Towards running robots for discontinuous terrain

Extended abstract

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1 Summary

Planar control is an important first step in the development of more complex running robots. This extended abstract describes a technique for control of a one-legged planar robot hopping over discontinuous surfaces. In simulations the robot is tasked with traversing across terrain which provides limited surface for foot placement. The robot has to hop between foot placement surfaces placed at varying distances and heights. The controller has to adjust leg landing angle and leg extension in order to produce the parabolic flight trajectory necessary to land at the next targeted foot placement spot.

2 Model

The simplified model of a running robot used for the development of the running controller is shown in Fig. 1. The model consists of a body and leg. The body is modelled as a simple point mass. The leg consists of a telescopic actuator and a spring-damper in series. The only control inputs to the system are displacement of the actuator y_{act} and the leg angle upon touch down θ_{td}.

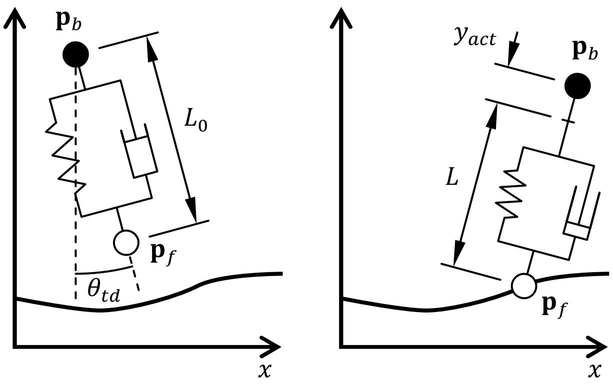

Fig. 1. Model of hopping robot in flight (left) and in ground contact (right).

adfa, p. 1, 2011.

3 Controller

Running speed is controlled by varying the leg touch-down angle θ_{td}. A simple proportional controller which adjusts the leg angle in response to forward speed error can be used to achieve a steady running speed.

It was found that a demanded lift-off velocity v_d could be achieved by extending the actuator at a constant velocity v_{act} during the stance phase if the vertical touch-down speed v_{td} is known:

$$v_{act} = K_1 v_d + K_2(v_d - v_{td}) \tag{1}$$

Because the trajectory of the robot in flight is parabolic, it is possible to target a given spot to land on if vertical lift-off speed is controlled accurately. There are many different parabolic flight trajectories which will land at the same point. One way to achieve a particular landing spot is to maintain a constant horizontal velocity while only varying the vertical lift-off velocity.

4 Results

Figure 2 shows hopping over a set of 0.1 m steps at a forward running speed of 0.15 m s^{-1}. The dotted line shows the trajectory of the point mass and solid lines are used to show the leg at touch-down and lift-off. It can be seen that the foot falls short of the target (centre of platform) when ascending stairs and overshoots when descending. This error may be reduced by taking into account the coupling between horizontal speed control and vertical hopping.

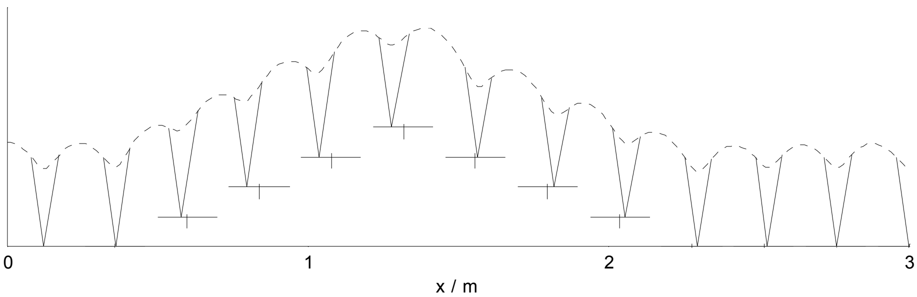

Fig. 2. Robot trajectory when ascending and descending platforms. Same scale on both axes.

5 Conclusion

Effective foot placement over rough terrain and over steps was achieved using a relatively simple control logic. Work is ongoing to experimentally validate and extend foot placement hopping into 3D.