Cockroaches Always Slip a Lot!

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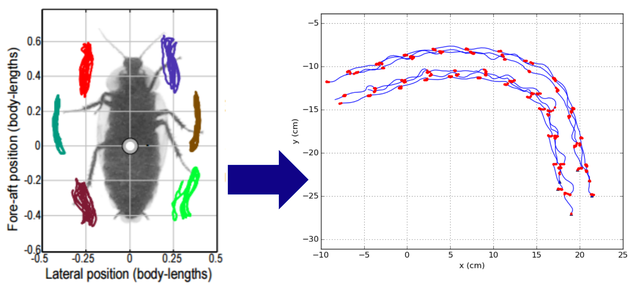
Background

Effective locomotion is an essential component of animal survival and fitness. Within biology, slippage avoidance strategies have been well documented [1,2]. However, while there is no obvious survival reason for small animals to avoid slipping, computational models of multi-legged locomotion still assume non-slip conditions in stance [3,4,5,6]. We have found non-slip constraints to severely impede the performance of some of our hexapod robots, and therefore set out to test if these non-slip assumptions apply to the animals that inspired their designs. We investigated slipping in running *Blaberus discoidalis* cockroaches.

Data Collection

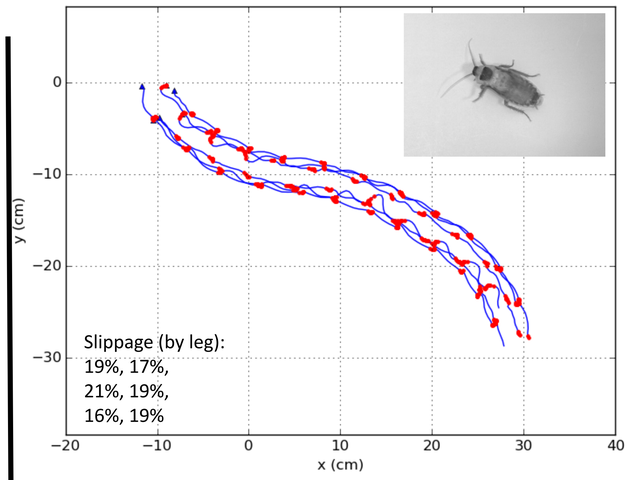


Body Frame

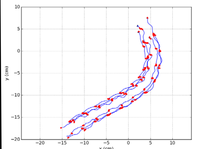
Lab Frame

We recorded 24 trials of *Blaberus discoidalis* cockroaches running at 15-77cm/s on foamcore [Elmer's 900803 Foam Board, Elmer's Products Inc., Atlanta GA].

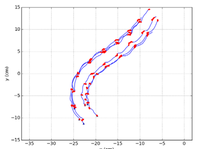
Slippage of Trials



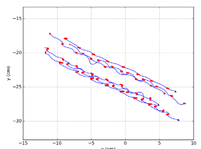
We found that front, mid, and hind legs slipped 21.%, 18.%, 20.% of their total travel distance in the lab frame.



Slippage (by leg):
23%, 19%,
18%, 17%,
20%, 21%

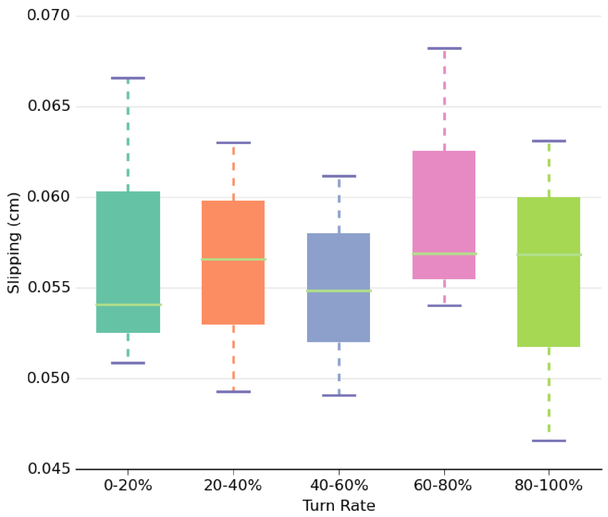


Slippage (by leg):
26%, 18%,
20%, 18%,
19%, 20%



Slippage (by leg):
20%, 18%,
18%, 18%,
20%, 24%

Turn Rate Results

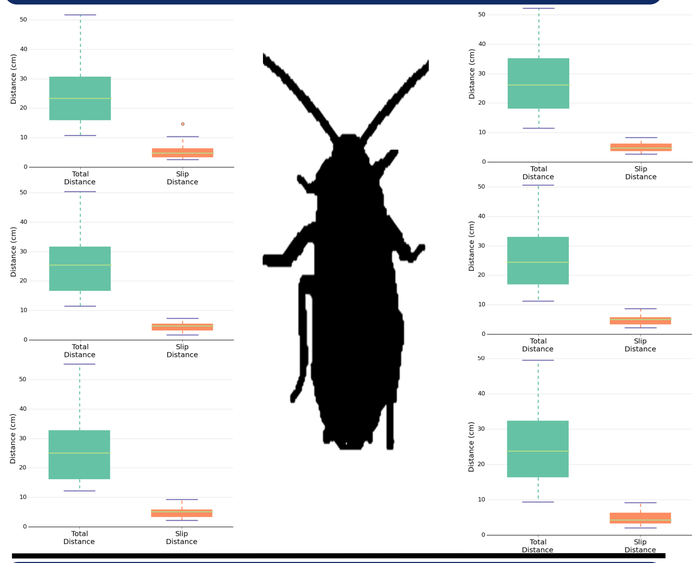


We separated video frames into quintiles sorted by turn rate and used Mann-Whitney U tests to compare median turn rate versus slipping distance.

Mann-Whitney Tests:
Front Legs: p > .16
Middle Legs: p < .008
Hind Legs: p> .19

We found median slippage distance was not significantly different in the turning rate bins.

Slippage of Legs



Conclusion

In our experiments, we found that cockroaches slip nearly $^1/_5$ of their total travel distance! Our results suggest that slipping is a routine part of cockroach locomotion, and is independent of turning speeds. Given the high propensity of slipping that we found, we advise that biologically-inspired locomotion models incorporate slipping.

References:

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[3] W. Xi and C. D. Remy, "Optimal gaits and motions for legged robots," 2014 IEEE/RSJ International Conference on Intelligent Robots and Systems, Chicago, IL, 2014, pp. 3259-3265.
[4] Ioannis Poulakakis, James Andrew Smith & Martin Buehler (2005). Modeling and Experiments of Untethered Quadrupedal Running with a Bounding Gait: The Scout II Robot. The International Journal of Robotics Research, 24, 239-256.
[5] J. E. Seipel, P. J. Holmes, and R. J. Full, "Dynamics and stability of insect locomotion: a hexapedal model for horizontal plane motions," Biological Cybernetics, vol. 91, pp. 76–90, Aug 2004.
[6] Servet Soyguder, Hasan Alli, Kinematic and dynamic analysis of a hexapod walking–running–bounding gaits robot and control actions, In Computers & Electrical Engineering, Volume 38, Issue 2, 2012, Pages 444-458, ISSN 0045-7906.