ISSN : 0974 - 7435 Volume 8 Issue 4

BioTechnology
An Indian Journal

FULL PAPER

BTAIJ, 8(4), 2013 [479-483]

Study on the wushu routine teaching based on the video analysis and human motion simulation

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ABSTRACT

Along with the introduction of digital technology in the process of sports training, the level of competitive sports training in our country has been improved greatly for quite a long time, which provides guarantee for the conservation of the Olympics. However, in a considerable range of wushu teaching, coaches usually draw their eyes and experiences on technical guidance for students, which might conduct negative effects on the development of martial arts. Based on the three-dimensional simulation and video analysis, questions such as global motion estimation, the extraction of the video moving object and human motion tracking in video analysis are put forward in this paper. According to the theory studies on the modification and design of three-dimensional human motion simulation exercise, this paper might provide a broader platform for martial arts development in our country, and provides a theoretical basis for better applicable domain of the three-dimensional motion video technology.

KEYWORDS

Affine motion;
Colour gradient;
State vector;
Offset.

INTRODUCTION

The video based human motion analysis techniques as well as three-dimensional computer modeling and simulation technology is a key technology to maintain and improve the sport achievement, its overall goal is to study sports training oriented three-dimensional human motion simulation and video analysis and other key technologies. Such technologies will be used in the 29th Olympics by China to study the advantages and prospective advantage of the diving and gymnastics, trampoline project and other projects. The video analysis and researches play a very important role for raising the level and maintaining the achievements of these projects. By the introduction of three-dimensional human body simulation and video analysis technology into wushu teaching, our "quintessence" can be carried forward. Three-dimensional human body motion analysis needs to solve the two problems of movement information acquisition and movement analysis in the process of implementation, the video based human motion tracking and three-dimensional reconstruction are the goals of the technology in sports teaching, this study also can promote the complex wushu routine teaching. Based on the study of the video analysis and three-dimensional human motion simulation technology, this

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paper provides a theoretical basis for the combination of wushu and computer technology.

For video analysis and 3D human body motion simulation technology, a lot of people have made contributions on them, beside the two technologies are accompanied by the developed of the findings. Based on the predecessors' research of video analysis and three-dimensional human body motion simulation analysis technology, and by combining the technology with wushu teaching, this paper provides the theoretical foundation for the combined development of both.

THE VIDEO ANALYSIS THEORY

The global motion parameters

Wushu video image usually contains the two kinds of motions: global motion and local motion. The movement of background caused by the camera's motion is called the global motion; the movement of background caused by the athletes' action is called local motion. In video analysis, the key of the synthesis of the body extraction and movements, panorama is the accurate achievement of the global motion parameters.

Using the six parameters of the affine motion model can represent global motion and its mathematical model is shown in formula (1)

$$\begin{cases} x = ax' + by' + e \\ y = cx' + dy' + f \end{cases} \quad (1)$$

In formul(1), (x, y) is the coordinate of the current frame, which is represented by p then $p = (x, y)$, (x', y') is the coordinate frame that is corresponding with point namely $p' = (x', y')$, (a, b, c, d, e, f) are global motion parameters a, b, c, d mean rotate and zoom e, f mean displacements.

The contour extraction of color gradient

Firstly, based on the dynamic background structure technology of the foreground separation, using multiple frames differences to separate of foreground area from the image and using the current frame's adjacent background information of multiple frames that are before or after the current frame to construct an accurate current background. Secondly, Removing the segmentations that show the background effectively by getting the segment the moving object through the background elimination. At the same time, checking the static prospect area by using the temporal information, and combining it to the object region, then a complete object area is obtained. Hence the irregular movement's influence on the segmentation accuracy of the object is overcome. Finally, viewing the edge of the object area as the initial position, using the colour gradient for external energy active contour algorithm to obtain accurate movement of the object contour.

