Multi-modal jumping and crawling in an autonomous, springtail-inspired microrobot

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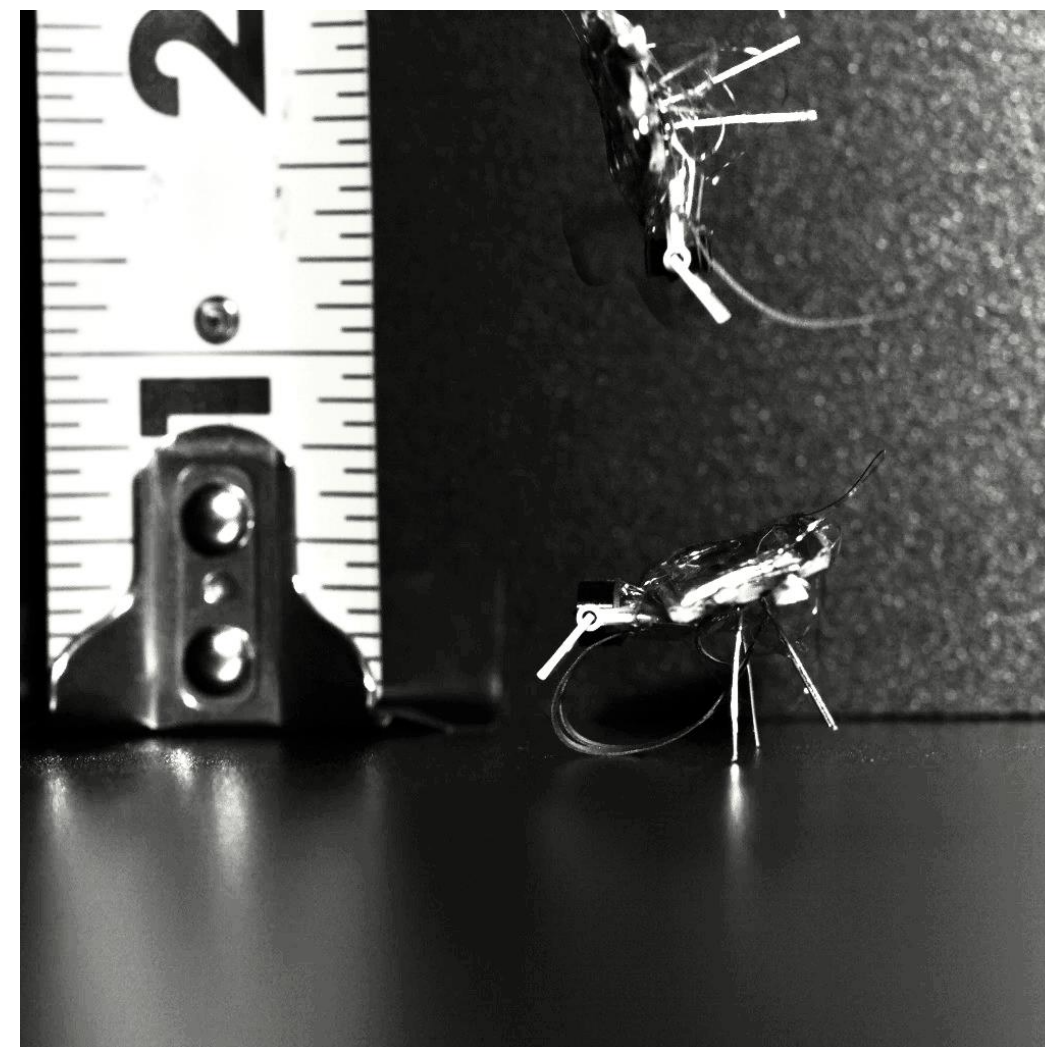*University at Buffalo[1], Carnegie Mellon University[2]*

