

Myung Hwangbo

CONTACT INFORMATION	Robotics Institute Carnegie Mellon University 5000 Forbes Ave Newell-Simon Hall 4115 Pittsburgh, PA 15215, USA	<i>Tel:</i> (412) 268-3818 <i>Cell:</i> (412) 245-7835 <i>Fax:</i> (412) 268-5570 <i>Email:</i> myung@cs.cmu.edu http://www.cs.cmu.edu/~myung
OBJECTIVE	A position in robotics research and development with emphasis on computer vision, motion planning and building complex robotic systems	
CITIZENSHIP	Republic of Korea (currently hold a cap-exempt H-1B in US)	
RESEARCH INTERESTS	Autonomous robot navigation, scene reconstruction in computer vision, multi-sensors fusion, sampling-based motion planning, machine learning	
EDUCATION	Carnegie Mellon University , Pittsburgh, Pennsylvania, USA	
	Ph.D., Robotics, Robotics Institute, School of Computer Science	Mar 2012
	- Thesis: <i>Vision-Based Navigation for a Small Fixed-Wing Airplane in Urban Environment</i> - Adviser: Prof. Takeo Kanade - Study Area: Unmanned aerial vehicle, computer vision, motion planning and sensor calibration	
	M.S., Robotics, Robotics Institute, School of Computer Science	Sep 2009
	- Thesis: <i>Monocular Vision-based Navigation for a Miniature Fixed-Wing Aircraft</i> - Advisers: Prof. Takeo Kanade and Prof. James Kuffner	
	Pohang Univ. of Science and Technology (POSTECH) , Pohang, South Korea	
	M.S., Mechanical Engineering,	Mar 1995 ~ Feb 1997
	- Thesis: <i>Control and design of a wheeled mobile robot</i> - Adviser: Prof. Young-il Youm - Study Area: Mobile robotics and autonomous system design	
	B.S., Mechanical Engineering,	Mar 1991 ~ Feb 1995
	- Minor in Electrical Engineering	
RESEARCH & WORK EXPERIENCE	Postdoctoral Fellow Robotics Institute, Carnegie Mellon University, Pittsburgh, Pennsylvania, USA	May 2012 ~ Present
	• FPV (First Person Vision) Project - Working on the development of a glasses-type wearable device based on TI-OMAP4 processor integrated with HD cameras and IMU - Developing a realtime indoor localization method for walking people using a monocular camera and IMU (Inertial Measurement Unit)	

Graduate Research Assistant

Aug 2004 ~ Mar 2012

Robotics Institute, Carnegie Mellon University, Pittsburgh, Pennsylvania, USA

- Vision-based Autonomous Navigation of a Fixed-wing UAV
 - Demonstrated an air-slalom task in experiments that demands the UAV to autonomously search, localize, and pass through multiple ground targets oriented in different directions.
 - Developed a sampling-based motion planning method that finds dynamic and feasible vehicle paths to a goal with the considerations of motion uncertainty and target visibility.
 - Integrated an off-the-shelf small model airplane with an autopilot system (ArduPilot) and low-cost sensors including a camera, IMU and GPS.
- Visual-Inertial Sensor Fusion
 - Enhanced the KLT feature tracker by gyroscope fusion in order to reliably handle large optical flows due to camera-ego motion and parallelized it in GPU CUDA implementation (achieved 1000 feature tracks at 30 fps).
 - Developed a driftless attitude (roll and pitch angles) estimation algorithm in a Kalman filter that combines IMU measurements with vertical/horizontal edges in images associated with multiple vanishing points.
 - Invented a convenient on-field camera/IMU calibration method that only requires natural references such as gravity and vertical edges.
- Visual Odometry in Monocular and Non-Overlapping Multi-Camera Systems
 - Implemented a realtime structure-from-motion method that recovers a camera motion trajectory from monocular images in car driving.
 - Developed a simpler and more efficient way to calibrate inter-camera relations and estimate camera motions by modeling multiple cameras as a single spherical imaging system.

Research Staff

Aug 2003 ~ Jul 2004

Field Robotics Center, Carnegie Mellon University, Pittsburgh, Pennsylvania, USA

- Autonomous Unmanned Ground Vehicle (in conjunction with Yamaha Corporation)
 - Surveillance terrain vehicle targeted for autonomous patrolling of US-Mexico border territory. Generated feasible paths with a limited curvature using clothoid function.
 - Enabled vehicle to pursue subjects by processing 3D scanned laser data. Developed a laser-based ground obstacle detection using a goodness map.
- Mobile Manipulation at Assembly (in conjunction with Caterpillar Inc.)
 - Worked as a team to focus on a variant of conventional manipulability measure to enhance locomotion and manipulation.
 - Delivered solution to problem involving the manufacture of large structures using a mobile manipulator, in which base locomotion tends to be less precise than manipulator control.