If $\overline{I_k}$ is the current frame, then $I_i (i = k - L, \ldots, k + L)$ is the Continuous image's $2L+1$ frames, in a continuous frame image, if there are L frames before and L frames after the frame I_k , then there are $2L+1$ frames in total, the global motion parameters between adjacent frames are respectively: $\theta_{k-L+1,k-L}, \ldots, \theta_{k+L,k+L-1}$, In order to construct the background of I_k, transformation parameters θ_i should be calculated , and I_i should be put to the right place of the coordinate of I_k, the relationship of global parameters is show in formula (2) :

$$\begin{cases} \theta_k = (1,0,0,1,0,0) \\ \theta_i = \theta_{i+1,i} \cdot \theta_{i+1} \quad if \quad i < k \\ \theta_i = \theta_{i-1,i} \cdot \theta_{i,i-1}^{-1} \quad if \quad i > k \end{cases} \quad (2)$$

Then θ is obtained, as for each P of the constructed background, the corresponding pixel P_i of $2L+1$ frames image can be calculated by inverse mapping, so that the value of P in the background can be constructed by using the $2L+1$ frames. Through the usage of multiple frames difference and preliminary separation of foreground and background, and the usage of the redundant information of adjacent images in a background, the accurately current background can be constructed.

When the background of the current frame is constructed, then the constructed background i be eliminated from current frame, and using the linearization to segment the moving object region rapidly. Due to the effects of all kinds of noise, the segmented edge area of the object is not accurately fits the moved object contour, so colour gradient based active contour algorithm is adopted to extract the more accurately contour.

Shape model video tracking

The video tracking method can be generally divided into shape-model-free method and shape based model

method. Shape based model method is more suitable for the observation and interpretation rule on external things. In this method, priori human body model is adopted to represent the observation targets, then the observed value constantly will be corrected in the later tracking process to correction, finally the information (position) provided by the can be got at any time, as the 2D human body model shown in Figure 1.

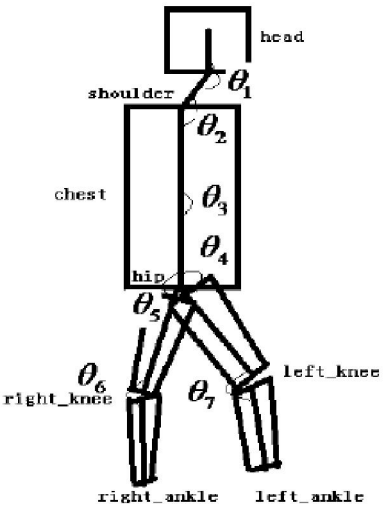

Figure 1 : 2Dhuman body model

As shown in Figure 1, the rod of graph represents the basic skeleton of human body, in the process of tracking; motion model is used for predicting the next frame's posture of the current frame's posture. In this article \ the second-order autoregressive process model is adopted, assuming that each state parameter performs a uniformly accelerated motion, the mathematical model cam be seen in formula (3)

$$x_t - x_{t-1} = x_{t-1} - x_{t-2} + \eta w_t \quad \textbf{(3)}$$

In formula (3), ηw_t stands for the noise component W_t obeys to the Gauss distribution with zero meanÿwhich can be obtain in a more complex motion model by BP neural network algorithm.

In order to improve the robustness of tracking, in this paper, two kinds of measurement metric are adopted that are color and edge. HSV color space is used for the color histogram; the histogram intersection is used for measuring the model histogram and the predicting the similarity of the histogram. Edge character uses the gray gradient values of the image, the first step is to convert color images to gray image, and then calculate the projection gradient of the model on the image, besides consider the gradient direction at the same time.

If the sate of a state vector meets Markov, then the tracking can be presented by the bayesian filter, as shown in the formula (4)

$$p(x_t|Z_t) = p(z_t|x_t) \int p(x_t|x_{t-1}) p(x_{t-1}|Z_{t-1}) dx_{t-1} \quad \textbf{(4)}$$

In formula (4), $X_{t-1} = (x_1, x_2, \ldots x_{t-1}), Z_{t-1} = (z_1, z_2, \ldots z_{t-1})$ Denote t Moments before the state vector and observations, state vector and the observed value before the moment of respectively, when the moving models $p(x_t|x_{t-1})$ and $p(x_t|x_{t-1})$ are obtained, the posterior probability $p(x_t|Z_t)$ can be calculated through formula (4).

