

# ATRIAS - a human size compliant bipedal robot walks efficiently

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## Introduction

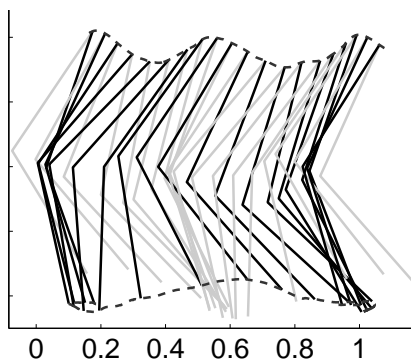
The efficiency and versatility of animal locomotion is still largely outperforming modern machinery. Complex bipedal robots sacrifice mechanical compliance to gain controlability. Template models suggest, that novel control approaches may incorporate mechanical compliance, allow for versatile motion and benefit from the system's passive dynamics.

## Robot Hardware

The bipedal robot ATRIAS has been developed for efficient and versatile locomotion. Its design was inspired by the spring-mass model, which has been proposed as a template for hopping, running and walking [1, 2]. The 60kg robot walks on two legs of 0.9m maximum length which are driven by two motors each, sharing the load of extending and rotating the leg. A carbon-fiber leaf spring connects the motor output to the leg, allowing to control the applied leg force. Each leg can be abducted by an additional motor [3].

## Experiments

The robot walked continuously restricted to the sagittal plane by a boom. Its motion was recorded using internal sensors (Fig. 1). An adaptation of a simple equilibrium

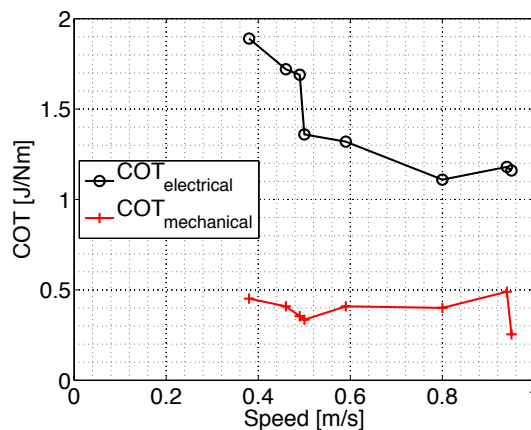


**Figure 1:** walking motion at 0.8m/s

point walking controller [4] has been used, to let the robot walk at different speeds. The robot has also been tested for hopping.

## Results

Although the controller was not yet optimized for the robot's passive dynamics to match a SLIP-model gait, it



**Figure 2:** mechanical and electrical cost of transport at different walking speeds

already showed the characteristic, sinusoidal CoM motion for walking. The power consumption and cost of transport (CoT, [5]) measured reveal a high potential for very efficient locomotion. The robot maintains its gait robustly over a wide range of walking speeds. The cost of transport of ATRIAS (comp. Fig. 2,  $COT^{electric}$ ) is currently about three times the metabolic CoT observed in humans. For humans [6] reported between 0.2 and 0.4 for walking at different speeds. In hopping ATRIAS was able to perform squad jumps up to 0.18m height over ground.

## Future Work

Evaluation of the robot's capability to resemble SLIP-like dynamics will be tested in hopping experiments on a force plate. We are aiming for highly dynamic walking and running.

## Acknowledgement

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## References

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