Stumble recovery of a simple walking model;
elevating versus lowering strategy

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SUMMARY

Current bipedal robots lack the ability to regain balance after stumbling. Stumble recovery is simulated for the simplest walking model, using humanlike strategies. Either the perturbed step is actively lengthened (i.e. elevating strategy) or aborted followed by a rapid next step (i.e. lowering strategy). The model suggests that the lowering strategy, which can be performed during mid and late swing, is favorable for robots when actuation power is limited.

INTRODUCTION

Current bipedal robots easily fall when their swing foot is perturbed by a small obstacle or when scuffing the floor. Humans show great ability to recover from this type of perturbation and clearly choose one of the following two strategies [1]: *(A)* ‘an elevating strategy’, where the perturbed foot is lifted and the step lengthened. *(B)* ‘a lowering strategy’', where the perturbed swing foot is immediately placed on the ground and the recovery effort is transferred to the other leg.
Our research question is: should we implement both strategies in our Limit Cycle Walking robots [2] or could a simple model show an advantageous recovery strategy from a mechanical point of view? Since our robots have relatively low power actuators, we focus on the required torque to successfully perform the recovery.

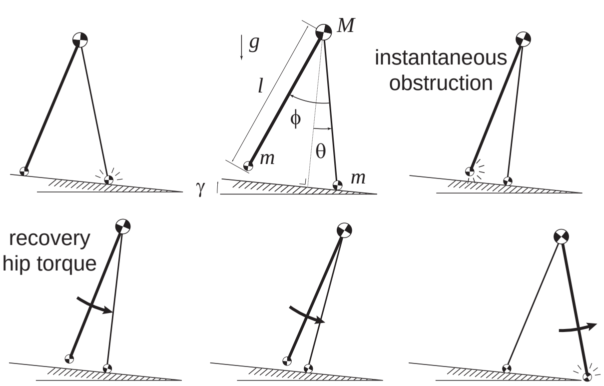

Figure 1 A schematic representation of the model being perturbed and showing an elevating strategy.

METHODS

In this study we use the simplest walking model [3]. During cyclic gait, swing leg perturbations are simulated by instantaneously setting the swing leg velocity to zero (fig. 1). Recovery strategies are added to the model, implemented as the ability to introduce a constant forward hip torque to: (A) move the perturbed swing leg forward in case of an elevating strategy, (B) move the new swing leg forward after placement of the perturbed foot.
The occurrence of the perturbation during a step is varied and the required torque to stabilize the system is determined for the two recovery strategies.

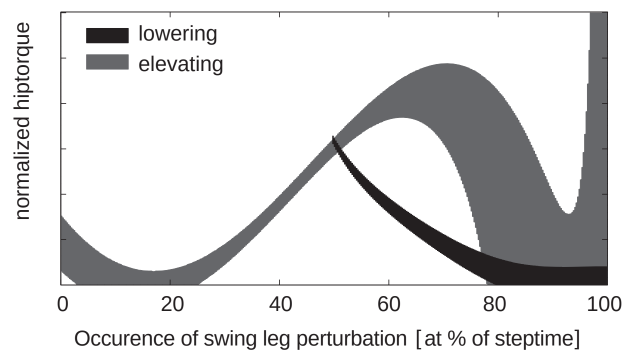

Figure 2 The contour maps show the range of hip torques that result in a successful recovery of the walking model after the swing leg perturbation.

RESULTS AND DISCUSSION

For both recovery strategies, figure 2 shows the range of hip torques that result in a successful recovery of the walking model for swing leg perturbations occurring from swing initiation at 0% to heel strike at 100%.
The simulation shows that the maximum torque required to perform a lowering strategy is lower compared to an elevating strategy. This suggests that, for perturbations after mid swing, a lowering strategy is favorable for low power robots.

REFERENCES

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