Roberto O. Shu

5000 Forbes Ave.
EDSH 119
Carnegie Mellon University
Pittsburgh, Pa 15213

(734) 355-8757
rshum@cmu.edu
www.robertoshu.com
https://www.linkedin.com/in/robertoshu/

Research Interests

I am interested in real-time whole-body optimal control for dynamic mobile manipulation around humans. I work on the CMU ballbot research platform, a single spherical wheel dynamically balancing mobile robot.

Education

2016- **The Robotics Institute, Carnegie Mellon University**, Ph.D. Robotics
Advisor: Dr. Ralph L. Hollis

2014-2016 **The Robotics Institute, Carnegie Mellon University**, M.S. Robotics
Thesis: Design and Analysis of a Biped Leg to Survive High-Impact Falls
Advisor: Dr. Koushil Sreenath

2010-2014 **The University of Michigan, Ann Arbor**
B.S. Mechanical Engineering: *Minor:* Multidisciplinary Design
B.S. Aerospace Engineering: *Minor:* Mathematics

Research Experience

Sep 2016 - Present **Microdynamic Systems Laboratory, Carnegie Mellon University**
Advisor: *Research Professor Ralph Hollis*

- Research focuses on nonlinear optimal control for dynamically balancing mobile manipulators, currently working on the CMU ballbot
- Designed and built a pair of lightweight compliant 7DoF anthropomorphic manipulator arms capable of lifting 20 kg for the ballbot, including the full software stack to control the arms
- Devised whole-body controllers to dynamically balance the ballbot while performing manipulations tasks
- Developed 2D, 2.5D and 3D dynamic simulations of the CMU ballbot with 7DoF arms in Matlab and V-REP for cross validation

Nov 2014 - May 2016 **Hybrid Dynamic Robotics Lab, Carnegie Mellon University**
Advisor: *Asst. Professor Koushil Sreenath*

- Designed human size robotic leg with active damping via M.R. damper and non liner compliance to withstand the high impact force of landing >3 m jumps
- Simulated leg design in SimMechanics, and implemented a quadratic program solver to find optimum control parameters, damping and joint profiles
- Created a native Simulink client to communicate with the Nano Quadcopter Crazyflie and implemented a position control

May 2013 - May 2014 **Biological Inspired Robotics And Dynamical Systems, University of Michigan**
Advisor: *Asst. Professor Shai Revzen*

- Designed, build, and controlled new generation of self-assembling modular robotics with expandable polyurethane foam *FoamBots*
- Redesigned an autonomous foam reagents mixing device and peristaltic pump manufactured only with a laser cutter and assembles without screws or permanent joints

Jan 2014 - May 2016 **Air Force Research Laboratory Aerospace Propulsion, Outreach Program (APOP)**
Advisor: *Dr. Timothy Smith*

- Designed and build a Turboprop add-on to harness the exhaust gas of an RC Jet engine to generate 500W of electrical power with minimum thrust lost

Teaching Experience

Spring 2019 **Humanoids, CMU Robotics Institute**
Instructor: Dr. Chris Atkeson

Fall 2018 **Kinematics, Dynamic Systems and Control, CMU Robotics Institute**
Instructor: Dr. Hartmut Geyer

Publications

1. **R. Shu** and R. L. Hollis, "Development of a Humanoid Dual Arm System for a Single Spherical Wheeled Balancing Mobile Robot," *2019 IEEE-RAS 19th International Conference on Humanoid Robotics (Humanoids)*, Montreal, QC, Canada, 2019.
2. F. Sonnleitner, **R. Shu** and R. L. Hollis, "The Mechanics and Control of Leaning to Lift Heavy Objects with a Dynamically Stable Mobile Robot," *2019 International Conference on Robotics and Automation (ICRA)*, Montreal, QC, Canada, 2019, pp. 9264-9270.
3. **Shu, R.**, Siravuru, A., Rai, A., Dear, T., Sreenath, K., Choset, H.."Optimal control for geometric motion planning of a robot diver." In *Intelligent Robots and Systems (IROS), 2016 IEEE/RSJ International Conference* on (pp. 4780-4785). (2016)
4. **Shu, R.**, A. Siravuru, and K. Sreenath. "On the utility of active damping leg for safe landing from a free fall." *Dynamic Walking Conference* (2015).
5. Li, X., Geraldo, D., Weng, S., Alve, N., Dun, W., Kini, A., Patel, K., **Shu, R.**, Zhang, F., Li, G., Jin, Q., Fu, J.. "Desktop aligner for fabrication of multilayer microfluidic devices." *Review of Scientific Instruments* 86.7 (2015): 075008.

Presentations and Demos

1. **Shu, R.**. "Building a Robotic Leg for High Impact Landing"
Bipedal Locomotion Seminar - Carnegie Mellon Univeristy. (February 2016)
2. Hollis, R., **Shu, R.**. "Ballbot: A single-wheeled balancing robot"
Carnegie Colloquium on Digital Governance and Security - Carnegie Endowment for International Peace (October 2016)

Relevant Coursework

16-720 Computer Vision
15-780 Graduate Artificial Intelligence
16-843 Manipulation Algorithm
16-742 Geometry of Locomotion
16-745 Dynamic Optimization
18-776 Non Linear Control
16-868 Biomechanics & Motor Control
16-711 Kinematics, Dynamic Systems and Control

Awards and Honors

Uber Presidential Fellowship at Carnegie Mellon University ($42,500)	Sep 2017
Graduate Student Assembly/Provost Conference Funds ($1,000)	Jul 2015
University of Excellence Scholarship for graduate studies ($200,000) - SENESCYT	Jul 2014
North Campus Dean's Rev. Dr. Martin Luther King Jr. Spirit Award	Feb 2014

SHPE - National Chapter of the Year	Oct 2013
SHPE - Region 6 Chapter of the Year	Oct 2013
SHPE - Blue Chip Award	Apr 2013
Stellar Multicultural Performance Award	Jan 2013
Undergraduate Achievement Award	Jan 2012, 2013, 2014
University of Excellence Scholarship for undergraduate studies ($130,000)	Sep 2012
1st place Case Study – National Institute for Leadership Advancement	Aug 2012
New student Achievement Award w/ Distinction	Jan 2011

Other Projects & Activities

High Altitude Balloons, *Proyecto Estratos Ecuador* – 1st ever Ecuadorian flag in space
Formula SAE Hybrid, *Michigan Hybrid Racing*, Aerodynamics Team Lead 2013-2014
President, Society of Hispanic Professional Engineers University of Michigan Chapter (2012-2013)
Member, IEEE Robotics and Automation Society
Member, The Epians – Engineering Leadership Honor Society
Member, University of Michigan Alumni Association
Single-engine private pilot license [in progress]

Skills

Software & OS:
PTC Creo/Pro E, SolidWorks & SW Simulation, Gazebo, V-REP, SNOPT, CVXGEN, CasADi
ROS, QNX, Linux (Ubuntu)
Programming Languages:
MATLAB/Simulink/SimMechanics, Python, C/C++, Bash, SNOPT, CVXGEN
Robots & Hardware:
Ballbot, Bi-manual 7DOF arms, CrazyFlie Quad-rotor, Intel RealSense, IMUs (VectorNav)
Manufacturing:
Mill, Lathe, CNC Router, CNC Mill, Composite material layup, 3D printer, Laser cutter
Other:
Experience writing successful research grants, Doxygen, Version Control/Git, LaTeX

Languages

Spanish (native speaker) • English (bilingual proficiency)