COMPARING THE EFFICIENCY AND ACCURACY OF SEVERAL CONTACT METHODS FOR HUMAN-ENVIRONMENT INTERACTION

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Introduction

Contact with the ground is common in typical activities, as gait, running, weightlifting, etc. But additional contacts may also appear in others, either with the environment, as in bag boxing or parkour, or between humans in partnering or opposing exercises, as duet dancing or martial arts. In the context of predictive simulation, inclusion of contact encompasses collision detection and contact force modeling, which may be computationally costly. In this work, several methods for considering human-environment contacts are compared in terms of efficiency and accuracy, seeking to provide criteria for their use in human motion simulation.

Methods

The case study is an exercise consisting of a subject kicking the half of a foam ball attached to a force plate hung from the roof by means of two cables. In the experiment, shown in Fig. 1 left, reflective markers were placed on the subject and on the force plate, their motions being captured by infrarred cameras. Moreover, the contact force between the kicking foot and the ball was measured by means of the force plate shown in the figure, while the foot-ground contact force of the supporting leg was measured by a second force plate. The same system was modeled in the computer, as illustrated in Fig. 1 right. A multibody model featuring 18 anatomical segments connected by 17 spherical joints, leading to 57 degrees of freedom, was used for the human [1], while a simple rigid body undergoing two constraints of constant distance to represent the effect of the cables was used for the force plate. In the human model, a CTC-type controller was in charge of tracking the captured joint trajectories, and the force measured by the force plate on the floor was applied to the supported foot. The geometries of foot and ball were represented either as triangular meshes or sets of spheres, and the corresponding collision detection method provided the contact parameters. With this information, the contact model (several were tested) yielded the impact force, which was applied to both the kicking foot of the human model and the rigid body representing the hanging force plate. The approximation introduced by considering the force plate measurement as the contact force was also investigated.

Two trials of the experiment were performed by the same subject, trying to kick the ball in the same way in both cases, the corresponding data being measured and stored. Then, for each combination of geometric representation of the contacting surfaces and contact force model, the following procedure was carried out. First, data from the first trial were used to calibrate the parameters of the contact model by optimization, seeking to minimize the discrepancy between the contact force measured by the force plate and calculated in the simulation. Second, data from the second trial were used to run a simulation in which the parameters of the contact model adopted the values obtained in the previous calibration process. The efficiency of this simulation was measured, and the accuracy was evaluated as the discrepancy between the contact force measured by the force plate and calculated in the simulation.

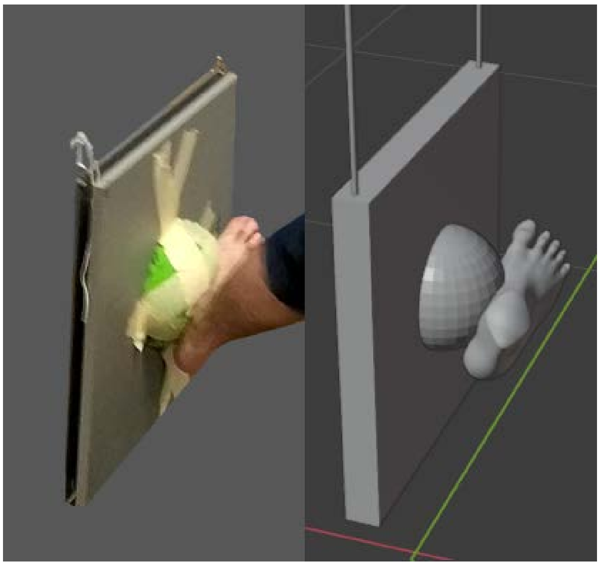

Figure 1: Experiment and simulation.

Results

A table was generated gathering the values of efficiency and accuracy obtained for each couple of geometric representation of contacting surfaces and contact force model.

Discussion

Based on the data gathered in the table mentioned in the previous section, conclusions were drawn, and criteria were provided for the use of the different alternatives to model contact between humans and environment in the context of predictive simulations.

References

1. F. Mouzo, U. Lugrís, R. Pamies-Vila and J. Cuadrado, “Skeletal-level control-based forward dynamic analysis of acquired healthy and assisted gait motion,” Multibody Syst Dyn 44(1):1-29, 2018.