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Survey of Skinning Method in 3D Character Animation

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Abstract: *Character skinning is one of the most important tasks in 3D animations, games design and visual effects in film production. With the development of 3D animations, a good way of skinning becomes an important role. With the increasing requirements of skinning, many new methods and techniques have emerged. The most core part is real-time shape deformations, to make the skin of characters to act more realistic, no informal deformation should happen. This paper introduces skinning technique in 4 categories: geometric methods, physical methods, example based approaches, energy based methods. A brief discussion and comparison of these methods are provided in the end.*

Keywords: *Character animation, Skinning, Physical method, Energy, Geometric approach*

1. Introduction

Character skinning was a very popular topic in 2000-2014, lots of methods were developed. Most problems like candy wrapper joint problem has been solved. In many video games, a more realistic scene is required. Skinning technique requires a more precise method to perform the deformations of the skin. Therefore, skinning technique is still improving in these years. Increasing number of research papers has been published.

There are four mainstreams in skinning techniques: methods based on physics, geometry, example and energy. These methods have their benefits in different problems, to solve problem fast and low cost with a good algorithm are the final goal of all the questions. Therefore more methods, which can solve problem fast, have been developed.

The following sections will be separated in three parts. There will be four different methods presented: geometric method, physical method, energy based method and example based method. Then a contrast of these methods will be presented. An illustration of the differences of these methods with a chart will be discussed. An explanation of the advantages and disadvantages of each methods will also be discussed. Finally there will be a conclusion presented in this paper.

2. Methodology

2.1. Physical Methods

Deul C.[1] proposes a multi-layer skin model to represent the interaction of fat, muscles, and bones(Figure 1).

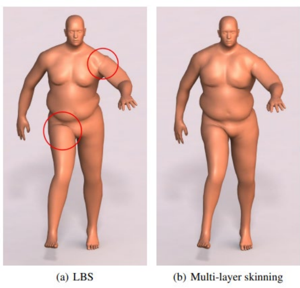

Figure 1: The visual performance of skinning method in Deul C.[1]

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Martin Komaritzan[2] proposes a skinning method that enhances the recent Projective Skinning based on quality of animation and the performance of computational. Marco Fratarcangeli.[3] proposes a two-layered method to overcome the issue of generating mesh-based skin deformation. Kim, Theodore[4] proposes a domain-decomposition method that within a subspace framework, we can simulate the whole articulated deformable. Ming Gao[5] proposes a method that can generate physical skinning animations of skeleton-driven characters. Fabio Turchet[6] proposes an extension of implicit skinning with wrinkles, this large amount of parameters will allow users to adjust the behavior of the wrinkles then find the solution. M.P. Cani.[7] proposes a new skinning technique that inherit the best feature of implicit skinning, and makes the method robust and applicable for production pipeline. Otman Benchekroun[8] proposes a elasto-dynamic decreased-space solution that is fit for the secondary motion of augmenting rigged character animations, the core of this method is a LBS-based deformation subspace.

2.2. Geometric Methods

Vaillant, R.[9] proposes a completely geometric method that can real-time handle skin contact effects and muscular bulges. This method well fits into the standard animation pipeline. HANNER, F.[10] proposes DQS is an rigging technique that binds a mesh to skeletal joints, it can avoids the candy-wrapper effect and can easily replace LBS. SIFAKIS, E.[11] proposes an algorithm that increase the precision of soft tissue and the speed of computation speed(Figure 2).

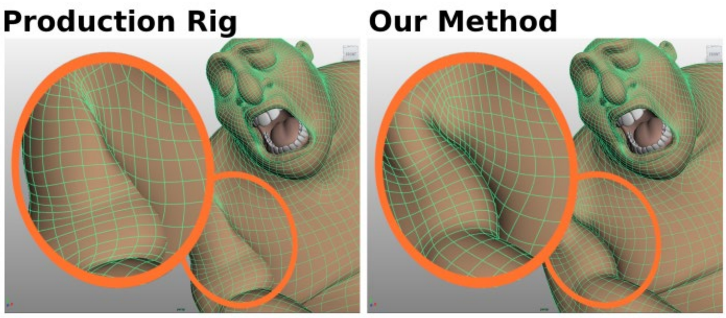

Figure 2: The visual performance of skinning method in SIFAKIS, E.[11]

