Design of a locust-inspired miniature jumping robot

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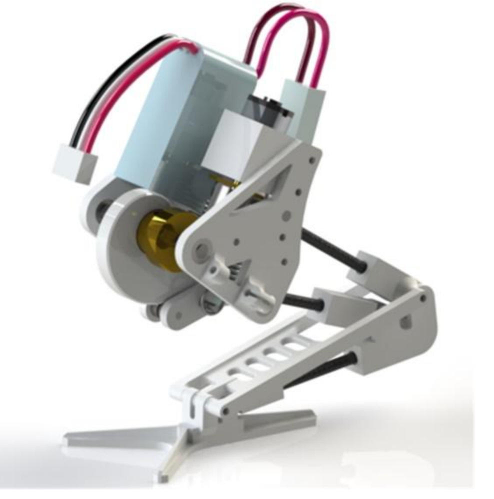
- The jumping function of locust was briefly introduced.
- The tumble of locust at flight phase after take-off was analyzed.
- Physical prototype was made to mimic the jump of locust.

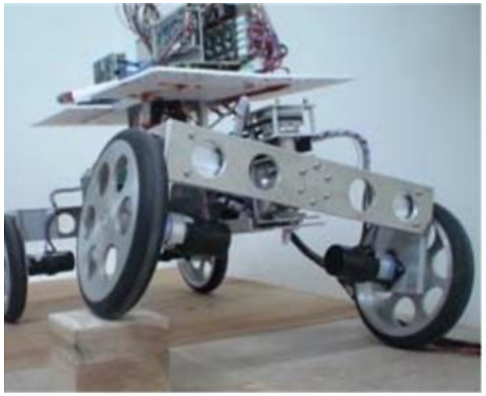


Virtual prototype of the jumping robot

Outline

1. Background of jumping robot
2. Jump locomotion of locust
3. Biological experiment
4. Analysis of locust take-off
5. Design of jumping robot
6. Physical prototype experiment
7. Conclusion and future work

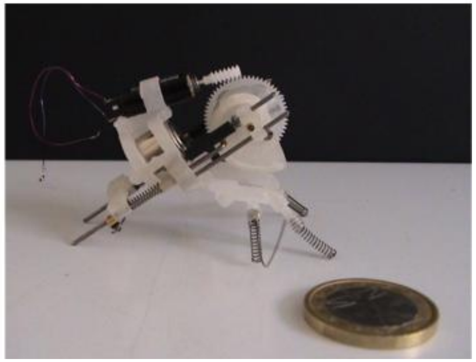
Background of jumping robot



(a) Wheeled robot [1]

(b) Walking robot [2]

(c) Snake-like robot [3]



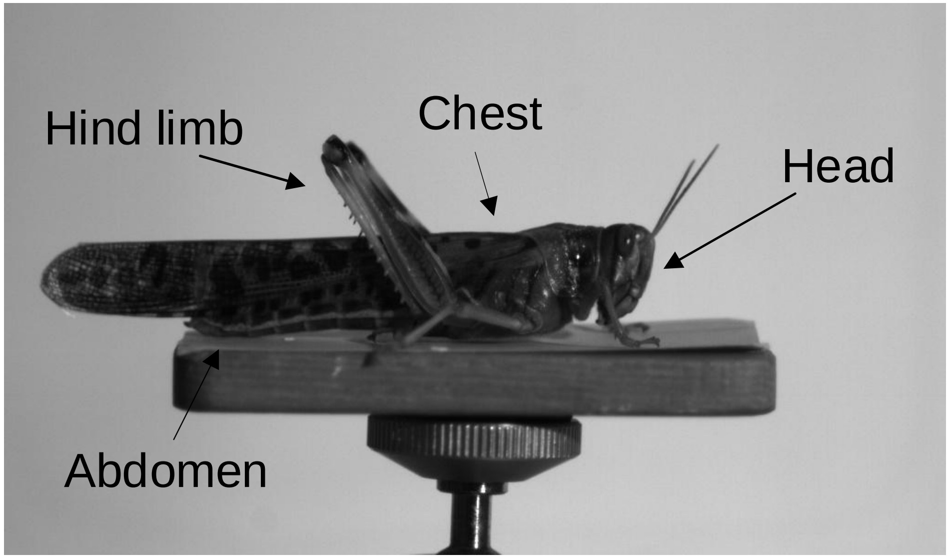
(d) Jumping robot [4]

