Uland Y. Wong, PhD

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BIOGRAPHY

Dr. Uland Wong is a Senior Computer Scientist at NASA's Ames Research Center. He is a member of the Intelligent Systems Division, where his research pushes the limits of perception capability for robots in extreme environments and he advocates for a portfolio of early-stage technology. Dr. Wong has over fifteen years of experience leading robotics technology demonstrations. He developed the NASA Ames Lunar Lab to characterize sensors for rover missions targeting the Moon's poles. Prior to his current role, Wong worked at Ames through SGT, Inc. and ultimately served as the company's subject matter expert for computer vision. He was also a Senior Project Scientist at Carnegie Mellon's Robotics Institute where he directed the Sensor Characterization Lab.

Dr. Wong has served as principal investigator, co-investigator, or technical lead on sixteen sponsored projects. Within seven years of earning his PhD, he co-proposed and received $9.5 million ($5.5M managed) in competed research grants in addition to directed funding. Wong's projects have been supported by NASA, DOD, NSF, NIOSH, and other entities. His *Tyrobot*, *Mosaic*, *Ferret*, *Cavecrawler*, and *CaveR* robots have explored and operated in extreme spaces ranging from mines and caves to fractured planetary surfaces. His work has resulted in the release of several ground-breaking analog datasets to the robotics community.

Dr. Wong received his PhD degree in Robotics from CMU. In his thesis, he developed the idea of *Lumenhancement*, which explores how the interaction of light, materials, and sensor fusion can be leveraged to model planetary surfaces. He has won best paper awards at the Field and Service Robotics (FSR) and IEEE Aerospace Conferences.

EXPERIENCE

Senior Computer Scientist, *NASA Ames Research Center* **Sept 2019 – Current**
- Term appointment in the US Civil Service through NEX special authority
- Career Grade: AD-00

Senior Computer Scientist V, *SGT Inc./NASA Ames* June 2015 – Sept 2019
- Served as company SME for Computer Vision since Jan 2017
- Started at L4 and promoted to L5 (highest contributor) in May 2018

Senior Project Scientist, *Robotics Institute, CMU* May 2012 – Nov 2014
- Appointments: Senior Project Scientist (Dec 2013), Project Scientist (Sept 2012), Postdoctoral Fellow (May 2012)

Graduate Research Assistant, *Robotics Institute, CMU* Aug 2006 – April 2012

Student Programmer, *Field Robotics Center, CMU* June 2004 – Dec 2005

EDUCATION

PhD in Robotics, Carnegie Mellon University (2012)
- Dissertation titled "Lumenhancement: Exploiting Appearance for Planetary Modeling"

- Committee: William “Red” Whittaker (Chair), David Wettergreen, Srinivasa Narasimhan, Larry Matthies (NASA JPL)

MS in Robotics**,** CMU (2009)
- Earned during the course of PhD

MS in Electrical and Computer Engineering**,** CMU (2006)
- Simultaneously earned with Bachelor of Science

BS in Electrical and Computer Engineering**,** CMU (2006)
- University Honors (GPA)
- CIT Research Honors (Thesis)
- GPA: 3.94/4.0

PROJECT LEADERSHIP

Versatile 3D Microscopy in 100 grams!
Role: PI | Sponsor: NASA CIF | Dates: 2020-2021

Skylight Mission Concept - Technologies Enabling the Exploration of Lunar Pits
Role: co-I | Sponsor: NASA NIAC Ph.3 | Dates: 2019-2021

PHALANX: Projectile Hordes for Advanced Long-term & Networked Exploration
Role: co-PI | Sponsor: NASA IRAD | Dates: 2018-2019

ICICLES: Intelligence for Choosing Icy Landing and Exploration Sites
Role: PI | Sponsor: NASA SMD | Dates: 2017-2019

BRAILLE: Biologic and Resource Analog Investigations in Low Light Environments
Role: co-I, Robotics Lead | Sponsor: NASA SMD | Dates: 2017-2020

SPEARS: Smart Projectiles for Environmental Assessment, Recon and Sensing
Role: PI | Sponsor: NASA CIF | Dates: 2016-2017

Robotic Scouts: Augmenting Perception for Underground Rescue
Role: co-I | Sponsor: NSF NRI | Dates: 2013-2016

[Selected projects only - see website for complete list]

RESEARCH THEMES

Extreme Perception
My research seeks to improve the performance of computer vision in extreme environments by understanding and exploiting the physics of light transport. It is well-known that use of active illumination in the form of “structured light” can greatly enhance image understanding; however, accurately modeled natural illumination can also be leveraged in the same manner. My dissertation explored such use of targeted vision and illumination for perception and I have continued this approach in my professional career.