ICRA2024
May 13-17, Yokohama, Japan

https://github.com/RobotFormAndFunction/Springtail_microrobot
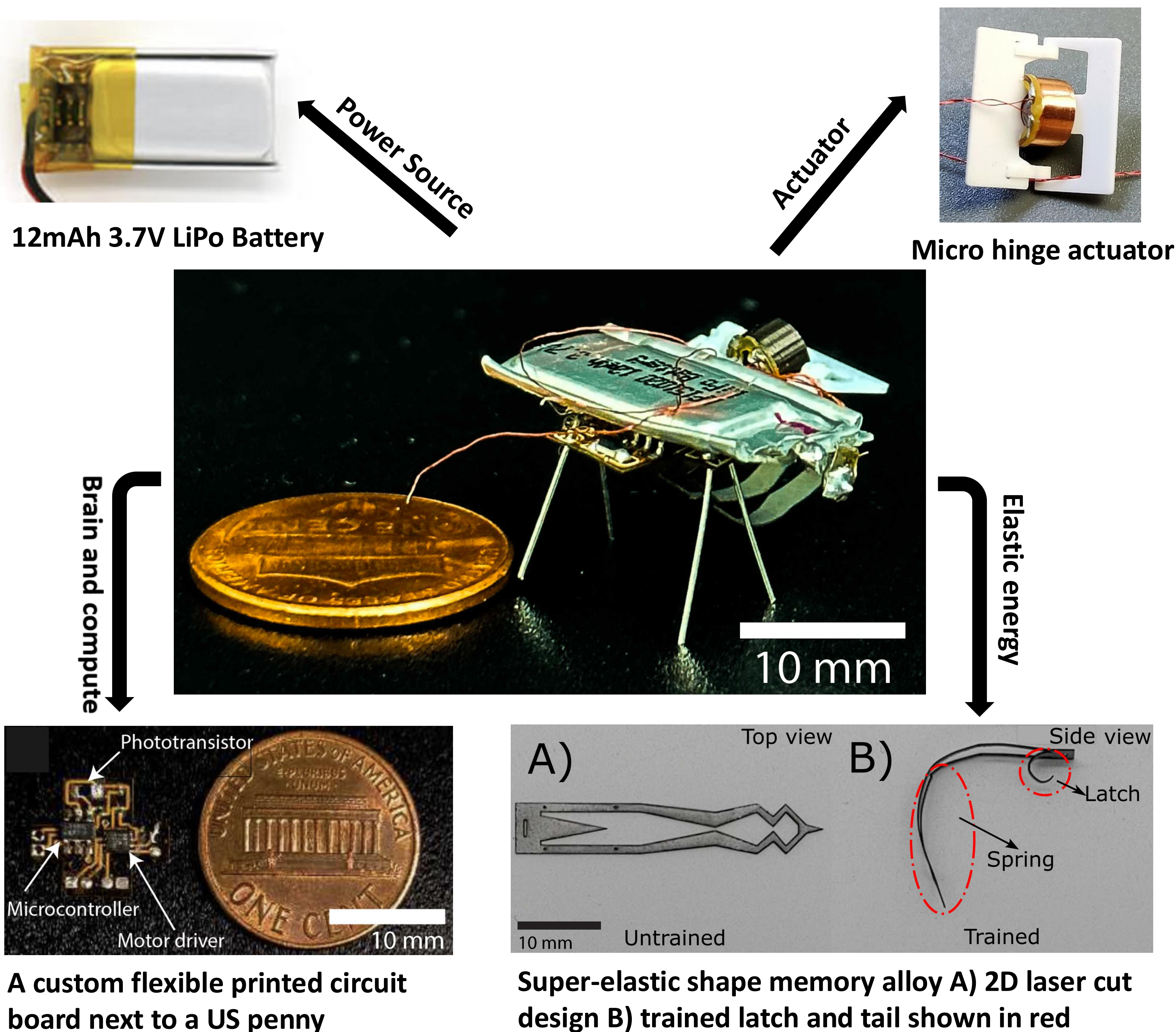
Bioinspiration from springtail insect

