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Chen Feng

Computer Vision Group
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RESEARCH INTERESTS

Computer Vision, Robotics, Photogrammetry, Augmented Reality, Remote Sensing, Machine Learning and their applications in Civil Engineering.

EDUCATION

University of Michigan, Ann Arbor, Michigan, USA

2015/08 **Ph.D. in Civil Engineering** Advisor: Prof. Vineet R. Kamat
- Thesis: *Camera Marker Networks for Pose Estimation and Scene Understanding in Construction Automation and Robotics*
- G.P.A. 3.98/4.0

2013/12 **M.S.E. in Electrical Engineering: Systems**
- Major: Signal Processing; Minor: Robotics and Computer Vision
- G.P.A. 3.93/4.0

2012/04 **M.S.E. in Construction Engineering and Management** Advisor: Prof. Vineet R. Kamat
- Thesis: *Local Pose Tracking Leveraged by Global Geometric and Appearance Constraints in Location-Aware AEC Applications*
- G.P.A. 4.0/4.0

Wuhan University, Wuhan, Hubei, China

2010/06 **B.Eng. in Geodesy and Geomatics**
- Major: Photogrammetry and Remote Sensing
- Thesis: *Research on Single View Reconstruction* Advisor: Prof. Deng Fei
- G.P.A. overall 3.58/4.0, major 3.66/4.0

AWARDS AND HONORS

2016 **Nominee of ProQuest Distinguished Dissertation Awards** (54 out of 800 grad students)
- Rackham Graduate School, University of Michigan

2015 **Rackham Pre-doctoral Fellowship** (72 out of 240 candidates)
- Rackham Graduate School, University of Michigan

2014 **Best Paper Award**
- International Symposium on Automation and Robotics in Construction and Mining

2014 **Tishman Pre-doctoral Fellowship**
- Department of Civil and Environmental Engineering, University of Michigan

2014 **Student Travel Grant for IEEE ICRA, Hong Kong**
- National Science Foundation (NSF)

2014 **Rackham International Travel Grant for IEEE ICRA, Hong Kong**
- Rackham Graduate School, University of Michigan

2013 **Rackham International Student Fellowship**
- Rackham Graduate School, University of Michigan

2012 **PARTNERBOT Award for General Contribution to Robotics** (awarded to 10 out of nominated 150 robotics research groups from over the world)
- CLEARPATH Robotics

2012 **Rackham International Travel Grant for ISARC, Eindhoven**
- Rackham Graduate School, University of Michigan

2011 **Best Ph.D. Student Scholarship** (3 out of 120)
- International Computer Vision Summer School 2011: Registration, Recognition and Reconstruction in Images and Video

2010 **C.E. Bottum and R. Harris Fellowship**
- Department of Civil and Environmental Engineering, University of Michigan

2009 **National Academician Xia Jianbai Award for Innovative Student** (awarded to 10 out of several thousand eligible Geomatics students in China)
- School of Geodesy and Geomatics, Wuhan University

2008 **"Baidu Cup" ACM Central and North China Collegiate Programming Contest, 1st class award**
- Wuhan University

2008 **Chinese Undergraduate Math Contest of Modeling, 1st class award in Hubei Province**
- Wuhan University

2007–2009 **Outstanding Student Scholarship**
- Wuhan University

RESEARCH EXPERIENCE

Mitsubishi Electric Research Laboratories (MERL), Cambridge, MA, USA

Visiting Research Scientist Manager: Dr. Alan Sullivan, Dr. Jay Thornton

2015/07–Present **Visual Simultaneous Localization and Mapping (SLAM)**
- Autonomous driving and parking.
- Automatic 3D reconstruction and modeling.

Research Intern Supervisor: Dr. Yuichi Taguchi

2012/05–2012/08 **Kinect SLAM**
2013/05–2013/08
- SLAM and Bundle Adjustment using Kinect (resulted in a **patent**).

2014/07–2014/08
- Fast plane extraction from point cloud (**fastest method to date**, led to a **patent**).
- Helped initiate and establish UM-LIVE and MERL collaboration.

Department of Civil and Environmental Engineering, University of Michigan, Ann Arbor, MI, USA

Research Assistant Advisor: Prof. Vineet R. Kamat

2013/05–2015/06 **Marker-based Articulated Machine Pose Estimation**
- Designed and implemented a visual marker based pose estimation solution for articulated machinery. Analyzed and improved its robustness and accuracy.
- This work led to a **patent**, a **startup company** and is featured in an **ENR report**.

2013/01–2015/06 **Autonomous Construction Robotic Onsite Assembly**
- Designed vision-guided robotic assembly for unstructured environment. Explored various digital fabrication techniques for construction in collaboration with Prof. Wes McGee from Taubman College of Architecture.
- This work won a **Best Paper Award** at the 2014 ISARC.