The modification and design of the tree-dimensional human body

The human body is a rigid body model of a multi degree of freedom, the movement of the rigid body follows the mechanics principle, in order to realize the realistic simulation results, theoretical study on the human body's structure of muscle and skeletal and moving mechanics is necessaryÿtheoretical analyses of the modification and design of the movement, the arrangement of the simulated movement and the contest of the simulated movement and video training contrast analysis.

First of all, selecting the initial frame, establishing bones and virtual point system that matches the captured. On the basis of optimization rule of the minimum distance between virtual landmarks and real punctuation, calculating the movements of the bones. The motion data obtained will produce noise, and the movement is not smooth, hence the post proceeding is need. In order to get the smooth movements of the bones, the quaternion linear time invariant filtering system is obtained in this paper. Secondly converting the Euler Angle data into the corresponding quaternion, and mapping the quaternion to tangent space by logarithmic algorithm, then using invariant filter for filter in the target space, finally mapping back results to the quaternion space by using the index calculation, then converse them into Euler Angle data.

In order to facilitate the completion of the visualization of interaction design, viewing the body motion as $motion(t)$, the old posture is $posture(t_i)$ then the modified posture is $posture'(t_i)$, selecting the corresponding rigid body in the X x Y user's windows by using the mouse,

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and in the process of dragging the mouse, the variations in direction are $|\Delta x|$ and respectively. According to Euler's theorem assuming the rotation process can be presented by using the Euler Angle $\langle \alpha, \beta, \gamma \rangle$ in ^{zxy} direction, then all variables meet formula (5)

$$\begin{cases} \sin\alpha = \dfrac{a\Delta x}{X} = \dfrac{(1-a)\Delta y}{Y} \\ \sin\beta = \dfrac{b\Delta x}{X} = \dfrac{(1-b)\Delta y}{Y} \\ \sin\gamma = \dfrac{c\Delta x}{X} = \dfrac{(1-c)\Delta y}{Y} \end{cases} \quad (5)$$

a,b,c are the influence degrees of Δx and Δy on Euler Angle in the three directions of respectively. Based on the formula (5) Euler Angle can be obtained, as shown in formula (6)

$$\begin{cases} \alpha = \arcsin\dfrac{a\Delta x + (1-a)\Delta y}{X+Y} \\ \beta = \arcsin\dfrac{b\Delta x + (1-b)\Delta y}{X+Y} \\ \gamma = \arcsin\dfrac{c\Delta x + (1-c)\Delta y}{X+Y} \end{cases} \quad (6)$$

The new posture $posture'(t_i)$ is set during the procedure of Euler Angle computation. And then an offset is gain by the new mapping technology. The first step is to calculate the offset at the moment t_i, as shown in (7)

$$\begin{cases} d(t_i) = posture'(t_i) - posture(t_i) \\ posture'(t_i) = \langle p'_0(t_i), q'_0(t_i), \ldots, q'_n(t_i) \rangle \\ posture(t_i) = \langle p_0(t_i), q_0(t_i), \ldots, q_n(t_i) \rangle \end{cases} \quad (7)$$

The second step is to calculate the offsets at other moments according to the Figure 2, the movement offset that corresponds with $|motion(t)$ can be obtained as shown in formula (8), then overlay the movement offsets to its original motion $motion(t)$, a new $|motion'(t)$ is obtained, as shown in type (9)

