An Untethered Shape Morphing Robot for Multimodal Locomotion

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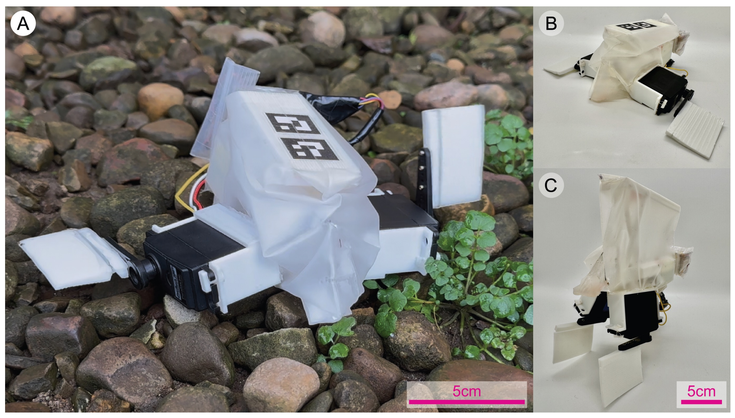
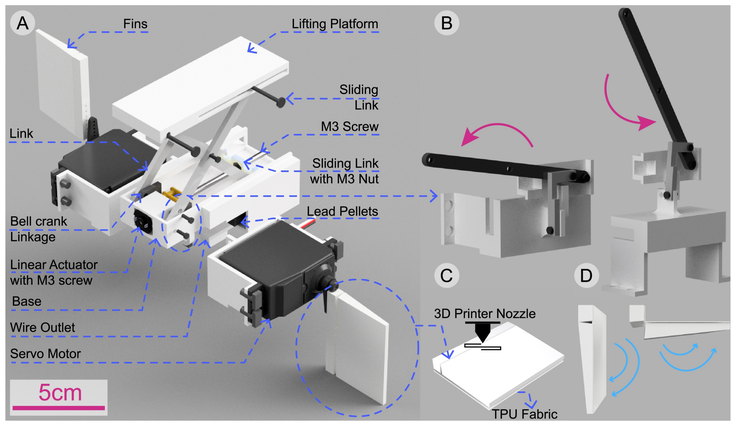
Shape Morphing Robot and Morphing Modes

Amphibians adapt their motions and morphologies to accommodate movement in both terrestrial and aquatic environments. Inspired by these biological features, we present an untethered, multimodal shape-morphing robot that can seamlessly crawl on land, swim in water, and navigate underwater surfaces.



The robot is compact and lightweight, weighing 330 g with dimensions of 9 cm in length and 4.5 cm in width. Its height dynamically adjusts between 4 cm and 9 cm, enabling efficient bimodal buoyancy control by modulating its overall volume. This design allows for smooth transitions across different terrains, mirroring the versatility of amphibious locomotion. **A) Robot B) Crawl Mode C) Swim Mode**

Design Overview

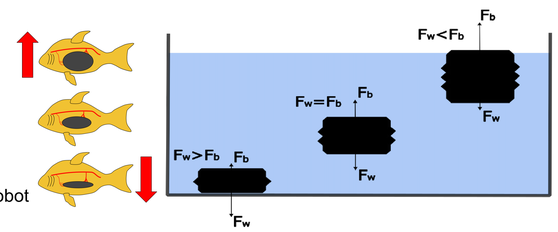


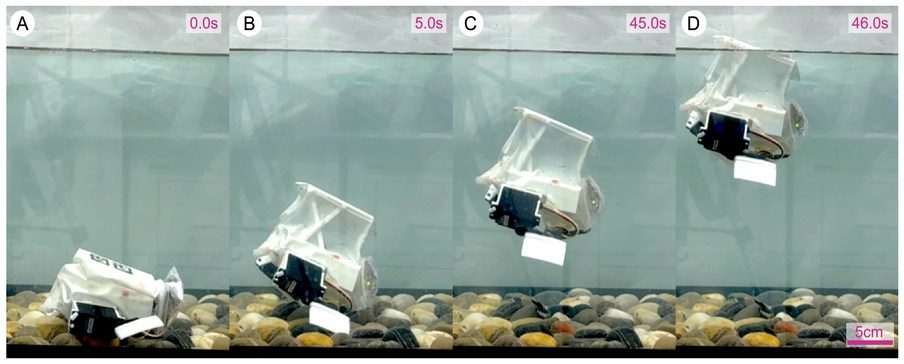
A) Exploded view of the robot.
B) Coupled bell crank linkage between scissor lift link and servo motor for switching between from horizontal walking and vertical swimming states.
C) 3D printing on TPU fabric for compliant fin design.
D) Compliant fin against and with the flow of water for forward resulting motion.