Some types of terrain mobile robots

Advantages of jumping robot

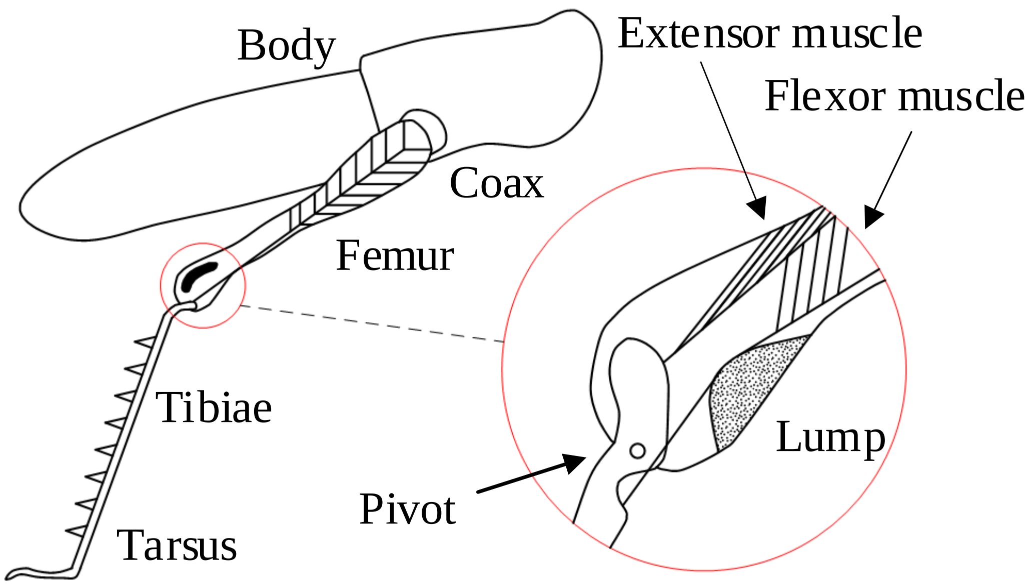
- Simple mechanical structure
- Fewer drivers
- Overcome obstacles