2011/12–2012/12 **Mobile Augmented Reality for Indoor Navigation**
- Designed novel indoor navigation for AECFM (e.g. way-finding) on mobile devices.

2010/09─2012/02 **Natural Marker Based Augmented Reality Registration**
- Designed a novel tracking algorithm for robust real-time Augmented Reality which outperforms state-of-the-art registration methods (e.g., KLT/ESM/FERNs).

Department of Electrical Engineering and Computer Science, University of Michigan, Ann Arbor, MI, USA

Project Member Advisor: Prof. Honglak Lee

2011/02─2011/05 **Learn to Sketch Up From Google Maps**
- Machine learning course project. Developed a graphical model to jointly identify 2D building regions and reconstruct 3D structures given multiple street-view images.

Michigan Autonomous Aerial Vehicles Team, University of Michigan, Ann Arbor, MI, USA

Major Research Fellow Advisor: Prof. Silvio Savarese

2010/11─2011/05 **Real-time Door Plate Recognition**
- Investigated algorithms to recognize door plate containing Arabic characters in real-time (15 Hz), as a subtask for the International Aerial Robotics Competition.

School of Geodesy and Geomatics, Wuhan University, Wuhan, Hubei, China

Research Assistant Advisor: Prof. Deng Fei

2009/05─2010/08 **Single View Image-based Modeling**
- Integrated methods of photogrammetry, computer vision and graphics, to reconstruct a 3D model from a single image and prior knowledge of geometric constraints.

Research Assistant Advisor: Prof. Shen Wenbin

2008/09─2010/06 **Estimation of Orthometric Height based on GPS signals**
- Computer simulation and field experiment of using gravity frequency shift in GPS signals based on Relativity Effects to estimate the orthometric height. Developed patented software based on the proposed method.

Wuhan Planning & Design Institute, Wuhan, Hubei, China

Major Software Engineer Advisor: Prof. Deng Fei

2008/05─2008/11 **Digital Wuhan 3D GIS Platform**
- Designed the data storage framework and developed pre-process software to automatically create paged level-of-details 3D models from raw 3D models, enabling smooth walk-through of a Digital City with massive geometry and texture data.

GRANT EXPERIENCE

National Science Foundation (NSF)

2014─2017 Scalable and Autonomous Post-Event Subsurface Characterization from UAV-based Quantitative Surface Measurements: $389,845 Co-PI: Prof. Vineet R. Kamat
- Contributed several technical sections to the grant proposal.

2013─2015 PFI: AIR Technology Translation - Development and Evaluation of Field Prototype for Determining Excavator Proximity to Buried Utilities: $150,000 PI: Prof. Vineet R. Kamat
- Contributed several technical sections to the grant proposal.

2015 submitted Vision-Based Metrology Network for Large-Scale Robotic Manipulation in Civil Infrastructure Environments PI: Prof. Vineet R. Kamat
- Initiated and led the grant proposal and most of its writing.

Rackham Graduate Student Research Grant, University of Michigan

2013─2015 UAV-based Civil Infrastructure Data Collection and Inspection: $3,000
- Developed and led the grant proposal and its writing.

TEACHING EXPERIENCE

Department of Civil and Environmental Engineering, University of Michigan, Ann Arbor, MI, USA

Co-instructor Instructor: Prof. Vineet R. Kamat

2014 Winter **CEE 501: Automation and Robotics in Construction**
- Co-developed the course; taught applications of vision and robotics in construction.

2013 Fall **CEE 531: Construction Cost Engineering**
2013 Winter
- Taught topics such as learning curves and unit price proposal.

2012 Fall **CEE 539: Construction Management Information Systems**
2011 Fall
- Taught construction simulation in EZSTROBE, STROBOSCOPE, and VITASCOPE.

JOURNAL PUBLICATIONS

2015 **Feng, C.**, Xiao, Y., Willette, A., McGee, W., and Kamat, V. R. (2015). "Vision Guided Autonomous Robotic Assembly and As-Built Scanning on Unstructured Construction Sites." *Automation in Construction*, 59, 128-138 (**Invited Paper**).

2015 Rezazadeh, A. E, **Feng, C.**, and Kamat V. R. (2015). "Feasibility of In-Plane Articulation Monitoring of Excavator Arm Using Planar Marker Tracking." *Journal of Information Technology in Construction*, 20, 213-229.