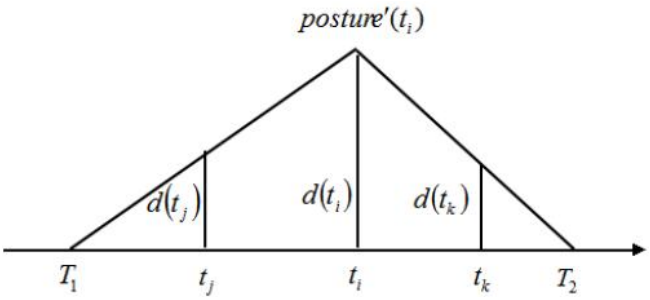

Figure 2 : the structure of offset

$$d(t) = \langle d_{-1}(t), d_0(t), \ldots, d_n(t) \rangle \quad (8)$$

$$motion'(t) = motion(t) \oplus d(t) = \langle p_0^m(t) + d_{-1}(t), q_0^m + d_0(t), \ldots, q_n^m + d_n(t) \rangle \quad (9)$$

Conclusion: human body inertia parameters can be predicted according to the athlete body parameter characteristics, which is used to determine the moment of inertia parameters of Newton Euler model, get personalized equation, and verify the rationality of the new movement according to the equation, so that, the modification and design of movement can be completed through visual interactions of design, motion validation and feedback.

COMPARING ALGORITHM OF STIMULATING MOVEMENT AND TRAINING VIDEO

As the main data storage medium for wushu routine practice, video describes the geometric attribute of movement, and the video stimulation of routine movement reflects human motion changes in physical properties. In this article, the writer uses false and true isomorphism algorithm to establish the mapping relationship between the geometric properties and physical properties of wushu routine movement and to construct a virtual camera based on the 3D stimulating result to make its point of view just be at the same position where the shooting video camera was, thus to set up a 3D stimulating movement based on the wushu routine movement video viewed at the same position which make people do video analysis through 3D motion stimulation analysis. It can achieve a better effect.

The external parameters of camera reflect the single transformation relationship between the camera coordinate system and the world coordinate system. The rotation matrix R and translation vector T consist of the parameters. Usually, the external parameters of camera can be achieved by calculating basis matrix F and essential matrix. The writer uses 3D reconstruction of feature points to achieve the information of external parameters of camera, and uses stimulation model of the camera to do the 3D reconstruction of feature points. Through the stimulation model, the 3D information can be resumed from the single image.

Suppose the two directions are named X and Y.

Establish the right-handed coordinate OXYZ. Suppose the origin position of the human motion overlaps the overall coordinate system. Pick up three-fixed point from the wushu routine practice video and express them as $p_1(u_1,v_1), p_2(u_2,v_2), p_3(u_3,v_3)$. Through camera orthogonal projection model the three fixed points can be mapped into the 3D space. The orthogonal projection model is as follows:

$$\begin{pmatrix} u \\ v \end{pmatrix} = s \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \end{pmatrix} \begin{pmatrix} X \\ Y \\ Z \end{pmatrix} \quad (10)$$

In formula (10), $^{(X,Y,Z)}$ are expressed as the points in 3D space p_1,p_2,p_3, in camera can be mapped into the space as. p_1,p_2,p_3 According to the dot product of orthogonal vectors being zero, the relationship can be achieved in formula (11):

$$\begin{cases} \overrightarrow{P_1P_2} \bullet \overrightarrow{P_2P_3} = 0 \\ \left\| \overrightarrow{P_1P_2} \right\| = L_1 \\ \left\| \overrightarrow{P_2P_3} \right\| = L_2 \end{cases} \quad (11)$$

In formula (11), L_1,L_2 are expressed as the length and width of the selected region. According to formula (11), the relative depths $|z_2-z_1|$ and. $|z_3-z_1|$ Thus the position of the wushu routine practice can be finalized. The 3D stimulating motion can be shown from the point of view in the video.

CONCLUSION

The three-dimensional human body movement simulation algorithm of wushu exercises is analyzed in this paper, and more appropriate analytical tools for the combination of 3D simulation technology d with video analysis of our country's martial arts development are provided;

Through reconstruction algorithm, training video and 3D simulation video can be combined together, which can provide theoretical platform for exactly reflection of wushu routine;

The algorithm provided in this paper can be implemented on the computer, and the writer hopes that the development of martial arts in China can develop together with computer technologies.

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