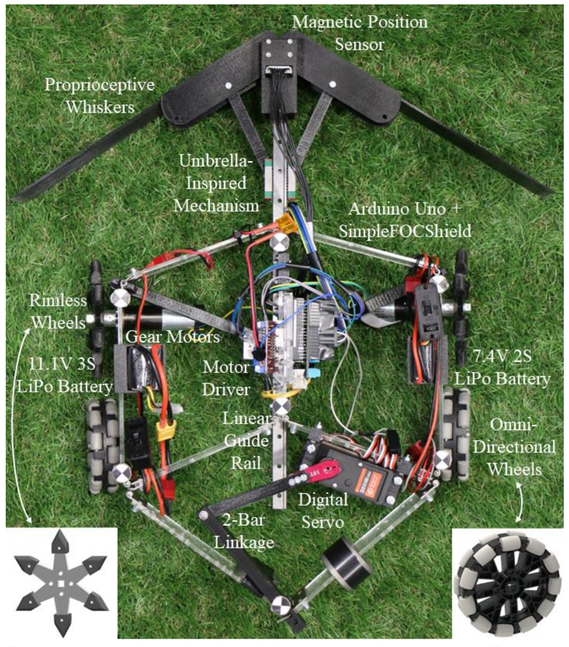
Imperial College London

Traversing Visually-Similar Physically-Different Obstacles with DeforMoBot, a Bio-Inspired Deformable Mobile Robot

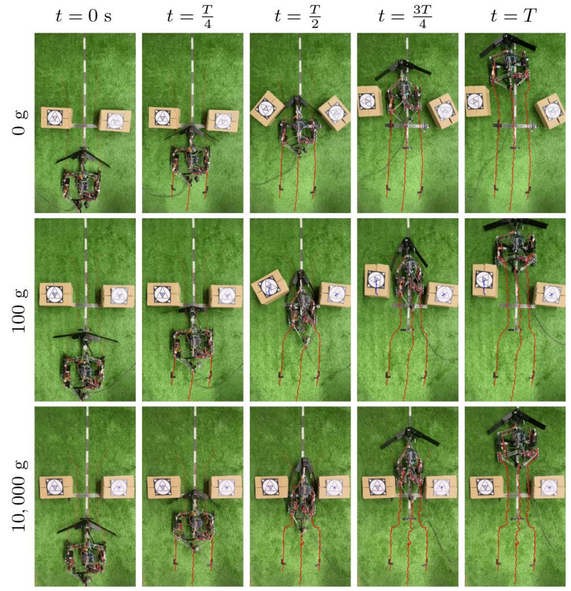
Barry William Mulvey, Thilina Dulantha Lalitharatne, and Thrishantha Nanayakkara
Dyson School of Design Engineering, Imperial College London, UK. Email: b.mulvey21@imperial.ac.uk

Abstract

- Many animals change their natural shape to fit through narrow gaps and spaces - generally not possible with rigid robots.
- Embodied intelligence is crucial for better performance and enhanced capability.
- DeforMoBot, a bio-inspired deformable robot, is tested attempting to traverse obstacles of various mass (movability).
- Shape-adjustment algorithm to traverse (rather than circumnavigate) obstacles.



Design of robot body with mounted sensors. Rimless wheels provide traction and grip, while omni-directional wheels assist with shape-changing ability.



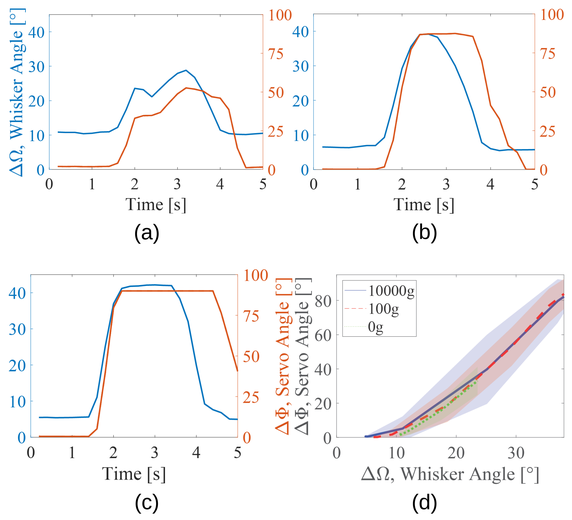
Comparison of the robot's path (in red) and obstacle displacement (in blue) from traversal experiments. Masses of obstacles shown in row headers (to left of figures); timestamps shown in column headers, where T = 5 s.

Method

- DeforMoBot can change shape between a regular hexagon and elongated rhombus (~66% of original width).
- Sensors mounted on body; spring-loaded "whiskers" at front tip.
- Aim to traverse obstacles in desired path keeping wide body shape for stability.
- Shape-adjustment algorithm accounts for real-time whisker angle deformation and current body shape.

Experiments & Results

- Experiments observe how the robot interacts with obstacles that have the same visual features but different masses.
- Robot attempts to traverse boxes (placed apart at narrowest robot width) of different mass (0 g, 100 g, 10,000 g).
- Based on obstacle movability, robot can push them away, narrow body to squeeze through gap, or combine these actions.



(a)-(c) Servo angle (orange) reacting to whisker angle data (blue). Obstacle masses are (a) 0 g, (b) 100 g, and (c) 10,000 g. (d) Direct comparison of obstacles, where the mean is plotted surrounded by standard deviation shading.

SUMMARY OF EXPERIMENT RESULTS

Obstacle Mass [g]	Success Rate	μ_s [cm]	δ_s [cm]
0	100 %	92.50	3.15
100	100 %	93.65	2.48
10,000	95 %	79.45	8.36

μ_s = mean distance travelled by the robot in 5 seconds
δ_s = standard deviation of the mean distance, μ_s

Conclusions

- DeforMoBot adapts shape to traverse visually-similar obstacles of various mass.
- Real-time shape-adjustment algorithm accounts for robot's current shape and proprioceptive whisker feedback.
- Achieved 100% success traversing lighter obstacles (pushing obstacles and slightly adjusting body shape), 100% success traversing moderate obstacles (combining shape adjustment and obstacle pushing), and 95% success rate traversing heavy immovable obstacles (relying fully on shape-changing ability).
- Results demonstrate inverse relationship of robot's degree of deformation and its ability to push against obstacles in its path.

EPSRC
Engineering and Physical Sciences Research Council

Paper & Video: