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Shubham Singh

A roboticist skilled in Dynamic Locomotion, Optimization, Estimation, Sensor Fusion, Model Predictive Controls, Dynamics, & Kinematics.

Education

2023 **PhD in Aerospace Engineering**, **The University of Texas at Austin**, TX

2016 **MS in Aerospace Engineering**, **Purdue University**, IN

2014 **B.Tech in Mechanical Engineering**, **Delhi Technological University**, India

Work Experience

Aug'24 – **Software Engineer- Legged Controls**, *Apptronik, TX*
- Skills used- Model Predictive Control, C/C++, Python, Git

Aug'23 – Aug'24 **Gait Control Engineer**, *Shift Robotics, TX*
- Design of Gait Control Software (Shift OS) for Moonwalkers
- Improved Gait sensing by improving Intuitiveness by 70%. (Release Notes)
- Added features- Training/Calibration Mode to Moonwalkers
- Skills used- Classical Control, Hardware Tuning/Troubleshooting, Estimation, Biomechanics, Sensor Fusion, Human-Robot Interaction C/C++, Python, Git

May'22 – Aug'22 **Robotics Intern**, *Flexiv Robotics, CA*
- Benchmarked a novel contact-aware MPC force controller on a 7-DoF manipulator
- Simulation using PyBullet, GramPC, Pinocchio, and communication using the LCM tool.
- Skills used- Trajectory Optimization, Model Predictive Control, C++, Python

June'20– July'20 **Data Scientist**, *AI Research Lab, Dell Technologies, Austin*
- Worked towards automation of Data-Driven Data Centers
- Skills used- Reinforcement Learning, Deep Learning, Tensorflow, DockerHUB

Research Experience

Aug'18 – Aug'23 **Graduate Research Assistant**, *The University of Texas at Austin*
- Theoretical and algorithmic contribution to the dynamic modeling of robots using Featherstone's Spatial-Vector Algebra
- Developed for the first time, the analytical expressions for first/second-order derivatives of Inverse/Forward dynamics for modeling robotic motion, new algorithms provide upto 5x speed-up over state-of-the-art Automatic Differentiation approach
- Worked on developing model-based control algorithms for legged robots. Contributed novel algorithms to open-source C++ library Pinocchio
- Motion-planning for the Mini Cheetah using the simplified quadruped model (Video)
- Skills used- Trajectory Optimization (CasADi), Spatial Vector Algebra, C++, Fortran

June'15 – Dec'17 **Graduate Research Assistant**, *Rapid Design of Systems Lab, Purdue University*
- Implementing indirect trajectory optimization methods for Hypersonic mission design
- Skills used- Trajectory Optimization, Control Theory, MATLAB

June'13 – Aug'13 **Summer Research Intern**, *Turbulence Research Lab, University of Toronto*
- Skills used- LABview, Hardware/software integration

Publications

1. **Singh, S.**, Russell, R. P., & Wensing, P. M., *Analytical Second-Order Derivatives of Rigid Contact Dynamics: Application to Multi-Shooting DDP*, 2023 IEEE-RAS Humanoids, Austin, TX. Paper
2. **Singh, S.**, Russell, R. P., & Wensing, P. M., *On Second-Order Derivatives of Rigid-Body Dynamics: Theory & Implementation*, IEEE Transactions on Robotics, vol. 40, pp. 2233-2253, 2024. Paper
3. **Singh, S.**, Russell, R. P., & Wensing, P. M., *Analytical Second-Order Partial Derivatives of Rigid-Body Inverse Dynamics*, 2022 IEEE/RSJ IROS, pp. 11781-11788, Kyoto. Paper, Code **Finalist for IEEE Model-Based TC Award 2023.**
4. **Singh, S.**, Russell, R. P., & Wensing, P. M., *Efficient Analytical Derivatives of Rigid-Body Dynamics using Spatial Vector Algebra.*, in IEEE RA-L, vol. 7, no. 2, pp. 1776-1783, April 2022, presented at ICRA 2022. Paper, Code **Honourable Mention for IEEE RA-L 2022.**
5. Russell, R., **Singh, S.**, & Wensing, P. (2019). *Advancing the Runtime and Robustness of Differential Dynamic Programming.* Workshop: Toward Online Optimal Control of Dynamic Robots, ICRA, Montreal, Canada.
6. **Singh, S.**, & Grant, M. (2018). *The use of Homotopy Analysis Method for indirect trajectory optimization.* Scitech AIAA, Kissimmee, Florida. Paper
7. O'Neill, W., Guariniello, C., Das-Stuart, A., Mall, K., **Singh, S.**, & Delaurentis D., (2017). *Application Of A Top Down System-of Systems Approach To Enable Human Mars Exploration Missions.* IAC, Adelaide, Australia. Paper
8. **Singh, S.** (2016). Applications of the homotopy analysis method to optimal control problems. Purdue University. Thesis
9. **Singh, S.**, & Zunaid, M. (2014). Numerical Study of the Generic Sports Utility Vehicle Design with a Drag Reduction Add-On Device. Journal of Computational Engineering, Hindawi. Paper

Patents

1. *Dynamic User-Customizable and Environmentally Adaptable Mobility Device*, U.S. Provisional Application No. 63/650,199, 2024.

Achievements & Awards

March,Sept'22 **IEEE RAS Travel Award (ICRA, IROS 2022)**, *IEEE, RAS*

Feb, Sept'22 **UT Austin Graduate Professional Travel Award**, *Graduate School, UT Austin*

August'21, July'22 **Warren A. and Alice L. Meyer Endowed Scholarship in Engineering**, *Cockrell School of Engineering Scholarship, UT Austin*

June'13 **MITACS Globalink Scholarship, Canada**, *University of Toronto*

Academic Reviewing (Web of Science Profile)

Journals (27) , *IEEE RA-L ('22-present), International Journal of Humanoid Robotics ('23, '24), Multibody System Dynamics ('23), IEEE Transactions on Mechatronics ('24), ASME Journal of Mechanism & Robotics ('24), International Journal of Robust & Non-linear Control ('24)*

Conf. (13) , *IROS ('22-'24), ICRA ('22-'24), Humanoids ('23), MECC ('24)*

Skills

, *Programming Skills:*

- **C/C++(Libraries-Eigen, STL), Fortran 90/77, Python**
- **Mathematica, Maple, MATLAB & Simulink**: Symbolic Math, Engineering Software

, *Technical Skills:*

- Expertise: Optimization (IPOPT/SNOPT), Dynamic Locomotion, ROS, Physics engines (PyBullet), Version control (Git), Debugging/Troubleshooting.

, *Non-Technical Skills:*

- Public Speaking and Effective Communication- Member of UT Science Toastmasters
- Peer Mentor at Blank Stuttering Institute, UT Austin

References

1. Dr. Ryan P. Russell (Ph.D. Supervisor)- Professor, The University of Texas at Austin.
2. Dr. Patrick M. Wensing - Assoc. Professor, University of Notre Dame.
3. Dr. Xiyang Yeh - Flexiv Robotics, CA.