Physics-Based Character Animation in Real-Time

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Virtual characters are ubiquitous in a wide range of graphics applications from real-time computer games to (offline) special effects in movies. Enabled by recent advances in 3D-scanning and character generation, realistic virtual avatars are also increasingly used in virtual reality applications, where they allow the user to act in and interact with the virtual environment. In particular in this rapidly growing field of research, the steadily improving fidelity of character appearance increases the demand for more realistic character animation - while retaining interactive frame rates. Existing approaches either suffer from artifacts, have high computational costs or require a lot of input data like multiple surface scans of the character in different poses or manually defined per-vertex skinning weights.

Our Fast Projective Skinning approach (FPS) [1, 2] introduces a two-layered model consisting of rigid bones and an elastic soft tissue layer that is efficiently constructed from a surface mesh of the character and its underlying skeleton. While maintaining real-time performance our method overcomes the well-known artifacts of commonly used geometric skinning approaches. It further enables dynamic effects and resolves local and global self-collisions. In particular, our method neither requires skinning weights, which are often expensive to compute or tedious to hand-tune, nor a complex volumetric tessellation, which fails for many real-world input meshes due to self-intersections. By developing a custom-tailored GPU implementation and a high-quality upsampling method, our approach is the first skinning method capable of detecting and handling arbitrary global collisions in real-time.

In the second part of our talk, we would like to briefly introduce our second model, which focuses on *human* virtual characters [3]. This restriction to human characters allows us to build an anatomically plausible three-layered representation of a person from a single surface scan. It is composed of three surfaces for bones, muscles and skin enclosing the volumetric skeleton, muscles and fat tissues. Our approach is able to compute this model for a specific person in just a few seconds. It includes a data-driven method for estimating the amount of muscle mass and fat mass from a surface scan, which provides more accurate fits to the variety of human body shapes compared to previous approaches. Our second model provides more realistic character animation than the former two-layered model and can further be used for physical simulation, statistical analysis and anatomical visualization in computer animation or in medical applications, which we demonstrate on several examples.

References

[1] M. Komaritzan and M. Botsch. Projective Skinning. *Proceedings of the ACM on Computer Graphics and Interactive Techniques*, 1, 2018.

[2] M. Komaritzan and M. Botsch. Fast Projective Skinning. *Proceedings of ACM Motion, Interaction and Games*, 22:1–22:10. 2019.

[3] M. Komaritzan, S. Wenninger and M. Botsch. Inside Humans: Creating a Simple Layered Anatomical Model from Human Surface Scans. *Frontiers in Virtual Reality*, 2. 2021.