Torque-Stiffness-Controlled Dynamic Walking

Yan Huang, Qining Wang
Intelligent Control Laboratory, College of Engineering,
Peking University, Beijing 100871, China.
email: qiningwang@pku.edu.cn

1 Motivation

We present torque-stiffness-controlled dynamic walking, in which the external actuated torques and the natural dynamics can be controlled independently during locomotion. It is advantageous in controlling walking velocity and step length simultaneously.

2 State of the Art

Previous studies indicated that introducing adaptable compliance to dynamic walking is beneficial to modulating walking performance and extending the versatility [1-3]. However, in most of these studies, the stiffness is changed off-line. The transition of different walking patterns in real time was not investigated. Our previous study [4] has demonstrated walking pattern transition with adjustable joint stiffness based on the concept of Controlled Passive Walking [5]. Nevertheless, it was a relatively preliminary validation without a systematic control method. The independently effects of joint torque and joint stiffness were not studied.

3 Own Approach

In this work, we present a dynamic bipedal walking model with an upper body, flat feet, and adaptable compliant joints. Joint stiffness is implemented by torsional springs. Both the equilibrium position and the spring constant are adjustable during walking.

A bio-inspired CPG control approach is applied to the walker. Fig. 1 indicates the control architecture. The coupled neural oscillators are driven by two signals u_e and u_s, for adjusting the joint equilibrium position and joint stiffness respectively.

4 Current Results

Experimental results show that the velocity and step length tend to increase for either increasing joint torques or increasing joint stiffness. Joint stiffness is the major determinant of gait frequency (the ratio of velocity to step length), which is almost independent of joint torque. Fig. 2 shows a typical walking gait.

Walking pattern transition can be achieved by changing u_e or u_s or both the two. Comparison of the three control methods (see Fig. 3) indicates that adjusting u_e and u_s simultaneously converges fastest with the highest accuracy. Moreover, the walking can achieve a specific pattern with desired velocity and step length by controlling both the two parameters.

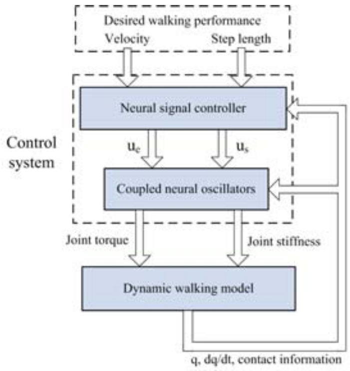

Fig. 1 The control architecture of torque-stiffness-controlled dynamic walking.

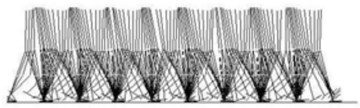

Fig. 2 Stickgram of stable walking of the proposed model.

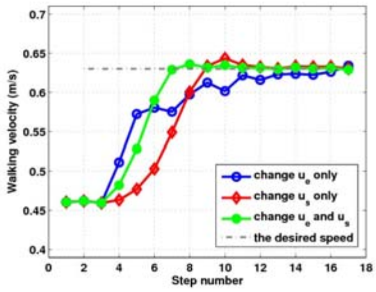

Fig. 3 Speed control with three different methods.

5 Best Possible Outcome

We are looking forward to implementing the proposed approach in a physical robot with adaptable joint torque and stiffness.

References

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