Patrick D. Holmes

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EDUCATION

University of Michigan	Ann Arbor, MI
PhD, MS in Mechanical Engineering; GPA: 3.74/4.00	Aug. 2015 - Aug. 2021
Focus: *Robotics, Control, Human Biomechanics*	
University of California, Berkeley	Berkeley, CA
BS in Mechanical Engineering, *High Honors;* GPA: 3.92/4.00	Aug. 2011 - May 2015

EXPERIENCE

Ford Center for Autonomous Vehicles at the University of Michigan	Ann Arbor, MI
Engineer in Research Senior	Oct. 2021 - Present
Focus: *Safe trajectory planning and control of autonomous robots, studying human trip recovery.*	
University of Michigan	Ann Arbor, MI
Graduate Student Research Assistant	Aug. 2015 - Aug. 2021
Focus: *Safe trajectory planning and control of autonomous robots, characterizing human stability during motion using control theoretic techniques, novel tools and applications for reachability analysis, human pose estimation for rehabilitation.*	

SKILLS SUMMARY

- **Programming/Software**: MATLAB, C++, Python, Git, LaTeX, SolidWorks, Simulink, LabVIEW, Microsoft Office
- **Technical**: Robot Kinematics and Dynamics, Linear/Nonlinear Systems and Control, Hybrid Systems, Motion Planning, Human Biomechanics, Reachability Analysis, Optimization, Machine Learning, Computer Vision, Real/Functional Analysis
- **Soft Skills**: Project leadership and management, technical writing and presenting, figure and video creation, paper reviewing

SELECTED PROJECTS

- **Guaranteed-Safe Trajectory Planning and Control for Robotic Manipulators with Model Uncertainty**:
  - Developed a robust trajectory-tracking controller for a robotic arm with bounded error despite model uncertainty.
  - Augmented the Recursive Newton-Euler Algorithm to operate over sets of desired trajectories plus tracking error.
  - Created novel receding-horizon reachability-based trajectory planner that satisfies collision-avoidance and torque limit constraints in the presence of static and dynamic obstacles, model uncertainty and tracking error.
  - Leveraged parallelization on a GPU to perform real-time nonlinear optimization over sets of safe trajectories.
  - Demonstrated in simulation and on hardware in real time with Fetch 7 DOF arm.
  - Extending method to the Digit walking robot, and to a robotic prosthetic leg to achieve real-time trip-recovery.
- **Characterizing Fall Risk during Sit-to-Stand using Reachable Sets**:
  - Designed and conducted an 11-subject Sit-to-Stand experiment with motor-driven cable pull perturbations.
  - Constructed individualized biomechanical models and trajectories from motion capture data.
  - Developed novel control models and reachability techniques for computing sets of safe Sit-to-Stand trajectories.
  - Experimentally demonstrated that the method predicted failure during Sit-to-Stand with over 90% accuracy.
- **Certifiably-optimal 3D Human Pose Estimation via Sums-of-Squares Programming**:
  - Developed sparse sums-of-squares optimization program for reconstructing 3D human pose from multi-view 2D estimates.
  - Demonstrated state-of-the-art accuracy and computational efficiency on Human3.6m dataset.
  - Certified global optimality of solutions obtained via semidefinite programming.

SELECTED PUBLICATIONS

- **Holmes**, et al. "Reachable sets for safe, real-time manipulator trajectory design", Robotics: Science and Systems (RSS), 2020. (Conference)
- **Holmes**, et al. "Characterizing the limits of human stability during motion: perturbative experiment validates a model-based approach for the Sit-to-Stand task", Royal Society Open Science, 2020. (Journal)
- Kousik, **Holmes**, Vasudevan, "Safe, Aggressive Quadrotor Flight via Reachability-based Trajectory Design", ASME Dynamic Systems and Control Conference (DSCC), 2019. **Best Student Paper Award** (Conference)
- Shia, Moore, **Holmes**, et al. "Stability basin estimates fall risk from observed kinematics, demonstrated on the Sit-to-Stand task", Journal of Biomechanics, 2018. (Journal)
- **Holmes**, et al. "Convex estimation of the α-confidence reachable set for systems with parametric uncertainty", IEEE Conference on Decision and Control (CDC), 2016. (Conference)

HONORS, AWARDS, AND LEADERSHIP

- RSS Pioneers Participant (July 2020) and Organizer (July 2021)
- Drake Scholar (one of six ME students, full academic scholarship to attend UC Berkeley) - Aug. 2011 to May 2015
- Reviewer - TRO, TCST, RA-L, IROS
- Designed LEGO robot lesson plan for public school teachers (U-M REACT workshop (2019, 2020)).
- Developed and led an introductory C++ summer course for my lab (2020, github.com/pdholmes/CppPrimerPrimer).