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Anatomy-Inspired Weight for Real-time Character Animation

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Abstract

In this paper, the use of anatomy-inspired weight (AIW) is proposed to automatically compute the skinning weights for real-time character animation. AIW is modeled as a function of the anatomical distance to consider anatomical structures, such as bones and muscles. The experimental results demonstrate that AIW's facilitate the natural animation of characters, which is an important part of VR/AR/MR contents.

Categories and Subject Descriptors (according to ACM CCS): I.3.7 [Computer Graphics]: Three-Dimensional Graphics and Realism—Animation

1. Introduction

Real-time character animation is important for applications such as VR/AR/MR contents. Linear Blend Skinning (LBS) the is most popular method for real-time application, which requires skinning weights. The skinning weights represent the influence of bones on a vertex and it should be bounded by considering the relationship between bone and skin. As a result, a binding process of the skinning weights depends on the artist's knowledge and experience.

Although novel methods such as elasticity-inspired weight [KS12] and the geodesic voxel-based weight [DdL13] can be employed to compute skinning weights automatically, it is challenging to bind skinning weights of the shoulder region because of the complex structure of the shoulder. However, anatomy-inspired weight (AIW) can automate binding the skinning weights based on knowledge of anatomy. The skinning results obtained using AIWs facilitate the realistic animation of the shoulder, such as movements of the scapula. As a result, AIW reduces costs for character modeling and improves the quality of character animation.

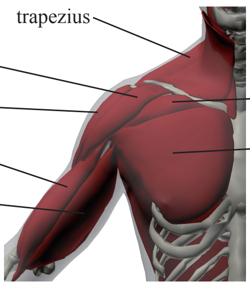

Figure 1: *Input meshes.*

2. The anatomic distance

AIW requires meshes of the skin, bones, muscles, and anatomy-inspired pass-penalty parameters β. Figure 1 and Table 1 show the input meshes and the pass-penalty parameters, respectively. The anatomic distance is modeled by considering the shape of internal structures and the relationships between the bones and muscles such as contacts or attachments.

The anatomic distance is computed in three stages. The first stage is voxelization of the input meshes. The second stage involves the measurement of the distance between the i-th bone and the boundary voxels. The main procedure is similar to the method of voxel-based geodesic distance [DdL13], but the equation for the distance update is modified as follows:

$$d_{n(u)} = d_u + w + \beta_{i,m(n(u))} * w, \quad (1)$$

,where u, n(u), d_u, and w represent the index of a voxel with non-infinite distance, the index of the voxel u's neighbor, voxel u's distance from the bone voxel, and the width of a voxel, respectively. In addition, $m(n(u))$ is the muscle's index of the voxel $n(u)$. The last term, which is called the anatomy term, allows the anatomic distance to consider the characteristics of muscles. The non-zero pass-penalty parameter $\beta_{i,m(n(u))}$ lengthens the i-th bone's anatomic distance when the distance is updated by a voxel of the $m(n(u))$-muscle. Note that the pass-penalty parameter between the i-th bone and j-th muscle is represented by $\beta_{i,j}$.

The pass-penalty parameters in Table 1 are based on the influence of bones on muscles, but the artist's impressions are also reflected. For example, the parameter between the lateral deltoid and the scapula is set to 1, although the shape of lateral deltoid is affected by the scapula. This reflects the artist's impressions, such as "The scapula's bone weights for the upper arm area should be de-

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Table 1: *The pass-penalty parameters.*

	Thorax	Clavicle Scapula	Humerus
Anterior Deltoid	1	1	0
Lateral Deltoid	1	1	0
Posterior Deltoid	1	1	0
Biceps Brachii LH	1	1	0
Biceps Brachii SH	1	1	0
Brachialis	1	1	0
Triceps	1	1	0
Pectoralis Majors	0	1	1
Trapezius	0	1	1
Latissimus Dorsi	0	1	1

creased". This modification is also applied to the posterior deltoid's parameter.

