SIDDHANT GANGAPURWALA

Date of Birth: 1994 - December - 07 | **Nationality:** Indian | **Address:** Oxford, United Kingdom
Email: siddhant@gangapurwala.com | **Website:** gangapurwala.com

EDUCATION

University of Oxford *October 2017 - Present*
Doctor of Philosophy (DPhil/PhD) in Autonomous Intelligent Machines and Systems
Research: *Reinforcement Learning and Optimal Control based Approach for Platform-Adaptive Robotic Locomotion*
Supervisors: Dr. Ioannis Havoutis and Prof. Ingmar Posner
Expected Date of Thesis Submission: 2021 - September - 15

University of Mumbai *July 2012 - June 2016*
Bachelor of Engineering (B.E.) in Electronics

INTERESTS

Reinforcement Learning, Optimal Control, Robotic Control and Locomotion, Multi-Agent Systems, Deep Learning

SELECTED PROJECTS

One Policy for Every Quadruped: Platform-Adaptive Robotic Locomotion *Present*
HuboLab, Korea Advanced Institute of Science and Technology — **Collaboration with Prof. Jemin Hwangbo**

- Trained a dynamics encoding network which maps a state transition tuple into a latent representation of the estimated Jacobian.
- Trained a locomotion policy whose behaviour adapts to different quadrupedal platforms using the estimated latent Jacobian.
- Training was performed using domain randomization with procedurally generated quadrupedal models based on a curriculum learning approach.
- Demonstrated multiple trained policies on different platforms in simulation and also on the physical Mini-Cheetah quadruped.
- Currently working on transferring the trained policy to the real ANYmal B, Unitree A1 and Ghost Robotics Vision 60 quadrupeds.

RLOC: Terrain-Aware Legged Locomotion using Reinforcement Learning and Optimal Control *2020*
Dynamic Robot Systems Group, Oxford Robotics Institute — ***Under review for T-RO journal***
Manuscript: arxiv.org/abs/2012.03094 | ***Video***: youtu.be/k1WGNDeTGXU

- Trained a perceptive quadrupedal footstep planning policy to map the proprioceptive and exteroceptive robot state to desired feet positions
- Additionally trained an emergency recovery policy and a domain adaptive tracking policy to adapt to uncertainties in modelled domains.
- Presented a combined reinforcement learning and optimal control based approach to track the neural network parameterized footstep plans using a model-based motion controller.
- Introduced a denoising approach to post-process the local terrain elevation and demonstrated the developed framework on physical systems, ANYmal B and ANYmal C, for locomotion over uneven terrain.

Real-Time Trajectory Adaptation using Reinforcement Learning *2020*
Dynamic Robot Systems Group, Oxford Robotics Institute — ***Published in ICRA 2021***
Manuscript: gangapurwala.com/cltt | ***Video***: youtu.be/Ve4SDl1wI9s

- Presented an approach to perform online replanning of a reference long-horizon motion plan generated using a trajectory optimization solver offline.
- Introduced a procedural terrain generation framework to obtain a policy which generalises to different kinds of environments and trajectories.
- Employed an autoencoding framework to represent terrain features as a reduced-dimensional latent vector given as an input to the trajectory adaptation policy.
- Demonstrated that the trained trajectory-adaptation policy increased the success rate of tracking long-horizon motion plans on a real ANYmal B quadruped even when subject to unexpected perturbations.

Guided Constrained Policy Optimization for Quadrupedal Locomotion *2019*
Dynamic Robot Systems Group, Oxford Robotics Institute — ***Published in RA-L 2020***
Manuscript: gangapurwala.com/gcpo.pdf | ***Video***: youtu.be/iPDmG9knkLs

- Developed a reinforcement learning algorithm for constrained policy optimization such that only policies that strictly obey the necessary safety-critical constraints are sampled for optimization.
- Addressed the issues of sample complexity associated with pure RL strategies by using reference oscillatory motions to warm-start the policy optimization.
- Deployed the trained policy on the real ANYmal B quadruped and demonstrated its performance outdoors on unstructured terrain.
- Additionally demonstrated the robustness of the obtained control policy by emulating a weak knee actuator on a real quadruped, introducing external perturbations, and also changing simulated gravity.