Designing a multimodal microrobot that both crawls and jumps and integrating on-board sensing, computation, and power is a problem to tackle for resource-constrained microrobots. We designed a springtail-inspired microrobot that overcomes these problems while weighing 980 mg and being 13mm tall.
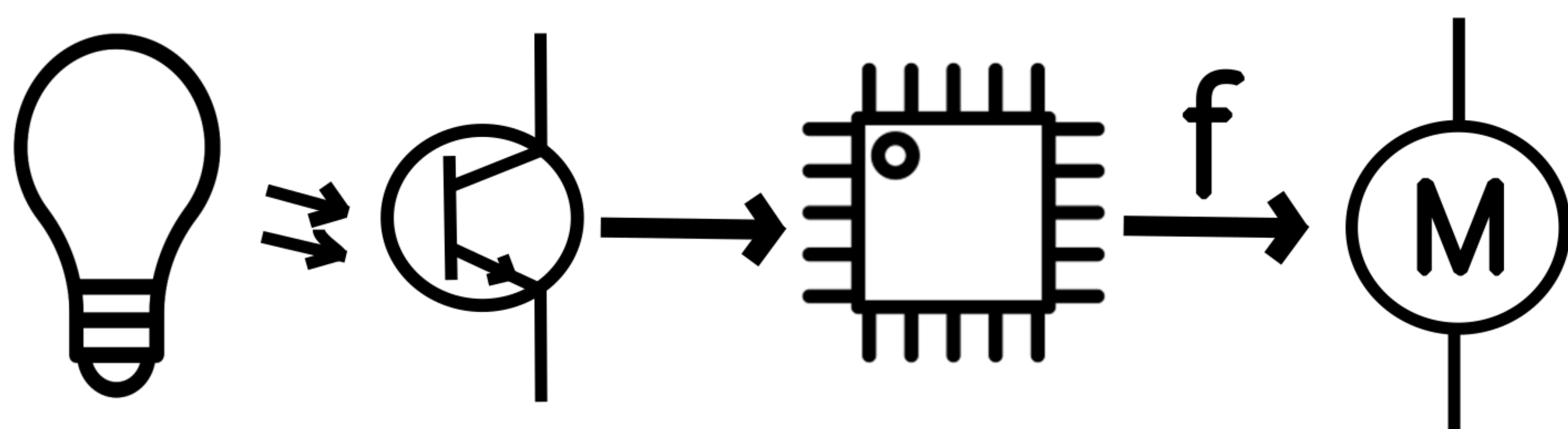