3. Bone weights based on the anatomic distance

To calculate the AIW, the proposed method adapts the approach of Dionne and de Lasa [DdL13], which is expressed as follows:

$$w_{i,j} = \left(\frac{1}{(1-\alpha)(d_{i,j})+\alpha(d_i,j)^2}\right)^2 \quad (2)$$

, where α is the bind smoothness parameter in the range [0,1], which was set as 0.7 in all of the experiments in this study.

4. Result

The experiments were performed using an Intel Core i7-3770 processor with 16 GB of memory. The LBS method and binvox were used for skinning and voxelization of the meshes, respectively [NT03]. The resolution of the voxel grid was 384 × 384 × 384.

To obtain the experiment results, data from bodyParts3D [MFT*09] were used to model the bones and musculature, which was originally created from a whole-body set of 2-mm interval MRI images. The data was modified manually for the skin meshes.

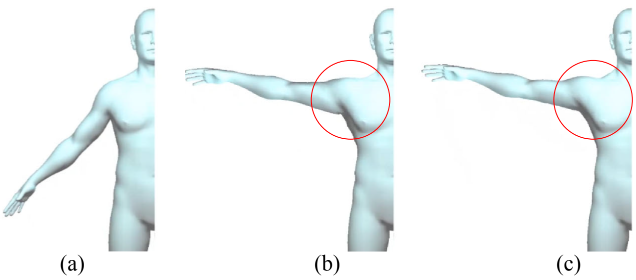

Figure 2: *Comparison of the skinning results. (a) Rest pose. (b) The geodesic distance-based weights [DdL13]. (c) AIWs.*

The skinning results obtained using the AIWs exhibited more realistic shoulder animations. Figure 2 shows the natural armpit and upper shoulder parts. Figure 3 shows that the skin reflects the movement of the scapula, which is not the focus of the previously proposed automatic skinning weight computation method.

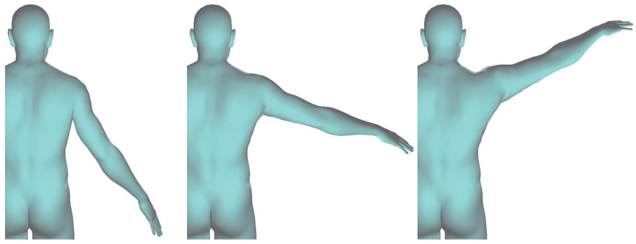

Figure 3: *Skinning results with AIWs in the back view.*

5. Conclusion and Future Work

AIW uses the anatomic distance which reflects the anatomic-knowledge and artist's impression. As a result, AIW reduces costs for character modeling and improves the quality of real-time character animation.

The main limitation of the AIW is the requirement for anatomic data, which is difficult to model manually. However, novel research has been conducted in anatomy modeling such as the anatomy transfer-based approach [AHLG*13]; thus, these approaches may resolve some of the modeling difficulties.

Much future development is also required. In particular, modification and verification are required for full body pass-penalty parameters, which partially depend on the insight of the artist. Future research will address these issues.

Acknowledgements

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References

[AHLG*13] ALI-HAMADI D., LIU T., GILLES B., KAVAN L., FAURE F., PALOMBI O., CANI M.-P.: Anatomy transfer. *ACM Trans. Graph. 32*, 6 (Nov. 2013), 188:1–188:8. 2

[DdL13] DIONNE O., DE LASA M.: Geodesic voxel binding for production character meshes. In *Proceedings of the 12th ACM SIGGRAPH/Eurographics Symposium on Computer Animation* (New York, NY, USA, 2013), SCA '13, ACM, pp. 173–180. 1, 2

[KS12] KAVAN L., SORKINE O.: Elasticity-inspired deformers for character articulation. *ACM Trans. Graph. 31*, 6 (Nov. 2012), 196:1–196:8. 1

[MFT*09] MITSUHASHI N., FUJIEDA K., TAMURA T., KAWAMOTO S., TAKAGI T., OKUBO K.: BodyParts3D: 3D structure database for anatomical concepts. *Nucleic Acids Res. 37*, Database issue (Jan 2009), D782–785. 2

[NT03] NOORUDDIN F. S., TURK G.: Simplification and repair of polygonal models using volumetric techniques. *IEEE Transactions on Visualization and Computer Graphics 9*, 2 (Apr. 2003), 191–205. 2