An Analog CMOS Circuit Implementing CPG Controller for Quadruped Walking Robot

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1. Introduction

Animal locomotion, such as walking, running, swimming and flying, is based on periodic rhythmic movements driven by the biological neural network, called the central pattern generator (CPG). As a result of coordination of physical parts induced by the rhythmic movements, smooth locomotion of animals is achieved. Therefore, the CPG play one of the most important roles in locomotion. In recent years, many researchers have applied the CPG to locomotion controllers for walking robots. However, most of these have been developed with digital processors, and thus have such problems as high power consumption. Hence, we propose an analog CMOS circuit implementing a CPG controller for a quadruped walking robot to make it coordinate physical parts in quadruped walking robots. By computer simulations, we confirm the operation of the proposed circuit.

2. The Role of The CPG Control

In this section, we describes the role of the CPG for rhythmic movemnts of animals. In particular, we describe fundamental roles of the CPG in locomotion.

3. The CPG model

In this section, we describe a neural network model as the CPG controller. First, we describe the Amari-Hopfield model [2] as the neural oscillator underlying the CPG controller. Second, we construct the neural network model as the CPG controller from the Amari-Hopfield model according to the CPG model proposed by Nagashino *et. al* [3].

4. The CPG Controller

In this section, the neural oscillator circuit underlying the CPG controller is described, and we construct the CPG controller from the neural oscillator circuit.

5. Results

As a result of several computer simulations, we confirmed performance of the proposed circuit. First, weconfirmed that the circuit has the capability of generating some rhythmic periodic patterns. Second, we confirmed the transitions from one pattern to another.

6. Conclusion

In this paper, we proposed an analog CPG controller for a quadruped walking robot. Inprevious works, some analog CPG controllers have been already developed. The present work differs from the previous works in several respects. First, the proposed circuit is based on the Amari-Hopfield neuron, which is suitable for analog circuit implementation. Second, it has the capability to produce various rhythmic patterns and transitions between the periodic rhythmic patterns promptly. Since the proposed circuit is constructed from the CMOS transistors, which operate in their subthreshold region, it can reduce power consumption. Moreover, it has achieved low-cost and a small area of a chip. These characteristics are sufficient as the CPG controller. Following the present reserch, we will be aiming to develop micro locomotor robots.

References

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