K-035

A Frame Work for Analysis and Synthesis of Actor's Stylistic Action

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1. Introduction

Towards the realization of the Cyber Theater, which enables anybody to produce contents (plays, cinemas etc.) as a performer and director and to see the contents as an audience in the virtual environment generated in the networks, we proposed the cyber theater directing system[1]. Motion is the basic underlying foundation of theater. In order to control the cyber actor in the cyber theater, we need the method to express various motion of cyber actor by a simple manipulation. In this paper, we describe a technique for expressive and realistic cyber actor's motion. We intend to reuse an existing database of motions by editing them to produce new motions and more or less expressive motions by parameters style of motion. We use an optical tracking system that extracts the 3D positions of makers attached to a real actor's body to capture the movement of the actor. We then form a vector space representation by using statistical method of Principal Component Analysis(PCA) of various action data. This method provides progressive transmission and decompression of various human stylistic motion data.

2. Data Compression by PCA

(1) Data Acquisition

A professional actress served as model to acquire motion data. She acted walking motion as a old woman, a young woman and a child. She acted the walking motion with emotions(for example happy, sad, tired, active) at each character.

Recording was done by means of a commercial motion capture system(ReActor) with a set of 30 optical markers. The system tracks the three-dimensional trajectories of the markers. From the trajectories of the 30 optical markers, we are able to obtain the angle data of avatar in each motion with the 18 rotational joints where located at the foots, knees, thighs, middle torso, upper torso, hands, lower arms, upper arms, shoulders, neck and head as shown Fig. 1.

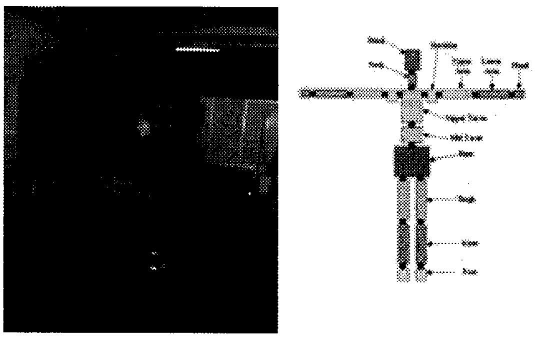

Fig. 1. Experimetal scene and DOFs of avatar

(2) Data Compression by PCA

Each motion can be regarded as a time series of postures. Each posture can be specified in terms of the positions of 18 rotational joints. Because three coordinates are needed for each joint, our avatar has 60 DOFs(degree of freedoms) with root's 3positons and 3 angles. We use the PCA technique to reduce the dimension of the data. PCA[2] is a way of identifying patterns in data, and expressing the data in such way as to highlight their similarities and differences. Mathematically the principal components are the eigenvectors of the covariance matrix of original data set. The main advantage of PCA is that we can find the patterns in the data, and compress the data by reducing the number of dimensions without much less of information.

At first, we applied PCA separately to each motion. Each posture of our avatar represented by the time series of 60 dimensional angular motion vector θ. θ motion vector can be approximated as a weighted sum of the average motion θ_0 and first some Principal Components.

$$\theta \cong \theta_0 + \sum_i \alpha_i \theta_i \quad (1)$$

Where the α_i are PCA scores(coefficients) that characterize the motion and θ_i are $_i$ th principal component. On average, across all walking motions by each ages and emotions, the first 4 or 5 components cover more than 90% of the data as shown Figs. 2 and 3. It turned out that PCA technique is useful for reducing data dimension.

Then we inspect the principal joints of each principal component by examining the eigenvector, in order to know which joint has weight in each principal component. Knowing the principal joints of each principal component, it is useful to control the avatar. As we expected, first three principal components are influenced much by leg and arm joints. After fourth principal component, other joints appeared weighted.

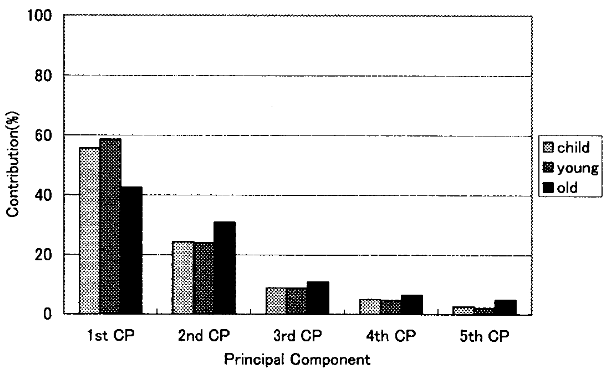

Fig. 2. Contribution of Each Component in Walking Motion by Ages

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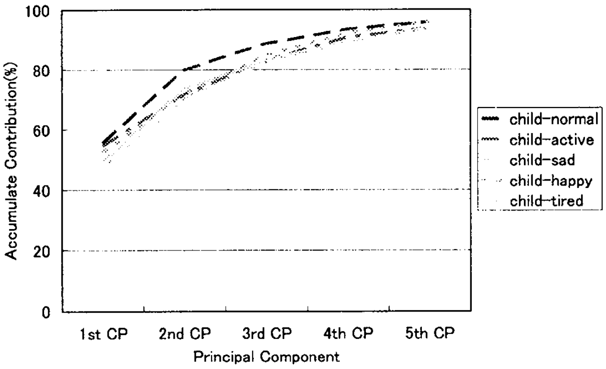