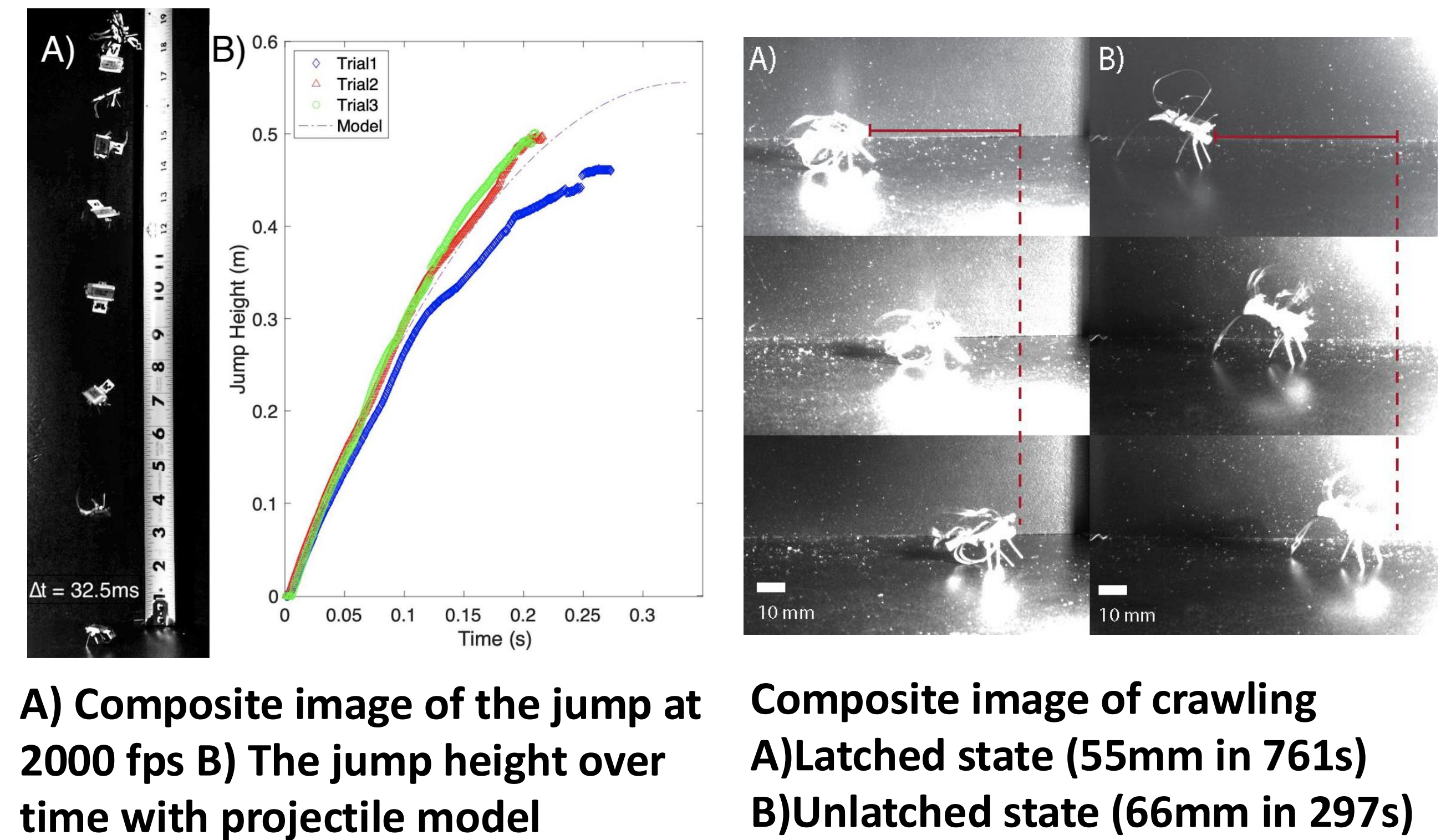**Image courtesy of Dr. Adrian Smith**

Design of microrobot

Power Source

12mAh 3.7V LiPo Battery

Actuator

Micro hinge actuator

Brain and compute

Elastic energy

10 mm

A custom flexible printed circuit board next to a US penny
Phototransistor, Microcontroller, Motor driver