Research Scientist

Feb 1997 ~ Aug 2003

Korea Institute of Science and Technology (KIST), Seoul, South Korea

Intelligent System Group

- Visitor Guidance Robot: Butler
 - Developed probabilistic approach to localization problem by using 16 ultrasonic and two laser sensors. Participated in design of a high-level controller that coordinates primitive robot behaviors such as navigating and guiding.

- Human-friendly Intelligent Home Service Robot: ISSAC (with Woori-Tech Co.): Implemented localization method based on two-pair infrared sensors and obstacle avoidance behaviors using ultrasonic sensors. This personal robot was developed for floor vacuuming and home security like video recording and invader detection.
- Underwater Manipulator for Semi-Autonomous Marine Vehicle (with Univ. of Hawaii): Analyzed the variation of dynamic characteristics under a high-pressure and oil-filled conditions. Designed a tele-operation controller under time delay when operated by a master haptic device in a mother-ship.
- Anthropomorphic Head-Eye System: Hector
Developed a 5-DOF active stereo head-eye system for the KIST humanoid robot CENTAUR. Tracked an object like a ping-pong ball with motion behaviors coordinated between eyes and the neck.

TEACHING
EXPERIENCE

Teaching Assistant Spring 2009
Robotics Institute, Carnegie Mellon University, Pittsburgh, Pennsylvania, USA

- 16-761 Introduction to Mobile Robotics (Graduate course)

Teaching Assistant Spring 1996
Department of Mechanical Engineering, Pohang University of Science and Technology (POSTECH), Pohang, South Korea

- MECH-320 Kinematics and Dynamics of Machine (Undergraduate class)

JOURNAL
PUBLICATIONS

Myung Hwangbo, Jun-Sik Kim, and Takeo Kanade, "IMU Self Calibration Using Factorization," *IEEE transactions on Robotics*, published online in Jan 2013

Myung Hwangbo, Jun-Sik Kim, and Takeo Kanade, "Gyro-Aided Feature Tracking for a Moving Camera: Fusion, Auto-Calibration and GPU Implementation," *International Journal of Robotics Research*, vol. 30, no. 14, pp. 1755–1774, Dec 2011

Jun-Sik Kim, **Myung Hwangbo**, and Takeo Kanade, "Spherical Approximation for Multiple Cameras in Motion Estimation: its Applicability and Advantages," *Computer Vision and Image Understanding*, vol. 114, no. 10, pp. 1068–1083, Oct 2010

CONFERENCE
PUBLICATIONS

Myung Hwangbo and Takeo Kanade, "Visual-inertial UAV Attitude Estimation Using Urban Scene Regularities," *IEEE Int'l Conf. on Robotics and Automation (ICRA)*, pp. 2451–2458, Shanghai China, May 2011.

Myung Hwangbo, Jun-Sik Kim, and Takeo Kanade, "Inertial-aided KLT Feature Tracking for a Moving Camera," *IEEE/RSJ Int'l Conf. on Intelligent Robots and Systems (IROS)*, pp. 1909–1916, St. Louis USA, Oct 2009.

Jun-Sik Kim, **Myung Hwangbo**, and Takeo Kanade, "Parallel Algorithms to a Parallel Hardware: Designing Vision Algorithms for a GPU," *5th IEEE Workshop on Embedded Computer Vision (in conjunction with ICCV)*, Kyoto Japan, Sept 2009.

Jun-Sik Kim, **Myung Hwangbo**, and Takeo Kanade, "Realtime Affine-photometric KLT Feature Tracker on GPU in CUDA Framework," *5th IEEE Workshop on Embedded Computer Vision (in conjunction with ICCV)*, Kyoto Japan, Sept 2009.

