Centre of Pressure Capture & Reconstruction in Physically-Based Character Animation

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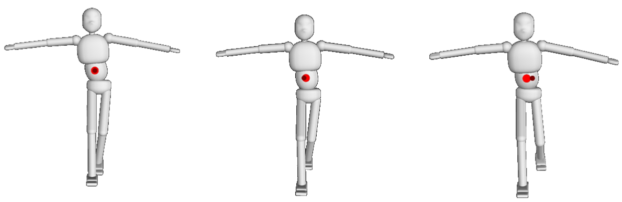

Figure 1: Virtual characters in mid-stride. The red dots signify their centres of mass. See the video.

ABSTRACT

Over the past two decades, research on controlling balance in virtual characters has largely focused on the problems of achieving robust standing balance and that of robust locomotion. Balance controllers have been developed around a variety of principles, including linear momentum control[1], angular momentum control[2], model-predictive control[3], and virtual model control[4]. They vary greatly in the assumptions about the nature of the balance or movement tasks, the abstractions used, and their reactive or anticipative nature. However, almost all balance algorithms presume that the center of mass and its velocity are known quantities that can be used within the control equations. This unfortunately allows virtual characters to potentially have super human balancing abilities. Previous work has demonstrated that natural and interesting degradation of a balance controller can be produced by injecting noise into the balance controller's gravity direction, or likewise by directly perturbing the control torques.

In this project, we have instead configured a force sensor apparatus (Figure 2) and captured data with the goal of building a model for the error that humans make in controlling their center of mass via the force they exert on the ground. The apparatus consists of four six-axis force sensors bolted to wooden boards. A participant is able to stand on the boards, with one sensor under the toe and heel of each foot.

A software system solves for the centre of pressure from the torques and forces of all four sensors. A recording system captures samples at 100 Hz in a variety of poses, which is later used as the training set for an autoregressive-moving-average (ARMA) model. The fitted model can then be used to reconstruct the signal in the context of a real-time graphics engine (Figure 3). As part of the project, we have incorporated our technique into the existing, opensource animation software *Cartwheel 3d*[5] (Figure 1).

Our system interfaces with the animation controller by modifying the percieved centre of *mass* with our model of the centre of *pressure*, plus some variable scaling coefficient. We have found this to be a reasonable approximation without sacrificing realism in the controller output.

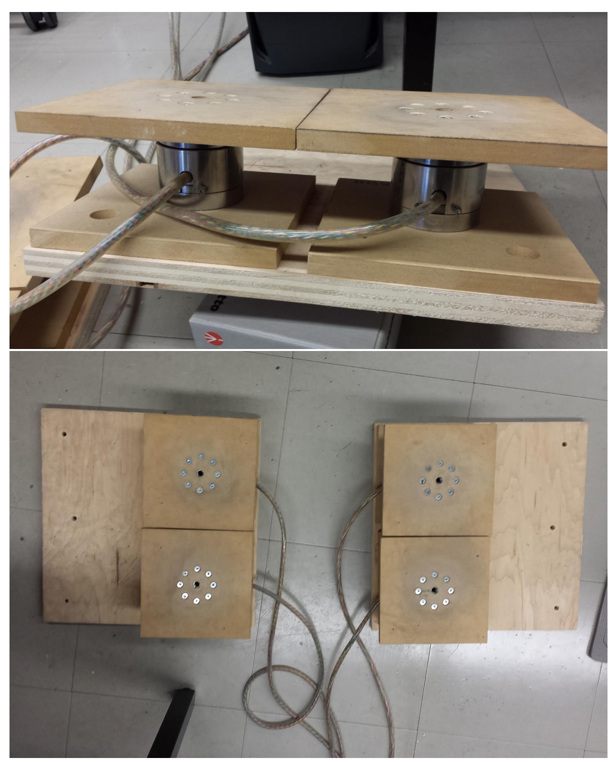

Figure 2: The force sensor apparatus

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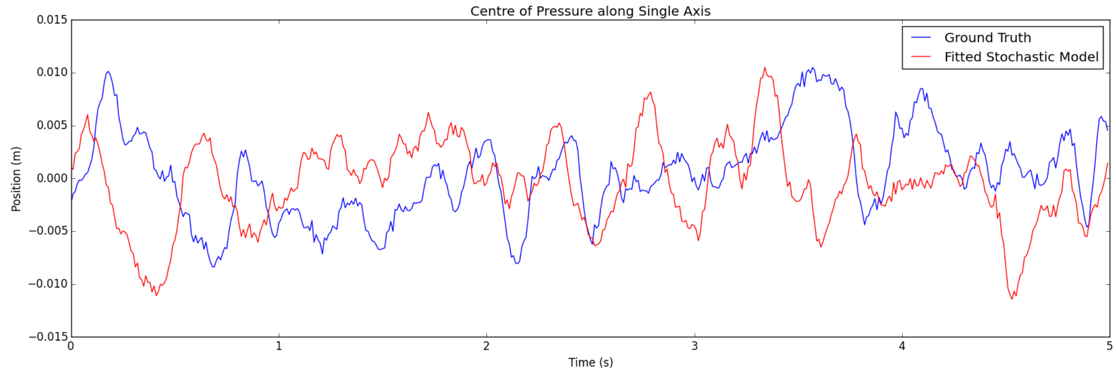

Figure 3: Samples from (blue) a one-foot-balancing training set and (red) the associated ARMA model.

The benefit of our appoach over a simple injection of white noise is that it can be powerfully generalized to incorporate exogenous variables: such examples include but are not limited to controller states and environmental factors that affect centre of balance. Such a system could allow one to develop a probabilistic approximation of character error to use alongside, for instance, motion-capture data. This is a possible route for future work in this area.

Our work finds application in any media involving animation. Video games and virtual reality are particularly relevant, as a physically-based animation approach merits user interaction and autonomy; moreover, realistic human locomotion in these domains have been rarely achieved, in part due to unrealistic assumptions that our research addresses.

1. REFERENCES

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