Jump locomotion of locust



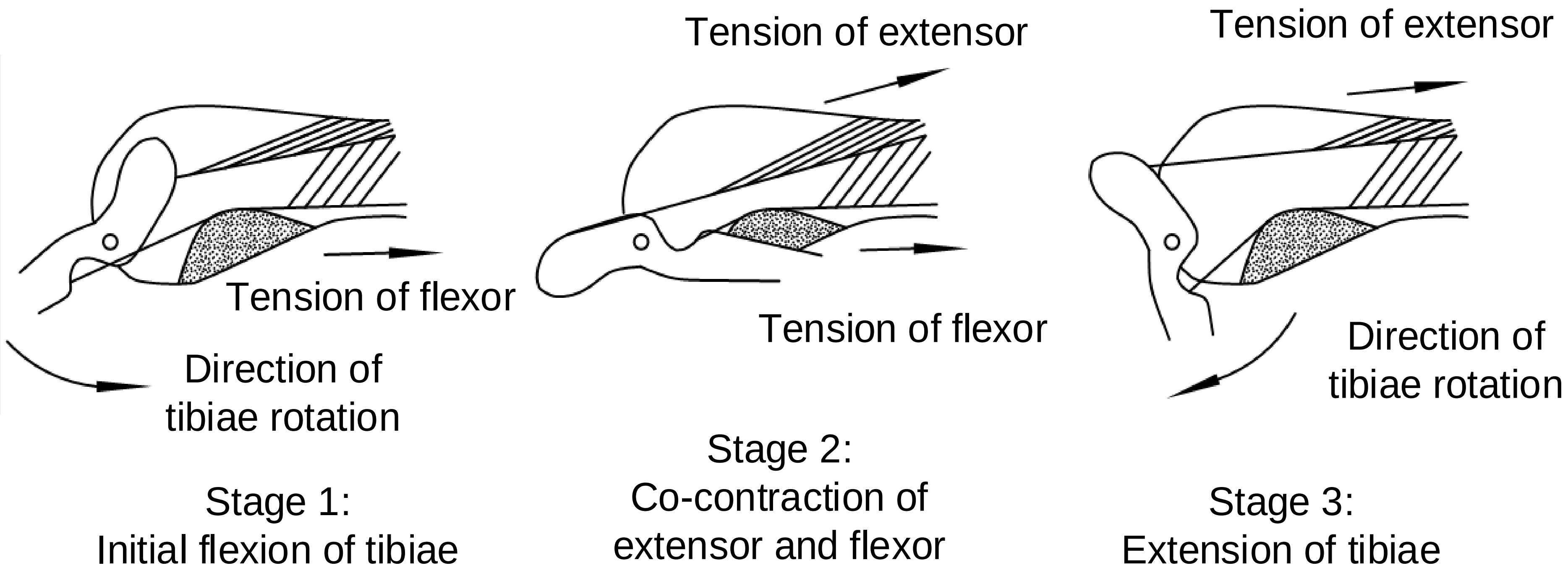
Structure of locust

The **hind limb** is the most important part for locust to jump.