- Myung Hwangbo** and Takeo Kanade, “Factorization-based Calibration Method for MEMS Inertial Measurement Unit,” *IEEE Int’l Conf. on Robotics and Automation (ICRA)*, pp. 1306–1311, Pasadena USA, May 2008.
- Jun-Sik Kim, **Myung Hwangbo**, and Takeo Kanade. “Motion Estimation Using Multiple Non-overlapping Cameras for Small Unmanned Aerial Vehicles,” *IEEE Int’l Conf. on Robotics and Automation (ICRA)*, pp. 3076–3081, Pasadena USA, May 2008.
- Myung Hwangbo**, James Kuffner, and Takeo Kanade, “Efficient Two-phase 3D Motion Planning for Small Fixed-wing UAVs,” *IEEE Int’l Conf. on Robotics and Automation (ICRA)*, pp. 1035–1041, Rome Italy, Apr 2007.
- Stephan Roth, Bradley Hamner, Sanjiv Singh, and **Myung Hwangbo**, “Results in Combined Route Traversal and Collision Avoidance,” *Int’l Conf. on Field and Service Robotics (FSR)*, pp. 491–504, Port Douglas Australia, Apr 2005.
- Sung-On Lee, Nak-Ju Do, **Myung Hwangbo**, Bum-Jae You, Dong T. Nguyen, and Sang-Rok Oh, “Butler: A Visitor Guide Robot,” *Int’l Conference on Automation and Robotics in Construction*, Jeju Korea, Sept 2004.
- Dong Hun Shin, Bradley Hamner, Sanjiv Singh, and **Myung Hwangbo**, “Motion Planning for a Mobile Manipulator with Imprecise Locomotion,” *IEEE/RSJ Int’l Conf. on Intelligent Robots and Systems (IROS)*, Las Vegas USA, Oct 2003.
- Nguyen Xuan Dao, Bum-Jae You, Sang-Rok Oh, and **Myung Hwangbo**, “Visual Self-Localization for Indoor Mobile Robots using Natural Lines,” *IEEE/RSJ Int’l Conf. on Intelligent Robots and Systems (IROS)*, pp. 1252–1257, Las Vegas USA, Oct 2003.
- Bum-Jae You, **Myung Hwangbo**, Sung-On Lee, and Sang-Rok Oh, Young Do Kwon, and San Lim, “Development of a Home Service Robot ISSAC,” *IEEE/RSJ Int’l Conf. on Intelligent Robots and Systems (IROS)*, pp. 2630 -2635, Las Vegas USA, 2003.
- Myung Hwangbo**, Bum-Jae You, Sang-Rok Oh, “Image-based Redundant Control of an Active Stereo Head-Eye System with Vergence,” *Intl Conf. on Intelligent Autonomous System 6 (IAS-6)*, Venice Italy, 2000.
- Sung-On Lee, Young-Jo Cho, **Myung Hwangbo**, Bum-Jae You, and Sang-Rok Oh, “A Stable Target-Tracking Control for Unicycle Mobile Robots,” *IEEE/RSJ Int’l Conf. on Intelligent Robots and Systems (IROS)*, Takamatsu Japan, Nov 2000.
- Myung Hwangbo**, Bum-Jae You, Sang-Rok Oh, Keon Young Yi, Seok-Ho Kim, Sam-Yong Chung, Song-Soo Han, Ill-Hong Suh, and Wan-Kyun Chung, “Development of an Unmanned Autonomous Concrete Floor Robotic Troweling System,” *16th IAARC/IFAC/IEEE Intl Symp. on Automation and Robotics in Construction*, pp. 79–84, Madrid Spain, 1999.
- Myung Hwangbo**, Bum-Jae You, Chong-Won Lee, and Sang-Rok Oh, “Design and Redundant Motion Control of Active Stereo Head-Eye System with Vergence,” *7th IEEE Int’l Workshop on Robot and Human Communication (ROMAN)*, Takamatsu Japan, Sep 1998.

PATENTS

- Open architecture network-based electric motor controller (Korea Patent No. 317220)
- Unmanned trowelling robot system (Korea Patent No. 310616)
- Remote controller for an autonomous trowelling robot system (Korea Patent No. 338187)

HONORS & AWARDS	KIST Outstanding Research Award, Nov 2001 First prize at 3rd Korea Intelligent Robot Competition (IRC), Sep 2001 Second prize at 1st Korea Intelligent Robot Competition (IRC), Sep 1999 Third prize at 3rd Samsung Human-Tech Paper Competition, Dec 1995
TECHNICAL SKILLS	Programming: C, C++, Java, OpenGL, and Matlab Computer-aided design: AutoCAD and OrCAD Parallel programming: NVIDIA GPU in CUDA Embedded systems: hardware and software design and implementation (Texas Instruments DSPs and Atmel ATmega MCUs)
MATHEMATICAL & ENGINEERING EXPERTISE	Geometry-based computer vision, Stochastic state estimation theory, Dynamic optimization, Probability theory, Sampling-based motion planning
REFERENCES	Prof. Takeo Kanade, Academic Advisor, University Professor, Robotics Institute and Computer Science, Carnegie Mellon University, tk@cs.cmu.edu Prof. Sanjiv Singh, Thesis committee member, Research Professor, Robotics Institute, Carnegie Mellon University, ssingh@cmu.edu Dr. Omead Amidi, Thesis committee member, Senior Systems Scientist, Robotics Institute, Carnegie Mellon University, CEO at SkEyes Unlimited Corporation, amidi@cmu.edu Prof. Randy Beard, Thesis committee member, Professor, Electrical and Computer Engineering, Brigham Young University, beard@byu.edu Dr. Sang-Rok Oh, Principal Research Scientist, Human-Centered Interaction and Robotics Research Center, Korea Institute of Science and Technology (KIST), sroh@kist.re.kr