First Results for the BioBiped1 Robot Designed Towards Human-Like Walking and Running

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1 BioBiped1 Robot Design Inspired by Human Leg

Biomechanics research shows that the abilities of the human locomotor system depends on the functionalities provided by its highly compliant motor system. As a new step in this direction, the design and implementation of the biologically inspired, compliant humanoid robot BioBiped1 are discussed in this presentation. Its three-segmented legs are actuated by compliant mono- and biarticular structures mimicking the main human leg muscle groups with series elastic actuators using cables with springs in combination with electrical actuators (Fig. 1).

With this platform, we aim to transfer versatile human locomotion abilities, namely walking and running, into one humanoid robot design. Robotic research in the recent decades has shown that this is a challenging task because of mechanical requirements and difficult control. Usually, control is achieved by adapting a control scheme to a given humanoid. Here, we try to do the opposite: we try to transfer biologically control patterns like the spring-loaded inverted pendulum to a robot. As a consequence, the main task is not to develop a sophisticated controller but to develop a robot that is capable of mimicking a human-like leg function, which would enable simple control laws. Because the control in biological systems is more robust and better understood for running systems than for walking systems, our first goal is to make the BioBiped1 run. Walking will be achieved in a subsequent step.

2 First Experimental Results

A series of experiments has been selected in a way to systematically evaluate the locomotor functionalities of the BioBiped1 robot and to improve them in subsequent versions to achieve the abilities required for human-like walking and running in one robot design. These experiments will be discussed in the talk and

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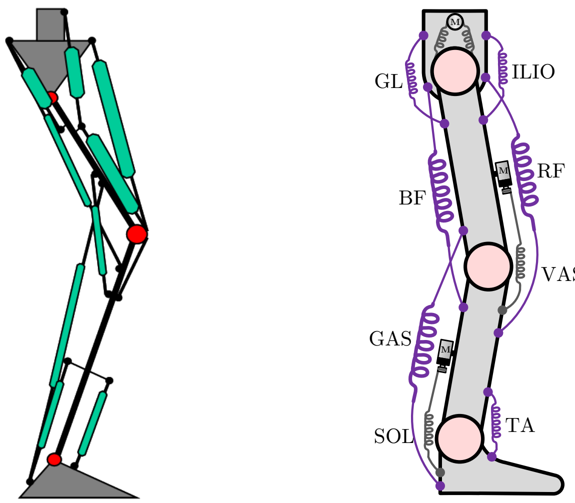

Fig. 1. The main muscle-tendon groups of the three segmented human leg span one or two leg joints (left schematic figure). Their functionality is mimicked by elastic cable-spring structures in the BioBiped1 robot design. Moreover, the monoarticular extensor muscle groups (VAS and SOL) are implemented as series elastic actuators, powered by electric DC motors (right).

aim to evaluate the fundamental functions of the leg, such as the repulsive (compression and extension during stance) and propulsive (fore and back swinging of the leg) functions of the leg, and the ability of the system to perform cyclic motions, such as continuous two-legged (Figs. 3 and 4) and alternate hopping.

More results can be found on the youtube-channel and the project homepage: http://www.youtube.de/biobiped, http://www.biobiped.de.

