PROCEEDINGS OF SPIE

SPIDigitalLibrary.org/conference-proceedings-of-spie

Front Matter: Volume 8387

, "Front Matter: Volume 8387," Proc. SPIE 8387, Unmanned Systems Technology XIV, 838701 (20 June 2012); doi: 10.1117/12.979014

SPIE.

Event: SPIE Defense, Security, and Sensing, 2012, Baltimore, Maryland, United States

PROCEEDINGS OF SPIE

Unmanned Systems Technology XIV

**Robert E. Karlsen
Douglas W. Gage
Charles M. Shoemaker
Grant R. Gerhart**
Editors

**25–27 April 2012
Baltimore, Maryland, United States**

Sponsored and Published by
SPIE

Volume 8387

Proceedings of SPIE, 0277-786X, v. 8387

SPIE is an international society advancing an interdisciplinary approach to the science and application of light.

Unmanned Systems Technology XIV, edited by Robert E. Karlsen, Douglas W. Gage,
Charles M. Shoemaker, Grant R. Gerhart, Proc. of SPIE Vol. 8387, 838701
© 2012 SPIE · CCC code: 0277-786X/12/\$18 · doi: 10.1117/12.979014

Proc. of SPIE Vol. 8387 838701-1

The papers included in this volume were part of the technical conference cited on the cover and title page. Papers were selected and subject to review by the editors and conference program committee. Some conference presentations may not be available for publication. The papers published in these proceedings reflect the work and thoughts of the authors and are published herein as submitted. The publisher is not responsible for the validity of the information or for any outcomes resulting from reliance thereon.

Please use the following format to cite material from this book:

Author(s), "Title of Paper," in *Unmanned Systems Technology XIV*, edited by Robert E. Karlsen, Douglas W. Gage, Charles M. Shoemaker, Grant R. Gerhart, Proceedings of SPIE Vol. 8387 (SPIE, Bellingham, WA, 2012) Article CID Number.

ISSN 0277-786X

ISBN 9780819490650

Published by

SPIE

P.O. Box 10, Bellingham, Washington 98227-0010 USA

Telephone +1 360 676 3290 (Pacific Time) · Fax +1 360 647 1445

SPIE.org

Copyright © 2012, Society of Photo-Optical Instrumentation Engineers

Copying of material in this book for internal or personal use, or for the internal or personal use of specific clients, beyond the fair use provisions granted by the U.S. Copyright Law is authorized by SPIE subject to payment of copying fees. The Transactional Reporting Service base fee for this volume is \$18.00 per article (or portion thereof), which should be paid directly to the Copyright Clearance Center (CCC), 222 Rosewood Drive, Danvers, MA 01923. Payment may also be made electronically through CCC Online at copyright.com. Other copying for republication, resale, advertising or promotion, or any form of systematic or multiple reproduction of any material in this book is prohibited except with permission in writing from the publisher. The CCC fee code is 0277-786X/12/\$18.00.

Printed in the United States of America.

Publication of record for individual papers is online in the SPIE Digital Library.

SPIDigitalLibrary.org

Paper Numbering: Proceedings of SPIE follow an e-First publication model, with papers published first online and then in print and on CD-ROM. Papers are published as they are submitted and meet publication criteria. A unique, consistent, permanent citation identifier (CID) number is assigned to each article at the time of the first publication. Utilization of CIDs allows articles to be fully citable as soon as they are published online, and connects the same identifier to all online, print, and electronic versions of the publication. SPIE uses a six-digit CID article numbering system in which:

- The first four digits correspond to the SPIE volume number.
- The last two digits indicate publication order within the volume using a Base 36 numbering system employing both numerals and letters. These two-number sets start with 00, 01, 02, 03, 04, 05, 06, 07, 08, 09, 0A, 0B ... 0Z, followed by 10-1Z, 20-2Z, etc.

The CID number appears on each page of the manuscript. The complete citation is used on the first page, and an abbreviated version on subsequent pages. Numbers in the index correspond to the last two digits of the six-digit CID number.