2014 **Feng, C.**, Deng, F., and Kamat, V. R. (2014). "Rapid geometric modeling for visual simulation using semi-automated reconstruction from single image." *Engineering with Computers*, 30(1), 31-39. (First published online in 2012)

2014 Menassa, C., Kamat, V., Lee, S., Azar, E., **Feng, C.**, and Anderson, K. (2014). "Conceptual Framework to Optimize Building Energy Consumption by Coupling Distributed Energy Simulation and Occupancy Models." *Journal of Computing in Civil Engineering*, 28(1), 50-62.

2013 **Feng, C.**, and Kamat, V. R. (2013). "Plane Registration Leveraged by Global Constraints for Context-Aware AEC Applications." *Computer-Aided Civil and Infrastructure Engineering*, 28(5), 325-343. (First published online in 2012)

2013 Dong, S., **Feng, C.**, and Kamat, V. R. (2013). "Real-Time Occlusion Handling for Dynamic Augmented Reality Using Geometric Sensing and Graphical Shading." *Journal of Computing in Civil Engineering*, 27(6), 607-621.

2013 Dong, S., **Feng, C.**, and Kamat, V. R. (2013). "Sensitivity analysis of augmented reality-assisted building damage reconnaissance using virtual prototyping." *Automation in Construction*, 33(0), 24-36.

2013 Dong, S., Behzadan, A. H., **Feng, C.**, and Kamat, V. R. (2013). "Collaborative visualization of engineering processes using tabletop augmented reality." *Advances in Engineering Software, 55*(0), 45 - 55.

2009 Wan, J., Shen, W., Yang, Q., and **Feng, C.** (2009). "Experimental Investigations of the GeoPotential Difference between Two Stations Based on the GPS Signals." *Surveying and Mapping Science, Special Issue (in Chinese)*, 34, 23-25.

2008 Zou, J., and **Feng, C.** (2008). "Search Algorithms for Least Independent Close Loops." *Geospatial Information (in Chinese)*, 34, 6.

CONFERENCE PUBLICATIONS

2016 **Feng, C.,** Kamat, V.R., and Menassa, C.C. (2016). "Marker Assisted Structure from Motion for 3D Environment Modeling and Object Pose Estimation." Construction Research Congress, San Juan, Puerto Rico.

2015 **Feng, C.,** Dong, S., Lundeen, K. M., Xiao, Y., and Kamat, V. R. (2015). "Vision-Based Articulated Machine Pose Estimation for Excavation Monitoring and Guidance." *Proceedings of the 32nd International Symposium on Automation and Robotics in Construction and Mining,* Oulu, Finland.

2015 Xiao, Y., **Feng, C.**, Taguchi, Y., and Kamat, V. R. (2015). "User-Guided Dimensional Analysis of Indoor Scenes Using Depth Sensors." *Proceedings of the 32nd International Symposium on Automation and Robotics in Construction and Mining,* Oulu, Finland.

2015 Mantha, B., **Feng, C.**, Menassa, C., and Kamat, V.R. (2015). "Real-time Building Energy and Comfort Parameter Data Collection Using Mobile Indoor Robots." *Proceedings of the 32nd International Symposium on Automation and Robotics in Construction and Mining*, Oulu, Finland. 639-647.

2014 **Feng, C.**, Xiao, Y., Willette, A., McGee, W., and Kamat, V. R. (2014). "Towards Autonomous Robotic In-Situ Assembly on Unstructured Construction Sites Using Monocular Vision." *Proceedings of the 31th International Symposium on Automation and Robotics in Construction and Mining*, Sydney, Australia, 163-170. (**Best Paper Award**)

2014 **Feng, C.**, Taguchi, Y., and Kamat, V. R. (2014). "Fast Plane Extraction in Organized Point Clouds Using Agglomerative Hierarchical Clustering." *Proceedings of the IEEE International Conference on Robotics and Automation.*, Hong Kong, China, 6218-6225. (**48% acceptance rate of 2085 submissions**)

2013 Taguchi, Y., Jian, Y.-D., Ramalingam, S., and **Feng, C.** (2013). "Point-Plane SLAM for Hand-Held 3D Sensors." *Proceedings of IEEE International Conference on Robotics and Automation*, Karlsruhe, Germany, 5182-5189. (**40% acceptance rate**)

2013 **Feng, C.**, Fredricks, N., and Kamat, V. R. (2013). "Human-Robot Integration for Pose Estimation and Semi-Autonomous Navigation on Unstructured Construction Sites." *Proceedings of the 30th International Symposium on Automation and Robotics in Construction and Mining*, Montréal, Canada, 1317-1325.

2013 Kang, W., **Feng, C.**, and Chen, Y. (2013). "Mask strategy and layout decomposition for self-aligned quadruple patterning." *Proc. SPIE 8684, Design for Manufacturability through Design-Process Integration VII*, 86840E.

