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Hopping peak height algorithm for a one legged robot hopping height control

A.H. Azahar[1,2*], S.H. Chong[1,2], A.M. Kassim[1]

[1)] Faculty of Electrical Engineering, Universiti Teknikal Malaysia Melaka,
Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia.
[2)] Motion Control Research Laboratory (MCon), Universiti Teknikal Malaysia Melaka,
Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia.

[*]Corresponding e-mail: rmnhadi_00@yahoo.com

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ABSTRACT – This paper presents the hopping peak height algorithm in controlling the hopping height of a one legged hopping robot. The hopping mechanism produces continuous and rhythmic pattern. The continuous and rhythmic pattern behaviors produce oscillation feedback to the closed loop system and continuously produce oscillation error to the controller. Therefore, hopping peak height algorithm is designed and embedded into the closed loop control system feedback to determine the hopping peak of each produced hopping as a feedback. The existence of the hopping peak height algorithm assists the PI-CPG controller to converge the hopping height error approximately to zero.

1. INTRODUCTION

Hopping mechanism is one of the locomotion dynamic produced by legged robot. Research on one legged robot quite isolated compared to the other types of robot. Most of developed legged robots having difficulties in mechanism and controlling system design. Hopping robots have complex control system in order to calibrate with the one legged mechanical design. Thus, each design of one legged robot has its specific control system.

In controlling the one legged hopping robot, there are three types of problem that have to overcome which are altitude control, horizontal control, and height control. Among the problems, height control problem is the most difficult to overcome. To overcome this problem, Prosser and Kam proposed a vertical control algorithm that differs from previous control algorithm. The first area, the algorithm used a near-inverse of the machine's dynamic. Second, used discrete-time output feedback and a numerical simulation method for height trajectory tracking [1-2]. Naik and Mehrandenz used P, PID, and an inverse dynamics based PID controller to control the hopping height at a desired constant hopping height [3-4]. To achieve the desired hopping height, the feedback is determined via duty cycle of each hopping.

In this paper, the hopping height of a one legged hopping robot is controlled by integrating a hopping peak height algorithm in the closed loop control feedback. The algorithm is designed to determine the hopping peak height for each hopping as a feedback in order to reduce the hopping height error towards reference hopping height.

2. METHODOLOGY

The one legged hopping robot is controlled by using a host target computer and a xPC Target computer. MATLAB & Simulink software is used to design the control system of the one legged hopping robot via Real-time Workshop.

A closed-loop control system with a PI-CPG controller is designed to control the hopping height of the one legged hopping robot. The sampling time, *Ts* is set to 5msec. A hopping peak height algorithm is embedded inside the S-Function and integrated at the closed-loop feedback as shown in Figure 1. The hopping peak height algorithm is designed to determine the hopping peak height for each produced hopping.

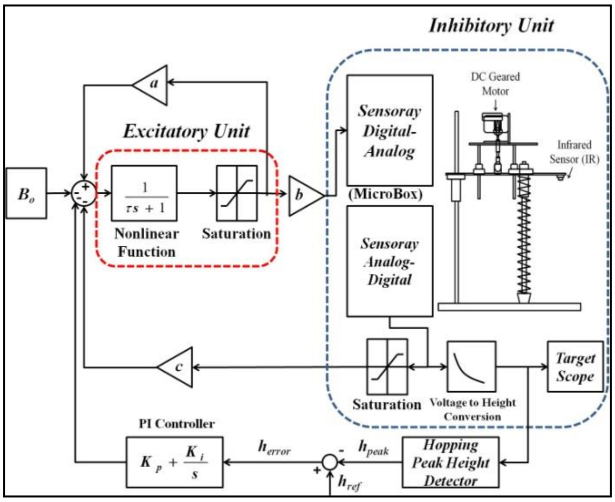

Figure 1 Closed loop system with hopping peak height algorithm

The hopping peak height algorithm is designed based on the rules that can be explained as following conditions:

a. If current value A is lower than the previous value B and the previous value B is greater than the previous value of B which is C, and the previous value B is greater than initial height of the one legged hopping robot, therefore the previous value B will be read out as the output height feedback and will be hold until the next hopping height is found.

