

Creation of Avatars in Sportive Poses through a Digital Human Model for Skin Shape Prediction

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Abstract

Accurately predicting how skin shape deforms during sportive movements is essential for developing better-fitting ergonomic products, from high-performance apparel to athletic equipment. A digital human model (DHM) with an anatomically parametrized skeleton was developed to combine the potential of skin shape reconstruction and movement analysis. The DHM is used to predict the skin shape of a person when changing the posture through the linear blend skinning method combined with a data-driven approach to improve the accuracy. A personalized anatomically parametrized skeletal model is used to estimate the positions of joint centers and drive the skin deformations. The DHM parameters were determined using a database of 4D scans from adults (15 men and 15 women) performing sportive movements. Previous studies related with the DHM development are available [1-3].

At the current stage, the skin prediction quality is evaluated. To this end, the DHM was used to predict the posed skin shape from an initial shape in A-pose and the predictions were compared with scanned posed data. The posed skin predictions were performed for 4 women and 4 men with body mass indices (BMI) on the underweight, healthy weight, overweight, and obese categories (see Figure 1). The predictions were performed in 6 varied sportive poses (see Figure 2). The prediction quality was expressed as the average vertex-to-surface error for the body without head, hands and feet.



Figure 1. Initial body shapes of the subjects tested

Figure 2 presents examples of the posed shapes predicted with the DHM. It can be observed that the posed bodies do not present the characteristic volume shrinkage artifacts inherent to the standard Linear Blend Skinning (LBS) method.



Figure 2. Examples of predicted skin shapes

The results of the prediction errors for each participant is presented in Table 1. The table presents the mean and standard deviation of the vertex-to-surface error computed for the 6 tested postures, along with the global maximum error obtained. The global average prediction error for the tested postures was 6.6 mm with values ranging between 0 and 74 mm.

Table 1. Prediction error [mm]

Gender	BMI category	Mean	Std. deviation	Global maximum
Female	Underweight	6,9	0,4	36,2
	Healthy	6,3	0,3	42,7
	Overweight	6,3	0,4	43,1
	Obese	6,8	0,8	47,7
Male	Underweight	5,5	0,4	51,1
	Healthy	6,7	0,5	59,2
	Overweight	5,9	0,6	51,4
	Obese	8,1	0,5	74,0

The model's vertex-to-surface distance error, while comparable to other data-driven approaches, is slightly greater than the values reported for reference models such as SMPL (4.9 mm) and GHUM (4.2 mm) [4,5]. However, this trade-off in positional accuracy can be justified by the model's anatomically parametrized skeleton, which provides a foundation for future movement analysis. When comparing the scanned bodies with the predicted ones (as exemplified in Figure 3), it is possible to observe that the body shape is conserved, but there is a slight difference in the position in space of the extremities. This could be due to a bias in the target posture estimation related with the complexity of determining the skeleton joint centers' positions, leading to larger prediction errors. The highest average error was obtained for the male in the obese BMI category, this can be related with the increased complexity of modeling soft tissue. It is worth highlighting that the postures for this study were selected to represent various types of body movement leading to complex postures, which are demanding to model due to significant skin deformation.

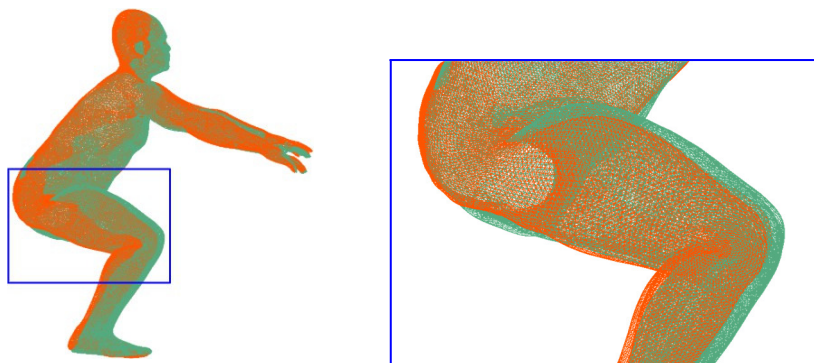


Figure 3. Comparison of scanned (green) and predicted (orange) posed shapes meshes

It was concluded that the DHM developed allows predicting the skin shape of people in the tested sportive postures starting from their A-pose shape. The evaluation was conducted on both men and women with a variety of body mass indexes (BMIs), from underweight to obese. This demonstrates the model's potential for broad applicability across different body shapes. The use of an anatomically parametrized skeletal model is a significant strength. This suggests the model's deformations are not just statistically inferred but are also constrained by a plausible underlying anatomy, which is crucial for biomechanical accuracy. In the following stages of the study it would be of interest to evaluate the skeletal model and its potential for movement analysis.

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