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.

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.

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.