Egocentric Normalization of Kinematic Path

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Figure 1: *Retargetting for online performance animation. Variation in proportion and thickness between the performer and the avatar causes artifacts in case of self-body interactions. (a, d) Performed postures. (b, e) Resulting postures with [KMA05]'s technique. (c, f) Our results.*

Abstract

We focus on retargetting the class of movements involving self-interactions onto characters with different size and proportion. Such postures may produce self-collisions and/or alter the intended semantics. We introduce a technique to normalize the spatial relationship vectors between the body parts of the source character. This allows for morphological adaptation of these vectors onto the target characters, hence preserving the semantics in postures with and without body-contact.

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

1. Introduction

Simply assigning the source character's joint angles, or even a normalized posture representation [KMA05], to the target character's pose works fine whenever there is no self-body interactions. However, it quickly produces artifacts in the opposite case since these techniques do not intrinsically encode the relationships between the body surface and the limbs (see Fig. 1). Our egocentric normalization technique addresses this issue by encapsulating the spatial relationships between the limbs' joints and the other body parts (see Fig. 2).

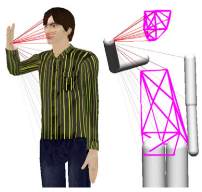

Figure 2: *The red lines are the spatial relationship vectors from other body parts to the right hand. Important parts on the body surface is sampled (magenta mesh) to build a crude representation of the body. Capsules are used for the limbs. The intensity of the red lines indicate the importance of a relationship which is inversely proportional to the distance.*

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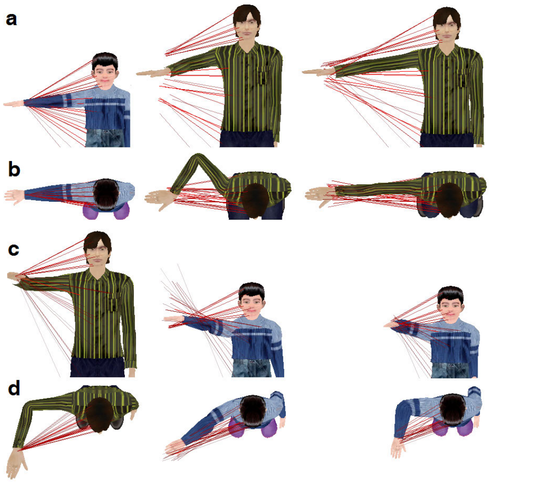

Figure 3: *Left: The "source" pose. Middle: Results without normalization on the "target" characters [AAKC13]. Using the relationship vectors in this way causes artifacts in both cases. Right: Our results. (a,b) and (c,d) are the front and top view of the same postures, respectively. The mapped hand position is obtained as a weighted average of the vectors.*

2. Related Work

A closely related work to ours is [AAKC13]. They use the spatial relationship descriptors without normalizing them, thus their method is applicable only in the context of close contact, so introduces artifacts in postures without any contact when the variation in the size is significant (see Fig. 3).

3. Kinematic Path Normalization

Given spatial relationship vector, $\mathbf{v}$, let j_0 and j_n denote the parent joint of the surface point and the expressed joints, respectively. Then, there exists a set of n segments along the kinematic path between them, $\{\mathbf{s}_1, \mathbf{s}_2, \cdots, \mathbf{s}_n\}$, where $\mathbf{s}_i$ denotes the vector pointing from j_i to j_{i+1} (see Fig. 4a). Hence

$$\mathbf{x}_{j_0} + \mathbf{v} = \sum_{i=1}^{n} \mathbf{s}_i \rightarrow \mathbf{v} = \sum_{i=1}^{n} \mathbf{s}_i - \mathbf{x}_{j_0} \tag{1}$$

where $\mathbf{x}_{j_0}$ is the vector from the parent joint, j_0 to the surface point. We can measure the contribution of any segment vector $\mathbf{s}_i$ into $\mathbf{v}$, by projecting it onto $\mathbf{v}$

$$\mathbf{s}_{i \rightarrow v} = |\mathbf{s}_i| \cos_i(\alpha), \textit{ where } \cos_i(\alpha) = \frac{\mathbf{v}}{|\mathbf{v}|} \cdot \frac{\mathbf{s}_i}{|\mathbf{s}_i|} \tag{2}$$

We use the following normalization factor, τ,

$$\tau = \sum_{i=1}^{n} |\mathbf{s}_i| |\cos_i(\alpha)|, \textit{ such that } \hat{\mathbf{v}} = \frac{\mathbf{v}}{\tau} \tag{3}$$

$c_i = |\cos_i(\alpha)|$ is the coefficient of the i^{th} segment.

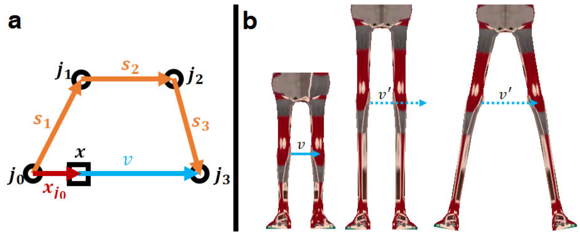

Figure 4: *a) The components of our normalization technique. b) Left: The source pose. Middle: The target character with the same pelvis width, but longer legs. $\mathbf{v}'$ is obtained if limb length is used as the normalization coefficient. Right: An artifact is obtained by ensuring v' constraint.*

Then, given the target character's segment lengths, $\{\mathbf{s}'_1, \mathbf{s}'_2, \cdots, \mathbf{s}'_n\}$, the vector, $\mathbf{v}'$, is mapped as

$$\mathbf{v}' = \tau' \hat{\mathbf{v}} \text{ where } \tau' = \sum_{i=1}^{n} |\mathbf{s}'_i| c_i \tag{4}$$

At first glance, this seems similar to preserving joint angles, but it has important properties. First, $c_i \geq 0$ holds for all i which ensures $\tau > 0$, since $|s_i| > 0$, by definition. This is crucial when denormalizing $\hat{\mathbf{v}}$, because the segment lengths of target character cannot lead $\tau' < 0$. It avoids the vectors from switching side, which could cause penetration. Second, it fits into our purpose of mapping: a target character with longer segments along the kinematic path obtains greater $\mathbf{v}'$. This lets exploit the full reach space.

Note that in case of near contact, Eq. 2 could cause instabilities, because $|v| \approx 0$. However, this case can easily be handled because $|v'|$ must also be approximately zero.

Although it seems possible to normalize these vectors with the body height or the limb's length [KMA05], it could cause unnatural poses as shown in Fig. 4b. Since the legs are nearly orthogonal to the relationship vector between knees, the pelvis width determines the projected gap, so our technique avoids the possible unnatural separation of the legs.

4. Conclusion

We introduced a technique to normalize the spatial relationships between the body parts. It handles conveying the semantic of postures with and without self interaction.

References

[AAKC13] Al-Asqhar R. A., Komura T., Choi M. G.: Relationship descriptors for interactive motion adaptation. In *Proceedings of SCA '13* (2013), pp. 45–53. 1, 2

[KMA05] Kulpa R., Multon F., Arnaldi B.: Morphology-independent representation of motions for interactive human-like animation. *Computer Graphics Forum, Eurographics 2005 special issue 24* (2005), 343–352. 1, 2