Porting Reflex-Based Muscles Control to Real Humanoid Robots

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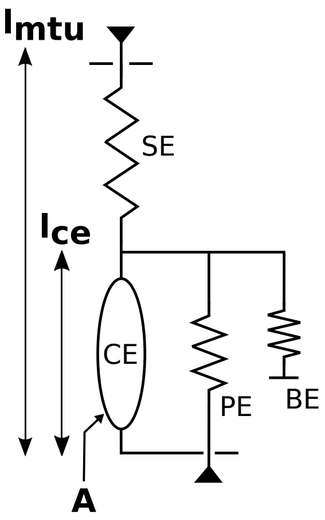
Motivation & Implemented algorithm

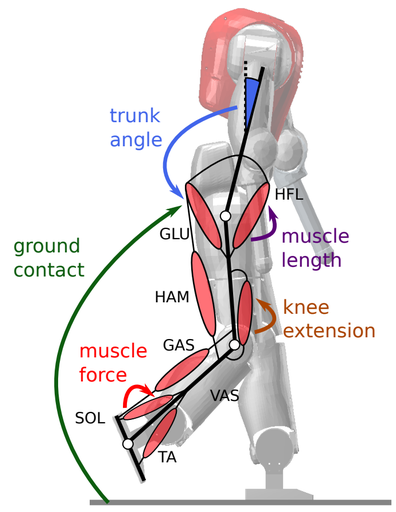
While many classical approaches achieve nice gaits with humanoid robots, we are still far from the **impressive human walking capabilities**.

Bio-inspired algorithms are being developed, generating more **energy-efficient** and **human-like** gaits, but they are mostly limited to simulation studies.

Geyer and Herr (2010) developed a controller based on **muscles controlled by reflexes** to perform human-like walking in simulation.

In this study, we want to **port this controller to a real humanoid robot**, namely the COMAN.





Challenges & Proposed solutions

Challenges appear compared to simulations:

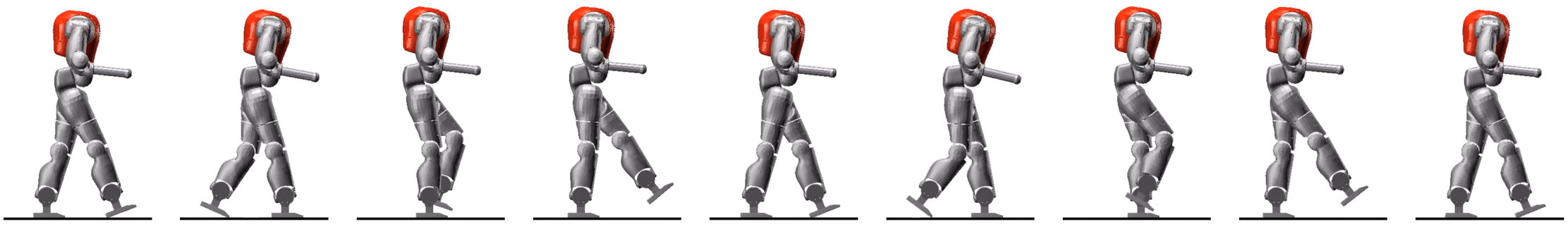
- world non-idealities
- heavy experimental procedure
- optimization difficult to do on the real robot
- lateral balance not ensured

Proposed **solutions**:

