# Roberto Shu
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| EDUCATION | **Carnegie Mellon University**, Pittsburgh, PA |

Ph.D., Robotics – *Advisor: Dr. Ralph Hollis*                    (expected) December 2021
*Thesis:* Development of an Agile and Dexterous Balancing Mobile Manipulator

M.S., Robotics – *Advisor: Dr. Koushil Sreenath*                    May 2016
*Thesis:* Design and Analysis of a Biped Leg to Survive High-Impact Falls

**University of Michigan**, Ann Arbor, MI                    May 2014
B.S., Mechanical Engineering        *Minor:* Multidisciplinary Design
B.S., Aerospace Engineering        *Minor:* Mathematics

**INDUSTRY EXPERIENCE**

**Amazon.com, Robotics & AI group**                    May 2020 – Aug. 2020
*Applied Scientist Intern*
- Developed and implemented a novel variable compliant controller in C++ for a torque controllable robot manipulator to further Amazon's warehouse automation efforts
- Validated the new controller over the existing controllers implemented with experiments on the robot hardware, code was merged into the production branch of the organization's code base
- Implemented and deployed a task space admittance controller based on a joint torque observer to estimate Force/Torque acting at the end-effector

**RESEARCH EXPERIENCE**

**Microdynamic Systems Laboratory,** *Carnegie Mellon University*                    Sep. 2016 – Present
Advisor: *Dr. Ralph Hollis*
- Researching whole-body planning and control for dynamically balancing mobile robots, currently working on the CMU ballbot humanoid, a 200 lb human size robot that balances on a single ball and has a pair of 7-DOF arms and multi-DOF hands
- Devised a centroidal based optimal whole-body planning and control framework to perform simultaneous locomotion and manipulation tasks, trajectory optimization generates whole-body motion plans offline and are tracked online with a whole-body MPC on the real robot
- Designed and built a pair of lightweight compliant 7-DOF anthropomorphic arms capable of lifting 20 kg for the ballbot, including the full software stack to control the arms. Actuation with BLDC + Harmonic Drive
- Performed system identification and developed 2D, 2.5D and 3D dynamic simulations of the CMU ballbot with 7-DOF arms in Matlab,V-REP and PyBullet for cross validation
- Contributed to the writing of a successful USD 1.5 million NSF research grant

**Hybrid Dynamic Robotics Lab,** *Carnegie Mellon University*                    Aug. 2016 – May 2018
Advisor: *Dr. Koushil Sreenath*
- Designed human size robotic leg with active damping via M.R. damper and non-linear spring element to withstand the high impact force of landing high jumps ($> 3$ m), performed FEA analysis and created custom BLDC + Harmonic Drive + Belts actuation unit
- Simulated leg design in SimMechanics and implemented and used CMAE-ES to solve for the optimum control gains, damping, and joint profiles for save landing
- Created a real-time simulink communication interface and LQR position control for Nano Quadcopter Crazyflie

**Biological Inspired Robotics And Dynamical Systems,** *U of M*                    May 2013 - May 2014
Advisor: *Dr. Shai Revzen*
- Designed, built, and tested new generation of self-assembling modular robotics with expandable polyurethane foam named FoamBots and implemented controllers in python
- Redesigned autonomous foam reagents mixing device and peristaltic pump manufactured only with a laser cutter that assembles without screws or permanent joints

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| TEACHING EXPERIENCE | **16-264 Humanoids, CMU Robotics Institute** | Spring 2019 |

**TEACHING EXPERIENCE**

**16-264 Humanoids, CMU Robotics Institute**                                    Spring 2019
Instructor: Dr. Chris Atkeson

**16-711 Kinematics, Dynamic Systems and Control, CMU Robotics Institute**  Fall 2018
Instructor: *Dr. Hartmut Geyer*

**SKILLS**

**Software & OS:**
PTC Creo/Pro E, SolidWorks, Gazebo, PyBullet, Pinocchio, CasADi, OSQP, IPOPT, QuadProg
ROS, QNX, Linux(Ubuntu)
**Programming:**
C/C++, MATLAB/Simulink/SimMechanics, Python
**Robots & Hardware**
Ballbot, Bi-manual 7DOF arms, Kinova Gen3, CrazyFile Quad-rotor,
Intel RealSense, IMUs (VectorNav), Hokuyo LIDAR, BLDC, Harmonic Drive
**Manufacturing:**
Mill, Lathe, CNC Router, CNC Mill, Rapid Prototyping (3D printing, Laser cutter)

**PUBLICATIONS**

1. **R. Shu**, and R. L. Hollis. "Momentum based Whole-Body Optimal Planning for a Single-Spherical-Wheeled Balancing Mobile Manipulator." *2021 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, IEEE, 2021 (to appear).

2. **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)*, IEEE, 2019.

3. 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)*, IEEE, 2019, (pp. 9264-9270).

4. **Shu, R.**, Siravuru, A., Rai, A., Dear, T., Sreenath, K., Choset, H.. "Optimal control for geometric motion planning of a robot diver." In *2016 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)* IEEE, 2016, (pp. 4780-4785).

5. **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).

6. 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**

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)

**AWARDS AND HONORS**

**Scholarships:**
Uber Presidential Fellowship Carnegie Mellon University (USD 42,500)
University of Excellence Scholarship for graduate studies (USD 150,000)
University of Excellence Scholarship for undergraduate studies (USD 130,000)
**Awards:**
2014 Dean's Rev. Dr. Martin Luther King Jr. Spirit Award
2013 Stellar Multicultural Performance Award
Society of Hispanic Professional Engineers (while U of M chapter president)
 2013 National Chapter of the Year
 2013 Region 6 Chapter of the Year
 2013 Blue Chip Award
2012, 2013, 2014 Undergraduate Achievement Award
2013 1st place Case Study - National Institute for Leadership Advancement