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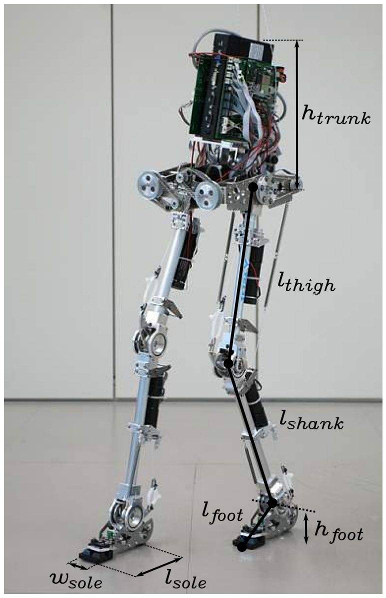
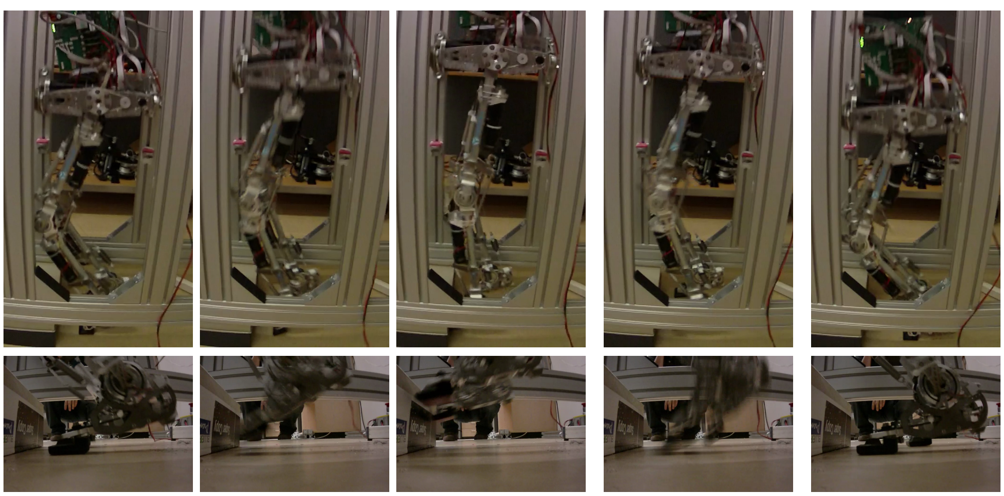


Dimensions	
h_{trunk}	269 mm
l_{thigh}	330 mm
l_{shank}	330 mm
l_{foot}	122 mm
h_{foot}	67 mm
l_{sole}	168 mm
w_{sole}	40 mm

Masses	
total mass	9.2 kg

Fig. 2. The BioBiped1 robot model and its main dimensions



base (10.73s) upwards (10.86s) apex (10.94s) downwards (11.01s) base (11.09s)

Fig. 3. Continuous two-legged hopping with feedforward control recorded with two cameras (timestamps from Fig. 4).

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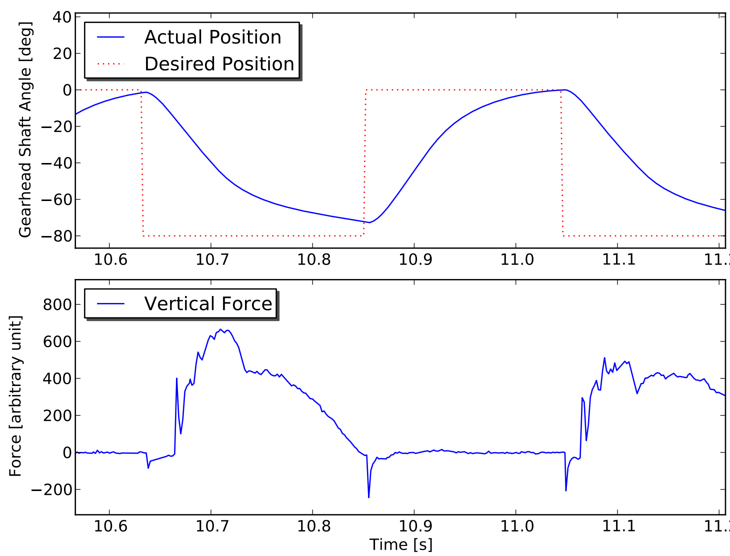

Fig. 4. Top: Desired (setpoint) and actual position of the knee motor (at the gearhead ouput shaft). Below: Force measured by the forefoot force sensor during the continuous hopping experiment. The exact intensity of the force during the stance phase is not known exactly yet because only the sensor offset has been identified so far. Nevertheless, flight phases (force ≤ 0) of approximately 200 ms can be clearly identified.

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