Bioinspiration for Shape Morphing Buoyancy Adaptation

Downward Force
$F_w = m_{robot} \cdot g$

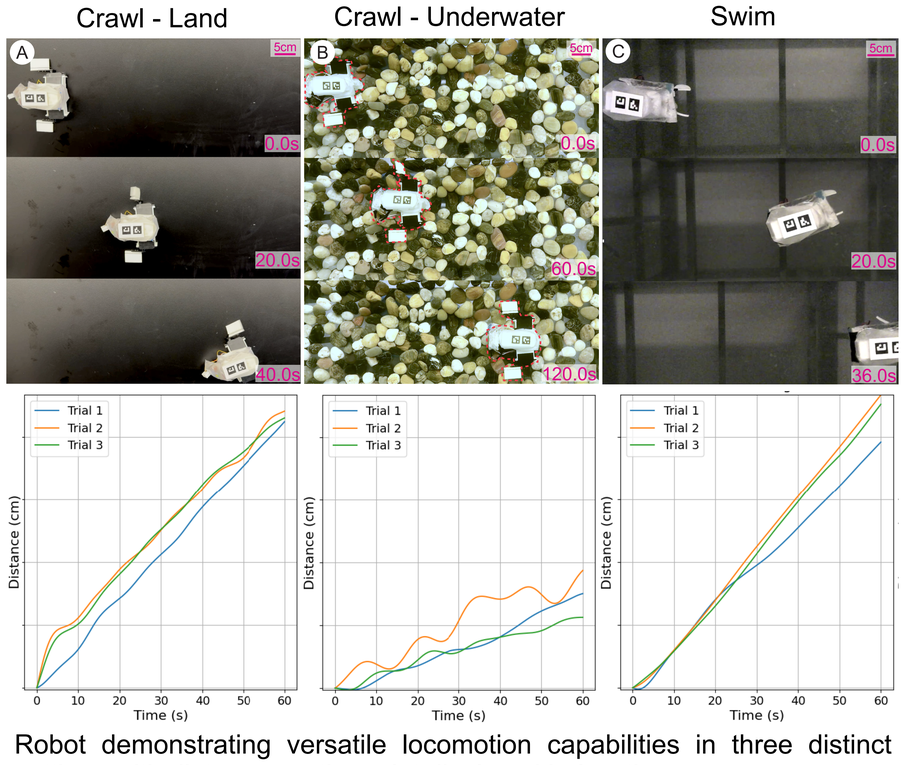
Upward buoyant force
$F_b = \rho_{water} . \Delta V_{robot} . g$
$= \rho_{water} . l_{robot} . w_{robot} . g . \Delta h_{robot}$





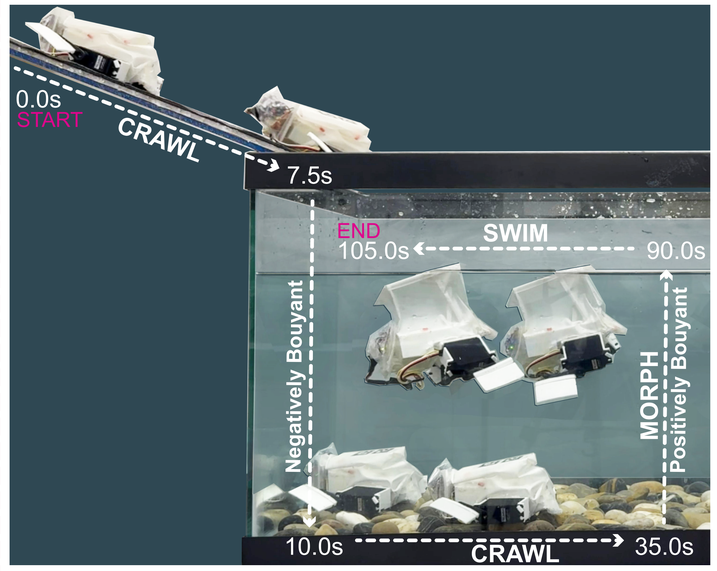
Bioinspiration from lung inflation in marine mammals and swim bladders in bony fish for efficient buoyancy control by adjusting internal volumes.

Crawling and Swimming Performances



Robot demonstrating versatile locomotion capabilities in three distinct settings with distance vs. time plot displayed below them.

Multi Environment Locomotion and Transitions



Demonstration of seamless land, water, and underwater locomotion, showcasing smooth transitions and adaptive buoyancy for efficient navigation across diverse environments.

Contributions

Multimodal Locomotion: The robot can traverse land, water, and underwater surfaces and change its buoyancy using shape morphing.
Low Cost and Accessible: The robot is low cost, accessible and scalable as most part of the robots are 3D printed and uses only three actuators to work.
Efficient Locomotion and Morphing: Achieves crawling, swimming, and underwater crawling with buoyancy adjustments and runs for 2 hours on a 3.7V 1000mAh battery and morphing takes 45 seconds for switching between different locomotion modes.

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