HUMANOID ROBOT CONTROL RECRUITING MUSCLES, REFLEXES AND A CENTRAL PATTERN GENERATOR

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Abstract

While many classical approaches achieve nice gaits with humanoid robots, we are still far from the impressive human walking skills. Bio-inspired algorithms are emerging, generating more energy-efficient and human-like gaits. However, they are mostly limited to simulation studies. We investigate how these kinds of controllers can be applied to a real full-body robotic platform, namely the COMAN. Our controller approach recruits virtual muscles driven by neuronal stimulations like reflexes and a central pattern generator.

Keywords: biomechanics, bioinformatics

1. EXPERIMENTAL VALIDATION

In [1], a muscle-reflex based controller was developed in simulation on a simplified seven-segment human model. This neuro-mechanical controller reproduces human-like gait features like stretched legs, heel strikes and rolling feet. On top of that, the resulting joint torques and positions, as well as the neuronal stimulations are similar to the ones observed during real human walking experiments.

In the first part of our work, we conducted an experimental validation of this controller on a full-body humanoid robot, namely the COMAN. This robot, developed by the Italian Institute of Technology, has the size of a five-year old child and features 23 actuated joints.

The controller described in [1] includes many unknown parameters to be tuned through an intensive optimization process. Because it is too difficult and too dangerous to perform it directly on the real robot, a simulation environment was first developed, with the purpose to reduce the reality gap. Then, the controller was optimized in simulation and ported to the real robot with no modification.

Due to the lack of lateral balance control in this controller, an extra upper body controller was developed to let a human operator provide lateral stability, without affecting the sagittal plane. We used this setup to make experiments with the real robot. The resulting gait was then compared to the one optimized in simulation.

2. CONTROLLER EXTRENSION TO SPEED MODULATION

The controller developed in [1] resulted in a single robot speed after the optimization process, so that no speed modulation was possible.

In order to solve this limitation, we extended this controller with a central pattern generator (CPG). A CPG is a neural circuit capable of producing a rhythmic output signal while receiving only non-rhythmic input signals [2]. This CPG mainly drove the proximal muscles, while the distal ones were still driven by reflex rules.

All parameters were optimized in a single optimization. The resulting gait can then reach any speed in a given range simply by adapting three high level parameters as linear rules of the target speed.

Using this approach in our simulation environment, we can modulate the speed of the robot in a range from 0.4 m/s to 0.9 m/s. Compared to the size of the robot, this range is similar to the normal human walking one. Both the step length and frequency are adapted to reach the desired speed. Moreover, this approach can be used to alter the foot landing location, and so to cross holes.

References

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