Contents

ix	Conference Committee
xiii	Introduction

SESSION 1 MULTI-ROBOT CONTROL: JOINT SESSION WITH CONFERENCE 8405

- 8387 02 **A layered control architecture for single-operator control of heterogeneous unmanned system teams** [8387-01]
S. P. Buerger, J. Neely, C. Little, W. Amai, R. Joyce, J. A. Love, Sandia National Labs. (United States)
- 8387 03 **Coordinating with Humans by Adjustable-Autonomy for Multirobot Pursuit (CHAMP)** [8387-02]
D. Dumond, J. Ayers, N. Schurr, A. Carlin, D. Burke, J. Rousseau, Aptima, Inc. (United States)
- 8387 04 **Reconnaissance and Autonomy for Small Robots (RASR) team: MAGIC 2010 challenge** [8387-03]
A. Lacaze, K. Murphy, Robotic Research, LLC (United States); M. Del Giorno, Del Services, LLC (United States); K. Corley, Embry-Riddle Aeronautical Univ. (United States)
- 8387 05 **Adaptive information interactive mechanism for multi-UAV visual navigation** [8387-58]
H. Liu, Q. Dai, Tsinghua Univ. (China)
- 8387 06 **A feedback-trained autonomous control system for heterogeneous search and rescue applications** [8387-05]
J. Straub, The Univ. of North Dakota (United States)
- 8387 07 **Adaptive electronic camouflage using texture synthesis** [8387-57]
N. Pezeshkian, J. D. Neff, Space and Naval Warfare Systems Ctr. Pacific (United States)

SESSION 2 NAVIGATION AND MOBILITY I

- 8387 08 **Cooperative 3D and 2D mapping with heterogenous ground robots** [8387-07]
J. G. Rogers III, Georgia Institute of Technology (United States); D. Baran, E. Stump, S. Young, U.S. Army Research Lab. (United States); H. I. Christensen, Georgia Institute of Technology (United States)
- 8387 09 **Fast online learning of control regime transitions for adaptive robotic mobility** [8387-08]
B. Yamauchi, iRobot Corp. (United States)

- 8387 0A **Safe operations of unmanned systems for reconnaissance in complex environments Army technology objective (SOURCE ATO): a year later** [8387-09]
N. J. Kott III, E. Mottern, T. Keys van Lierop, General Dynamics Robotic Systems (United States); J. P. Gray, U.S. Army Tank-Automotive Research, Development and Engineering Ctr. (United States)
- 8387 0B **Challenges to autonomous navigation in complex urban terrain** [8387-10]
J. P. Gray, R. E. Karlsen, U.S. Army Tank Automotive Research, Development and Engineering Ctr. (United States); C. DiBerardino, E. Mottern, General Dynamics Robotics Systems (United States); N. J. Kott III, U.S. Army Tank Automotive Research, Development and Engineering Ctr. (United States)

SESSION 3 INTELLIGENT BEHAVIORS

- 8387 0C **Approximate dynamic programming recurrence relations for a hybrid optimal control problem** [8387-11]
W. Lu, S. Ferrari, Duke Univ. (United States); R. Fierro, The Univ. of New Mexico (United States); T. A. Wettergren, Naval Undersea Warfare Ctr. (United States)
- 8387 0D **Enabling civilian applications of unmanned teams through collaboration, cooperation, and sensing** [8387-12]
C. Brune, T. Dityam, J. Girwar-Nath, K. Kanistras, G. Martins, A. Moses, I. Samonas, J. L. St. Amour, M. J. Rutherford, K. P. Valavanis, Univ. of Denver (United States)
- 8387 0E **Trust method for multi-agent consensus** [8387-13]
D. G. Mikulski, U.S. Army Tank Automotive Research, Development and Engineering Ctr. (United States) and Oakland Univ. (United States); F. L. Lewis, The Univ. of Texas at Arlington (United States); E. Y. Gu, Oakland Univ. (United States); G. R. Hudas, U.S. Army Tank Automotive Research, Development and Engineering Ctr. (United States)
- 8387 0F **Intelligent behaviors through vehicle-to-vehicle and vehicle-to-infrastructure communication** [8387-14]
R. D. Garcia, P. Sturgeon, M. Brown, Southwest Research Institute (United States)
- 8387 0G **UGV navigation in wireless sensor and actuator network environments** [8387-15]
G. Zhang, J. Li, C. A. Duncan, J. Kanno, R. R. Selmic, Louisiana Tech Univ. (United States)
- 8387 0H **Neural-network-based navigation and control of unmanned aerial vehicles for detecting unintended emissions** [8387-16]
H. Zargarzadeh, D. Nodland, V. Thotla, S. Jagannathan, Missouri Univ. of Science and Technology (United States); S. Agarwal, U.S. Army Night Vision & Electronic Sensors Directorate (United States)

SESSION 4 HUMAN ROBOT INTERFACE

- 8387 0I **Evolution of a common controller** [8387-17]
D. Powell, D. Barbour, G. Gilbreath, Space and Naval Warfare Systems Ctr. Pacific (United States)

