Novel test bench for robotic leg characterization

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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:

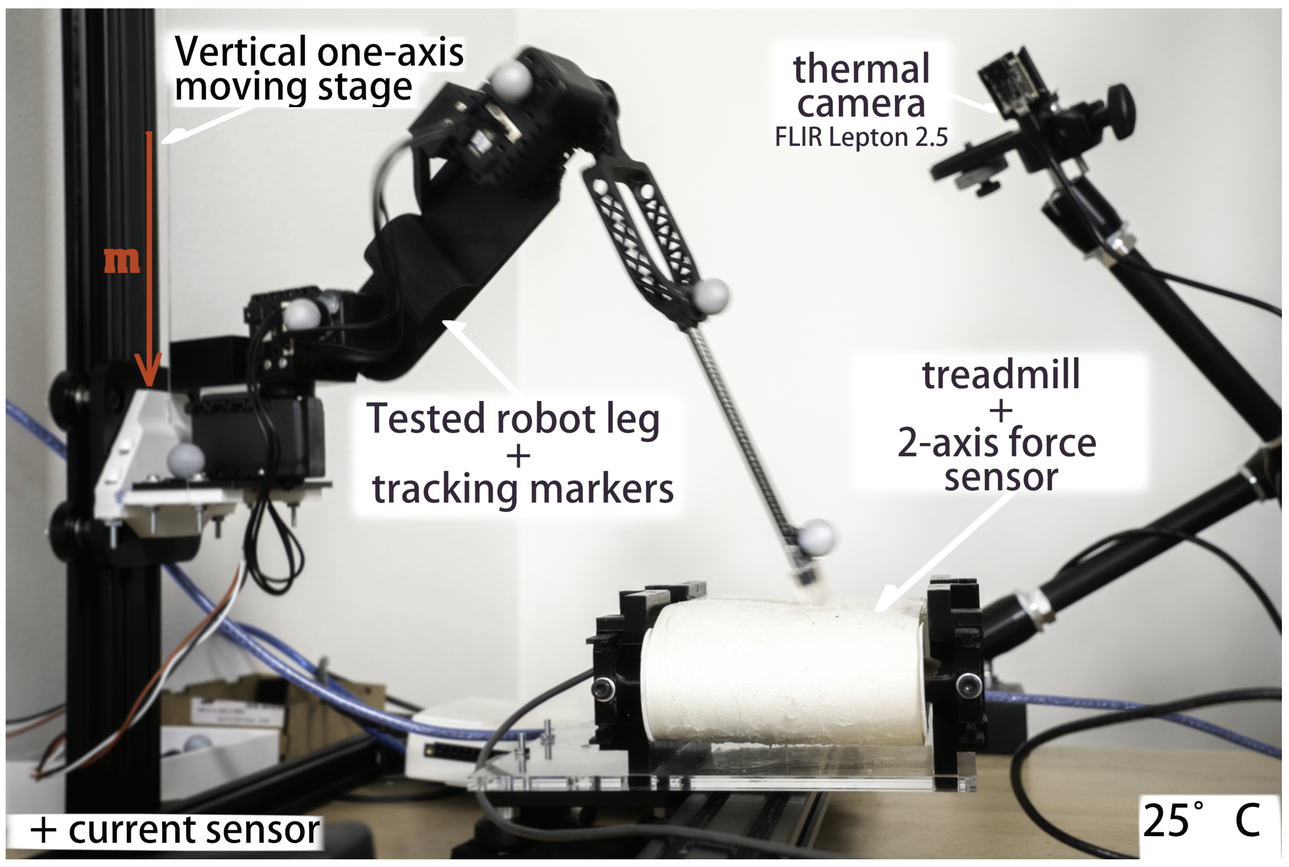
1- Walking leg on a free treadmill
Giving an estimation of the locomotion characteristics.
2- Walking leg on a resistive treadmill
Giving an estimation of the locomotion forces.
3- Weight lifting
Giving an estimation of the structure resistance, leg maximal load and temperature.

