Human motion retargeting with trajectory constraints

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***Abstract*—The captured motion data can be utilized to produce kinds of animation for different characters. We propose a method to represent simulated motion, especially exaggerative motion by filtering the joint trajectories. The motion style is changed by shrinking or squashing the corresponding 3D trajectories. The similar but exaggerative motion with articulated constraints is generated by the inverse kinematic method. The motion of different characters can be combined to generate interactive human animation. Our method can also be utilized for motion segmentation.**

I. INTRODUCTION

Researches are interested in understanding the movements of humans or animals. Multiply movements can be captured by motion capture system. However, the experimental environment is restricted firmly. Furthermore, it is not realistic to provide special motions for some characters such as animals or little children. So motion animation based on the captured data is still attractive and meaningful.

In this paper, we tend to use the motion capture data to generate various kinds of human motion for different characters and try to represent exaggerative motion. Our method is based on the filtering method of the joint trajectories. We change the motion style by shrinking and squashing the 3D trajectories to produce similar but exaggerative motion. We filter the joint trajectory by the inverted Laplacian of Gaussian (LoG) filter to analyze motion data and produce various kinds of motion styles. We provide a simplified method to determined the parameters to shrink or squash the curve of joint trajectories. The end positions of trajectories are defined by user. The normal human motion with articulated constraints is generated by inverse kinematic method. We can generate exaggerative motion to represent the "important" property. The motion can be animated by different characters such as a child. Our method can be utilized to segment a sequence of motion into several motion clips.

II. RELATED WORK

The research of motion animation has been studied for more than twenty years and is significant for many applications including 3D games, movies and human-computer interaction system. The original applications of filtering were mainly for the fields of image processing and speech processing. In 1995, Bruderlin et al. [1] advanced the approach to modify and adjust animated motion by multiresolution filtering. The joint angles were convolved with a B-spline filter kernel to construct a pyramid of lowpass and bandpass sequences. The user could exhibit exaggerating motion and synthesize realistic motion by adjusting values of bands. The cartoon animation filter, equivalent to an inverted Laplacian of Gaussian (LoG) filter, was applied to motion to achieve exaggeration and squash-and-stretch effects in [2]. The parameters of LoG filter were automatically chosen and it was told that skilled users could animate to generate a class of existing motions by modifying the parameters. The filtering processes were both applied to joint angles independently. The changed motion kept the link-length constraints. However, they did not propose any criteria for motion exaggeration and the new motion relied on the parameters of filtering. The motion might be exaggerated but not similar to the existing motion signal satisfied with user expectation. There were not any joint position constraints so that it might produce the motion "stretch out in the direction of the left hand" while the original signal was "pull forward". Different characters are also required to act similar motion with the same frequency. It is necessary to provide natural, similar and synchronous motion.

Progress in motion similarity measurement is mainly focused on obtaining a probabilistic model for high dimensional data reduction and searching for the similar posture of high dimensional data through a distance metric in the lower latent space. The non-linear Gaussian Process Latent Variable Model (GPLVM) [3] is widely utilized. Grochow et al. [4] used a scaled GPLVM to learn a probability distribution function in latent space, then find the pose which was most likely compared to the input with a set of constraints. The user could appoint two styles for interpolation or create sequence of poses by giving a trajectory for one part of the body. The experimental results seemed to be sensitive to the user input. Kwon et al. [5] proposed a trajectory-based technique to exaggerate human motion. They stretched the trajectory of each joint by extrapolating the original trajectory and the changed curve. The lengths of bones were also modified to construct sequences of new animation. The magnitude of exaggeration was determined by constraints.

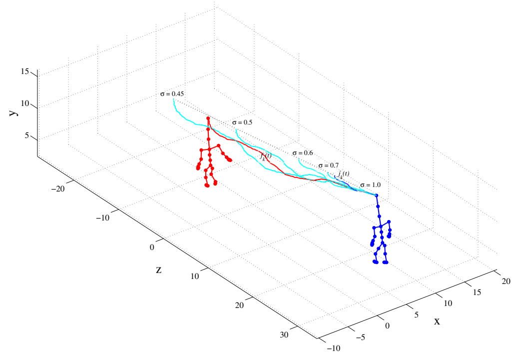

Fig. 1. Trajectory exaggeration.