- 8387 OJ **A monocular leader-follower system for small mobile robots** [8387-18]
C. S. Monnier, S. German, A. Ostapchenko, Charles River Analytics, Inc. (United States)
- 8387 OK **Constraint-based semi-autonomy for unmanned ground vehicles using local sensing** [8387-19]
S. J. Anderson, S. B. Karumanchi, Massachusetts Institute of Technology (United States);
B. Johnson, V. Perlin, M. Rohde, Quantum Signal LLC (United States); K. Iagnemma,
Massachusetts Institute of Technology (United States)
- 8387 OL **Study of high-definition and stereoscopic head-aimed vision for improved teleoperation of an unmanned ground vehicle** [8387-20]
D. R. Tycza, R. Wright, B. Janiszewski, M. J. Chatten, Chatten Associates, Inc. (United States);
T. A. Bowen, B. Skibba, U.S. Air Force Materiel Command (United States)
- 8387 OM **Control solutions for robots using Android and iOS devices** [8387-21]
A. W. Evans III, U.S. Army Research Lab. (United States); J. P. Gray, U.S. Army Tank Automotive
Research, Development and Engineering Ctr. (United States); D. Rudnick, DCS Corp. (United
States); R. E. Karlsen, U.S. Army Tank Automotive Research, Development and Engineering
Ctr. (United States)
- 8387 ON **Development and human factors analysis of an augmented reality interface for multi-robot tele-operation and control** [8387-22]
S. Lee, N. P. Lucas, R. D. Ellis, A. Pandya, Wayne State Univ. (United States)

SESSION 5 PERCEPTION

- 8387 OO **Large-scale experimental design for decentralized SLAM** [8387-23]
A. Cunningham, F. Dellaert, Georgia Institute of Technology (United States)
- 8387 OP **Real-time lidar-based place recognition using distinctive shape descriptors** [8387-24]
J. Collier, Defence Research and Development Canada, Suffield (Canada); S. Se,
V. Kotamraju, P. Jasiobedzki, MacDonald, Dettwiler and Associates Ltd. (Canada)
- 8387 OQ **Fully self-contained vision-aided navigation and landing of a micro air vehicle independent from external sensor inputs** [8387-25]
R. Brockers, S. Susca, D. Zhu, L. Matthies, Jet Propulsion Lab. (United States)
- 8387 OR **Flight test evaluation of a prototype optical instrument for airborne sense-and-avoid applications** [8387-26]
C. Minwalla, York Univ. (Canada) and National Research Council Canada (Canada);
P. Thomas, York Univ. (Canada); K. Ellis, National Research Council Canada (Canada);
R. Hornsey, York Univ. (Canada); S. Jennings, National Research Council Canada (Canada)
- 8387 OS **Saliency detection and model-based tracking: a two part vision system for small robot navigation in forested environment** [8387-27]
R. Roberts, D.-N. Ta, J. Straub, K. Ok, F. Dellaert, Georgia Institute of Technology (United
States)

- 8387 OT **Multiple object detection and classification on uneven terrain using multi-channel lidar for UGV** [8387-28]
K. Cho, Univ. of Science & Technology (Korea, Republic of); S.-H. Baeg, S. Park, Korea Institute of Industrial Technology (Korea, Republic of)

SESSION 6 ROBOTICS CTA

- 8387 OU **Foundations of autonomy for ground robotics** [8387-29]
J. A. Bornstein, U.S. Army Research Lab. (United States); R. R. Mitchell, General Dynamics Robotic Systems (United States)
- 8387 OV **High degree-of-freedom dynamic manipulation** [8387-30]
M. P. Murphy, B. Stephens, Y. Abe, A. A. Rizzi, Boston Dynamics (United States)
- 8387 OW **Laboratory on legs: an architecture for adjustable morphology with legged robots** [8387-31]
G. C. Haynes, Carnegie Mellon Univ. (United States); J. Pusey, U.S. Army Research Lab. (United States); R. Knopf, A. M. Johnson, D. E. Koditschek, Univ. of Pennsylvania (United States)
- 8387 OX **Connecting a cognitive architecture to robotic perception** [8387-32]
U. Kurup, C. Lebiere, A. Stentz, M. Hebert, Carnegie Mellon Univ. (United States)
- 8387 OY **Semantic perception for ground robotics** [8387-33]
M. Hebert, J. A. Bagnell, Carnegie Mellon Univ. (United States); M. Bajracharya, Jet Propulsion Lab. (United States); K. Daniilidis, Univ. of Pennsylvania (United States); L. H. Matthies, Jet Propulsion Lab. (United States); L. Mianzo, General Dynamics Robotic Systems (United States); L. Navarro-Serment, Carnegie Mellon Univ. (United States); J. Shi, Univ. of Pennsylvania (United States); M. Wellfare, General Dynamics Robotic Systems (United States)
- 8387 OZ **Robust mobility in human-populated environments** [8387-34]
J. P. Gonzalez, General Dynamics Robotic Systems (United States); M. Phillips, B. Neuman, M. Likhachev, Carnegie Mellon Univ. (United States)
- 8387 10 **The importance of shared mental models and shared situation awareness for transforming robots from tools to teammates** [8387-35]
S. Ososky, D. Schuster, F. Jentsch, S. Fiore, R. Shumaker, Univ. of Central Florida (United States); C. Lebiere, U. Kurup, J. Oh, A. Stentz, Carnegie Mellon Univ. (United States)