Structure of hind limb

Jump locomotion of locust

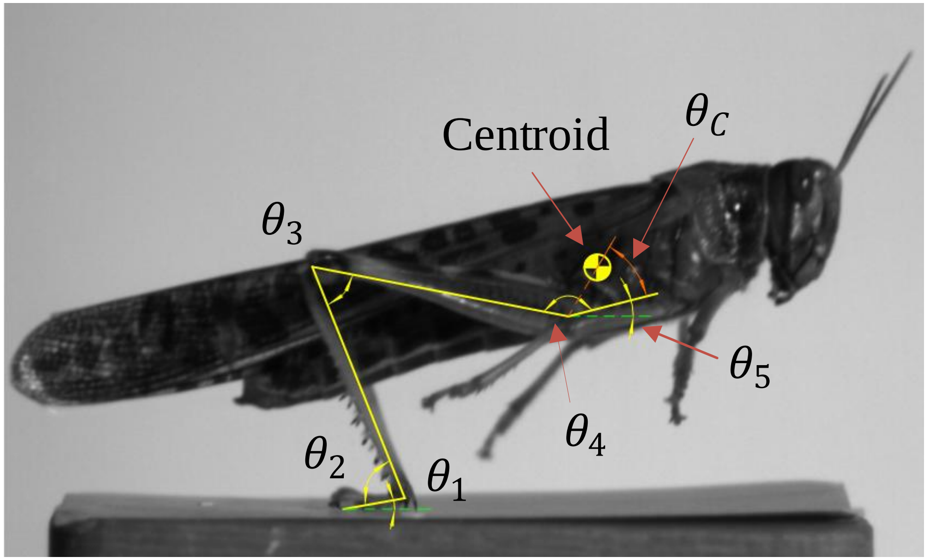


Three stages of locust take-off

Biological experiment of locust jump

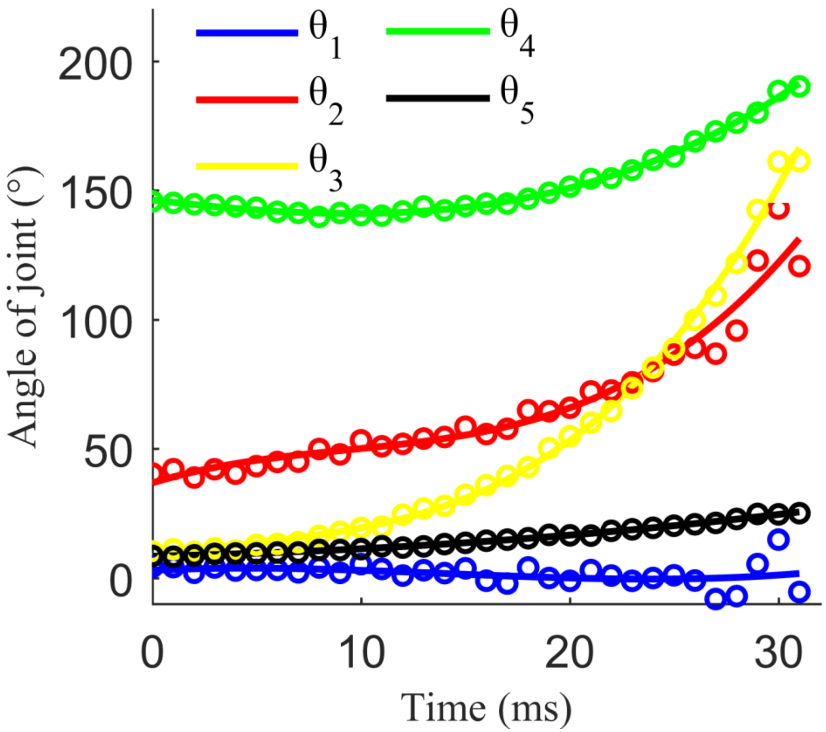
Experimental video of locust jump

- Basic parameters (length, mass)
- Variation of joint angles

