

Self-Anchoring Burrowing Device for Sensor Placement with Low Reaction Force

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BACKGROUND

Robots have been engineered for efficient locomotion over ground, underwater, and through air. However, subterranean locomotion through granular media without previously formed paths or tunnels has proven difficult to achieve as the environmental interaction forces found underground exceed those found in water and air by orders of magnitude. A commonality of existing mechanical burrowing techniques is that they require a large axial force (reaction force), typically provided by an overhead mass, to overcome these environmental interaction forces. This is impractical for small, minimally invasive robots due to the heavy equipment required. Therefore, a burrowing mechanism that eliminates the need for a large reaction force in addition to overcoming the environmental interaction forces is highly desirable for minimally invasive burrowing applications, such as underground sensor placement for extraterrestrial exploration or for monitoring plant growth or soil conditions.

DESCRIPTION

Researchers at the University of California, Santa Barbara have developed a self-anchoring, self-deploying soft burrowing robot that uses tip extension to navigate through granular media. The self-anchoring feature eliminates the requirement of external reaction force to burrow, allowing the device to be implemented into small, mobile robots and enabling remote placement of underground sensors with minimal soil disturbance. Inspired by a plant root, which remains stationary relative to its surroundings as its tip grows, the soft burrowing robot consists of a thin-walled tubular body that is initially inverted inside itself and everts when pressurized, passing new material out of the tip. It can also deploy root hairs, branch, swell radially, and retract by pulling back on the tip to reinvert material. Since there is no relative motion of the body with respect to the granular medium, frictional forces along the sides is eliminated and only the normal forces at the tip oppose the robot's growth.

ADVANTAGES

- ▶ Tip-extension reduces soil disturbance compared to drilling or hammering
- ▶ Enables remote sensor placement in various granular media and organic soils with little or no reaction force
- ▶ Pneumatic tip extension enables robot to burrow faster than alternative mechanisms
- ▶ Ability to create hollow conduits for applications such as wire or irrigation line installation

APPLICATIONS

- ▶ Agriculture and Botany

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OTHER INFORMATION

KEYWORDS

Robotics, Soft Robot, Sensor Placement, Minimally-invasive, Burrowing, Subterranean Locomotion, Mining, Low-gravity, Soil Monitoring, Crop Monitoring, Extraterrestrial Anchoring

CATEGORIZED AS

- ▶ **Agriculture & Animal Science**
 - ▶ Devices
- ▶ **Environment**
 - ▶ Sensing
- ▶ **Sensors & Instrumentation**
 - ▶ Environmental Sensors
- ▶ **Engineering**
 - ▶ Robotics and Automation

RELATED CASES

2022-790-0, 2022-793-0

▶ Civil and Geotechnical Engineering

▶ Space Exploration

PATENT STATUS

Country	Type	Number	Dated	Case
United States Of America	Issued Patent	12,577,837	03/17/2026	2022-793
Patent Cooperation Treaty	Published Application	WO 2023/244927	12/21/2023	2022-793

Additional Patent Pending

RELATED MATERIALS

▶ [Controlling subterranean forces enables a fast, steerable, burrowing soft robot - 06/23/2021](#)

ADDITIONAL TECHNOLOGIES BY THESE INVENTORS

- ▶ [Everting Pre-Shaped Soft Device for Access during Medical Interventions](#)
- ▶ [Soft Burrowing Robot for Simple & Non-Invasive Subterranean Locomotion](#)
- ▶ [Fluidic Camming for Grasping](#)

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