2012 Taguchi, Y., Jian, Y.-D., Ramalingam, S., and **Feng, C.** (2012). "SLAM Using both Points and Planes for Hand-Held 3d Sensors." *Proceedings of IEEE International Symposium on Mixed and Augmented Reality*, Georgia, USA, 321-322.

2012 **Feng, C.**, and Kamat, V. R. (2012). "A plane tracker for AEC-automation applications." *Proceedings of 2012 International Symposium on Robotics and Automation in Construction*, Eindhoven, NL, 83.

2012 **Feng, C.**, and Kamat, V. R. (2012). "Augmented Reality Markers as Spatial Indices for Indoor Mobile AECFM Applications." *Proceedings of the 2012 Conference on Construction Applications of Virtual Reality*, Taipei, Taiwan, 235-242.

2011 Dong, S., **Feng, C.**, Kamat, V. R. (2011). "Occlusion handling method for ubiquitous augmented reality using reality capture technology and GLSL." *Proceedings of the 2011 ASCE International Workshop on Computing in Civil Engineering*, Reston, VA, 494-503.

2010 **Feng, C.**, Deng, F., and Kamat, V. R. (2010). "Semi-Automatic 3d Reconstruction of Piecewise Planar Building Models from Single Image." *Proceedings of the 10th International Conference on Construction Applications of Virtual Reality*, Sendai, Japan, 309-317.

INVITED TALK

2016/04 Camera Marker Networks for Pose Estimation and Scene Understanding in Construction Automation and Robotics

- Texas A&M University

PATENTS

2012/06 U.S. Serial No. 13/539,060, "*Method for Registering Points and Planes of 3D Data in Multiple Coordinate Systems*", Patent 9,183,631 held by MERL, issued Nov 10, 2015.

2013/12 U.S. Serial No. 14/096,378, "*Method for Extracting Planes from 3D Point Cloud Sensor Data*," Patent application filed by MERL.

2015/06 U.S. Serial No. 14/568,870, "*Estimating Three-Dimensional Position and Orientation of Articulated Machine*," Patent application filed by University of Michigan.

OPEN SOURCE SOFTWARE

peac http://www.merl.com/research/license

- A C++ library with Matlab interface for extracting planar regions from organized point cloud in real-time
- The library received many download requests across the world from various academic/business domains

cv2cg http://github.com/simbaforrest/cv2cg

- A lightweight library with applications for computer vision, computer graphics and augmented reality interactions, including KEG tracker and AprilTag for robotics applications.
- The library was used and cited by the best paper of 2014 IEEE ICRA.

vpdetection http://github.com/simbaforrest/vpdetection

- A library to automatically detect vanishing points using jlinkage+lsd, by grouping line segments by their corresponding vanishing point.

TECHNICAL SKILLS

Programming: C, C++, Matlab, Java, Python, C#, VBA, JavaScript, VCS (Hg, Git, SVN)

Library: OpenCV, ROS, PCL, Ceres, LCM, OpenSceneGraph, OpenGL

Text Editing TeX (LaTeX, BibTeX), LyX, MS Office

OS: MS Windows family, Linux, Android

MENTORED GRADUATE STUDENTS

Master Students Civil Engineering: Yuhang Xu, Da Li, Yingqi Liu, Chao-Chung Yang

Robotics: Zhiyuan Zuo

PhD Student Lichao Xu

PROFESSIONAL SERVICES

2016 Computer Vision Workshop Organizer and Speaker

- International Symposium on Automation and Robotics in Construction and Mining

Reviewer

- Journal of Image and Vision Computing (IMAVIS)
- Journal of Automation in Construction (AUTCON)
- Journal of Computing in Civil Engineering
- Journal of Sensing and Imaging (SSTA)
- Journal of Electronic Imaging (JEI)
- IEEE Transactions on Human-Machine Systems (THMS)
- IEEE/ASME International Conference on Advanced Intelligent Mechatronics (AIM)
- International Conference on Computing in Civil and Building Engineering (ICCCBE)
- Journal of Computer Assisted Surgery

2015 Technical Committee Member

- International Conference on Construction Applications of Virtual Reality (CONVR)

Reviewer
- Journal of Robotics and Computer Integrated Manufacturing
- Journal of Computing in Civil Engineering
- IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)
- IEEE/ASME International Conference on Advanced Intelligent Mechatronics (AIM)

2014 Reviewer
- Advanced Engineering Informatics
- Visualization in Engineering
- IEEE International Conference on Robotics and Automation (ICRA)

2013 Reviewer
- IEEE International Conference on Automation Science and Engineering (CASE)
- IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)

2011 Technical Session Chair of Civil and Environmental Engineering
- the 6th Engineering Graduate Symposium, University of Michigan