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## Novel test bench for robotic leg characterization

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► **To cite this version:**

Ilya Brodoline, Stéphane Viollet, Julien Serres. Novel test bench for robotic leg characterization. 46ème congrès de la Société de Biomécanique, Oct 2021, Saint-Etienne, France. . hal-03418366

**HAL Id: hal-03418366**

**<https://amu.hal.science/hal-03418366v1>**

Submitted on 7 Nov 2021

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## CONTEXT

How to evaluate and compare the performances of a robot's leg with one and a same test bench ?

### A unique test bench structure

Like procedures used to evaluate human walk specific aspects[1], or test benches built to study insects' locomotion [2], our test bench **merges the commonly used structures** in a one and a same setup, allowing **to assess characteristics of the locomotion**.

The tested leg, attached to a vertical moving stage, walks on a **3D printed treadmill simulating the ground movement**, according to three scenarios:

#### 1- Walking leg on a free treadmill

Giving an estimation of the locomotion characteristics.

#### 2- Walking leg on a resistive treadmill

Giving an estimation of the locomotion forces.

#### 3- Weight lifting

Giving an estimation of the structure resistance, leg maximal load and temperature.

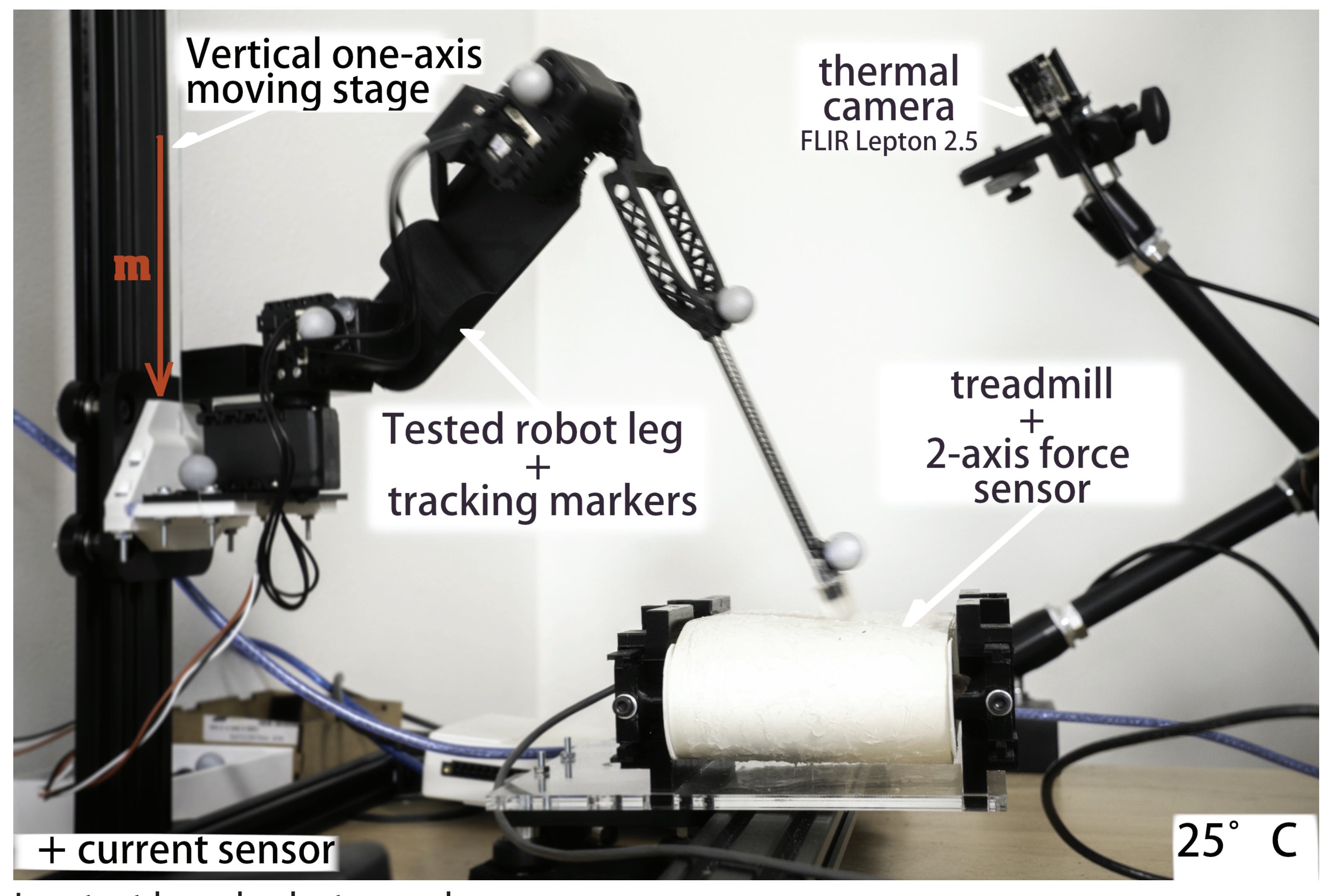
## RESULTS

Result table, computed from the data provided by the test bench, comparing characteristics estimated from the robot leg and from of an artificial or biological agent, here a *Cataglyphis fortis* ant.