Super-elastic shape memory alloy A) 2D laser cut design B) trained latch and tail shown in red
A) Top view, Untrained B) Side view, Latch, Spring, Trained
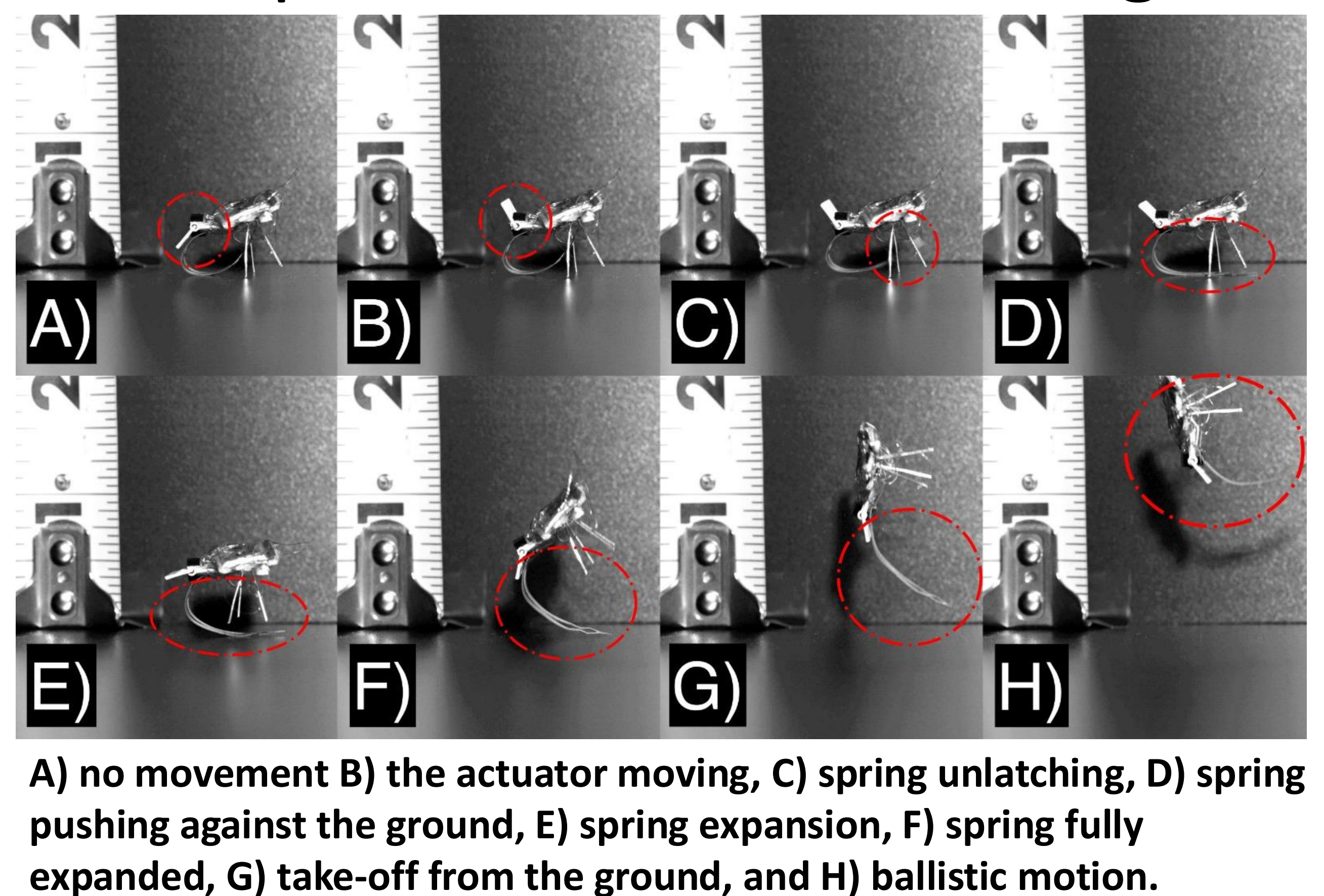
Autonomous behavior

