Developing Robotic Systems for Locomotion on Granular Media

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How can we develop robots that can efficiently move on granular terrain?

Motivation

Current robotic systems are limited in their abilities to adeptly traverse solid, deformable substrates (e.g. sand, mud, snow) due to a lack of understanding of the physics governing the complex interactions between solids and such surfaces. As there are many animal species biologically designed for navigation of specific terrains, it is useful to study their mechanical ground interactions, and the kinematics of their movement.

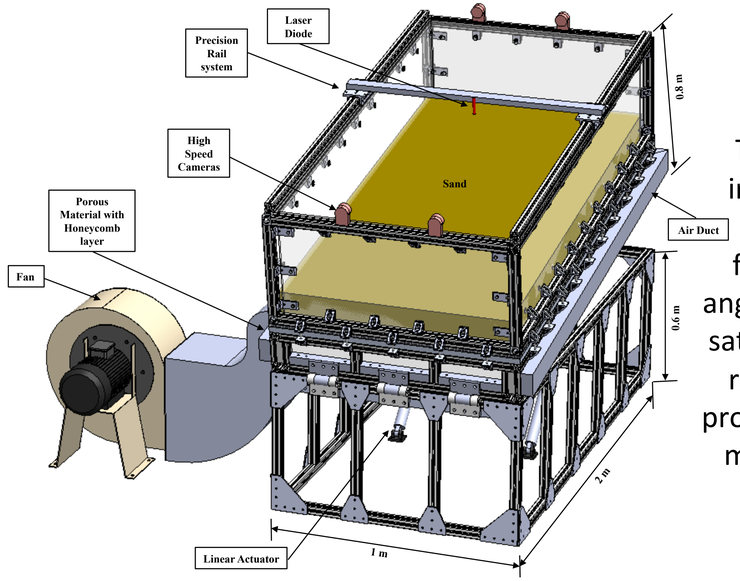
Snake robot

Methods

To study animal species that can adeptly navigate through wet and dry granular environments, a fully automated, fluidized test bed is designed. Simulated environmental conditions are varied by manipulation of slope angle and packing fraction (dry) or saturation level (wet). Data collected from these experiments will be studied and used to optimize morphologies and gait parameters of robots.

Experimental Setup

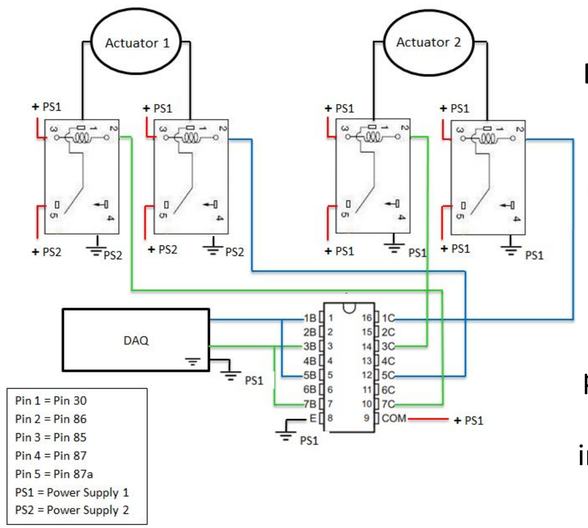
The fluidized bed consists of a support stand, air chamber, air distribution layers, and test bed. Main sub-system components include the tilting actuators, blower, linear rail guideways, IR cameras, laser diode, z-direction actuators, and a load cell.



Model of fluidized test bed setup

Controls

The automated features of the design include systems for data collection and manipulation of test conditions. The functions of these systems are varying angle of incline, varying packing fraction or saturation level, optically tracking animal/ robot movement, obtaining 3D surface profile data, and conducting stress tests on models of animal and prototyped robot limbs.



Wiring schematic for tilting actuator system

Future Work

Developed robotic systems will be tested in the same bed for validation of optimized parameters. Theoretical models can be developed for solid interactions on various types of substrates. Ultimately, these can be integrated into a single robotic system capable of sensing its environment and adapting its morphology and gait parameters for effective locomotion on any surface. These systems would be invaluable for applications such as planetary exploration or rescue operations.

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