Parameters	Hexapod ×6 legs (scaling)	Scale factor $\alpha$ 20:1	Ant
<b>Global characteristics</b>			
Mass	1572g (196.5mg)	$\alpha^3$	4.3 mg
Power	80W		-
<b>Locomotion</b>			
Max. speed	19cm/s (0.475cm/s)	$\alpha^{\frac{1}{2}}$	9.5cm/s <sup>[4]</sup>
Stride length	104mm (5.2mm)	$\alpha$	5-15 mm <sup>[4]</sup>
Stride max frequency	1.8Hz (8Hz)	$\alpha^{-1/2}$	30Hz <sup>[4]</sup>
Ineffective stance	13%	-	-
Step accuracy	±11.5mm	-	-
Max normal / tangent stress	12N / 1N	-	0.32mN / -
<b>Energetics</b>			
Cost of transport <sup>[5]</sup>	6.18	-	39
Temp. increase	3.2°C/min	-	-

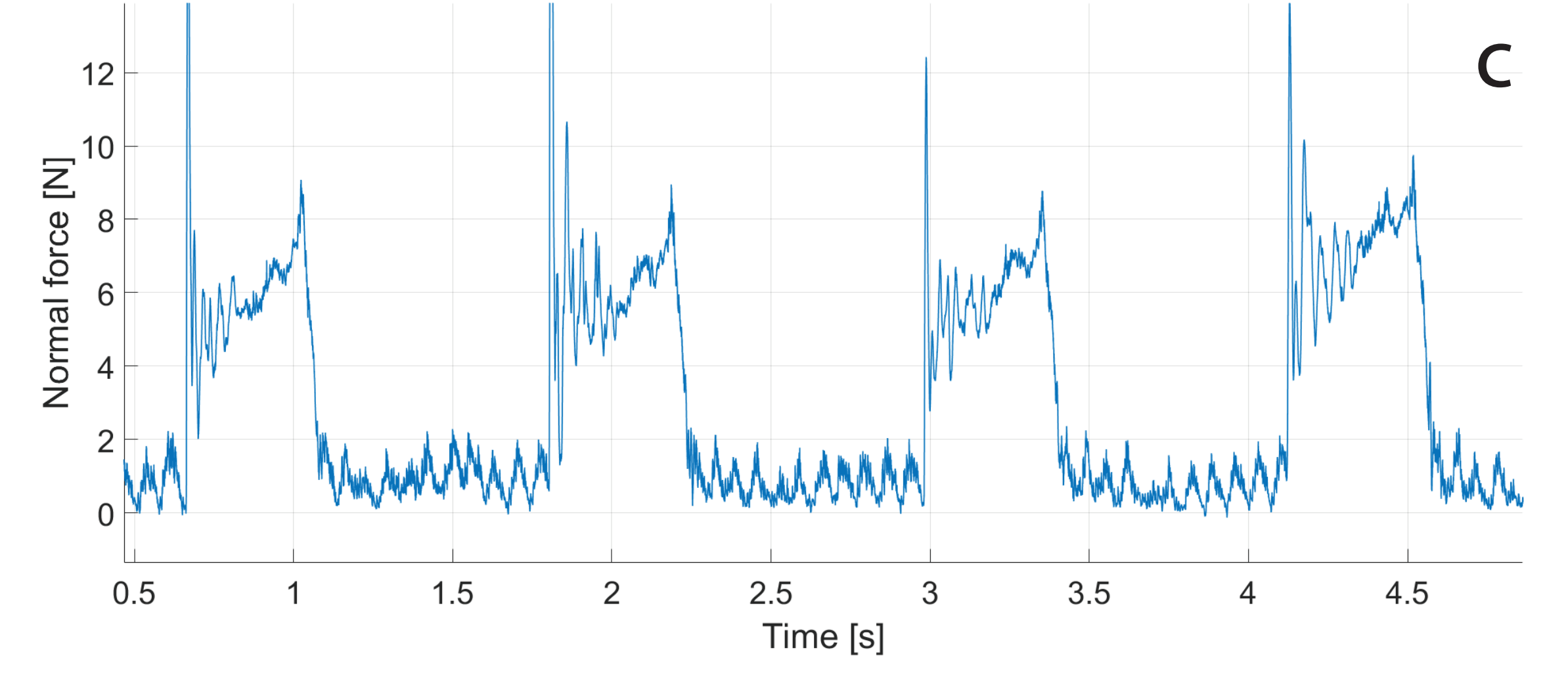
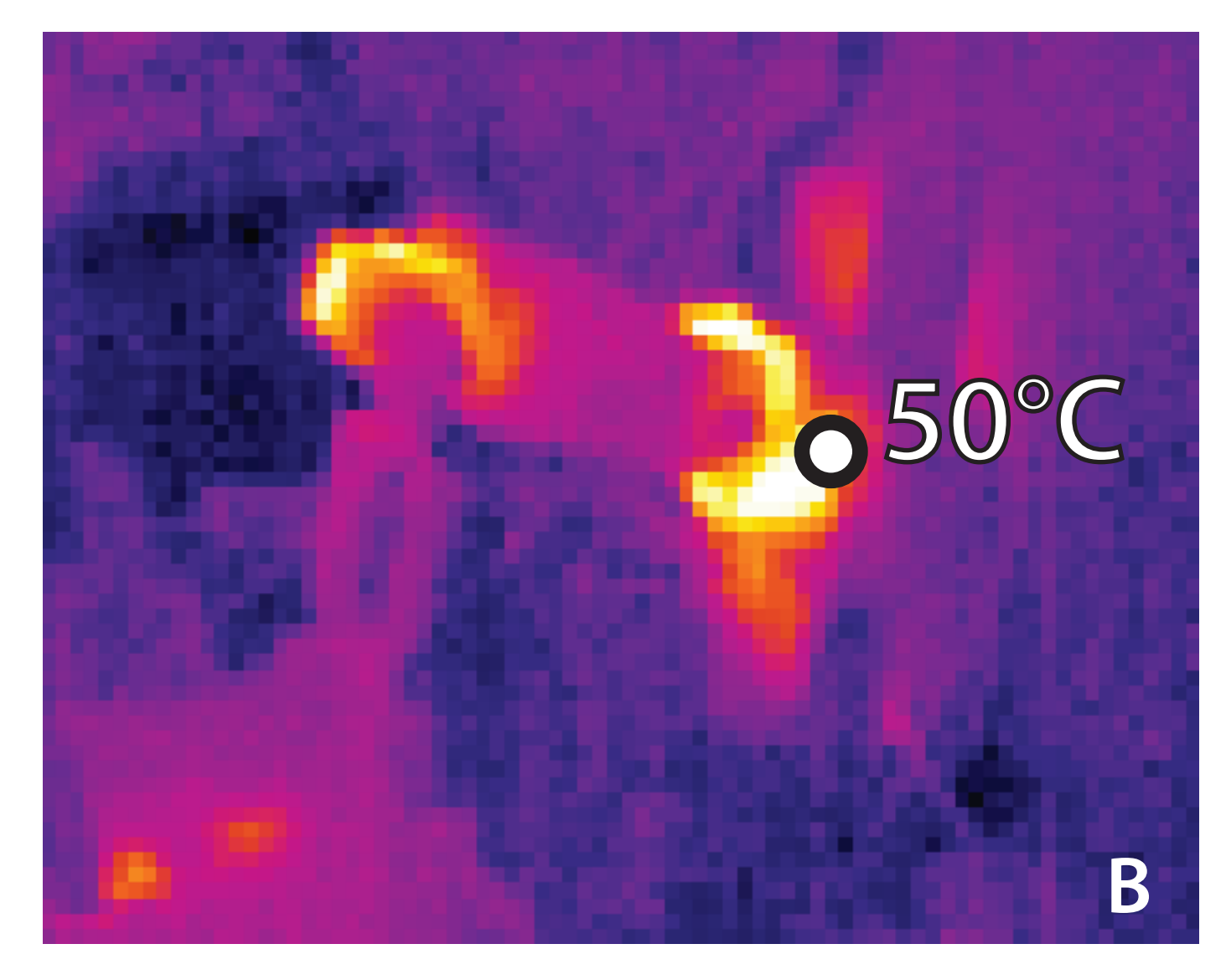
