Award Abstract # 2128568

Asymmetric Gait Generation for Legged Locomotion in Complex Environments via Off-Line Model Reduction and Real-Time Optimal Control

NSF Org:	CMMI Div Of Civil, Mechanical, & Manufact Inn
Awardee:	UNIVERSITY OF ILLINOIS
Initial Amendment Date:	August 10, 2021
Latest Amendment Date:	August 10, 2021
Award Number:	2128568
Award Instrument:	Standard Grant
Program Manager:	Jordan Berg jberg@nsf.gov (703)292-5365 CMMI Div Of Civil, Mechanical, & Manufact Inn ENG Directorate For Engineering
Start Date:	September 1, 2021
End Date:	August 31, 2024 (Estimated)
Total Intended Award Amount:	$499,673.00
Total Awarded Amount to Date:	$499,673.00
Funds Obligated to Date:	FY 2021 = $499,673.00
History of Investigator:	Pranav Bhounsule (Principal Investigator) pranav@uic.edu (312)355-8991
Awardee Sponsored Research Office:	University of Illinois at Chicago 809 S. Marshfield Avenue Chicago IL US 60612-4305 (312)996-2862
Sponsor Congressional District:	07
Primary Place of Performance:	University of Illinois at Chicago IL US 60612-4305
Primary Place of Performance Congressional District:	07
DUNS ID:	098987217
Parent DUNS ID:	041544081
NSF Program(s):	FRR-Foundationl Rsrch Robotics
Primary Program Source:	040100 NSF RESEARCH & RELATED ACTIVIT
Program Reference Code(s):	6840

Program Element Code(s):	144Y
Award Agency Code:	4900
Fund Agency Code:	4900
CFDA Number(s):	47.041

ABSTRACT

This Foundational Research in Robotics (FRR) project will create new control tools to improve the locomotion capabilities of legged robots in real-world environments. The goal is a generalizable and broadly applicable control framework for legged robots with highly articulated limbs. These new control tools will address the complexity of the robots, the hybrid dynamics caused by intermittent ground contact, and the limited control authority provided by small motors. Although current humanoid robots are highly proficient at moving at a constant speed in a straight line, they can be challenged in situations requiring unanticipated changes in speed and direction. Overcoming this challenge will facilitate the broader adoption of legged robots for mainstream applications in homes, offices, factories, and warehouses. This project will also train the next generation of engineers and roboticists through undergraduate research, capstone projects, and robotics outreach to minorities in Science, Technology, Engineering, and Mathematics.

The most extensively investigated control approach for legged robots is to use symmetric force/torque profiles, which leads to symmetric gaits characterized by a constant speed, straight-line movement. However, to move at variable speed and to steer, robots need to use asymmetric torque/force profiles, which leads to asymmetric gaits. The high degrees of freedom of the legged system makes asymmetric gait generation to be computationally demanding and the underactuation (fewer actuators than degrees of freedom) makes gait stabilization to be challenging. The central idea of the grant is to use data-driven methods to approximate the dynamics between key instances in the gait. These approximations are done with low-order polynomials and they capture the asymmetry of the gaits. These reduced-order models, when incorporated within an optimization framework, can be solved in real-time. Finally, extensive experimental verification and validation is planned on a high-dimensional bipedal robot in real-world scenarios.

This project is supported by the cross-directorate Foundational Research in Robotics program, jointly managed and funded by the Directorates for Engineering (ENG) and Computer and Information Science and Engineering (CISE).

This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the Foundation's intellectual merit and broader impacts review criteria.

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National Science Foundation, 2415 Eisenhower Avenue, Alexandria, Virginia 22314, USA

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