3.2. CGC Networks

The difference is clearer in the CGC controller. This controller is a multi-layered controller that combines the CGC and the controller of the hopping robot. The CGC controller generates the reference signal for the hopping motion, while the CGC controller generates the control signal for the hopping motion. The hopping robot follows the generated motion, and the CGC controller provides the reference signal for the hopping motion. The two controllers work together to control the hopping motion of the robot.

2. Quadruped Hopping Robot

The quadruped hopping robot is a four-legged robot that can jump and run on rough terrain. The robot is equipped with quadruped legs and a computer-controlled brain. The robot uses a combination of sensory information and decision-making algorithms to control its movements. The robot can jump, run, and perform various tasks on rough terrain.

Introduction

Hopping Robot Using Adaptive CGC Networks

Moving and Breaking Motion Control of Quadruped Robots

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among the CPGs is required. Figure 3 shows the configuration of typical CPG networks. By using this ring-and-cross type CPG networks, we could obtain the stable, continuous and rhythmical hopping performances. In addition, we included the reference height control system with CPG model into each of robot's leg. Therefore, the hopping height of each leg can be controlled according to the reference height which have been set. The structure of CPG networks are illustrated in Fig.3.

![CPG networks diagram]

**Fig. 3: Ring-and-cross type CPG networks**

### 4 Moving and Breaking Method

Here, the method which we approached is used the reference height feedback control system to create the difference height of front legs and back legs to make body posture incline ahead for moving performance. Then, the correction of body posture which has inclined by setting the reference height for all legs to 20cm could make the quadruped hopping robot jump in one dimension called breaking motion. We have conducted the whole experiment in 60sec which in the first 10sec period, we set the reference hopping height for all legs to 20cm to maintain the oscillation of hopping performances, in advance. Then, after 10sec until 40sec, the moving performance are been set. Therefore, started from 40sec to 50sec, our proposed breaking motion performance are set following with the moving performance from 50sec to 60sec.

### 5 Experimental Setup

The proposed CPG network is expressed using a MATLAB/Simulink model on a host computer. Then the model, built by a realtime workshop, is downloaded to a xPC target computer. The xPC target computer is run by using a realtime OS. The position of the center and each leg are measured using ultrasonic sensors which are used as sensory feedback signals of the CPG. We also included the current sensors into the system which are used to monitor the current value which have given to each leg on each jumping motion. In this experiment, the sampling time for the control is set to 0.01 sec.

### 6 Experimental Results

Here, the internal parameters of CPGs are set to the typical value as \(a = 0.1, b = 2, c = 1, B_0 = 0.01, \tau_c = 0.1, f = 0.1\) and the PI controller's gains are set as \(K_P = 5.5\) and \(K_I = 0.4\) in advance, in order to generate the efficient hopping performances. As the results, we could see the changing of control signals, current values and hopping height values in Fig. 4 in order to generate the successful moving and breaking motion. For the breaking performance, the control signals for leg 1 and leg 3 are increasing to -10V to achieve the reference height which have set to 20cm. However, the control signals for leg 2 and leg 4 are unchanged according to reference height which unchanged. At the same time, the maximum height for leg 1 and leg 3 are increasing from 18cm to 20cm while maximum height for leg 2 and leg 4 are still remain at 20cm to make the vertical hopping motion.

![Experimental results for moving and breaking performances]

**Fig. 4: Experimental results for moving and breaking performances**

### 7 Conclusions

In this paper, we have proposed the moving and breaking motion method in action to give stabilization to our quadruped hopping robot. Here, we confirmed the effectiveness of approach method to generate moving and breaking motion control of quadruped hopping robot while making continuous jumping vertically. On the other hand, we also obtained the effectiveness of CPG networks which act as a command center for the musculoskeletal system to generate the continuous hopping performances and to keep the stability of quadruped hopping robot and avoiding it from tumble ahead.

### References