Learning locomotion movements in a physical cartoon simulation

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Abstract : (200 mots)

Physics-based character animation has seen significant advances in recent years. Optimization and reinforcement learning methods have made it possible to increase the complexity of learned movements [1, 3, 8, 9, 10]. These approaches generally aim to produce realistic movements, similar to those of humans, while respecting real physical laws based on motion capture data. However, in the field of cartoons or cinema (action, science fiction, or fantasy films), physics is often distorted [2]: the laws of motion are deliberately exaggerated or modified to enhance the humor, expressiveness, or spectacular nature of the scenes (see Figure 1).

We propose to explore a motion generation model in a "zany" physical simulation [2], where the laws of physics are adjusted to produce expressive and unexpected behaviors. We want to integrate physical parameters into the learning process, such as adding virtual forces to assist or disrupt the character. Experiments will begin on a simplified model before moving on to more complete morphologies, guided by data from movie scenes or cartoons.

Project description :

Physics-based character animation has seen rapid progress in recent years. Data-driven optimization and reinforcement learning methods have enabled the field to evolve. These methods can generate a wide range of natural and realistic movements, from locomotion to athletic or acrobatic actions [1, 3, 8, 9, 10]. These approaches often aim to produce realistic movements, similar to those observed in humans, based on accurate physical models and real movement data.

However, in cartoons, as in certain film genres (action, science fiction, and fantasy films), physics is deliberately altered: the laws of motion are exaggerated, distorted, or suspended to enhance the humor, expressiveness, or spectacular impact of scenes, as illustrated in Figure 1. Traditionally, this type of movement could be generated manually by animators, but also more automatically using signal processing operations to reproduce the effects of inertia, anticipation, or exaggeration [6, 7].

We want to explore a new avenue, that of automation based on data and advanced calculation methods within a "zany" physical simulation [2], where physical consistency remains

present but is modulated to produce dynamic, expressive, and unexpected behaviors inspired by cartoon animation or movie special effects.

We want to continue using existing physics engines, especially since some now offer significant parallelization, which is particularly well suited to automated approaches. In this context, we propose developing a method that directly integrates modifications to the parameters of physical laws into the calculation process in order to generate movements that are exaggerated or physically difficult or even impossible to achieve. We plan to include virtual or external forces that assist or disrupt the character's actions, or modify the direction and intensity of gravity, suspend the application of certain forces, modify kinematic and physical properties such as joint limits, degrees of freedom, masses, and inertia, or modify contact management to allow bodies to pass through or slide over each other or to support themselves without requiring contact. One of the major challenges will be to guide the calculation in such a way as to remain within the bounds of "reasonable" physics, while producing dynamic and expressive movements suited to our target applications. To do this, we will introduce terms to minimize alterations to physics.

The proposed approach will begin testing on a very simple 2D character, for example with just rigid bodies for the upper body and both legs, in order to validate an initial prototype. Then, gradually, we will be able to take into account a more complete morphology (in 3D with numerous bodies and degrees of freedom) and complex environments (numerous objects present in the scene). An additional avenue would be to exploit data from motion capture applied to movie or cartoon scenes featuring such behaviors, in order to guide or assist the model's learning by providing it with plausible poses, even if they are physically unrealistic.

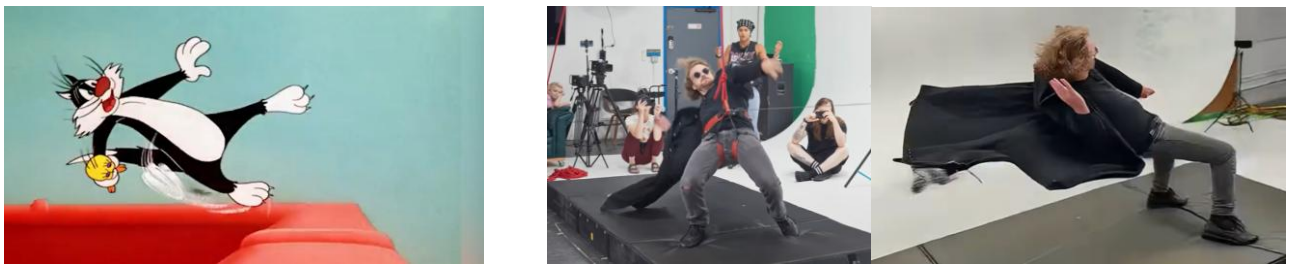

Figure 1. Two examples of physically unrealistic movements, but frequently seen in many films and cartoons [4, 5]. Our goal is to reproduce this type of movement by learning to adapt the laws of physics within a motion controller based on physical simulation.

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[3] FreeMusco: Motion-Free Learning of Latent Control for Morphology-Adaptive Locomotion in Musculoskeletal Characters. Kim et al. SIGGRAPH Asia 2025
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[6] Wang etal, The cartoon animation filter. SIGGRAPH 2006
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