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Design and Implementation of a Snakeboard Robot

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Abstract— **We report on the development of a snakeboard robot. It consists of three motors, mimicking the ankle motion and torso motion of the rider. The robot was empirically built and experimentally validated its locomotion performance.**

I. INTRODUCTION

A snakeboard is a board which fuses the original concept of skateboard with elements of snowboarding and surfing to create a fun and new-type of riding experience. The board has two footpads connected by a coupler link via revolute joints, so these three parts can have relative rotational motion with respect to the vertical axis. By twisting the footpads and the torso correspondingly in certain pattern, a rider can create a wavy motion toward a desired direction. We are attracted by this unusual and non-direct locomotion mechanism (i.e., the wheels are passive), thus motivated to build a robotic version of the board as shown in Fig. 1. We made our rotor adjustable and can make it more efficient by decreasing vibration caused by imbalance.

II. METHODS AND RESULTS

The mechanism of the board was designed based on the simplified model reported in [1], which consists of three active rotational joints. The front and hind joints are used to turn the corresponding wheels, mimicking the ankle motion of the rider. The middle joint is connected to a rotor with heavy inertia, simulating the rotational motion of the rider's torso. The joints are actuated by DC motors with shafts collinear to the joint axes, keeping the mechanism simple. In order to optimize structure and mechanism parameters, we referenced the dynamic model of the snakeboard in [2]:

$$\dot{\psi}(t) = \dot{\psi}(0) + \frac{M}{J_r}\left(\int_0^t \frac{\tilde{z}(\tau)\tilde{w}(\tau)}{\tilde{v}(\tau)^3\tilde{u}(\tau)^2}d\tau - \frac{\tilde{r}(\tau)}{\tilde{v}(\tau)^2\tilde{u}(\tau)}\Big|_0^t\right), \quad (1)$$

where M is mass of the snakeboard, J_r and $\dot{\psi}$ are inertia and angular velocity of the rotor, and $\tilde{z}, \tilde{w}, \tilde{u}, \tilde{v}, \tilde{r}$ describe the motion of C.M. From this equation, we found the ratio of M and J_r significant to board motion---The larger the inertia, the farther the displacement of the board per period. Thus, the mass on the robot were reinstalled away from the axis to increase the inertia without altering the mass.

The trajectory planning of the snakeboard was firstly done in a simplified prototype built with Lego NXT components. Our initial investigation revealed that the board with square control signals moves faster than that with sinusoidal signals. However, our initial investigation also revealed that specifications of the LEGO platform in many aspects were not able to meet our experimental requirements, which is also a

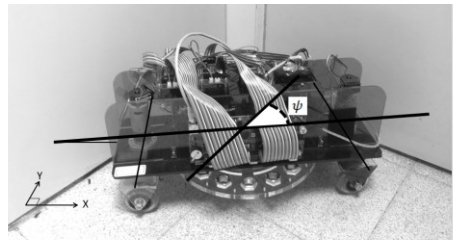

Fig. 1. Photo of the snakeboard.

crucial reason that we had to build the customized platform as shown in Fig. 1. With the new platform, the effect of using two different control signals was revealed more clearly and systematically. The square signal still makes the board moving faster, but the motion is shakier because of the rapid change of acceleration. The planar trajectory of one of the typical experimental run is shown in Fig. 2, which was taken by a camcorder mounted on the ceiling and point down to record the planar motion of the board.

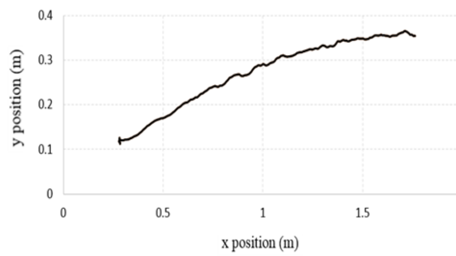

Fig. 2. Planar trajectory of the robot (square signal).

III. CONCLUSION AND FUTURE PLAN

In this paper we presented the design and implementation of a snakeboard robot, exploring the mechanism how this non-direct driving board creates locomotion. We have successfully built a robot and found some fundamental relations between the control commands and the board motion. We are in the process of investigating the dynamics of the board via modeling aspect, and in the meantime we are also planning to implement an inertial measurement unit as the sensory input for feedback motion control.

REFERENCES

[1] A. Nikbakht, H. Sayyaadi, *"Design, Dynamics Simulation, and Controllability of Snakeboard,"* in International Conference on Mechanical Engineering 2007 (ICME2007), pp29-31, Dec. 2007, Dhaka, Bangladesh.

[2] E. Shammas and M. de Oliveira, *"Motion planning for the Snakeboard"* in The International Journal of Robotics Research June 2012 vol. 31 no. 7 872-885

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