

How Should an Oscillator Best Adapt to Legged Motion Dynamics?

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Motivation:

Simulated neural oscillators are frequently used to control legged locomotion both in modeled and robotic systems. The oscillators can dictate actuation patterns of the limbs as a form of feedforward control. Oscillators can also incorporate system feedback to stabilize against some perturbation disturbances. It is, however, unclear how crucial the oscillatory behavior of the controller is to the dynamics of the system. For example, feedback control could also incorporate feedback in control but without need for oscillatory behavior. This raises the question of the effectiveness and importance of oscillatory behavior in controlling legged motion.

State of the Art:

Animal studies show that isolated spinal neural networks from various animals can produce rhythmic electrical outputs similar to those observed during locomotion [1]. As a result, it is commonly hypothesized that such neural networks, frequently referred to as central pattern generators (CPGs), also play a large role in governing human locomotion. These networks are often simulated with artificial neural oscillators and used to drive robotic and simulated locomotion [2] [3]. Simulated neural networks can also be entrained to the system through sensory feedback. This is particularly important, since it has been shown that sensory feedback is crucial to the control of moment [4]. However, CPGs have been found only in a select group of vertebrates and it is still unclear how significant they are in human motor control [5]. It has also been suggested that such neural networks act more as filters of sensory information rather than active controllers [6]. This is particularly useful if there is noise in the sensory information, since there is an internal model of the system with which the feedback information can be compared [6]. The purpose of this study is to define and differentiate between the benefits of adding sensory feedback to the system controller and having the controller be based on an oscillator.

Our Approach:

To address the benefits and drawbacks of an oscillator based controller for legged locomotion, we propose to develop a simulation of a biped walker walking on level ground and governed by either a pure feedforward (FF), pure feedback (FB), or balanced (B) controller with both oscillatory feedforward and state feedback. All three controllers will be based on a neural oscillator model, which could incorporate no system feedback and behave as a strictly FF controller, some system feedback and exhibit both intrinsic properties and adapt to the system (B), or be completely entrained to the system and exhibit none of its intrinsic properties (FB). The bipedal model will be of an anthropomorphic, rigid leg walker with curved feet, with the controller dictating hip torque and the angle between the legs acting as the system feedback to the controller. These three models will be evaluated on their ability to reject sensory noise and external perturbations. We hypothesize that having an intrinsic model system behavior, such as in the form of an oscillator, will be beneficial strictly for rejecting sensory noise, since the oscillator dynamics will act as a filter of information. Feedback will be crucial in rejecting external perturbations, regardless of the controller.

Discussion:

Artificial neural oscillators are commonly used to control legged robots and simulated walkers. However, if the importance of having an oscillator based controller is strictly to provide an intrinsic model of the system that will filter sensory noise, we ask how necessary it is to base the controller on an oscillator in the first place. Are there perhaps other controller types that would provide the same

filtering properties but have other advantages over artificial neural networks? Given this, understanding the advantages and drawbacks of oscillator based controllers could lead to more computationally efficient controllers that are not necessarily based on artificial neural networks.

Format: Poster

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