$$If\ (A < B \ \&\&B > C \ \&\&B > h_i)$$
$$h_{peak(i)} = B,$$

b. If the current value A, previous value B, and previous value of B, C did not meet the rule before the previous hopping peak height value will be read out as the output height feedback of the system.

$$h_{peak(i)} = h_{peak(i-1)}$$

3. RESULTS AND DISCUSSION

This section presents the experimental result of hopping height by one legged hopping robot with and without the existence of hopping peak height algorithm as shown in Figure 2 and Figure 3.

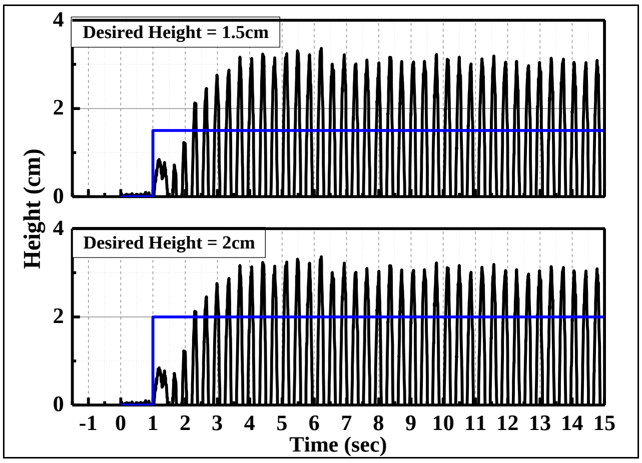

Figure 2 Hopping height without the existence of hopping peak height algorithm

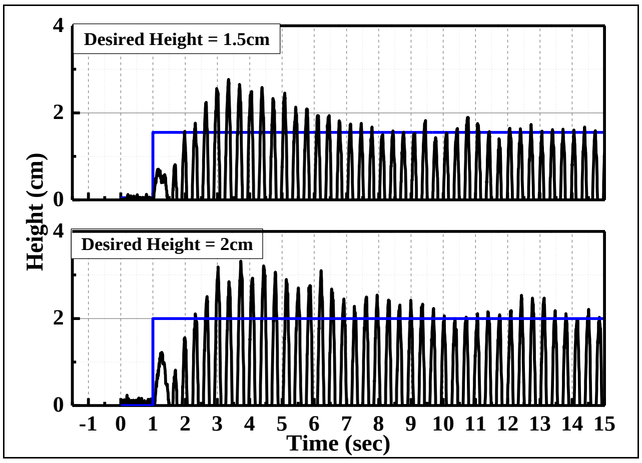

Figure 3 Hopping height with the existence of hopping peak height algorithm

From Figure 2, the hopping height produced by one legged hopping robot without the existence of hopping peak height algorithm demonstrates that there is huge error presents towards reference hopping height given. The huge error occurs caused by the oscillation pattern of hopping height output is directly used as a feedback to the system. According to that situation, the difference of hopping height to reference height keeps changing continuously for every sampling time. Therefore, the controller does not able to compensate the error and directly cannot achieve the reference hopping height.

Meanwhile, the produced hopping height by integrating the hopping peak height algorithm achieves the reference hopping height given as shown in Figure 3. The hopping peak height algorithm determined the hopping peak height for each hopping cycle and used the determined hopping peak height as a feedback to the system. Consequently, the hopping height error towards reference hopping height reduced approximately to zero and the one legged hopping robot achieved the reference height.

4. CONCLUSIONS

As a conclusion, the existence of hopping peak height algorithm in the closed loop control system feedback of a one legged hopping robot reduces the hopping height error towards reference hopping height and demonstrates better performance in achieving the reference hopping height.

5. ACKNOWLEDGEMENT

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