Fig. 3. Accumulate Contribution of Components in Child Walking Motion by Emotions

(3) Spanning of PCA Space

We captured various walking motions, not only ages but also emotions. We want to benefit from the PCA. In order to compare the characteristic traits, we represent all the motions in the same coordinate system. We composed of PCA spaces about various walking motion sequences that differ in ages and emotions are estabilished as shown in Fig. 4. Figure 4 depicts the original data in terms of transformation of first three principal components as axis. (x axis is the first principal component, y axis is the second principal component and z axis is the third principal component) As shown in Fig. 4, each style of motion forms a cluster.

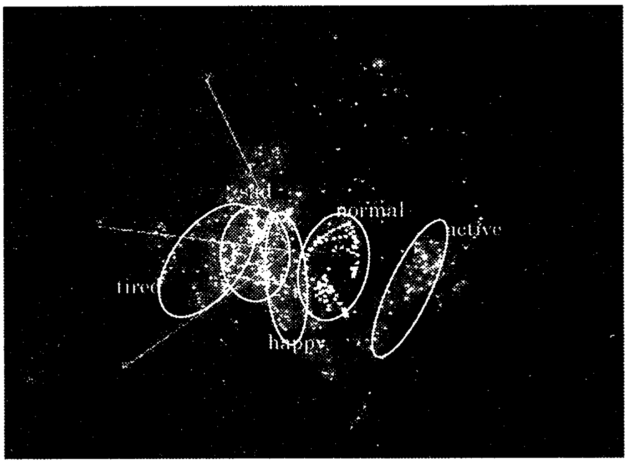

Fig. 4. Spanning of PCA space about walking motion of old man by emotion.

(4) Normalization and Characterization

The style of motion as shown in Fig. 4 is encoded by PCA scores(coefficients). However, since each motion which separated by ages and emotions have different speeds, we need to normalize each motion data to same speed. We set the starting point of data at time 0 and ending point at time 1 during two steps(full one gait) for comparing the speed. Figures 5 and 6 indicate the traits of each stylistic motion in a same speed. As shown in Fig. 5 and 6, PCA scores of the first principal component express that each motion has different characteristic traits. That's why we can catch the peculiarity of motion and can control the stylistic motion by a few compressed principal components.

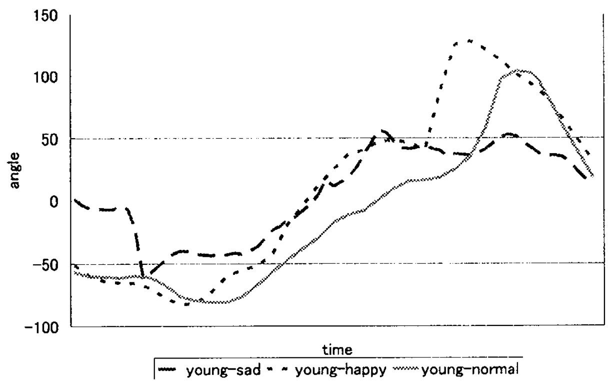

Fig. 5. Comparison between the PCA scores of the first component for emotions.

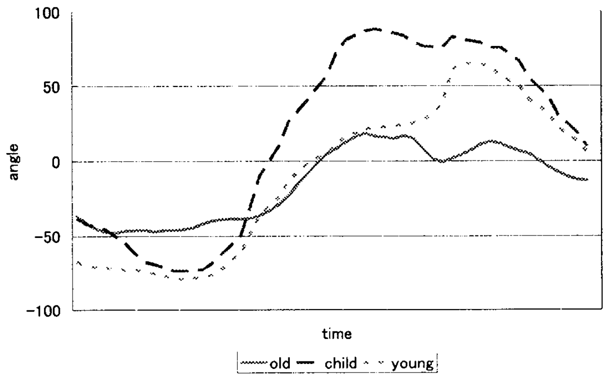

Fig. 6. Comparison between the PCA scores of the first component for ages.

3. Results and Future Work

We create PCA spaces for the stylistic motion we captured. To present 90% of the total data 4 or 5 Principal component were necessary. From PCA method, we can separate the space by emotions and ages. PCA method presents many advantages. First of all, it is successful method to reduce the data dimensions. and first few principal components do not lose the characteristic traits of data.

In next step, we represent the human motion by just few principal components. We also want to apply our method to other locomotion types to enlarge our database.

References

[1] Jieun Cho, Jun Ohya, "The Cyber Theater Directing System based on the Analysis of Drama Scripts", IEICE, 2003.3(In Japanese)

[2] Lindsay I Smith, "A tutorial on Principal Components Analysis, February 26, 2002. www.cs.otago.ac.nz/cosc453/ student_tutorials/principal_components.pdf