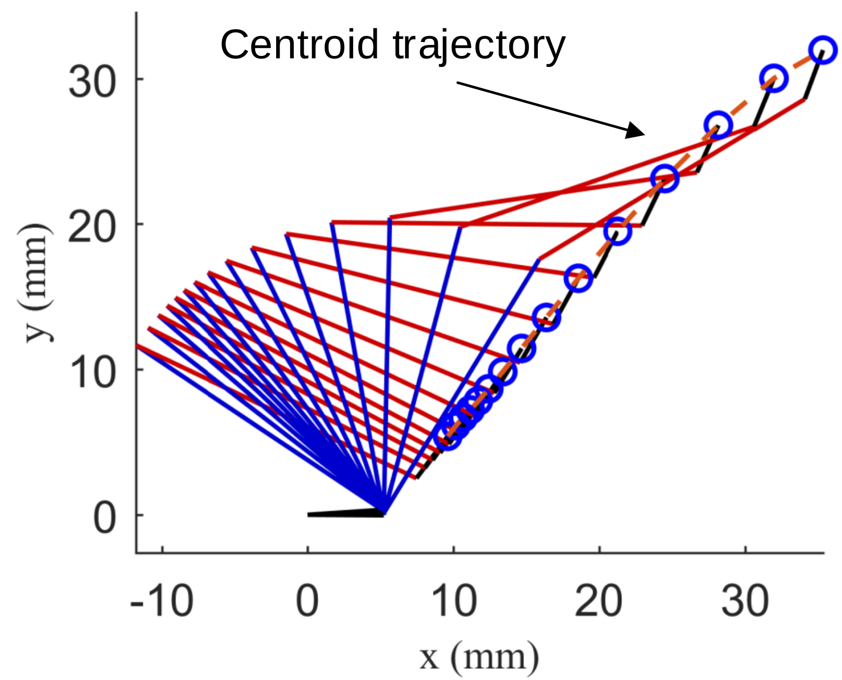


Calibration of joint angles

Kinematical analysis of locust take-off



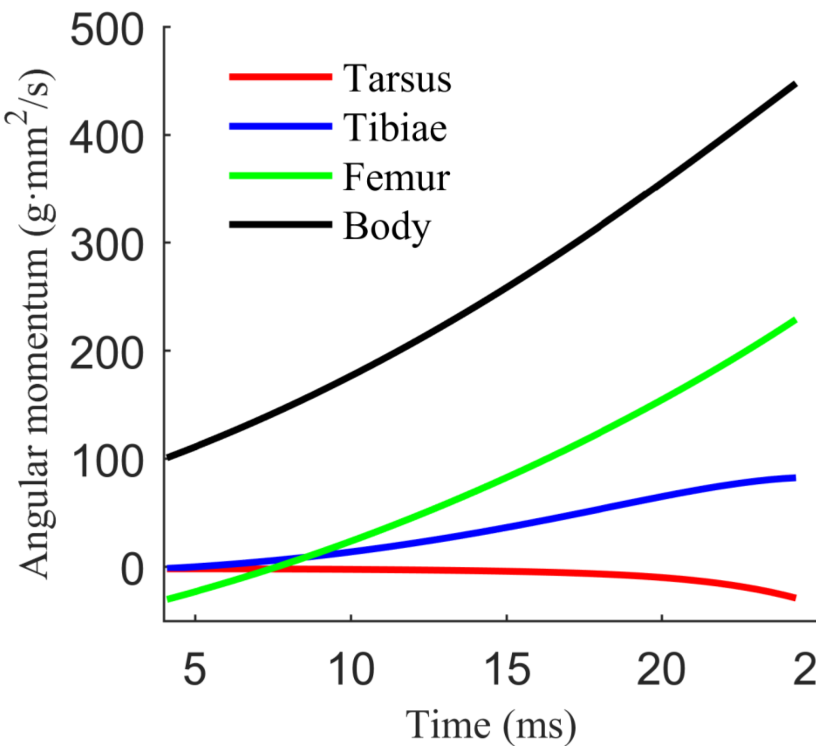
Joint angles at locust take-off



Posture of locust at take-off

The trajectory of locust centroid is approximatively a **straight line**, which makes locust has a certain jump direction.

