Practical Character Physics for Animators

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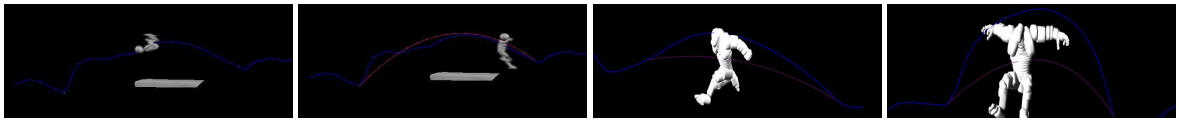

Figure 1: *The blue curve is the trajectory of the center of mass of the character's animation that an animator created manually. Our system suggests the physically correct ballistic path (the red curve) that the character's center of mass should follow. The system allows an animator to automatically change the original animation to match physical laws.*

CR Categories: I.3.7 [Computer Graphics]: Three-Dimensional Graphics and Realism—Animation; I.3.6 [Computer Graphics]: Methodology and Techniques—Interaction Techniques

1 Exposition

Physical realism is an important aspect of producing convincing 3D character animation. This is particularly true for live-action visual effects where animated characters occupy the same scene as the live actors. In such a scenario, a virtual character's movements must visually match the behavior and movements of the live environment, else the discrepancy will be obvious to the viewer.

We present an animation system that significantly improves the visual quality of certain types of 3D character motion animated through traditional means by inferring physical properties and correcting the results through the use of dynamics. These physical characteristics are visualized and provide information not normally available to traditional 3D animators, such as displaying the center of mass, angular momentum and zero moment point. By comparing the original path as generated by an animator, against a proper physically-based path generated by our tool, the animator is able to interactively modify the original motion path to more closely match the generated physics-based path. This often results in better quality character motion. Two different types of motion can be adjusted: animations which involve ballistic paths, such as falling and jumping, as well as animations involving character movement which require balance and posture, such as walking or running. This dynamics visualization method is integrated into a professional software system for use in a visual effects studio that incorporates live-action with 3D animated characters in feature film production. Our research shows that between 10% and 16% of the shots of a character-heavy feature film will incorporate ballistic motions that may be improved by our system.

Additionally, we investigate the physical accuracy of the high quality animations that are manually created by professional animators. Our study shows the capabilities and limitations of the conventional kinematic animation process in terms of physical realism. We compute the center of mass and momentum of the ballistic motions and investigate how accurately these properties follow Newton's laws. For walking and running animations, we compute the zero moment point (ZMP) and measure how far it falls from the support polygon.

Many animators found this system useful for improving physical realism of the keyframed animation. Interestingly, we found that the visualization tools introduced here can also serve as a gavel. Individual animators may have their own sense of physical correctness, which can cause debate over how a character should move when collaborating animators have a different sense of physical intuition. We have observed that our tool helps animators reach an agreement on physically correct animation by quantifying the discrepancy in the motion. For example, our system can indicate exactly how many frames an animation should be slowed down or sped up.

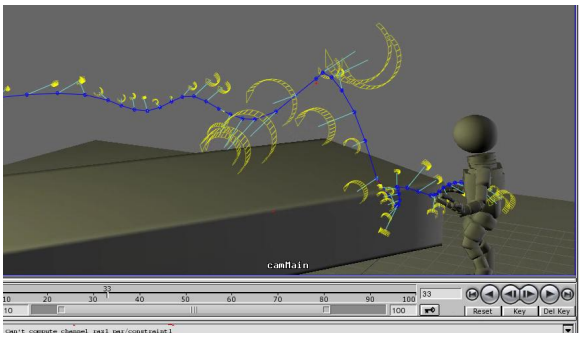

Figure 2: *Visualization of angular momentum, shown as a vector protruding from the center of mass of the character. The yellow arrows indicate the direction of the motion. The length of the momentum vectors indicate the relative amount of rotation about that axis. Note that our system is able to detect subtle animation problems, such as large discrepancies in angular momentum during the ballistic phase. In this case, the character rotates counter-clockwise, and then clockwise during flight, which is not physically valid.*

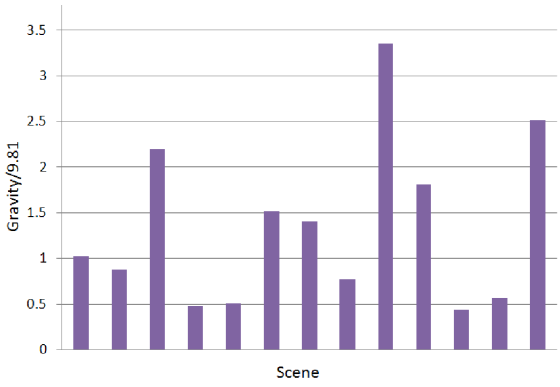

Figure 3: *Measurement of physical correctness of ballistic motions created created by professional animators conventional key framing process . The y-axis indicates the relative measurement of gravitational force in the scene, where 1 = normal gravity.*