Continuous force reaction in animation of avatars

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Abstract

Pre-recorded animation is the best way to reproduce detailed and natural human movements. However, in interactive animations we need techniques to modify the avatar movement in a feasible way. This research combines pre-recorded and physics-based animation to simulate the movement of the body when it is perturbed by external forces. The main results of this work are the possibility of separately animating different parts of the body and to obtain the reaction to forces that last long intervals of time.

1. Introduction

Pre-recorded animation of avatars, using techniques such as motion capture, are able to reproduce detailed and natural human movements [vWvBsZRO09]. However, in interactive animations, they have the limitation that the characters cannot react to unpredicted situations, e.g, an impact or other physical interactions with other objects. On the opposite side, physics-based animation of avatars can react to any physical interaction provided that we have an adequate collision response model. However, these models are complex and obtaining realistic and natural movements is a very difficult problem [vWvBsZRO09].

In order to overcome these difficulties, several authors have proposed hybrid approaches that mix, in different ways, pre-recorded animations with interactive simulation. Shapiro and co-workers [SPF03, SCAF07] use a three layered system to control an interactive character; a key-frame animation controls the pose; a second layer decides if interaction has to be considered; then, a third layer controls the body movement during interactions. Mandel [Man04] considers the simulation of situations such as falling down or getting up, also using control algorithms. Zordan et al. [ZMCF05, ZMM*07] propose a methodology for a realistic animation of impacts in a fight game. During a fraction of time just after an impact, the body movement is highly influenced by contact forces. Based on this fact, they use motion capture data to perform the avatar movement and, when the avatar receives an impact, a physics-based full body model is used to simulate body reaction during a short interval of time. The physically computed trajectory is blended with a properly selected animation from the database to achieve a smooth transition back to key-framing.

In this work we present a method based on this hybrid approach but, in our case, we are interested in a different range of interactions. We will consider forces that act locally in one part of the avatar's body. The force is considered strong enough to change the movement of the affected region but not strong enough to displace the whole body. Also, we want to consider forces that last during a longer interval of time than impacts. This kind of interactions can be considered when, e.g., two people interact gently or when someone is holding on to an object that can move. The main contribution of our work is twofold; on the one hand, we only activate the physic model for the body parts affected by external forces, thus saving computations, and, on the other hand, we use a basic controller to consider long interaction intervals.

2. Animation procedure

In this section we describe the animation procedure proposed. As a starting point we consider an avatar which is animated using a key-frame animation. When an interaction takes place, by means of contacts or any other external force, the perturbation is animated in three phases:

1. An articulated rigid body model is activated to simulate only the affected region of the body. The dynamic bones are linked to the key-frame animation path by means of damped springs.

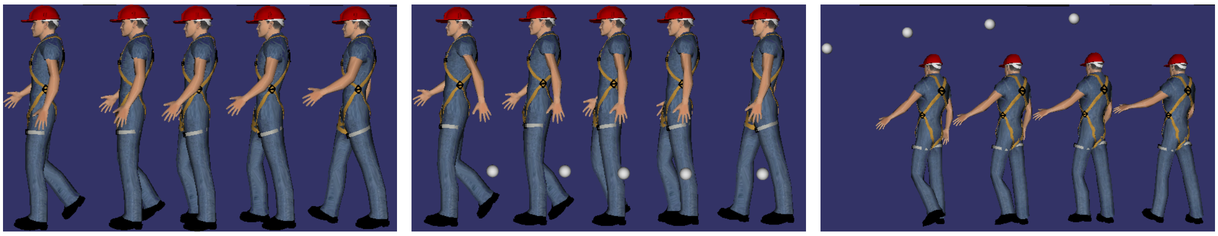

Figure 1: *From left to right; selected frames from the original key-frame animation; the animation with an horizontal force acting on the arm; the animation with a vertical force acting on the arm. The force acts on the wrist, towards the white ball.*

2. When the force ceases, the springs are stiffened to make the body go back to the animation path.
3. When the physics model is closer than a threshold to the original animation, it is deactivated, and the bones are driven back to animation by interpolation.

During the process, the rest of the body is animated using the original animation path. The activation of bones is done per extremity; If any bone of the arm is affected by interaction, then all the arm up to the shoulder is activated. To avoid unnatural poses, a set of thresholds are considered for the articulations and, when surpassed, the trunk is also activated.

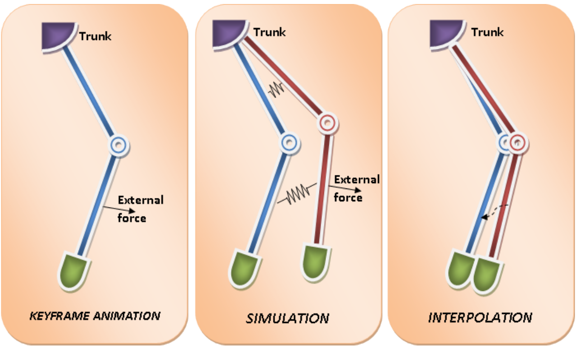

Figure 2: *Scheme of an animation of the arm. When a force acts on an extremity, a physic model (bones in red) is activated and linked to the key-frame animation (bones in blue) using springs. When the force ceases, and the physics model is close to the key-frame animation, then it is interpolated.*

3. Results and conclusions

For our simulations we have used avatars based on Cal3D, with 52 bones. The physics based model is composed of 17 bodies with 16 joints of different types and has been implemented using Bullet. In order to test the methodology, we have considered an avatar that is walking. On user request, a force is applied to his hand in different directions.

The obtained animations are plausible, and can simulate forces acting during unlimited intervals of time. When the trunk is activated, however, the movement can result unrealistic in some situations, specially when it's needed to keep the body balance.

We have presented a methodology that is based in the idea of activating a physics based body under interaction. The methodology allows the simulation of long-lasting gentle interactions in a feasible manner, with smooth transitions. This work, however, is still ongoing research, and several improvements are being prepared. As future work, we have the intention, in the first place, to change the linear springs by higher order controllers. With this improvement we could drive the bones to produce more realistic animations, including the avatar opposition to forces, such as body bending against wind. We are also considering the activation of bones only when unnatural postures or movements are to happen. In order to do this we will define an objective function which will help to decide when to activate or deactivate a bone. The main limitation of the approach is that it is not robust enough for strong interactions. In order to tackle with such situations we intend to combine our technique with the one proposed by Zordan [ZMM*07] when the forces is strong enough to make the avatar to fall or have a big displacement.

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