# Bilateral Decoupling in the Neural Control of Biped Locomotion

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## 1. Introduction

In this past, the control of biped locomotion using neural oscillators has assumed explicit connections between ipsilateral and contralateral oscillators [1]. However, in the control of a robot arm using oscillators it has been shown that coupling can emerge due to the sensing of mechanical coupling through the physical structure of the robot [2]. In this paper, the aim was to investigate whether such mechanical coupling could be responsible for phase-locking of contralateral oscillators in biped locomotion.

## 2. Neural Controller

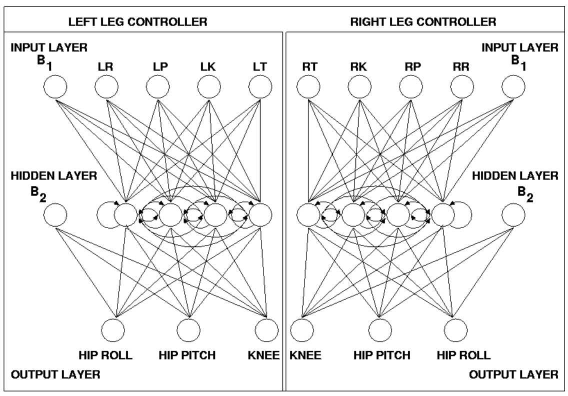


Figure 1: Bilaterally decoupled neural controller including joint angle and foot contact sensors.

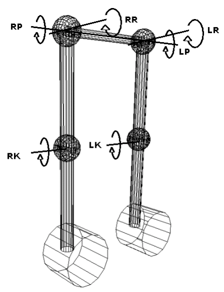


Figure 2: The 6 DOF biped physical structure

To investigate complete bilateral decoupling, a neural controller was designed with independent identical neural rhythm generators for each leg (Fig. 1). Each rhythm generator was a recurrent neural network consisting of an input layer with sensory input nodes and a bias neuron, a hidden layer of 4 nodes with lateral connections and a second bias neuron, and an output layer with motor outputs.

The sensory inputs of the network were from the 6 DOF biped robot, implemented in a virtual physics based simulation environment (Fig. 2). The biped has proprioceptive sensors at each joint. It also has haptic sensors on the feet to sense ground contact. It is actuated by torsional actuators attached to the six joints. The neural rhythm generator received sensory inputs representing joint angle and foot contact from one side of the biped's body, and sent motor commands to the same side. The weights of the were optimized using an evolutionary algorithm, and were identical for left and right sides.

## 3. Results

The results showed that by only using sensory feedback from the mechanical coupling of the legs through the body, they can synchronize to produce coordinated stepping movements resulting in stable locomotion. Furthermore, improvements in the quality of the gait can be achieved only with global sensory information on waist orientation, position and foot position. The results suggest the possibility that there may not be a need for explicit contralateral sensory coupling or neural connections in bipedal locomotion.

## References

[1] Taga, G., Yamaguchi Y. and H. Shimizu. Self-organized control of bipedal locomotion by neural oscillators in unpredictable environment In *Biological Cybernetics*, 65, pages 147-159, 1991.

[2] Williamson, M. M. Rhythmic Robot Arm Control Using Oscillators, In *Proc. of IEEE/RSJ Int. Conf. on Intelligent Robots and Systems* Victoria, pp.77-83, (1998)