SESSION 7 ARTICULATION AND MANIPULATION

- 8387 11 **Enhanced operator perception through 3D vision and haptic feedback** [8387-36]
R. Edmondson, Polaris Sensor Technologies, Inc. (United States); K. Light, A. Bodenhamer, U.S. Army Research Lab. (United States); P. Bosscher, L. Wilkinson, Harris Corp. (United States)
- 8387 12 **Autonomous urban reconnaissance ingress system (AURIS): providing a tactically relevant autonomous door-opening kit for unmanned ground vehicles** [8387-37]
D. J. Shane, M. A. Rufo, Boston Engineering Corp. (United States); M. D. Berkemeier, J. A. Alberts, Autonomous Solutions, Inc. (United States)

- 8387 13 **Haptics-based immersive telerobotic system for improvised explosive device disposal: Are two hands better than one?** [8387-38]
D. Erickson, Defence Research and Development Canada, Suffield (Canada); H. Lacheray, Quanser Inc. (Canada); J. M. Lambert, I. Mantegh, National Research Council Canada (Canada); D. Crymble, J. Daly, Y. Zhao, Quanser Inc. (Canada)
- 8387 14 **Game theory applied to legged robotics: a variant of the dolichobrachistochrone problem** [8387-39]
P. Muench, D. Bednarz, U.S. Army Tank Automotive Research, Development and Engineering Ctr. (United States)
- 8387 16 **Improving UGV teleoperation performance using novel visualization techniques and manual interfaces** [8387-41]
S. Vozar, D. M. Tilbury, Univ. of Michigan (United States)

SESSION 8 NAVIGATION AND MOBILITY II

- 8387 17 **Autonomous exploration and mapping of unknown environments** [8387-42]
J. Owens, U.S. Army Research Lab. (United States); P. Osteen, Motile Robotics Inc. (United States); M. Fields, U.S. Army Research Lab. (United States)
- 8387 18 **Development and demonstration of autonomous behaviors for urban environment exploration** [8387-43]
G. Ahuja, D. Fellars, G. Kogut, E. Pacis Rius, M. Schoolov, A. Xydes, Space and Naval Warfare Systems Ctr. Pacific (United States)
- 8387 19 **Development of an info-gap-based path planner to enable nondeterministic low-observability mobile sensor nodes** [8387-44]
D. Mascareñas, C. Stull, C. Farrar, Los Alamos National Lab. (United States)
- 8387 1A **Energy usage for UGVs executing coverage tasks** [8387-45]
J. Broderick, D. Tilbury, E. Atkins, Univ. of Michigan (United States)

SESSION 9 SPECIAL TOPICS

- 8387 1B **Enabling unmanned capabilities in the tactical wheeled vehicle fleet of the future** [8387-46]
N. Zych, Oshkosh Corp. (United States)
- 8387 1C **ROBODEXS: multi-robot deployment and extraction system** [8387-47]
J. P. Gray, J. R. Mason, M. S. Patterson, M. W. Skalny, U.S. Army Tank Automotive Research, Development and Engineering Ctr. (United States)
- 8387 1E **Mesh networking optimized for robotic teleoperation** [8387-49]
A. Hart, N. Pezeshkian, H. Nguyen, Space and Naval Warfare Systems Ctr. Pacific (United States)

