consortium (RTC)
- Aided in preparation of a proposal for ascending and descending stair detection, modeling, and

traversal, submitted to the National Science Foundation (NSF)
- Aided in preparation of a proposal for mobile manipulation using the PR-2 as a cart-pushing human assistant, submitted to Willow Garage
- Presented numerous robot demonstrations for lab visitors, ranging from middle school students to visiting researchers

Honeywell Aerospace, Advanced Technology (CNS)   May – Aug. 2010
Graduate Intern
- Derived a wavelet-based gait-classification method for identifying more than ten different human gait modes with 97% accuracy
- Improved performance on human positioning system by designing biometric-based human motion models to reduce dead-reckoning errors
- Developed vision-aided inertial navigation algorithms for an autonomous ground vehicle operating in a GPS-denied environment
- Extended Honeywell's intellectual property by taking the lead on writing two US patent applications covering work completed during graduate internship

NASA, Jet Propulsion Laboratory   Aug. 2009
Planetary Sciences Summer School (PSSS)
- Developed an early-phase concept study for a New Frontiers class robotic space mission
- Applied concurrent engineering methodologies, working with JPL Team X, to design mechanical systems and sensors for a Trojan/Centaur reconnaissance flyby
- Collaborated with PSSS colleagues to generate cost and schedule estimates, as well as mitigate risks

BBN Technologies   May – Aug. 2009
Graduate Intern
- Designed a real-time algorithm for tracking the 3D position, velocity, and heading direction of multiple human targets within crowds using a Velodyne 3D laser scanner
- Enabled Simultaneous Localization and Mapping (SLAM) capabilities for an unmanned underwater vehicle (UUV) using inertial and sonar sensors
- Developed map initialization and merging for Rao-Blackwellized Particle Filter (RBPF) SLAM
- Implemented a device driver for the Velodyne 3D laser scanner written in C++ for the Mac OSX operating system

University of Minnesota, Department of Computer Science   May – Dec. 2004
Undergraduate Research Assistant (UGRAII)
- Implemented and tested components of CLARAty, a reusable robotic software framework developed in collaboration with the Jet Propulsion Laboratory (JPL), NASA
- Developed a real-time device driver for the ISIS Inertial Measurement Unit (IMU) written in C++ for the GNU/Linux operating system

TEACHING EXPERIENCE

University of Minnesota, Department of Computer Science   Jan. – May 2010
Teaching Assistant
- CSci 5552: Sensing and Estimation in Robotics
- Held office hours for students with questions on course material
- Maintained hardware and software installed on mobile robots and manipulators

University of Minnesota, Department of Computer Science Jan. – May 2006
Teaching Assistant
- CSci 2031: Introduction to Numerical Computing
- Taught a class of 30 students for 1 hour each week
- Designed and graded homework sets and exams

HONORS AND AWARDS

- **Honeywell International**
  Innovator Scholar Fellowship, 2010 – 2011
- **National Science Foundation (NSF)**
  Grassroots Travel Fellowship, IEEE/RSJ International Conference on Intelligent Robots and Systems, Oct. 18 – 22, 2010
- **Institut National de Recherche en Informatique et en Automatique (INRIA)**
  Student Travel Fellowship, European Conference on Computer Vision, Sep. 5 – 11, 2010
- **National Institutes of Health (NIH)**
  Neuro-physical-computational Sciences Graduate Training Fellowship, 2007 – 2009
- **National Aeronautics and Space Administration (NASA)**
  Student Travel Fellowship, Planetary Sciences Summer School, Aug. 3 – 7, 2009
- **Naval Research Laboratory (NRL)**
  Student Travel Fellowship, Robotics: Science and Systems, Jun. 28 – Jul. 1, 2009
- **University of Minnesota (UMN)**
  CSE Excellence in Research Award Fellowship for paper [C9], 2007

PUBLICATIONS

Book Chapters:

[B1] J. Hesch, A. I. Mourikis, and S. I. Roumeliotis, *Computer Vision – ECCV 2010*, ser. Lecture Notes in Computer Science. Berlin, Germany: Springer-Verlag, 2010, vol. 6314, ch. Extrinsic Camera Calibration Using Multiple Reflections, pp. 311–325.

[B2] J. A. Hesch, A. I. Mourikis, and S. I. Roumeliotis, *Algorithmic Foundation of Robotics VIII*, ser. Springer Tracts in Advanced Robotics. Berlin: Springer-Verlag, Dec. 2009, vol. 57, ch. Mirror-Based Extrinsic Camera Calibration, pp. 285–299.

Journal Articles:

[J1] J. A. Hesch, F. M. Mirzaei, G. L. Mariottini, and S. I. Roumeliotis, "A laser-aided inertial navigation system (L-INS) for semi-structured indoor environments," *(in preparation)*, 2011.

[J2] J. A. Hesch, A. I. Mourikis, and S. I. Roumeliotis, "Concurrent extrinsic camera calibration and 3D scene reconstruction using multiple mirrors," *(in preparation)*, 2011.

[J3] J. A. Hesch and S. I. Roumeliotis, "Design and analysis of a portable indoor localization aid for the visually impaired," *International Journal of Robotics Research*, vol. 29, no. 11, pp. 1400–1415, Sep. 2010.

Conference Papers:

[C1] J. A. Hesch and S. I. Roumeliotis, "A direct least-squares solution for the PnP problem," in *(in preparation for the Int. Conf. on computer vision)*, 2011.

[C2] J. A. Hesch, G. L. Mariottini, and S. I. Roumeliotis, "Descending-stair detection, approach, and traversal with an autonomous tracked vehicle," in *Proc. of the IEEE/RSJ Int. Conf. on Intelligent Robots and Systems*, Taipei, Taiwan, Oct. 18–22, 2010.

[C3] J. A. Hesch, A. I. Mourikis, and S. I. Roumeliotis, "Extrinsic camera calibration using multiple reflections," in *Proc. of the European Conf. on Computer Vision*, Crete, Greece, Sep. 5–11, 2010.

[C4] J. Shackleton, B. VanVoorst, and J. A. Hesch, "Tracking people with a 360-degree lidar," in *Proc. of the IEEE Int. Conf. on Advanced Video and Signal-Based Surveillance*, Boston, MA, Aug. 29 – Sep. 1, 2010.

[C5] J. A. Hesch, F. M. Mirzaei, G. L. Mariottini, and S. I. Roumeliotis, "A laser-aided inertial navigation system (L-INS) for human localization in unknown indoor environments," in *Proc. of the IEEE Int. Conf. on Robotics and Automation*, Anchorage, AK, May 3–8, 2010.

[C6] ——, "A 3D pose estimator for the visually impaired," in *Proc. of the IEEE/RSJ Int. Conf. on Intelligent Robots and Systems*, St. Louis, MO, Oct. 11–15, 2009, pp. 2716–2723.

[C7] J. A. Hesch, A. I. Mourikis, and S. I. Roumeliotis, "Mirror-based extrinsic camera calibration," in *Proc. of the Int. Workshop on the Algorithmic Foundations of Robotics*, Guanajuato, Mexico, Dec. 7–9, 2008, pp. 285–299.

[C8] ——, "Determining the camera to robot-body transformation from planar mirror reflections," in *Proc. of the IEEE/RSJ Int. Conf. on Intelligent Robots and Systems*, Nice, France, Sep. 22–26, 2008, pp. 3865–3871.

[C9] J. A. Hesch and S. I. Roumeliotis, "An indoor navigation aid for the visually impaired," in *Proc. of the IEEE Int. Conf. on Robotics and Automation*, Rome, Italy, Apr. 10–14, 2007, pp. 3545–3551.

[C10] B. H. Kim, C. D'Souza, R. M. Voyles, J. A. Hesch, and S. I. Roumeliotis, "A reconfigurable computing platform for plume detection with mobile sensor networks," in *Proc. of the SPIE Conf. on Unmanned Systems Technology VIII*, Orlando, FL, Apr. 17–21, 2006.

Technical Reports, White Papers, and Patents:

[R1] Y. Ma and J. A. Hesch, "A system and method for constructing distance estimate models for personal navigation," US Patent, Nov. 24, 2010.

[R2] J. A. Hesch, P. Lommel, and Y. Ma, "A system and method for wavelet-based gait classification," US Patent 12/900 315, Oct. 7, 2010.

[R3] E. Ryan, S. Hörst, M. Benfield, F. C. III, D. Cersosimo, R. Citron, R. Effinger, K. Gibson, D. Gombosi, J. Hesch, D. Ionita, E. Jensen, C. Jolley, D. Takir, and M. Turner, "The TRACER mission: a proposed Trojan and Centaur flyby mission," white paper submitted to the NASA Planetary Science Decadal Survey, Tech. Rep., Aug. 2009.

