**Docket #:** S25-368

# 2-DOF External Actuation for Vine Robot Confined Space Operations

Stanford researchers in the CHARM Lab have developed a steerable vine robot specifically designed for pipe and burrow environments. The adaptable steering device mounts to the tip of a soft growing robot which re-configures itself based on its environment such that the vine robot passively follows a desired path within confined spaces. External sensors and other mechanisms are mounted to the robot without reducing the bending radius. The robot's unique combination of growth-based movement, two-degree-of-freedom (2-DOF) steering actuation with independent roll and pitch, and compliant design makes it particularly valuable where space is extremely limited, and conventional robots cannot effectively operate.

**Stage of Development – Proof of Concept Prototype**

## Applications

- Infrastructure Inspection & Maintenance for Pipelines, Cable, HVAC, Bridges, etc.
- Oil & Gas Inspection, Maintenance & Monitoring
- Industrial Inspection, Maintenance & Quality Control for Chemical Plants, Nuclear Facilities, Aerospace & Maritime
- Medicine & Healthcare – e.g. Robotic Surgery, Endoscopy
- Search & Rescue
- Security & Defense
- Archeology, Environmental & Scientific Research

## Advantages

- **Agile**
  - **Up to 51.7° turning angle** allows the robot to navigate complex 3D path networks with branches and sharp turns
  - **Navigates artificial (pipes) and natural (burrows)** confined spaces as small as 2.5 cm
- **Versatile** – multiple sensors/actuators can be deployed outside the robot
- **Accurate** - Real-time 3D localization in GPS-denied environments
- **Faster, Less Complex, and More Reliable**

## Publications


- Qin, Y., Grinberg, J., Heap, W., & Okamura, A. M. (2025). 3D steering and localization in pipes and burrows using an externally steered soft growing robot . *arXiv preprint arXiv:2507.07225*.


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