Skysong Innovations
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Horizontal Self-Burrowing Robot

Burrowing robots are a class of robot that can move themselves in soil for geotechnical site investigation, search and rescue, sensor deployment, inspection, monitoring, and construction purposes. Moving through soil is a challenging problem due to high drag force and complex underground environments. Many organisms adopt well-evolved strategies and traits to facilitate burrowing/penetration in soils. Example features include the "dual-anchor" strategy used by razor clams and rotational drilling adopted by scarab beetle larva and some seed awns. Overall, underground burrowing requires overcoming resistances to advance forward and forming anchorage to prevent slip backward.

The motility of a burrowing organism is typically enabled by internal forces and body deformations. On one hand, organisms coordinate the movement of different body parts to promote generations of anchorage and thrust to resist backward slip and facilitate forward advancement. On the other hand, organisms manipulate the surrounding soil by changing the shape of different body parts to improve the effectiveness and efficiency of the locomotion. Similar to the soil structure interaction problems in geotechnical engineering, underground locomotion in nature is fundamentally a soil-organism interaction problem. It is therefore expected that the effectiveness and efficiency of underground locomotion is related to the implemented burrowing kinematics and the properties of surrounding soil. Many biological burrowing mechanisms can be translated to robotic design principles resulting in bio-inspired burrowing robots.

Researchers at Arizona State University have developed a self-burrowing, modular robot that moves horizontally in soil or other granule media. The robot design includes one or more of: an extensible body and a rotatable tip.

Related publications:

Bioinspired Horizontal Self-Burrowing Robot

Multiscale analysis of rotational penetration in shallow dry sand and implications for self-burrowing robot design

Comparative Analysis of Horizontal Self-Burrowing Strategies Using Full-Scale DEM-MBD Co-Simulations

Potential Applications:

- Burrowing robots used for:
  - Evaluating soil conditions
  - Monitoring ground contaminants
  - Studying below-ground geotechnics, biologics, and water

- Predicting vulnerability or resiliency of land impacts from earthquakes or flooding

Benefits and Advantages:

- Self-contained and minimalist in design
- Burrowing speed increases with increase of rotational speed of tip and based on tip shape
- Simple kinematic control strategy