Reinforcement Learning based Solution for Heterogeneous Swarm Optimization *2018*
Robotic Systems Lab, ETH Zürich — **Collaboration with Prof. Jemin Hwangbo**
Manuscript: gangapurwala.com/hsrl.pdf
Summary: Developed a reinforcement learning training environment to utilise an aerial robot to inspect and map obstacles along the locality of a quadrupedal robot to navigate to a goal while avoiding obstacles.

Generative Adversarial Imitation Learning for Quadrupedal Footstep Planning *2018*
Dynamic Robot Systems Group, Oxford Robotics Institute
Manuscript: gangapurwala.com/gail.pdf | ***Demo***: gangapurwala.com/gtest
Summary: Used an imitation learning strategy to train a footstep planner for locomotion over stairs. The generated foot plans were tracked using a kino-static whole-body motion controller.

Development of Electronics and Navigation Framework for an Autonomous Mobile Robot *2017*
Rucha Yantra, Aurangabad
Summary: Designed low-level control circuit board housing an STM32 micro-controller interfaced with on-board navigation computers. Further developed ROS based navigation and perception frameworks for robot autonomy.

Micro-controller based Low-Powered Semi-Autonomous Quadcopter *2016*
Electronics Engineering Department, D. J. Sanghvi, University of Mumbai
Manuscript: gangapurwala.com/aq.pdf

PRESENTATIONS

IEEE International Conference on Robotics and Automation (ICRA) *2021*
Real-Time Trajectory Adaptation for Quadrupedal Locomotion using Reinforcement Learning
Presentation: youtu.be/bMtb0raqtaM

NVIDIA GPU Technology Conference (GTC) *2021*
Learning Dynamic and Robust Control Solutions for Robotic Locomotion
Presentation: nvidia.com/en-us/on-demand/session/gtcspring21-s31585

IEEE International Conference on Robotics and Automation (ICRA) *2020*
Guided Constrained Policy Optimization for Dynamics Quadrupedal Robot Locomotion
Presentation: youtu.be/C6n2ZMVxun4

TECHNICAL SKILLS

Programming Languages	C++, Python
Libraries and Frameworks	Eigen, PyTorch, OpenAI Baselines, ROS, NVIDIA IsaacGym
Physics Simulators	RaiSim, PyBullet, Gazebo

PUBLICATIONS

'RLOC: Terrain-Aware Legged Locomotion using Reinforcement Learning and Optimal Control', **Siddhant Gangapurwala**, Mathieu Geisert, Romeo Orsolino, Maurice Fallon and Ioannis Havoutis. IEEE Transactions on Robotics (T-RO) - **Under Review**.

'Real-Time Trajectory Adaptation for Quadrupedal Locomotion using Deep Reinforcement Learning', **Siddhant Gangapurwala**, Mathieu Geisert, Romeo Orsolino, Maurice Fallon and Ioannis Havoutis. IEEE International Conference on Robotics and Automation (ICRA), 2021.

'Rapid Stability Margin Estimation for Contact-Rich Locomotion', Romeo Orsolino, **Siddhant Gangapurwala**, Oliwier Melon, Mathieu Geisert, Ioannis Havoutis and Maurice Fallon. IEEE International Conference on Intelligent Robots and Systems (IROS), 2021.

'CPG-ACTOR: Reinforcement Learning for Central Pattern Generators', Luigi Campanaro, **Siddhant Gangapurwala**, Daniele De Martini, Wolfgang Merkt and Ioannis Havoutis. Towards Autonomous Robotic Systems Conference (TAROS), 2021.

'First Steps: Latent-Space Control with Semantic Constraints for Quadruped Locomotion', Alexander Mitchell, Martin Engelcke, Oiwi Parker Jones, David Surovik, **Siddhant Gangapurwala**, Oliwier Melon, Ioannis Havoutis and Ingmar Posner. IEEE International Conference on Intelligent Robots and Systems (IROS), 2020.

'Guided Constrained Policy Optimization for Dynamic Quadrupedal Robot Locomotion', **Siddhant Gangapurwala**, Alexander Mitchell and Ioannis Havoutis. IEEE Robotics and Automation Letters (RA-L), 2020.