Highly Dynamic Bio-Inspired Legged Running on Water Surface

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1 Motivation

Basilisk lizards have a unique water surface locomotion capability using their high frequency (5-10 Hz) rotation of legs and feet in a specific trajectory and high-speed (~1.5 m/s) body motion. Such locomotion is enabled by the lift and propulsion due to inertial and hydrostatic drag forces mainly on their feet. Inspired by this lizard, this study studies the design and control of a quadruped robot, which can run on water with a similar dynamics.

2 State of the Art

Water surface robotic locomotion systems using buoyancy [1] and repulsive surface tension forces [2] were proposed before. The former approach works well for large and heavy robots at moderate or slow speeds while the latter is optimal for insect scale miniature robots. We aim to develop a highly dynamic robotic platform, which is in between insect scale and large robot scale, and has a high-speed water surface and potentially ground and other complex surface striding capability.

3 Approach

We proposed a quadruped robot with a passive tail to run on water similar to basilisk lizards using the same lift and propulsion principle. Each leg, driven by a separate motor, could rotate at 5-8 Hz rotation speeds and the robot's body speed can reach up to ~1 m/s at a trotting gait. The current designs were optimized for water surface locomotion mainly.

4 Results

The quadruped robot's simplified first prototype could run on water surface (see Fig. 1) [3]. Roll and pitch dynamic stability of the robot was challenging [4]. In a second prototype (see Fig. 2), a passive tail was shown to stabilize the pitch motion while a wide body with a large roll moment of inertia at the trotting gait enabled a stable roll motion. The robot's dynamics favors scaling down of the robot size scale.

5 Best Possible Outcome

While the robot's water surface locomotion is shown to be feasible, it would be a higher impact to design the same robot as a multi-terrain locomotion platform as in the case of the lizard, which could also scale ground. However, it is not exactly known how to control and stabilize leg and foot compliance and damping to enable such multi-terrain operation at high speeds. Especially, such multi-terrain transitions are crucial to understand biologically and robotically.

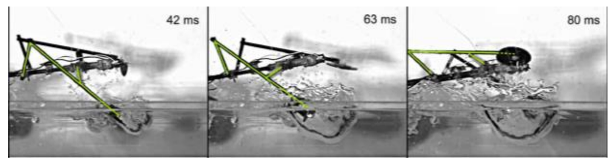

Fig. 1. High-speed footage of the water runner in a small aquarium. Links on the right front leg have been highlighted for emphasis. Time in milliseconds is provided in the top right corner of each frame.

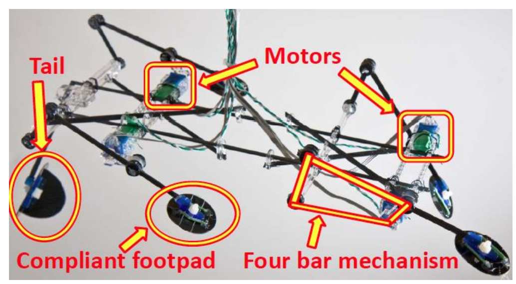

Fig. 2. Photo of the four-motors and passive tail based water runner robot prototype.

Acknowledgement

The author thanks to Steven Floyd and Hyun Soo Park for their significant contributions to this study.

References

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