- 8387 1F **Getting it right the first time: predicted performance guarantees from the analysis of emergent behavior in autonomous and semi-autonomous systems** [8387-50]
R. C. Arkin, Georgia Institute of Technology (United States); D. Lyons, Fordham Univ. (United States); J. Shu, Georgia Institute of Technology (United States); P. Nirmal, Fordham Univ. (United States); M. Zafar, Georgia Institute of Technology (United States)
- 8387 1G **Characteristics of a maritime interdiction operations unmanned ground vehicle** [8387-51]
H. G. Nguyen, M. Baker, Space and Naval Warfare Systems Ctr. Pacific (United States)

POSTER SESSION

- 8387 1I **Rapid position estimation and tracking for autonomous driving** [8387-54]
P. K. Wang, P. A. Torriano, L. M. Collins, K. D. Morton, Jr., Duke Univ. (United States)
- 8387 1J **An enhanced inertial navigation system based on a low-cost IMU and laser scanner** [8387-55]
H.-S. Kim, Korea Univ. (Korea, Republic of); S.-H. Baeg, K.-W. Yang, K. Cho, S. Park, Korea Institute of Industrial Technology (Korea, Republic of)
- 8387 1K **A pose estimation method for unmanned ground vehicles in GPS denied environments** [8387-56]
A. Tamjidi, C. Ye, Univ. of Arkansas at Little Rock (United States)
- 8387 1M **A statistical approach for performance analysis of uncertain systems** [8387-61]
X. Chen, Southern Univ. (United States)
- 8387 1N **Review of multi-robot taxonomy, trends, and applications for defense and space** [8387-62]
N. P. Lucas, A. K. Pandya, R. D. Ellis, Wayne State Univ. (United States)
- 8387 1O **Videometric terminal guidance method and system for UAV accurate landing** [8387-63]
X. Zhou, Z. Lei, Q. Yu, H. Zhang, Y. Shang, J. Du, Y. Gui, P. Guo, National Univ. of Defense Technology (China)

Author Index

Conference Committee

Symposium Chair

Kevin P. Meiners, Office of the Secretary of Defense (United States)

Symposium Cochair

Kenneth R. Israel, Lockheed Martin Corporation (United States)

Conference Chairs

Robert E. Karlsen, U.S. Army Tank Automotive Research, Development and Engineering Center (United States)

Douglas W. Gage, XPM Technologies (United States)

Charles M. Shoemaker, U.S. Army CERDEC (United States)

Grant R. Gerhart, U. S. Army Tank Automotive Research Development and Engineering Center, *Retired* (United States)

Program Committee

Stephen Balakirsky, National Institute of Standards and Technology (United States)

Johann Borenstein, University of Michigan (United States)

Jonathan A. Bornstein, U.S. Army Research Laboratory (United States)

Jared Giesbrecht, Defence Research and Development Canada, Suffield (Canada)

Rajiv V. Dubey, University of South Florida (United States)

Hobart Ray Everett, Space and Naval Warfare Systems Center Pacific (United States)

Gene A. Klager, U.S. Army Night Vision & Electronic Sensors Directorate (United States)

James H. Lever, U.S. Army Engineer Research and Development Center (United States)

Larry H. Matthies, Jet Propulsion Laboratory (United States)

Paul L. Muench, U.S. Army Tank Automotive Research, Development and Engineering Center (United States)

Hoa G. Nguyen, Space and Naval Warfare Systems Command (United States)

James L. Overholt, U.S. Army Tank Automotive Research, Development and Engineering Center (United States)

Mike Perschbacher, RovnoTech (United States)

Marc Raibert, Boston Dynamics (United States)

Klaus-Juergen Schilling, Julius-Maximilians-Universität Würzburg (Germany)

Nahid N. Sidki, SAIC (United States)
Harpreet Singh, Wayne State University (United States)
Anthony Stentz, Carnegie Mellon University (United States)
David L. Stone, Mechatron Consulting (United States)
Venkataraman Sundareswaran, Teledyne Scientific Company
 (United States)
Brian H. Wilcox, Jet Propulsion Laboratory (United States)
Gary Witus, Turing Associates, Inc. (United States)
Brian M. Yamauchi, iRobot Corporation (United States)

Session Chairs

- 1 Multi-Robot Control: Joint Session with Conference 8405
Raja Suresh, General Dynamics Advanced Information Systems
 (United States)
Grant R. Gerhart, U. S. Army Tank Automotive Research Development
 and Engineering Center, *Retired* (United States)
- 2 Navigation and Mobility I
Robert E. Karlsen, U.S. Army Tank Automotive Research, Development
 and Engineering Center (United States)
Brian M. Yamauchi, iRobot Corporation (United States)
- 3 Intelligent Behaviors
Frank L. Lewis, The University of Texas at Arlington (United States)
Dariusz G. Mikulski, U.S. Army Tank Automotive Research,
 Development and Engineering Center (United States)
- 4 Human Robot Interface
Jeremy P. Gray, U.S. Army Tank Automotive Research, Development
 and Engineering Center (United States)
- 5 MAST: Small-Scale Autonomous Platforms: Joint Session with
 Conference 8373
Christopher M. Kroninger, U.S. Army Research Laboratory
 (United States)
- 6 MAST: Sensors for Small-Scale Autonomous Platforms: Joint Session with
 Conference 8373
William D. Nothwang, U.S. Army Research Laboratory (United States)
- 7 Perception
Camille Monnier, Charles River Analytics, Inc. (United States)
Roland Brockers, Jet Propulsion Laboratory (United States)
- 8 Robotics CTA
Jonathan A. Bornstein, U.S. Army Research Laboratory (United States)

- 9 Articulation and Manipulation
 Paul L. Muench, U.S. Army Tank Automotive Research, Development
 and Engineering Center (United States)
- 10 Navigation and Mobility II
 Robert E. Karlsen, U.S. Army Tank Automotive Research, Development
 and Engineering Center (United States)
 Brian M. Yamauchi, iRobot Corporation (United States)
- 11 Special Topics
 Douglas W. Gage, XPM Technologies (United States)
 Charles M. Shoemaker, U.S. Army CERDEC (United States)

Introduction

The Unmanned Systems Technology XIV Conference consisted of eleven sessions that spanned three days and were devoted to current robotic technologies relevant to commercial and military applications. The opening session on Wednesday was Multi-Robot Control, which was a joint session with Defense Transformation and Net-Centric Systems 2012, Conference 8405. Increasing the number of robots that one person can efficiently control is of interest for both military and security applications. One paper described their team's entry in the joint U.S./Australia multi-robot competition, MAGIC 2010, while another paper discussed multi-robot pursuit and evasion in an indoor environment. The Navigation and Mobility I session included papers on the challenges of developing and testing autonomous ground platforms, both small and large, as well as research on control techniques to enable autonomous vehicles to drive fast. The Intelligent Behaviors session described a variety of techniques for enabling behaviors ranging from driver assistance to full autonomy, including work in approximate dynamic programming, trust and consensus, and vehicle-to-vehicle communication. The last session of the day was on developments in the area of Human Robot Interface, which included papers on dismounted leader follower, semi-autonomous control coordination, and different controllers and viewing devices.

The Thursday morning sessions were joint with Conference 8373, Micro- and Nanotechnology Sensors, Systems, and Applications IV, and consisted of work performed under the Army Research Laboratory's (ARL) MAST CTA. The papers described the development and manufacturing of micro flapping wing air vehicles, as well as research into micro cyclocopters and legged ground robots. Presentations were also made of micro inertial, hair, infrared, radar and gas sensors that will enable autonomous behaviors and other useful capabilities beyond navigation. The afternoon's Perception session described work in decentralized and appearance-based SLAM techniques, as well as some navigation methods for air platforms, including the fully self-contained landing of a micro-air vehicle. The final session consisted of papers from ARL's Robotics CTA, which described current research on manipulation and mobility, cognitive architectures, semantic perception, and shared mental models. Demonstrations of physical prototypes are always well received and we saw implementations of flying and crawling micro-robots, along with Big Dog throwing concrete blocks! Thursday concluded with a well-attended poster session and some more interesting papers in robotics.

Friday began with a session on Articulation and Manipulation, where a paper was presented on autonomous door opening, which is often neglected in urban autonomy scenarios. Other papers included work showing the advantages of stereovision for tele-operated manipulation, as well as research on haptic

controllers and immersive displays. The Navigation and Mobility II session described work in autonomously exploring multi-story buildings, as well as non-deterministic and energy conserving path-planning techniques. The final session of the conference was the Special Topics session, which included papers on diverse topics such as developing large autonomous military vehicles, a system for storing and deploying marsupial robots, communication latency and mesh networking, as well as the development of a throwable robot.

This year's conference contained a wide array of cutting-edge unmanned systems technologies and shows why robotics is such an exciting area. We hope you enjoy these proceedings and are able to attend our conference next year.

Robert E. Karlsen
Douglas W. Gage
Charles M. Shoemaker
Grant R. Gerhart