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- Light sensed by the phototransistor.
- The microcontroller checks the voltage threshold from the phototransistor.
- If it is above the set threshold, the microcontroller sends a preprogrammed frequency to the motors.
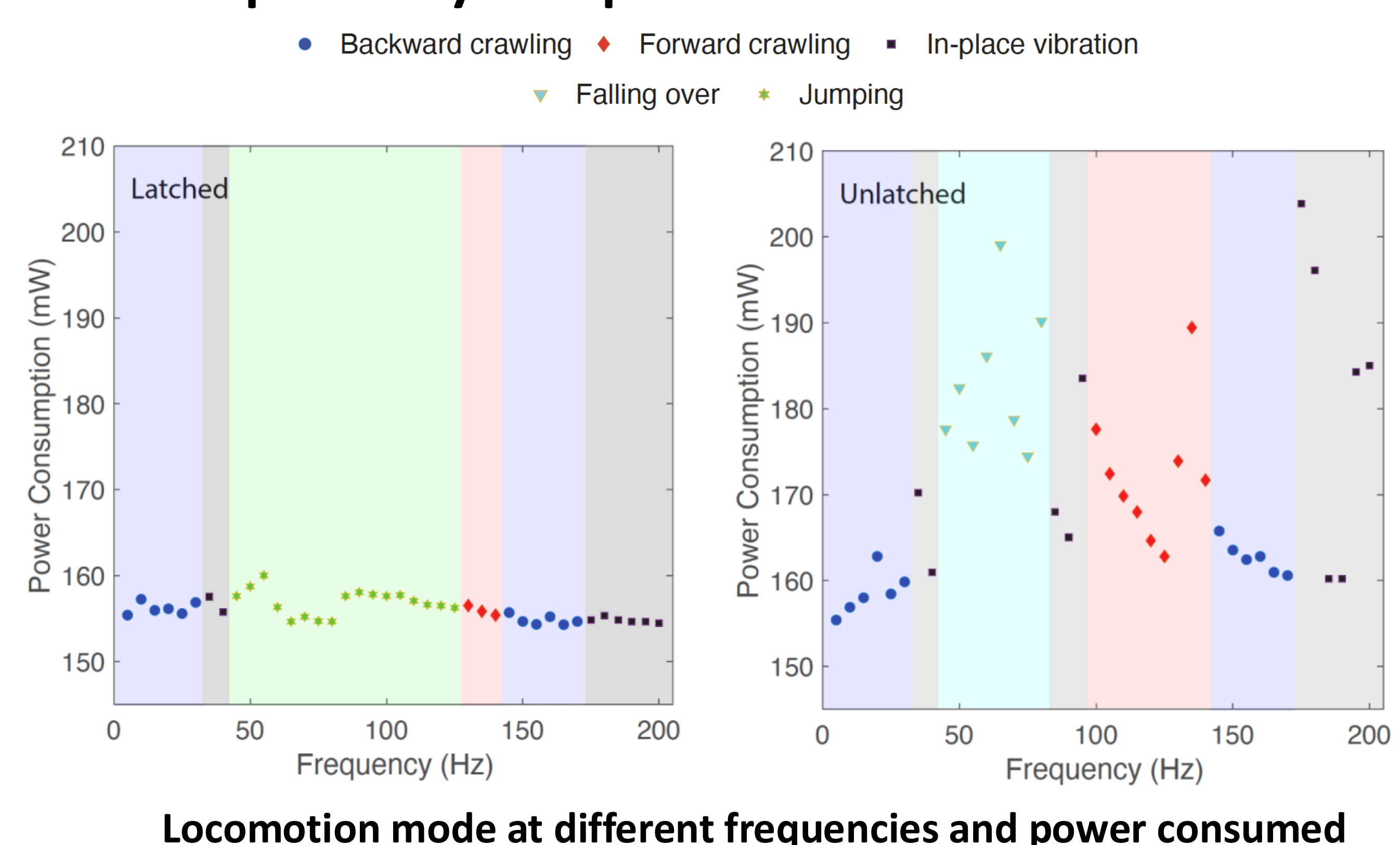- Depending on the actuation frequency, the robot will exhibit different locomotion modes.

Multimodal locomotion

A) Composite image of the jump at 2000 fps B) The jump height over time with projectile model

Composite image of crawling A)Latched state (55mm in 761s) B)Unlatched state (66mm in 297s)

Steps involved in unlatching

A) no movement B) the actuator moving, C) spring unlatching, D) spring pushing against the ground, E) spring expansion, F) spring fully expanded, G) take-off from the ground, and H) ballistic motion.

Frequency dependent locomotion

Backward crawling • Forward crawling • In-place vibration • Falling over • Jumping

Locomotion mode at different frequencies and power consumed

Contributions

- Autonomous microrobot with on-board computation, sensing, actuation, and power under one gram.
- Multi-modal crawling and jumping in microrobot.
- Needs 160mW of power to jump 45cm in height.
- A step closer to the deployment of microrobots into the real world.
- Open-access source files and code on GitHub.