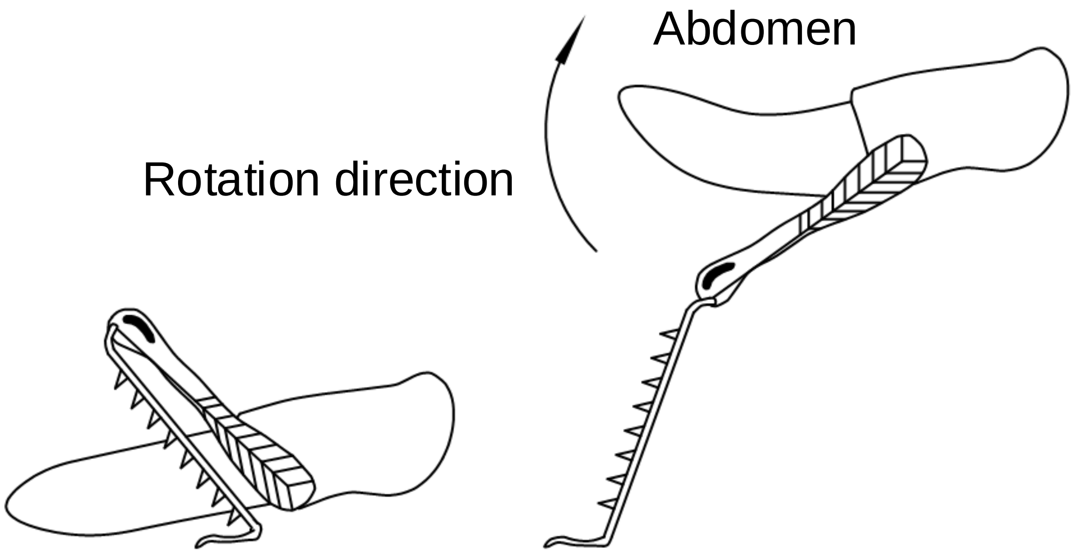
Analysis the tumble at locust jump



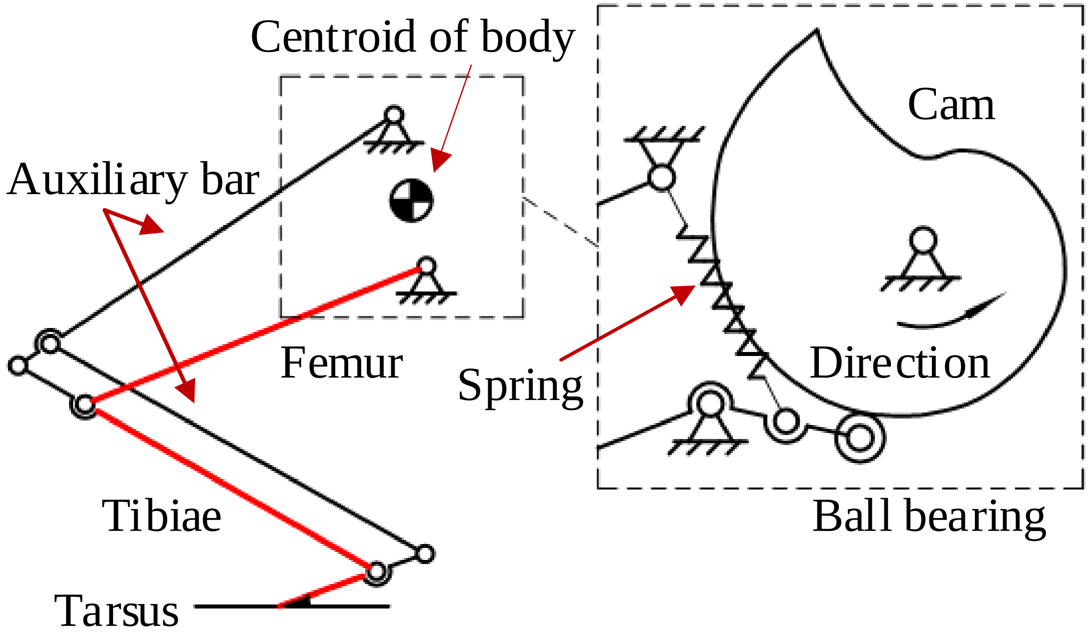
Angular momentum of each part at take-off

The **positive rotation** of **body** and **femur** directly cause the positive tumble.

Locust use its **abdomen** to adjust when it tumbles at jumping process.