- Developed robotic systems to operate in the extremes of permanent darkness, confined sensing horizon, high dynamic range, specularities, retroreflection, and particulates.
- Conceived novel approaches to map unexplored planetary features like giant sinkholes (i.e. *skylights*) and the poles of airless bodies with active and dynamic natural illumination strategies.
- Served as Navigation Sensor Lead for NASA’s VIPER Rover Mission: the first robot to visit a permanently shadowed environment and use active flash stereo imaging. (2019-current)

- Developed photorealistic simulation for extraterrestrial worlds using physics-based modeling of photometry, material BRDFs, and surface geometry. Led imaging fidelity thrust for both NASA's Lunar RoverSim and OceanWATERS (icy moon) simulators built for ROS. (2015-current)

Sensor Characterization

Many types of range and imaging sensors exist on the market. Manufacturer specifications are often non-comparable, collected in ideal settings, and ill-suited for robotics application. My work has resulted in standardized methodologies and reference datasets to provide a basis for empirical comparison of optical sensors. These tools are used to facilitate trades when designing perception systems.

- Developed the "Lunar Lab" with the SSERVI institute at NASA Ames. Championed cross-modal characterization of rover navigation sensors for Lunar and airless body missions. Customers included the Resource Prospector Mission and the VIPER Mission. (2015-current)
- Created and led the Sensor Characterization Lab at CMU which focused on the sensor selection problem for subterranean robots. Started the lab as a graduate student, supported by the DOD and NIOSH. (2010-2014)
- Released datasets to public: *CMU Pits and Caves Analog Dataset* (2014); *NASA Polar Optical Lunar Analog Reconstruction (POLAR) Stereo Dataset* (2017); *NASA Features Relevant to Ocean-worlds Surface Terrain (FROST) Dataset* (2020)

Novel Optical Systems

I develop novel sensors for robotic mapping and imaging using a computational optics approach. The key idea is to explore synergies resulting from tight integration of optics, vision algorithms, and embedded computing in field application. My innovations include:

- Miniature light field microscopes for mapping grains of regolith using gonioreflectometry and spatial light modulation. Can be utilized on the smallest planetary rovers. (2018-current)
- Expendable projectile sensors for scouting, mapping, and *in situ* science monitoring in hazardous terrain. Projectiles are fired from a rover cannon using a cold gas launch system. (2014-current)
- A scene-intelligent 3D scanner that optically co-located a DLP structured light system with a stereo camera pair to enable efficient high-resolution reconstruction of salient regions. (2011)
- A room-sized gonioreflectometer that enabled BRDF recovery for bulk terrain features as opposed to small samples. Design could be put together with commodity parts at $1/100^{th}$ the cost of traditional spherical gantries. (2011)
- The first borehole-based LIDAR scanners and panoramic imagers used by commercial entities in civic infrastructure and resource extraction. (2006-2009)

Multi-sensor Fusion for Navigation and Mapping

Robot navigation state-of-art is limited by decades-old range sensing technology. Only multi-sensor (LIDAR, RADAR, vision and multispectral) approaches can provide the performance necessary to tackle tomorrow's field environments. My research explores multi-modal optical sensing for super-resolution, saliency-driven reconstruction, and robust navigation.

- Developed thermal-visual-inertial navigation for landing on icy surfaces. Applications range from Europa landing to terrestrial glacier and over-water operations. (2018)
- Investigated fusion of color imaging and phase-shift depth cameras for tomography of atmospheric plumes. Application was to "see" through smoke and dust in underground rescue. (2014)
- Demonstrated fusion of LIDAR and image-based Shape-from-Shading for dense

3D reconstruction in mines and caves. (2009)

SELECTED PUBLICATIONS

G. Pettersson, M. Dille, S. Abrahamsson, U. Wong. *Miniature 3D Microscope and Reflectometer for Space Exploration*. IEEE International Conference on Computational Photography (ICCP), 2019.

M. Allan, U. Wong, T. Welsh, P.M. Furlong, et al. *Planetary Rover Simulation for Lunar Exploration Missions*. IEEE Aerospace Conference, 2019. **[Best Paper in Track Award]**

A. Arora, P. M. Furlong, U. Wong, T. Fong. *Sampling-based Descent Trajectory Planning and Autonomous Landing Site Selection for Icy Moon Lander Missions*. International Symposium on Artificial Intelligence, Robotics and Automation in Space (i-SAIRAS), 2018.

