A Tai Chi Training System Based on Fast Skeleton Matching Algorithm

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Abstract. In this paper, we introduce a Tai Chi training system based on Microsoft's Kinect, which automatically evaluates a user's performance and provides real-time feedback for the user to refine his current posture. A novel method to measure posture is also described. The experimental results are promising, demonstrating the effectiveness of our approach.

Keywords: Tai Chi Training System, Kinect, Skeleton Matching.

1 Introduction

After Microsoft released its Kinect, many applications based on Kinect have being emerging, such as dancer's performance system[2], human detection[1], etc. One distinct advantage of the Kinect is that, besides color map data, it could also provide depth map data and skeleton position data. Most of these existing applications utilized these special data to implement their ideas.

In this paper, we also present a Kinect-based system which can help a Tai Chi trainee to improve his performance. The system can evaluate a Tai Chi trainee's performance automatically and provide feedback on how to correct the trainee's current posture in real-time. The underlying mechanism of our evaluation system is measuring the difference between the trainee's posture and the standard one by matching their skeleton. The main challenge is to find an effective skeleton matching algorithm. In hence, we propose a new method to measure the difference between two skeleton frames.

2 System Overview

Our system can help a Tai Chi trainee to improve his performance. The user is supposed to follow the standard video to play Tai Chi, and the system, at the same time, will provide feedback to the user to refine his posture. The flow chart of our method is shown in Fig. 1. The Kinect outputs the user's data,

* Work on this paper was supported by National High-Tech Research and Development Plan of China under Grant No.2011AA01A202.

A. Fusiello et al. (Eds.): ECCV 2012 Ws/Demos, Part III, LNCS 7585, pp. 667–670, 2012.

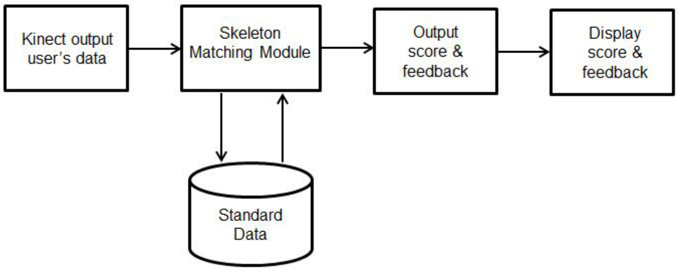

Fig. 1. System Flow Chart

which includes color images, depth images and joint positions. Then the skeleton matching module, taking as input the joint positions of the user and the ones from standard data, outputs the similarity score and feedback to the user.

2.1 Methodology

In our system, we simply compare the user's current posture to the standard one that is being displayed. A skeleton matching algorithm is applied to get the similarity score and feedback for every frame of user's posture. Furthermore, an overall score of user's performance is calculated as the weighted means of all frame's scores. The weight of frame depends on the importance of the corresponding posture.

2.2 Similarity Evaluation

The core of the matching algorithm is how to measure the difference between two skeleton frames. The methods used in [2,3] process all joint as a whole, which makes it hard to know the difference contributed by each joint. In order to measure the skeleton distance separately by each joint, we introduce a novel method here.

We measure the similarity between two skeleton frames on the base of joint angles rather than joint positions, to avoid a calibration procedure which is usually used to eliminate the errors caused by the difference between people's body shapes. Furthermore, measurement with angle is easier to provide precise feedback than measurement with position, because the former's relativity distribute the total distance to each joint. We know that the rotational degrees of freedom (RDOF) of joints are not the same, that is the shoulder joints and hip joints have three RDOF, the elbow joints and knee joints have one RDOF, so we measure these two kinds of joints in different ways. We use axis-angle as measurement for the three RDOF joints and difference of intersection angles for the one RDOF ones. We externally use one angle to measure the difference of spine's rotation angles.

The whole similarity between two skeleton frames is calculated as the weighted mean of the score of nine joints (L/R shoulder, L/R elbow, L/R Hip, L/R knee, spine). The weights are determined by the importance of every joint in the evaluation criteria. The movement distance is calculated as the following formula:

$$S = \sum_{i=1}^{4} \alpha_i J_S^i + \sum_{j=1}^{4} \beta_j J_e^j + \gamma J_{sp} \tag{1}$$

Where J_S^i and α_i are the score weight of the i-th joint that has 3 RDOF, J_e^j and β_j are the score and weight of the j-th joint that has 1 RDOF, and J_{sp} and γ are the score and weight of spine joint.

3 System Evaluation

3.1 Graphic User Interface

The GUI is shown in Fig. 2. It provides 1) Standard video, 2) User's video, 3) User's skeleton map, 4) the instantaneous score and overall score, 5) Weights setting, 6) Angle difference, 7) System information, 8) Control buttons. In 2) and 3), joints with errors over a threshold are highlighted with red. The yellow lines through the 3 RDOF joints in 2) are the axises. The red indication "Extend" and "Bend" near the 1 RDOF joints are correction advices. The button "search" helps user to find which section a fragment of movement belongs to. After the use, the system will switch to playback mode when "playback" is pressed.

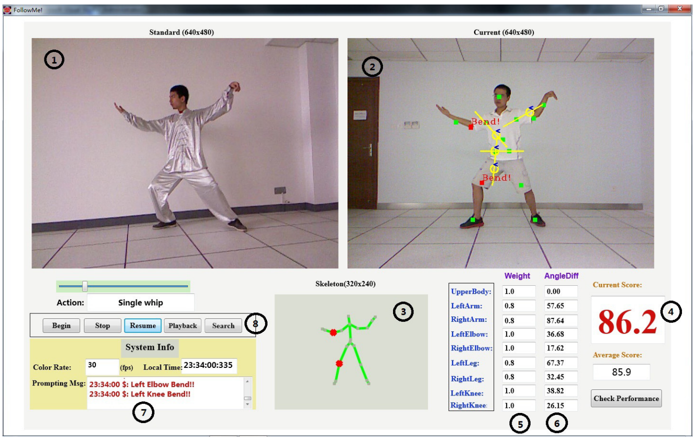

Fig. 2. GUI of the system

3.2 Experimental Result

In order to evaluate the effectiveness of our system, we use the human's scoring as the benchmark, then compare the system's result with the benchmark. We choose a user as our test case whose performance is judged by the system and three observers respectively. For each frame of the performance, scores are given. We compute the average of the observer's scores and compare it with that from system. The results are shown in Fig. 3. According to the figure, the two curves have the same trend, demonstrating that the system's results are comparable and the adopted methodology is effective.

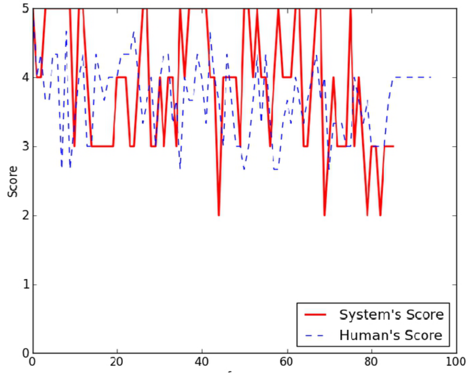

Fig. 3. Results

4 Conclusions and Future Work

In this paper, we introduced a Tai Chi training system and described a novel method measuring difference between skeleton frames. The experimental results were promising, showing effectiveness of our methodology.

In future, we plan to present user 3D visualization, so the feedback will be clearer. Besides, more criteria of Tai Chi performance, such as fluency of movements, will be taken into consideration in our system.

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