KAVAN L.[12] proposes an extension of the work published in [Kavan et al. 2007]. Added a more complete dual quaternion. Twigg[13] proposes that skinning can automatically skin deformable mesh animations by not applying any particular skeletons or bones. FORSTMANN, S.[14] proposes a high quality real-time geometric deformations provided by a new skeletal animation system. Le B. H.[15] proposes a better algorithm on it's efficiency and apply better on Delta Mush compare to some previous geometric weight blending algorithms.Rohmer D.[16] proposes a method to smooth skinning which can prevent lossing volume when deformation. Rumman N. A.[17] proposes a two-layered deformation model to skin in real-time. Stavness I[18] proposes a geometric-based skinning method that combine geometric blending for rigid-body models with embedded surfaces for finite-element models. ANGELIDIS A.[19] proposes a method of skinning where skeletal motion induce divergence-free vector fields, and discuss the speed of skin deformation. Seungbae Bang [20] proposes a interface to edit skinning weights by suing splines [Bang and Lee 2018]. Yang X[21] proposes surface skinning by using a particular class of T-spline surfaces. Nasri A[22] proposes a T-splines solution to solve the problem of increasing number of control points by knot inserting in the interpolating approach. Funck, W. V.[23] proposes a good way of remaining the volume mesh skinning. M. Chai[24] proposes a self-adaption skinning method on hair for interactive hair simulations with hair-solid collisions. M.-J. Oh et al.[25] proposes a way to remove the wiggles on the skinned T-spline surface. Y. Li[26] proposes a formulae to construct T-spline skinned surfaces, this approach generates less control points than NURBS skinning. Jaillet, F.[27] proposes a method for smooth closed surface approximation from 2D contours. J. Li[28] proposes a way of automatically skinning and animation of skeletal models. G. Slabaugh[29] proposes a calculation of a continuous interpolation of a discrete set of balls. L. Kavan[30] proposes a new method calls bones blending to replace vertex blending, and bones blending can overcome artifacts of vertex blending.C. Chen[31] proposes a framework to transfigure a skeleton-driven animation model, this approach can generate surface motions. Yash Kant[32] proposes a invertible neural skinning which is a reversible ,end to end differentiable pipeline to repose human.

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2.3. Energy based Methods

Jeruzalski T[33] proposes a method to reverse the deformations undergone by traditional skinning techniques by a pose parameter neural network. Jacobson A.[34] proposes automatic skinning pipeline and defining skinning weights. Kavan, L.[35] proposes a way to skinning without any skeleton. Komaritzan M.[36] proposes a skinning technique based on projective dynamics which can handle typical skinning artifacts, can generate high quality skin deformations.

2.4. Example based Methods

YANG, X.[37] proposes this method can solve candy wrapper joint problem, can also remain the same hierarchical joint-skeleton based system. This will reduce the complexity in the skinning and deformation, it also has a faster computation speed by using only one weight(Figure 3).

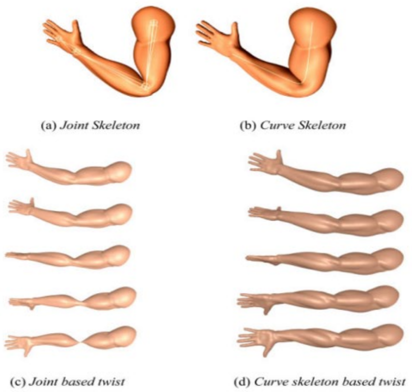

Figure 3: The visual performance of skinning method in YANG, X.[37]

L. Kavan[38] proposes a method that works in a linear subspace, and the subspace is obtained by a dimensionality reduction, reduces the complexity of the iterative optimization. XIAN, X.[39] proposes a layered framework to combine the example-based skinning algorithms into an existing character animation system. Binh Huy Le[40] proposes a compression method, it separate the DDM model into two layers , this two-layer model can remain the original DDM model and lower the costs. LARBOULETTE C.[41] proposes a method to enrich character animations by adding a dynamic reply of the skin to the movement of the underlying skeleton. Fechteler, P.[42] proposes an example-based framework to generate a well optimized shape pose and skinning parameters kinematic 3D human body model . KAVAN, L.[43] proposes a real-time animation system, shows a new algorithm which removes the disadvantages while maintaining almost the same time and memory complexity as the LBS. D. Murtagh.[44] proposes to combine skeletal subspace deformation(SSD) and the skeleton based dual-quaternion skinning and find out the new property of the combination algorithm.

3. Discussion

In this part, an assessment of these methods will be presented. Normally when a skinning method needs to be assessed, it's computation speed, realistic and robustness will be discussed. Therefore a chart to have a contrast of these methods is presented. Each of these methods will be assessed by low, medium and high. Low means this method is bad for this assessment, medium is ok for this assessment, high means this method is very good at this assessment.

Table 1: Comparison of each methods

Approaches	Computation speed	Realistic	Robustness
Physical methods([1]-[8])	Low	High	Medium
Geometric methods ([9]-[32])	High	low	Medium
Energy based methods ([33]-[36])	medium	high	High
Example based methods([37]-[44])	high	medium	low

Physical methods([1]-[8]) normally use finite element or spring mass model, so the realistic is quite nice. However the computation speed is not high. Geometric methods ([9]-[32]) has a quite high computation speed, the typical method is LBS. However, high computation speed brings low realistic

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on its quality. Its robustness is not bad. Sometimes it may bring candy-wrapper effect. Energy based methods([33]-[36]) normally use energy function to set up a model, so it's computation speed is not so fast. However the quality is quite high, and normally energy function has high robustness. Example based methods([37]-[44]) normally defines a model. Therefore the computation speed and quality will not be bad. However over-fitting could appear in models, so robustness is not good here (Table 1).

4. Conclusion

Character skinning plays an important role in animations, games and some other fields. Some scene usually include many characters, and lots of real-time skin deformations happens at same time. Therefore the final target is to perform a fast and accurate real-time skin deformation. This paper introduces the related methods in four different classes, and make a comparison of them. The satisfaction of computation speed, realistic and robustness will be the challenges in the future.The satisfaction of these challenges will improve the efficient and accuracy of the skinning technique .Eventually the skinning technique will be more useful in the future.

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