III. Trajectory squash-and-stretch

If the motion data of an adult is directly applied to a character of child, it is most likely to be an unnatural slip motion. The natural animation will be created if the velocity of the translation is reduced according to the ratio of the usual velocities between adults and children. It is obvious that the child cannot follow up with the adult. Therefore, we should exaggerate motion of the child or shrink that of the adult if we expect they fall into line with each other. The principle of exaggeration/stretch or shrink/squash is same of our proposed method so we mainly explain it through exaggeration.

We define the squashed trajectory of the k^{th} joint J_k by $j_k(t)$. Let P_k denote the expected end point. Then the issue is converted to stretch $j_k(t)$ to P_k keeping the shape of the three dimensional curve and remaining the start point unchanged. It is known that the inverted LoG filter has stretch and squash effects while adjusting the controlling parameters. A stretched curve $s_{k,\sigma}(t)$ of $j_k(t)$ can be calculated as follows:

$$s_{k,\sigma}(t) = j_k(t) \otimes -LoG_\sigma(t), \tag{1}$$

$$LoG_\sigma(t) = \frac{t^2 - 2\sigma^2}{\sigma^4} e^{-t^2/2\sigma^2}. \tag{2}$$

$LoG_\sigma(t)$ is a function with the Gaussian standard deviation σ. Fig. 1 shows the squashed/stretched curves with different values of σ. The blue skeleton is the beginning frame and the character is required to move to the end posture of the red skeleton. Until now, most of the techniques of filtering have focused on choosing the suitable value of the filter width σ. It is common to determine it through experiences. In our proposed approach, we convert the problem of searching for the appropriate filter width to a linear interpolation and a rigid rotation. There is no need to calculate the accurate value for σ. It is simple and fast to achieve the final stretched curve $f_k(t)$ which is stretched to the corresponding end point.

$$\begin{aligned} s_{k,\sigma}(t) &= -\int j_k(\tau) \frac{(t-\tau)^2 - 2\sigma^2}{\sigma^4} e^{-(t-\tau)^2/2\sigma^2} d\tau \\ &\overset{\frac{t-\tau}{\sigma}=x}{=\!=\!=} -\int j_k(t-\sigma x) \frac{x^2 - 2}{\sigma^2} e^{-x^2/2} \sigma dx \\ &= -\int \frac{j_k(t-\sigma x)}{\sigma} (x^2 - 2) e^{-x^2/2} dx \end{aligned} \tag{3}$$

The generated curves by inverted LoG filters are translated to let the beginning vertices be in the initial position of the joint. It looks like that the corresponding points are in a line. Assume $s_{k,\sigma_1}(t)$ and $s_{k,\sigma_2}(t)$ to be the stretched trajectories with different standard deviations σ_1 and σ_2. It is shown in Eq. 3 that the curve is near a line while the variable $\sigma \in [0.4, 1.0]$ while $f_k(t)$ is a polynomial curve. Therefore we can obtain the appropriate trajectory by interpolating curves with two differences values of σ. Usually, the end positions of joints are given and if they are not in the lines we rotate to generate the exaggeration/stretch curves. Then we can obtain a sequence of exaggerative motion. The normal one can be provided by the inverse kinematic method which requires the lengths of bones to be constant. This method is simply and efficient to provide natural human motion by different characters.

IV. Experiments

We use the MoCAP dataset provided by CMU university which include kinds of human motion including walking, running, dancing and so on. Also we utilize the SCAPE model to extract the skeleton model for different human body in order to animate human motion. The changed model and motion seem nature. We found that our retargeting method is better for human animation of fast motion clips.

V. Conclusion

We proposed a motion retargeting method by filtering the trajectories of joints. We can provide various kinds of human motion for different characters. The motion tracking data can be presented by a child with a synchronous but exaggerative motion. Also we can produce unusual exaggerative motion such as exaggerating the motion and segmenting it according the changes of bone lengths. In addition, the interactive motion of two or more characters can be provided by our proposed method. In the future,we plan to generate sequences of 3D models with exaggerative motions by filtering the trajectories of vertices of mesh surfaces for different kinds of characters such as a child of some humanoid characters.

References

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