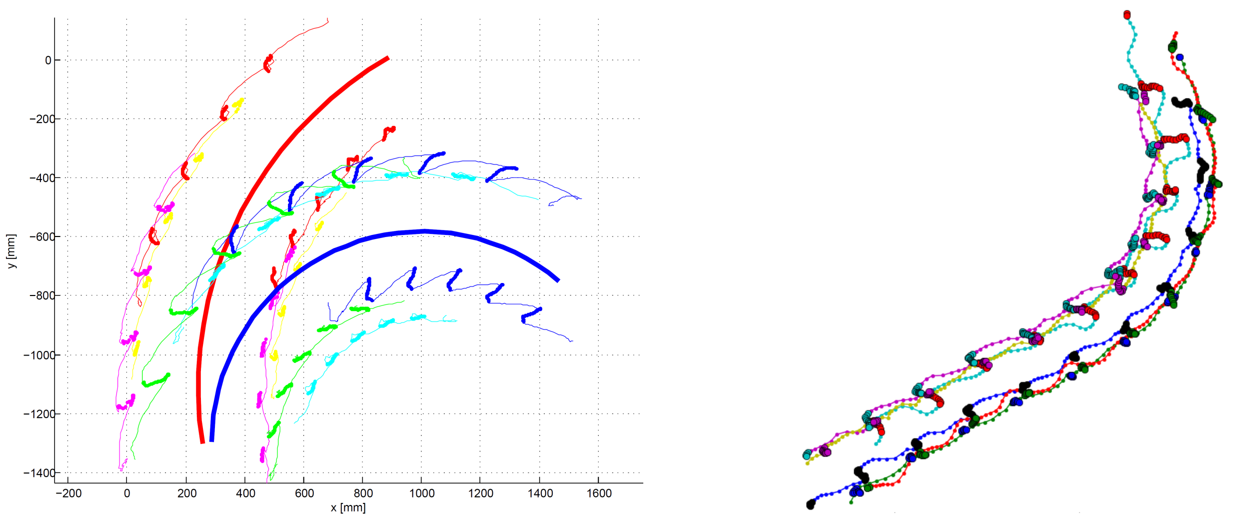
Slip Matters in Hexapedal Steering

Dan Zhao[1], Shai Revzen[2]

Abstract

Multilegged robots offer a potentially useful locomotion platform for both controlled and unstructured environments, as well as models for the scientific study of biological locomotion. Commonly, most engineers and biologists make non-slip contact assumptions for multilegged locomotion[1][2]. In our research into hexapedal "steering" (gaits that allow heading change while moving forward), we found foot slipping to be crucial to understanding the outcomes. Contrary to the influence of slipping on wheel and tread based vehicles, increased slipping produces an improved ability to steer our robot. In conjunction with a twofold increase in distance the feet travel while slipping, turning radii decreased nearly 45% and non-dimensional turning rate (deg/cycle) grew by 50%. Despite a large difference in robot motion in world frame on different surfaces, foot trajectories in the body frame hardly changed with substrate, which indicates the robot adopted the same cycle of postures on different surfaces, yet produced noticeably different world frame results. In our preliminary analysis of cockroach running, we see that the cockroaches do slip while running, and that feet slip an even longer distance when the direction of motion is changing — quite similar to the robot steering observations. Having learned that allow for and employing slipping makes our robots steer more effectively, we think slippage also plays a significant role in cockroach steering. We are developing a multi-legged locomotion model that accommodates slipping to be used in planning and design for our robots, and could potentially be applied to animals as well.



(a) Robot steering

(b) Cockroach steering

Fig. 1. (a) Robot Mechapod steering on low friction(cold color) and high friction(warm color) substrate. (b) Cockroach steering on white foam board.

References

[1] Justin E Seipel, Philip J Holmes, and Robert J Full. Dynamics and stability of insect locomotion: a hexapedal model for horizontal plane motions. *Biological cybernetics*, 91(2):76–90, 2004.

[2] Shibendu Shekhar Roy and Dilip Kumar Pratihar. Kinematics, dynamics and power consumption analyses for turning motion of a six-legged robot. *Journal of Intelligent & Robotic Systems*, 74(3-4):663, 2014.

[1]Mechanical Engineering, University of Michigan, danzhaoy@umich.edu, [2]Electrical Engineering and Computer Science, Ecology and Evolutionary Biology, University of Michigan, shrevzen@umich.edu