[R4] J. A. Hesch, A. I. Mourikis, and S. I. Roumeliotis, "Camera to robot-body calibration using planar mirror reflections," University of Minnesota, Dept. of Comp. Sci. & Eng., MARS Lab, Tech. Rep. 2008-001, Jul. 2008.

[R5] J. A. Hesch and S. I. Roumeliotis, "On attitude and position estimation for assisted human guidance," University of Minnesota, Dept. of Comp. Sci. & Eng., MARS Lab, Tech. Rep. 2005-002, Aug. 2005.

[R6] J. A. Hesch and N. Trawny, "Simultaneous localization and mapping using an omni-directional camera," University of Minnesota, Dept. of Comp. Sci. & Eng., MARS Lab, Tech. Rep. 2005-001, May 2005.

Poster Presentations:

[P1] J. A. Hesch, A. I. Mourikis, and S. I. Roumeliotis, "Extrinsic camera calibration using multiple reflections," in *Poster session of the European Conf. on Computer Vision*, Crete, Greece, Sep. 5–11, 2010.

[P2] S. Hörst, M. Benfield, F. C. III, D. Cersosimo, R. Citron, R. Effinger, K. Gibson, D. Gombosi, J. Hesch, D. Ionita, E. Jensen, C. Jolley, E. Ryan, D. Takir, and M. Turner, "A JPL planetary science summer school Trojan and Centaur reconnaissance mission: Science," in *Division of Planetary Sciences, meeting 49*, Fajardo, Puerto Rico, Oct. 4–9, 2009, poster 16.17.

[P3] E. Ryan, S. Hörst, M. Benfield, F. C. III, D. Cersosimo, R. Citron, R. Effinger, K. Gibson, D. Gombosi, J. Hesch, D. Ionita, E. Jensen, C. Jolley, D. Takir, and M. Turner, "A JPL planetary science summer school Trojan and Centaur reconnaissance mission: Mission design," in *Division of Planetary Sciences, meeting 49*, Fajardo, Puerto Rico, Oct. 4–9, 2009, poster 16.26.

[P4] J. A. Hesch, A. I. Mourikis, and S. I. Roumeliotis, "Determining the camera to robot-body transformation from planar mirror reflections," in *Poster session of the IEEE/RSJ Int. Conf. on Intelligent Robots and Systems*, Nice, France, Sep. 22–26, 2008.

Selected Coursework

- Sensing and Estimation in Robotics, Professor Stergios Roumeliotis
- Detection and Estimation Theory, Professor Georgios Giannakis
- Advanced Estimation and Filtering, Professor Tryphon Georgiou
- Convex and Nonconvex Optimization Theory, Professor Tom Luo
- Image Processing and Applications, Professor Guillermo Sapiro
- Dictionary Learning, Professor Guillermo Sapiro
- Computer Vision and Pattern Recognition, Professor Paul Schrater
- Matrix Theory and Perturbation Analysis, Professor Yousef Saad
- Sparse Matrix Computations, Professor Yousef Saad
- Linear Systems and Optimal Control, Professor Mihailo Jovanovic
- Computational Algebraic Geometry, Professor Joel Roberts

Programming Languages and Software

- C/C++, Haskel, Java, Matlab, Maple, Mathematica, ML, Octave
- boost, OpenCV, Qt, OpenGL, Subversion, LaTeX, MS Office, Open Office
- GNU/Linux, Mac OSX, Unix, Windows NT/2000/XP/Vista/7

SERVICE

Reviewer for
Journals:
- Autonomous Robots, 2006
- IEEE Transactions on Robotics, 2007, 2010
- International Journal of Computer Vision, 2006
- International Journal of Robotics Research, 2006

Conferences:
- Canadian Conference on Computer and Robot Vision, 2006
- IEEE Computer Society Conference on Computer Vision and Pattern Recognition, 2008
- IEEE International Conference on Robotics and Automation, 2005 – 2010
- IEEE/RSJ International Conference on Intelligent Robots and Systems, 2008 – 2010
- Robotics: Science and Systems Conference, 2006 – 2010

Workshops:
- Workshop on the Algorithmic Foundations of Robotics, 2008
- Workshop on Computer Vision Applications for the Visually Impaired, 2008

AFFILIATIONS

- Institute of Electrical and Electronics Engineers (IEEE), student member
- IEEE Robotics and Automation Society (RAS)
- Engineers Without Borders