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

EXPERIMENTAL SETUP



Leg test bench photography.
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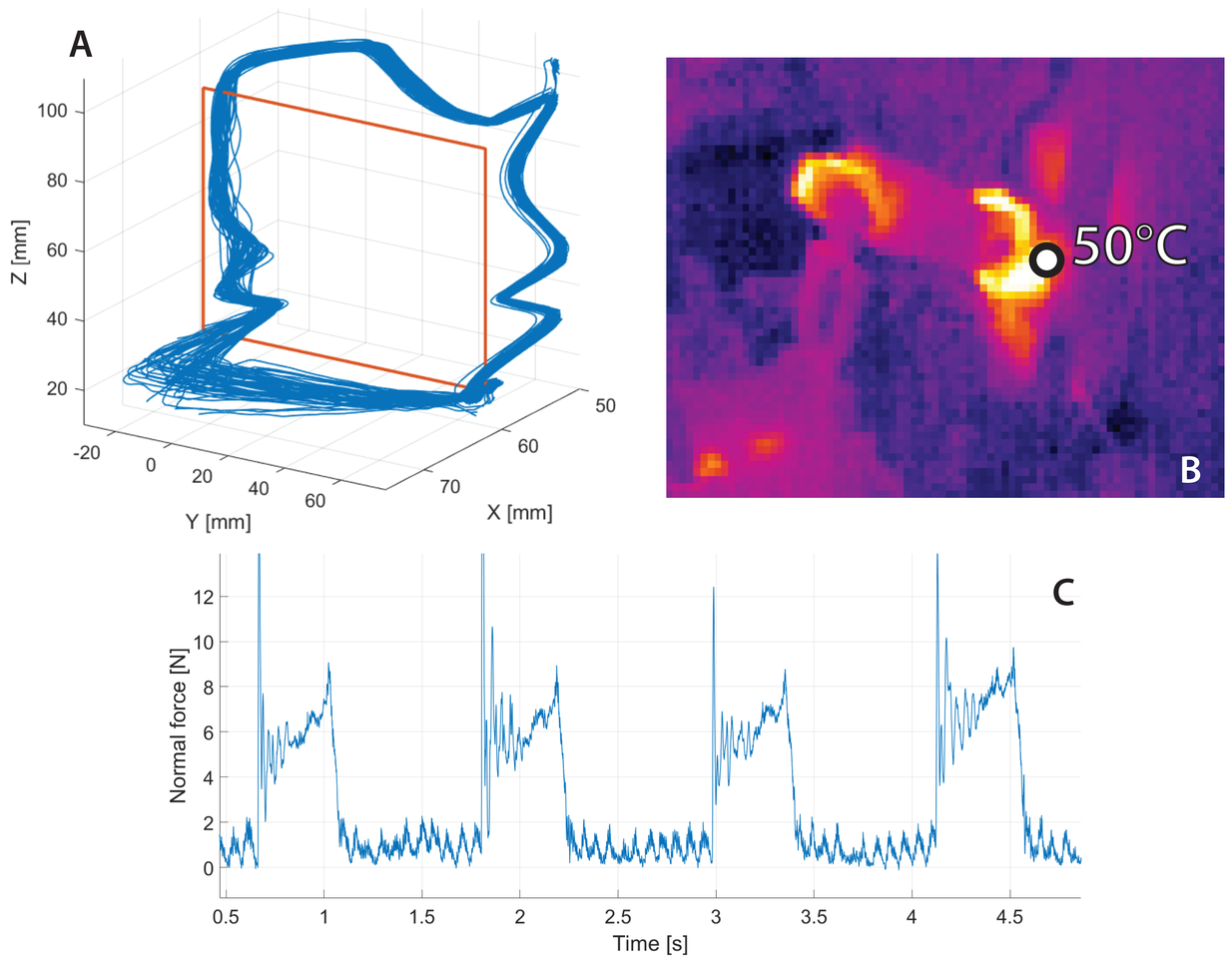

Sample of data, measured by the test bench during a walk.
(A) Leg tip 3D coordinates, given by motion capture.
(B) Thermal camera image after a 10min walk with no load.
(C) Treadmill normal force measurement.

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] CJ. Dallmann et al. Proceedings of the Royal Society B: Biological Sciences, 2016
[3] JE 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

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