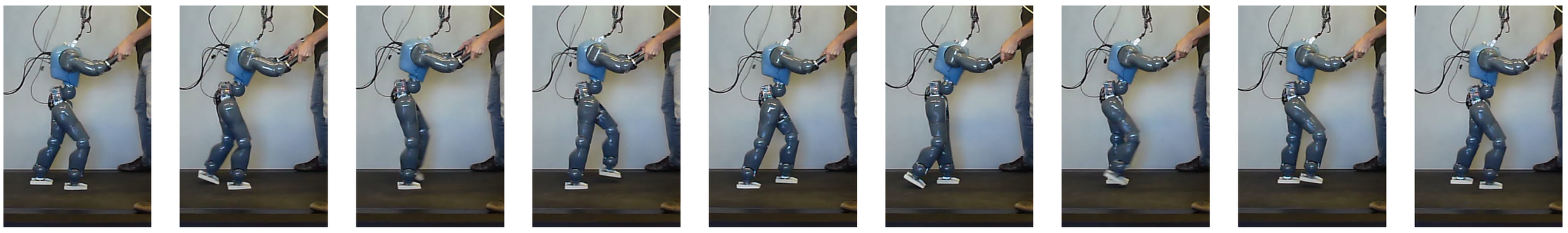
- controller development and optimization **first performed in simulation**
- lateral balance achieved using an **extra controller for the upper body**

Results - From simulation to real hardware

The gait controller is optimized in a **simulation environment**, rewarding solutions minimizing the metabolic energy comsumption.



The gait controller optimized in simulation is ported to the **real robot** with no modification.



Gait analysis

Main features

- similar behaviour during **stance** and **swing initiation**
- **human gait** characteristics (stretched stance leg. . .)
- **flexed swing** leg
- **swing knee flexion issue** impacts step length, step frequency and heel strikes, reducing the walking speed
- robot manages to perform a 50 steps walk, demonstrating some kind of **robustness** for this bio-inspired controller

Similarities with simulation

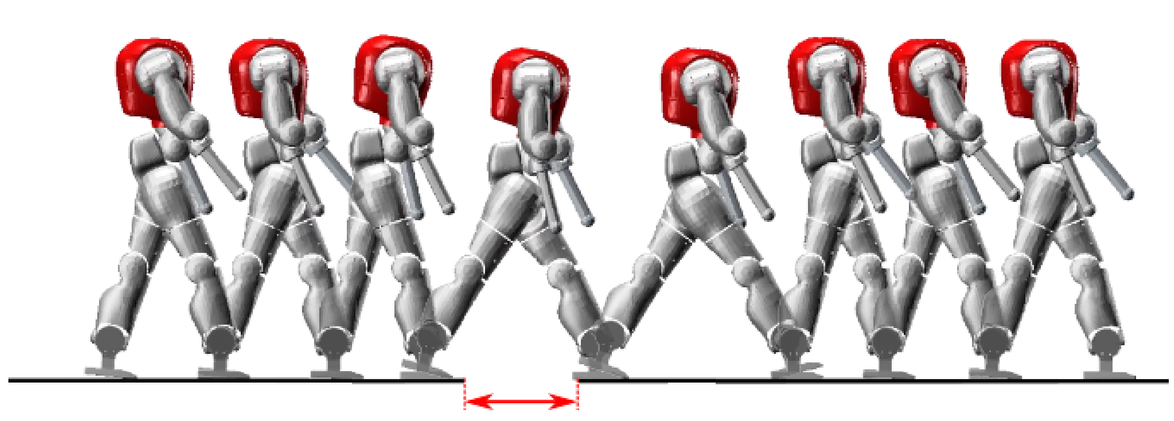
- stretched stance leg
- rolling foot at swing initiation

Differences with simulation

- flexed knee during late swing
- shorter steps with lower frequency
- missing heel strikes

Further developments

- solving the knee flexion issue
- implementing lateral balance control
- achieving gait modulation through feed-forward signals



During this ICRA conference, we will present a new bio-inspired controller recruiting **central pattern generators** on top of the reflexes to modulate the steps length and frequency (FrP2T7 Regular Session, WSCC 612, Friday May 29, 16:10).

Acknowledgment & References

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H. Geyer and H. Herr. "A muscle-reflex model that encodes principles of legged mechanics produces human walking dynamics and muscle activities", in *Neural Systems and Rehabilitation Engineering*, 18(3):263 - 273, 2010.