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A Dynamic Vertical Climbing Robot

Wei-Hung Ko, Wei-Hsuan Chiang, Ya-Han Hsu, I-Lin Fang, Hung-Sheng Lin, Ming-Yuan Yu, and Pei-Chun Lin

***Abstract*—We report on the development of a dynamic climbing robot which is capable of moving freely on the vertical plane. The robot is empirically built and its performance is experimentally evaluated.**

I. Introduction

A significant difference between climbing robots and general legged robots on ground is role of gravity in locomotion. For the latter one, the driving force of the robot usually relies on the friction force, and this force is proportional to the normal force generated by the gravity. In contrast, for the former case, the driving force should come from a difference source, and gravity is in general acting in the direction against that of the robot's motion. Thus, finding a useful surface attachment mechanism is usually the first challenge in designing a climbing robot. However, the limited success on attachment mechanism constrains the developed robots to move dynamically like animals [1][2]. Aiming at exploring the dynamic climbing characteristics, a bio-inspired two-arm dynamic vertical climbing robot had been developed [3], which uses claws to attach to the carpet wall and can climb upward at 1.5 body-length per second. However, because of insufficient degree-of-freedoms (DOFs), it can only climb upward but not move laterally or climb down. Here, we report on a revised version of the dynamic climbing robot with an extra DOF which allows the relative configuration change between two arms, and through the right coordination among three active DOFs, the robot can move freely on the vertical plane.

II. Methods and Results

Figure 1(a) shows the photo of the robot. The periodic extension and withdraw of the arm is done by a continuous rotating motor with a crank-and-slider mechanism. The spread and close between two arms is achieved by a motor with a worm-and-worm-gear mechanism. Because this mechanism is not back-drivable, when this DOF is not used or when the arms reach the desired position, the arms can hold their configuration without power supplying to the motors.

Though the robot only has 3 DOFs, development of proper dynamic gait still cannot be achieved by empirical turning of the robot parameters. In addition, this approach also provide very limited insight to the dynamic characteristics of the robot. As a result, a mathematical model with configuration similar to the robot is also developed simultaneously [4], where the gait development can be firstly done in simulation. In order to make the model realistic enough to have similar dynamic behavior as the robot, the parameters of the model are directly set according to the physical parameters of the robots when it climbs straight up, except for the damping term. That term in the model is regarded as the summed damping loss of the whole robot, and it is empirically derived by minimizing the performance difference between the model and the robot. Next, the oblique climbing gait is developed and investigated in simulation environment, and the proper and feasible one is then implemented on the robot for experimental evaluation. Figure 1(b) shows the trajectories of the robot and the model. The differences between model and robot is 0.0175(m) measuring in standard deviation.

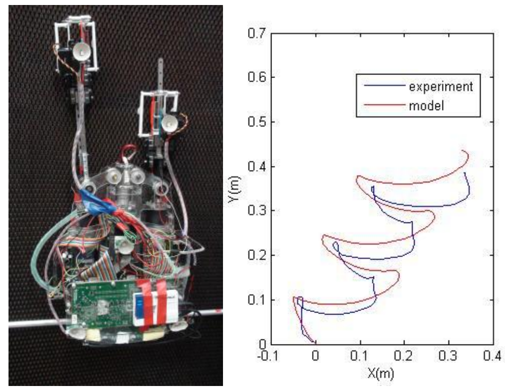

Fig. 1. (a) Photo of the climbing robot; (b) trajectories of the robot and the model.

III. Conclusion

The experimental evaluation of the robot confirms that the robot can move freely on the vertical plane. It can climb dynamically straight up at *0.18m/s* and can climb obliquely at *0.06~0.08m/s*. We are currently in the process of finding a precise mapping between motion of the motors (i.e. joint angles) and that of the robot center of mass, and this mapping will allow us to control the robot with only specifying final destination.

References

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Authors are with Department of Mechanical Engineering, National Taiwan University (NTU), No.1 Roosevelt Rd. Sec.4, Taipei 106, Taiwan. (Corresponding email: peichunlin@ntu.edu.tw).