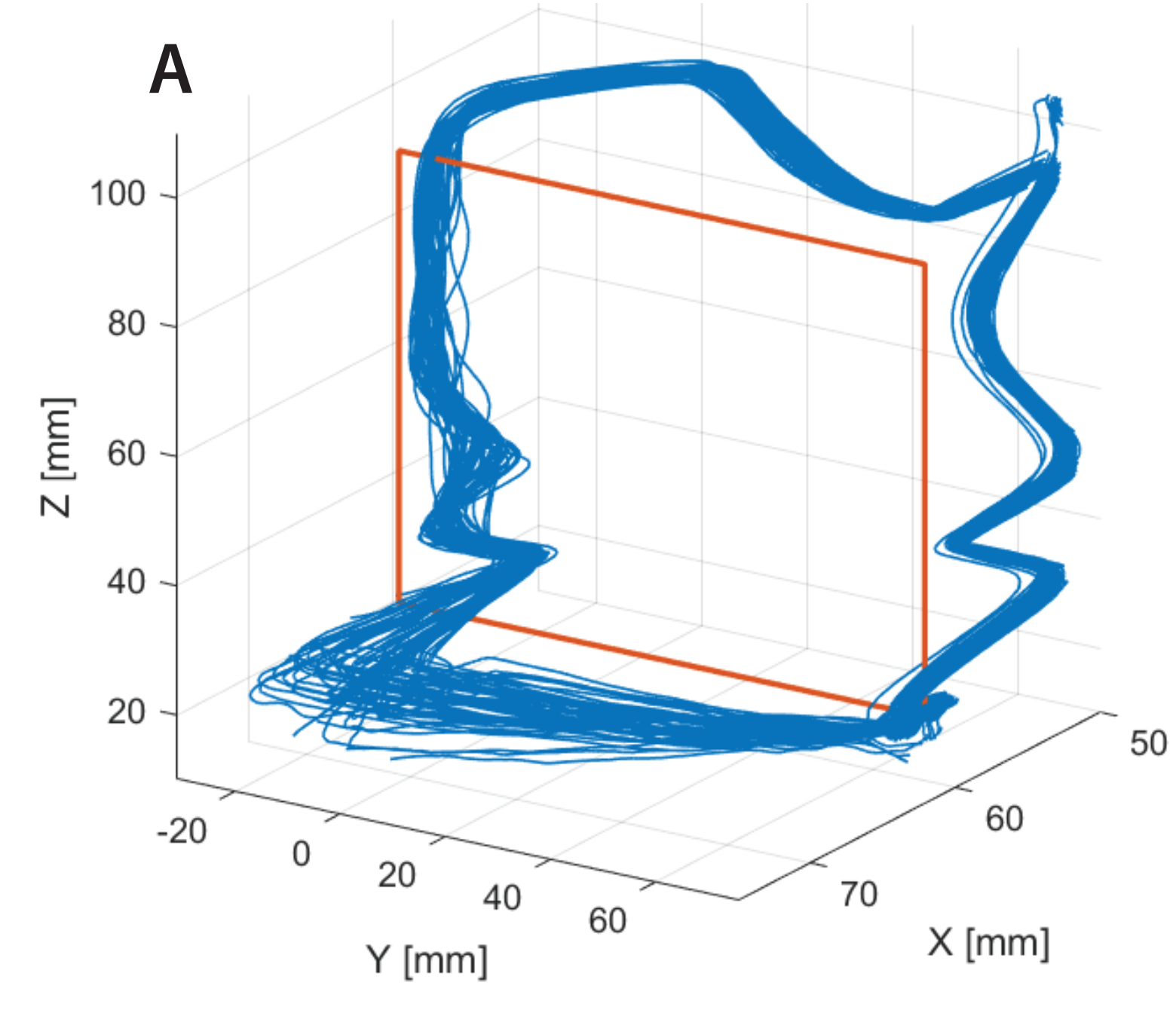


## EXPERIMENTAL SETUP



Leg test bench photography.

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Sample of data, measured by the test bench during a walk.

- (A) Leg tip 3D coordinates, given by motion capture.
- (B) Thermal camera image after a 10min walk with no load.
- (C) Treadmill normal force measurement.

## CONCLUSION

The resulting table shows the extremal values reached during a robot walk, giving the limits of the structural leg design.

These values provide:

- **Information about the usability of the robot**, giving us the possibility to predict the maximum distance travelled over a flat terrain with a specific roughness.
- **Criteria to compare** performances between various robotic legs, then those of animal counterparts, here ants.
- **Thermal performances**, since overheating of the servomotors during the walk is one of the main limiting factors of the robot's endurance.

[1] M. Hashmi et al. Applied Sciences, 2019

[2] C.J. Dallmann et al. Proceedings of the Royal Society B: Biological Sciences, 2016

[3] J.E. Clark et al. Robotics: Science and Systems, 2008.

[4] V. Wahl et al. Journal of Comparative Physiology, 2015

[5] S. Seok et al.. Proceedings of the IEEE International Conference on Robotics and Automation; 6-10 May; Karlsruhe, Germany, 2013