A Bidirectional Weak Coupling Approach To Rhythmic Movement

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1. Introduction

This paper describes the properties of a set of simple neural network oscillators suited to two robotic tasks. One robotic task is "wall-bouncing," in which the robot repeats the process of hitting balls that rebound from a wall. Another robotic task is "passing a ball," in which two robots repeat the process of passing balls to each other. The motions of the robot (paddle) are controlled by a set of neural oscillators consisting of four weakly coupled Bonhöffer-van der Pol (BVP) oscillators. We demonstrate that rhythmic movement of the paddle emerges as a stable limit cycle generated by the global entrainment between the paddle, the neural system, and the environment, including balls.

2. Rhythmic Movement Generation

The proposed bottom-up fork connected (BFC) robotic rhythm oscillator can be interpreted as being inspired by the mechanism of the reflection generated by perception and the Central Pattern Generator (CPG). We know that the CPG can modify the reflection pattern by using sensor inputs as well as higher-level brain commands. The reflection here can be regarded as a solution of inverse kinematics. The BFC robotic rhythm oscillator autonomously acquires this solution due to the oscillator's entrainment property.

3. Simulation

3.1. Task1: wall-bouncing task with two balls

We simulate the wall-bouncing task with two balls and confirm that a robot autonomously generates stable rhythmic movement without any global synchronization or control, due to the local interaction of the oscillators and their entrainment properties, called bidirectional weak coupling. Furthermore, it is shown that rhythm bifurcations occur due to the phase difference of balls.

3.2. Task2: two robots passing two balls

We simulate the passing a ball task with two balls and two robots and confirm that the same BFC robotic rhythm oscillator achieves this task by transferring the rhythmic information between two robots through the environment. Coordinated motion of robots is developed in this task. The robotic oscillating objects mutually synchronize through the balls, performing the task successfully.

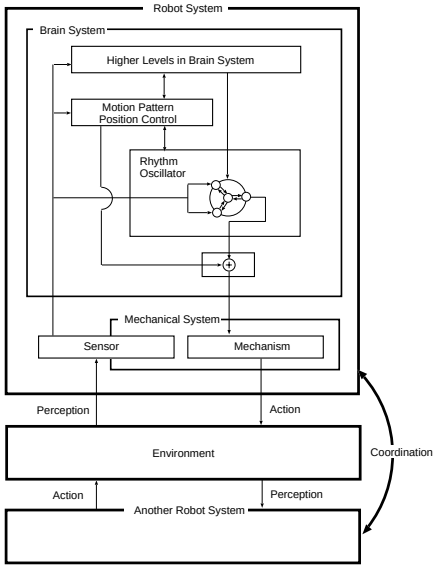

Figure 1: Perceptual-motor system for rhythmic movement

In these tasks, only tactile information about the ball contact is used. Our results suggest the importance of kinetic information (timing information) about the impact in rhythmic movement.

References

[1] M. M. Williamson, 1998, "Neural Control of Rhythmic Arm Movements", *Neural Networks Special Issue on Neural Control of Movement*.

[2] E. L. Amazeen, P. G. Amazeen, A. A. Post and P. J. Beek, 1999, "Timing the Selection of Information During Rhythmic Catching", *J. Motor Behavior*, vol.31, No.3, pp. 279–289.

[3] D. Sternad, M. Duarte, and H. Katsumura et al., 2000, "Dynamics of a Bouncing Ball in Human Performance", *Phys. Rev. E63*, 011902-1–011902-8.