A. Nefian, U. Wong, M. Dille, X. Bouyssounouse, et al. *Structured Light-Based Hazard Detection for Planetary Surface Navigation*. IEEE/RSJ Conference on Intelligent Robotics and Systems (IROS), 2017.

P.M. Furlong, M. Dille, U. Wong, A. Nefian. *Safeguarding a Lunar Rover with Wald's Sequential Probability Ratio Test*. IEEE International Conference on Robotics and Automation (ICRA), 2016.

U. Wong and W.L. Whittaker. *Robotic Exploration and Science in Pits and Caves: Results from Three Years and Counting of Analog Field Experimentation*. 2nd International Planetary Caves Conference, 2015.

C. Cunningham, U. Wong, K. Peterson, W.L. Whittaker. *Predicting Terrain Traversability from Thermal Diffusivity*. International Conference on Field and Service Robotics (FSR), 2013.

U. Wong. *Lumenhancement: Exploiting Appearance for Planetary Modeling.* PhD Dissertation. Robotics Institute, Carnegie Mellon University, 2012.

U. Wong, B. Garney, C. Whittaker, W. Whittaker. *Image-Directed Sampling for Geometric Modeling of Lunar Terrain.* International Conference on Field and Service Robotics (FSR), 2012.

H.L. Jones, U. Wong, K. Peterson, J. Koenig, et al. *Complementary Flyover and Rover Sensing for Superior Modeling of Planetary Features.* International Conference on Field and Service Robotics (FSR), 2012.

U. Wong, A. Morris, C. Lea, J. Lee, C. Whittaker, B. Garney, W. Whittaker. *Comparative Evaluation of Range Sensing Technologies for Underground Void Modeling.* IEEE/RSJ Conference on Intelligent Robotics and Systems (IROS), 2011.

U. Wong, B. Garney, C. Whittaker, W. Whittaker. *Camera and LIDAR Fusion for Mapping of Actively Illuminated Subterranean Voids*. International Conference on Field and Service Robotics (FSR), 2009. **[Best Student Paper Award]**

A. Morris, U. Wong, Z. Omohundro, C. Whittaker, W. Whittaker. *3D Modeling of Subterranean Environments by Robotic Survey.* CMU Technical Report, 2007.

[See website for complete bibliography]

HONORS AND AWARDS

NASA Ames Research Center

- NASA Group Achievement, Lunar Rover Navigation (2019)
- Division Achievement, Resource Prospector Localization Team (2018)

SGT Inc. at NASA Ames

- Named as Subject Matter Expert for Computer Vision, 3D Sensing, and Sensor Characterization (2016)
- Significant Contributions to Rover Software Development (2017)
- Excellent Performance on Rover Software for RP Mission (2016)

Carnegie Mellon University

- NSF Travel Award (IROS 2011)
- Judge's Choice award for Human Odometer at Lockheed Martin/Eta Kappa Nu project competition (2006)
- Edward J. Sargent scholarship for Electrical Engineering (2004-2005)
- Member of Tau Beta Pi honors society (2004-2006)
- Member of Eta Kappa Nu honors society (2003-2006)
- Member of National Society of Collegiate Scholars (2002-2005)
- Dean's List Honors Fall 2002 – Fall 2003, Fall 2004 – May 2006

PROFESSIONAL SERVICE

Review Panelist, NASA Space Technology Mission Directorate

Fellowship Research Coordinator and Mentor for NASA NSTRF, VIP, and I2 programs, 15+ students

Chair, CMU Field Robotics Seminar Series (2012-2014)

Thesis Committee: James Lee (CMU MS, 2013), Eugene Fang (CMU PhD, 2020)

Robotics Institute Graduate Admissions Committee

Robotics Institute Summer Research Experience for Undergrads (RISS)
Mentor (2009-2013), 12+ students

Reviewer for IEEE ICRA, IEEE IROS, FSR, Journal of Field Robotics

TEACHING EXPERIENCE

Robotics 865, *Advanced Mobile Robot Design* Spring08, S09, S13

- Graduate course to engineer robot prototype for the Google Lunar X-prize
- Taught lectures, designed curriculum, and managed student activities
- Ran large public demonstrations of robot and lunar technology (2009)

CS 212, *Principles of Programming Languages* Fall05, F06

- Foundations class in language design, functional programming and semantics
- Taught recitations, led review sessions and developed assignments
- Responsible for the development of an interpreter for Standard ML and a compiler for music notation as class projects

REFERENCES

[Contact information for references available upon request]