Angular Motion Control Using a Closed-Loop CPG for a Water-Running Robot

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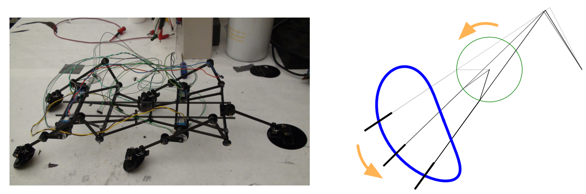
Motivation The Basilisk Lizard's striking ability to sustain highly dynamic legged locomotion on a range of surfaces from hard-ground to water is a remarkable feat [1]. Most legged robots would have difficulty emulating this animal's ability to robustly locomote on yielding or deforming surfaces. Therefore, to explore the dynamics of legged locomotion in this regime, we are studying the design of a bio-inspired water-running robot. Analyzing water-running dynamics may also help us gain insight into mobility on other yielding surfaces, such as granular media and mud. It is crucial that we develop locomotion models for these surfaces as robots continue to venture out of the laboratory and into the real world.

State of the Art The mechanical design of the water-running robot has undergone several design iterations. The current design, which can be seen in Figure 1(a), features four four-bar linkage legs producing foot trajectories, as in Figure 1(b), optimized for power consumption and lift. Park et al. analyzed the roll and pitch dynamics of this robot and proposed an active tail for achieving stable robot pitch angles [2]. However, addition of an active tail requires integration of another actuator, adding mass and complexity. Furthermore, no method for controlling roll angles has been proposed as of yet.

Own Approach To control the roll and pitch motion of the robot, we propose a novel, closed-loop central pattern generator (CPG) that modulates the velocity of each foot during the downwards and upwards phases of their trajectories using a control input parameter we call duty-factor. This approach takes advantage of non-linear fluid drag to generate differing forces on each foot, thereby imparting moments on the robot.

To deal with the hybrid and time-variant nature of the system we will utilize a time averaging approach. We will then find the force generated by an approximated foot trajectory in order to yield a linear expression for the average lift force over a cycle. Finally, we will design a controller, based on this force equation, to achieve a desired spring-like virtual model.



(a) Robot Design (b) Foot Trajectory

Figure 1

Best Possible Outcome The best possible outcome for this project is that our proposed controller robustly stabilizes the roll, pitch and height of the water runner robot in simulation. This outcome will require that we adhere to the following schedule, which outlines how complexity will be added to our model and controller:

Task	**Start**	**End**
1-DOF Hopper	3/10/13	3/23/13
3-DOF Planer QuadHopper	3/17/13	3/30/13
6-DOF QuadHopper	3/24/13	4/6/13
SimMechanics Robot Implementation	3/10/13	4/21/13

References

[1] JW Glasheen and TA McMahon. A hydrodynamic model of locomotion in the basilisk lizard. *Nature*, 380(6572):340–341, 1996.

[2] Hyun Soo Park, Steven Floyd, and Metin Sitti. Roll and pitch motion analysis of a biologically inspired quadruped water runner robot. *The International Journal of Robotics Research*, 29(10):1281, 2010.