Humans are able to exploit ground oscillations to achieve greater hopping height

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Summary

To evaluate human hopping performance on oscillating grounds, data from 11 participants performing a hopping task on an oscillating surface were analyzed. Greatest hopping heights were achieved when the take-off occurred during the upwards motion of the ground. With 56.6 % of the take-offs occurring during this phase, humans show the tendency to exploit this upward acceleration for their hopping.

Introduction

While perturbations to human hopping can allow insights into the underlying biomechanical processes, vertical ground movements have not yet been extensively studied [1]. Simulations point towards specific combinations of ground properties and human neuromechanics [2] which allow stable hopping [3]. We therefore investigated, if humans can identify and exploit these ground properties during a hopping task.

Methods

The experiment was conducted on the HUMVIB bridge [4], a structure consisting of two steel beams covered by slabs of concrete. The structure with an eigenfrequency of 2.0 Hz is excitable by humans. Ground Reaction Forces (GRF) and Motion Capture Data from 11 participants performing subsequent hops with 2.0 Hz were analyzed (total hops = 1170) to assess both hopping height and the timing of take-off in relation to the bridge's oscillation.

Results and Discussion

In general, highest hopping heights were achieved when the take-off occurred during the upwards motion of the ground (Fig. 1), while take-offs during the downward motion led to reduced hopping heights. Since 56.6 % of the take-offs occurred during the first half of the upward motion, humans seem to prefer an upwards ground acceleration during take-off (as in trampoline jumping), allowing for greater height. Further analysis aims to show, how this timing influences the peak torque and power in the leg joints both in experimental data and simulation models [3].

Conclusions

Humans prefer an upward acceleration during take-off in a hopping task. Greater hopping heights can be achieved, when such an upwards acceleration is present during take-off.

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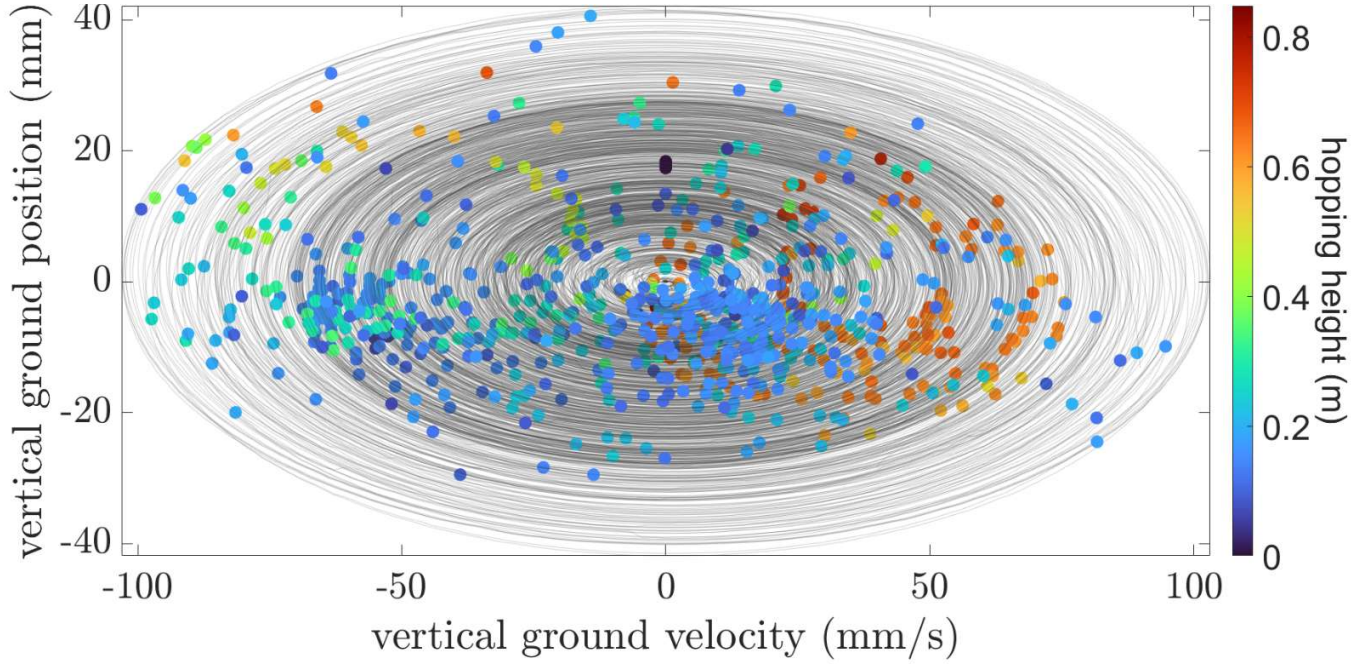

Figure 1: Phase plot of the ground oscillation (grey lines). The oscillation is shown counterclockwise with positive vertical ground position being higher than the resting position of the ground. Positive velocities indicate an upwards motion. Dots denote take-offs with the colour representing the achieved hopping height.