SLIDER: A Novel Bipedal Walking Robot without Knees

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Abstract. This extended abstract describes our work on SLIDER: a novel bipedal robot with knee-less legs and hip sliding motion. Compared with conventional anthropomorphic leg design, SLIDER's leg design enables the robot to have very lightweight legs and is suitable to perform agile locomotion. To validate this design, we created a dynamics model and implemented a walk pattern generator capable of walking with a speed of 0.18 m/s in Gazebo. Currently, a physical prototype is under construction for real-world testing. The initial mechanical design and the control strategy for SLIDER are introduced.

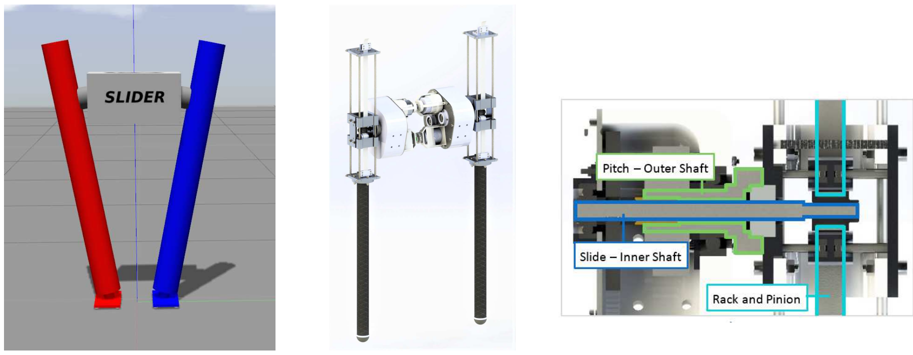
Keywords: Bipedal Walking, Legged Robot Design, Gait Pattern Generation

1 Introduction

Most bipedal robots have knees with actuators mounted on the thighs, making their legs relatively heavy. This design either limits the robot's ability to perform agile behaviors (jumping, push recovery, etc.) or requires powerful motors to accomplish them. Here we propose a novel design for a bipedal robot called SLIDER that replaces the conventional legs which have knees with knee-less legs. A vertical hip sliding motion is added, to compensate for the missing degree of freedom (DOF) of the knee. To the best of our knowledge, there is no such existing bipedal robot design in the published research. The only similar robot design that we know of is in a video by Schaft [1] whose design details, however, are unknown. The purpose of building SLIDER is to explore novel designs for bipedal robots and novel actuation mechanisms.

2 Mechanical Design

SLIDER is 96 cm tall and has a weight of 18 kg. Each leg has 5 DOFs: hip pitch, hip roll, hip slide, ankle roll and ankle pitch. The novel aspect of SLIDER's design lies in its compact and lightweight vertical hip sliding mechanism. The top half of each leg consists of a one-axis gantry with four guide rods and a belt fixed internally, as shown in Figure 1b. The inner shaft is attached to the



(a) (b) (c)

Fig. 1: (a) SLIDER model simulated in Gazebo. (b) A rendering of the initial mechanical design. (c) The inner view of the motor box.

pulleys moving along the belt controlling the sliding motion, while the outer shaft is responsible for the hip pitch motion as shown in Figure 1c. To further minimize the weight of the leg, a carbon rod is used for the bottom half. At the bottom of each leg a rubber ball is added to absorb the energy when the foot contacts the ground, as shown in Figure 1b. A prototype is currently under construction in our lab.

3 Control Strategy and Future Work

To validate the walking capability of SLIDER, we created a model in Gazebo that has the same kinematic and dynamic properties as the physical version of SLIDER, as shown in Figure 1a. We adapted our previous two-stage gait pattern generation approach [2] to match the novel kinematics of SLIDER. In this approach an average velocity of the center of mass is given as a reference. At the first stage an inverted pendulum model is used to calculate the foot position and timing in sagittal and coronal plane. This information is then passed to the second stage and a Multi-Body Dynamic model is used to compute the trajectory of each joint. We implemented joint controllers in Gazebo to follow the reference trajectories, enabling SLIDER to walk stably with a speed of 0.18 m/s.

In the future, we will continue building and improving the design of SLIDER. Addtionally, we plan to add ZMP feedback to the controller to achieve more stable and faster walking.

References

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