Design of jumping robot

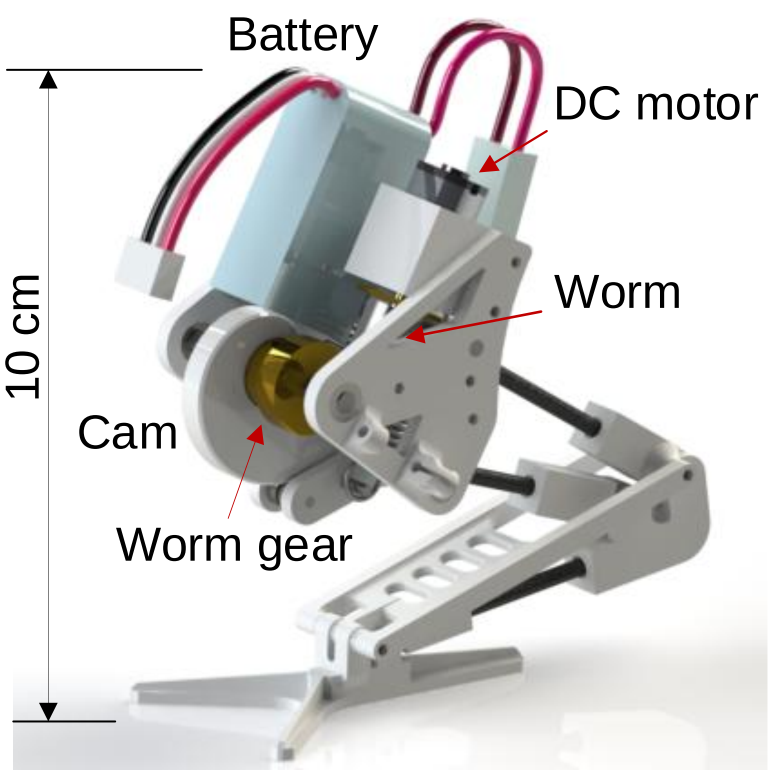


Mechanism of jumping robot

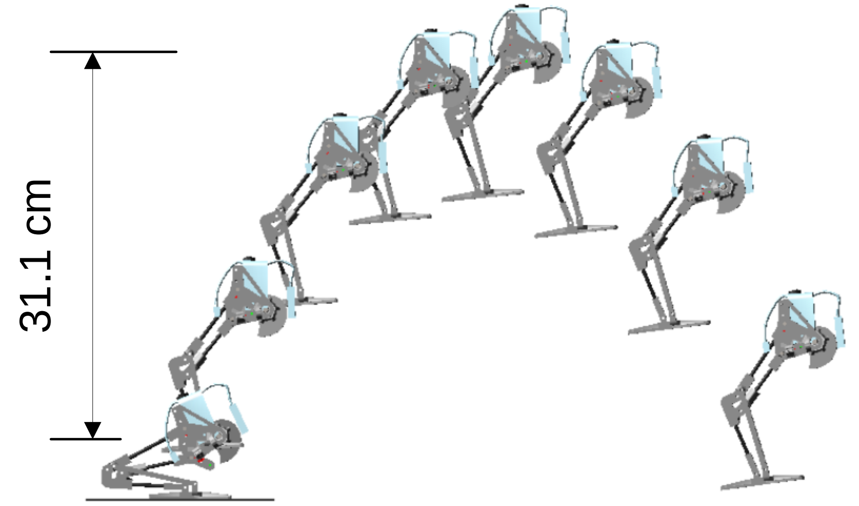
Design targets

- Morphological similarity
- Jump function
- Negative rotation of body

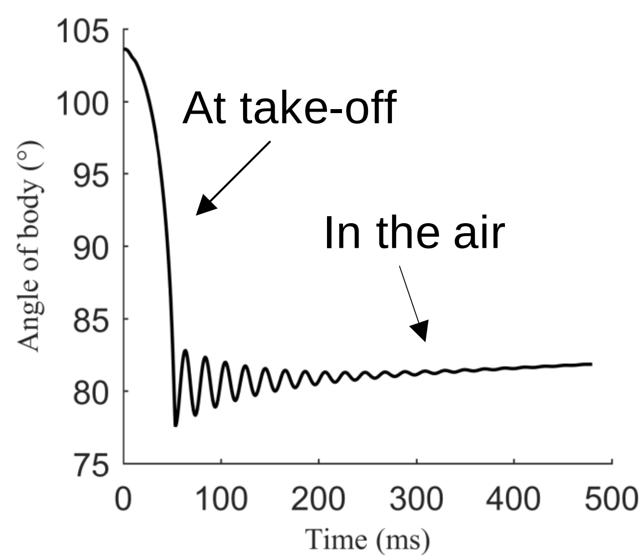
Design of jumping robot



Virtual prototype in CAD



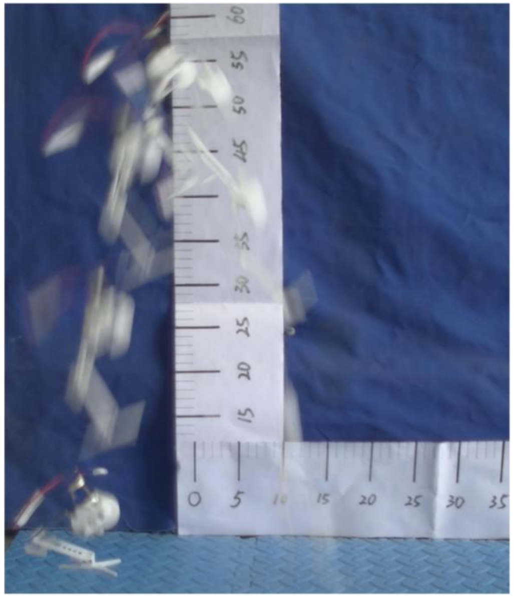
Jump simulation in ADAMS



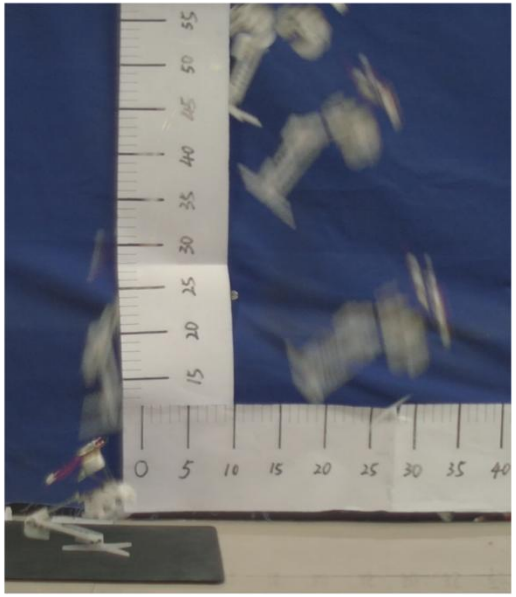
Rotation of body during jump

Virtual prototype keep stable at flight phase.

Physical prototype experiment

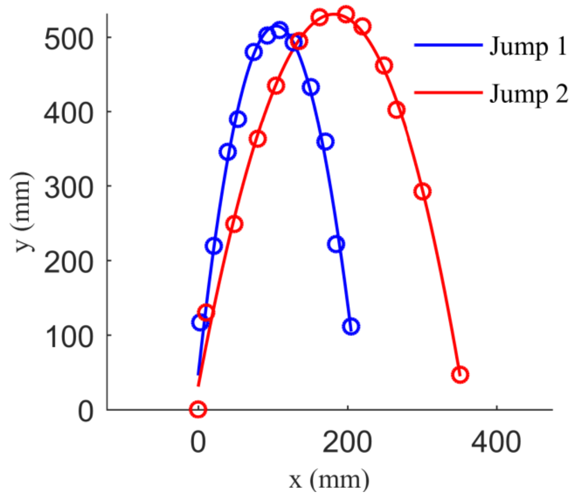


Jump 1

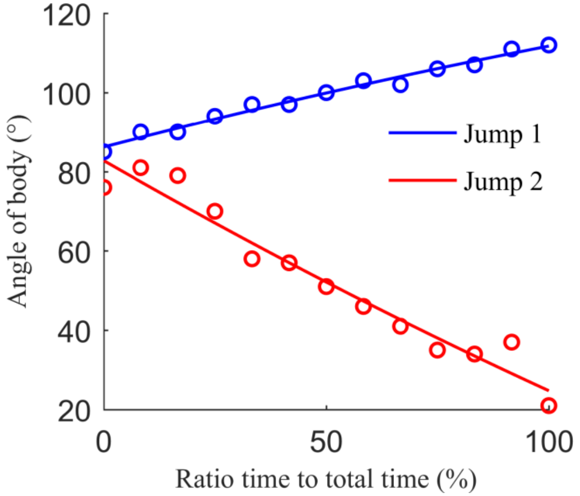


Jump 2

Two jump experiments. Jump 1 was on foam board, Jump 2 was on nylon cushion.



Trajectory of body centroid



Rotation of body during jump

Conclusion and future work

Conclusion

- Analyze the tumble
- Physical prototype
- Improve the jump stability

Future work

- Mimic the grasping of tarsus
- Analyze landing process

Reference

[1] S. Nakajima. "Concept of a novel four-wheel-type mobile robot for rough terrain, RT-Mover." IEEE/RSJ International Conference on Intelligent Robots and Systems, pp. 3257-3264, 2009.

[2] B. G. A. Lambrecht, A. D. Horchler, and R. D. Quinn. "A small, insect-inspired robot that runs and jumps." IEEE International Conference on Robotics and Automation, pp. 1240-1245, 2005.

[3] B. Lin, S. Ma, C. Y, et al. "Development of an amphibious snake-like robot." Proceedings of the 8th World Congress on Intelligent Control and Automation, pp. 613-618, 2010.

[4] U. Scarfogliero, F. Li, D. Chen, C. Stefanini, W. Liu, P. Dario. "Jumping mini-robot as a model of scale effects on legged locomotion." IEEE International Conference on Robotics and Biomimetics, pp. 853-858, 2007.