Imperial College London

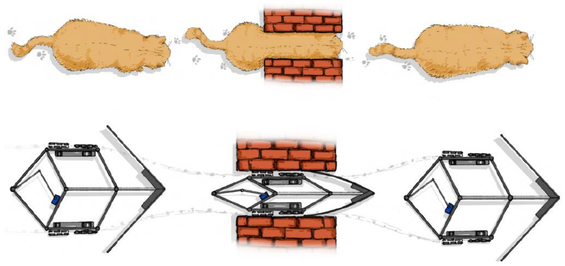
DeforMoBot: A Bio-Inspired Deformable Mobile Robot for Navigation Among Obstacles

Barry William Mulvey, Thilina Dulantha Lalitharatne, and Thrishantha Nanayakkara

Dyson School of Design Engineering, Imperial College London, UK. Email: b.mulvey21@imperial.ac.uk

Abstract

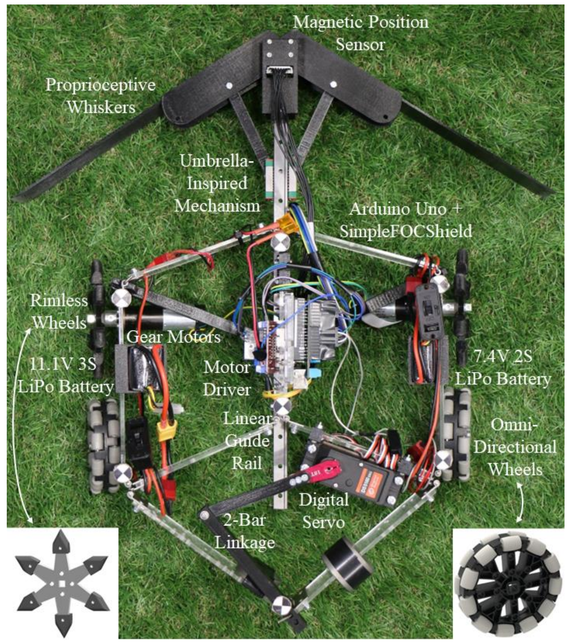
- Navigation around compliant obstacles leads to loss of efficiency—and possible mission failure—compared to progression through them.
- We propose the design of DeforMoBot, a deformable mobile robot; it adopts a wider stance for stability or a narrower stance to fit through gaps and traverse obstacles.



The ability of animals—such as cats—to morph their shape in order to traverse small spaces is the bio-inspiration for the design of our deformable mobile robot.

Method

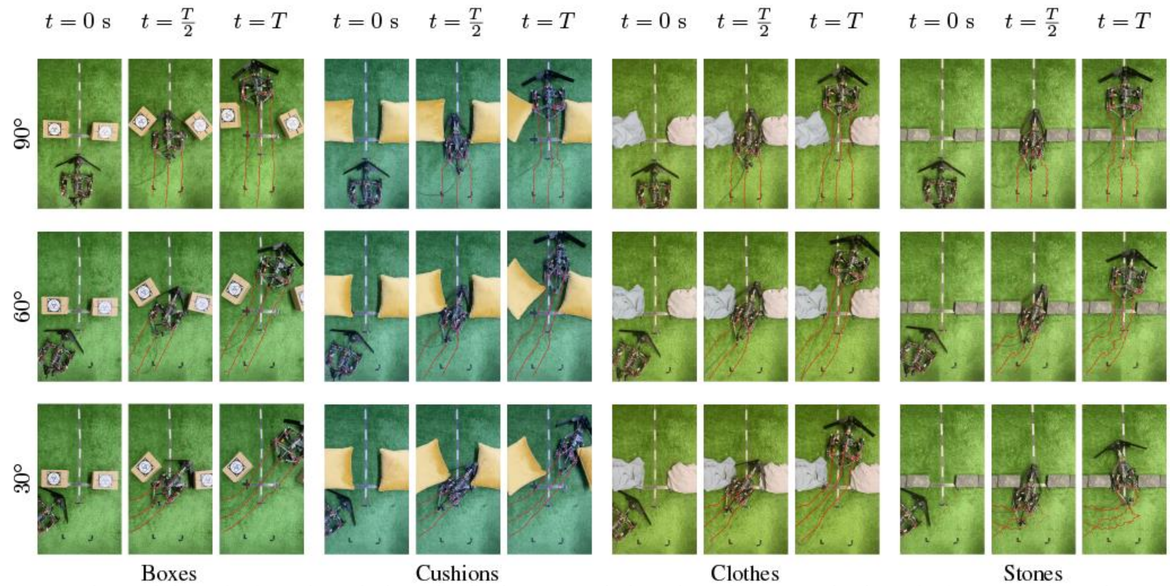
- DeforMoBot changes shape from a regular hexagon to an elongated rhombus ~66% of its original width.
- Spring-loaded “whiskers” match amount of robot’s deformation with compliance level of the obstacles.
- Real-time algorithm uses this whisker feedback to change shape in uncalibrated environments.
- Experiments observe how the robot interacts with obstacles with varied parameters from different approach angles.
- Boxes, cushions, clothes, and stone blocks used as obstacles to cover a range of different physical properties.



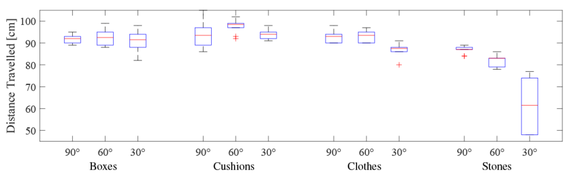
Design of robot body with mounted sensors. Motor-driven 3D-printed rimless wheels provide traction and grip on unstructured terrain, while passive omni-directional wheels assist with the robot’s shape-changing ability.

Results

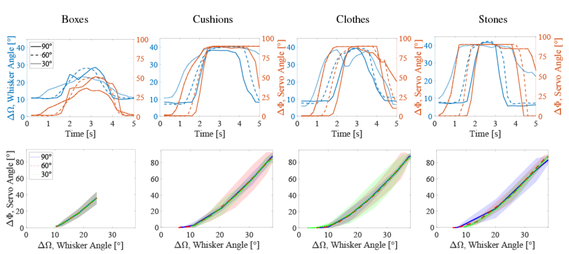
- Based on obstacle movability, robot can push these away, narrow body to squeeze through gap, or combine these actions.
- Robot achieved 100% success rate in 11 of the 12 cases: boxes at approach angles of 90°, 60°, and 30°; cushions at 90°, 60°, and 30°; clothes at 90°, 60°, and 30°; and stone blocks at 90° and 60°. 60% success rate in other case, stone blocks at 30°.
- Results show the importance of tuning haptic perception to match the robot’s physical capabilities.



Comparison of the robot’s path and obstacle displacement during obstacle traversal. The robot’s approach angles are shown in the row headers and the timestamps are shown in the column headers, where T = 5 s.



Experimental results of the robot attempting to traverse various obstacles from different approach angles.



Top Row: Servo angle reacting to whisker angle data. Bottom Row: Direct comparison of the angles’ relationship.

Conclusions

- DeforMoBot changes shape for obstacle traversal, rather than circumnavigation.
- Ability to interpret proprioceptive whisker feedback relative to body shape leads to meaningful obstacle negotiation behaviors.
- Shows importance of co-development of environment perception and physical reaction capabilities for better performance of robots in unstructured environments.

EPSRC
Engineering and Physical Sciences Research Council

Paper & Video: