Research on Measurement Method of 3D Motion Image Attitude Parameters of College Football Players

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Abstract: To study the accurate measurement of three-dimensional image attitude parameters in athletes' movement, using traditional three-dimensional motion image modeling using fixed constraint model research method, it was difficult to describe dynamic small-area image changes. As a result, the measurement effect on image attitude parameters was poor. The research on image attitude parameter measurement method based on MIAS3D system was proposed. The MIAS3D system was used to reconstruct the three-dimensional coordinates, the minimum motion function value was solved, and the first-order Newton iterative method was integrated to deal with the large-scale parameter optimization problem. According to the first-order Newton iteration point list, the three-dimensional coordinate system of the motion image was constructed, and the parameters were measured according to the reconstruction result. The projection error method of minimizing the image sequence was used to obtain the motion parameter and structure parameter matrix of the athlete during the three-dimensional motion process, and finally the accurate analysis of the three-dimensional motion parameters could be completed. The experimental results showed that the highest research effect of this method could reach 96%, which provided an important basis for the study of athletes' motion characteristics.

Keywords: College football player; Three-dimensional motion image; Action posture; Parameter measurement; Action parameter

1. Introduction

In recent years, injuries and injuries caused by incorrect posture during exercise are extremely common. The degree of scientific and technological development of sports is constantly improving. The use of science and technology can effectively analyze the characteristics of athletes' movements, thereby improving athletes' skills and avoiding unnecessary injuries to athletes. The human body includes a large number of tissues and organs, and these bones and muscles produce different behavioral information, thereby realizing the regulation of human behavior. Comprehensive analysis of bone and muscle motion information enables accurate judgment of human body motion parameters. The analysis of the posture parameters of the moving human body mainly includes the theoretical principles in the fields of exercise physiology and computer image processing. Three-dimensional human motion measurement has been widely used in the fields of intelligent monitoring, virtual reality, sports training analysis, animation production, medical treatment, etc [1].

The traditional measurement method is based on electromechanical and electromagnetic physical methods. Such methods have the disadvantages of complicated hardware equipment, low measurement accuracy, inconvenient operation, and difficulty in maintenance. Effective analysis of athletes' exercise parameters can improve their motor skills and avoid injury [2]. Therefore, it is necessary to find an effective method to accurately analyze the athlete's exercise parameters, and to maximize the avoidance of athletes' injuries and become a key issue for scholars in the field of sports science. In order to solve the above problems, a three-dimensional motion image attitude parameter measurement technique has been developed. The final simulation experiment can verify that the measurement method can improve the accuracy measurement of athletes' three-dimensional motion parameters and has high application value [3].

2. Research on Image Attitude Parameter Measurement Method based on MIAS3D System

The measurement of athlete's motion parameters is an image sensing device that measures the movement of an athlete in a two-dimensional space and transforms it into a three-dimensional image. Then the three-dimensional image data is analyzed by the corresponding algorithm to obtain the motion parameters in different spatial coordinates [4].

Based on the MIAS3D system, it can process up to 8 images, and can be equipped with a variety of cameras. The image frame rate is related to the camera model. The camera model and related parameters are shown in Table 1.

Table 1. MIAs3D system for camera type and its parameter list

Camera type	Collection frame rate
DV camera (all model)	PAL (752X582 pixel) 20frame / second
General industrial camera	35 frame / second
High speed industrial camera	PAL (650X490 pixel) 120frame / second
High speed infrared camera	PAL (650X480 pixel) 70frame / second
High-resolution camera	PAL (1024X1024 pixel) 50frame / second

The system is suitable for various Microsoft operating systems such as Wirldows 2000, XP, Vista.

2.1. Three-dimensional coordinate reconstruction

The prediction process of the athlete's motion parameters is a process of predicting the non-rigid body three-dimensional motion, and can also be regarded as the process of obtaining the minimum motion parameters. Describe the motion function with $\mathrm{b}=k(\mathrm{a})$, where b is an n -dimensional vector. Usually b is taken as the actual value $\bar{\mathrm{b}}$ measurement vector, because there is a certain deviation in the actual measurement process, so the variable a cannot be fully met with the requirements of $\mathrm{b}=k(\mathrm{a})$. Therefore, the minimum motion function value can be solved to ensure that the best value of a is obtained. The specific expression is as shown in equation (1):

$$\min\left\|b-k(\mathrm{a})\right\| \qquad (1)$$

Based on the MIAS3D system, an optimized first-order Newton iterative algorithm is used, which can deal with large-scale parameter optimization problems in a timely and effective manner [5]. This method combines the first-order Newton iterative method, in which the specific operation process of the first-order Newton iterative method for analyzing the minimization problem is:

Suppose the original solution is a^i , make $k^i=\mathrm{b}-k\left(\mathrm{a}^i\right)$.

If k is around a^i , the value can be obtained by $k\left(\mathrm{a}^i+\Delta^i\right)=k\left(\mathrm{a}^i\right)+R_a\Delta^i$ (first order) approximation, where $R_a{}^i=\frac{\beta a}{\beta b}\,|\,a=a^i$ represents the value of k 's Jacobean matrix at a^i [6]. Get the next iteration point $a^{i+1}=\mathrm{a}^i+\Delta^i$ to ensure that equation (2) holds:

$$\left\|\mathrm{b}-k\left(a^{i+1}\right)\right\|=\min\left\|\mathrm{b}-k\left(a^i\right)-R_a{}^i\Delta^i\right\| \qquad (2)$$

The final obtainable first-order Newton iteration point list is:

$$\mathrm{a}^{i+1}=a^i+R_a{}^i\left(\mathrm{b}-k\left(a^i\right)\right) \qquad (3)$$

The second-order Newton is the same as the first-order Newton method, and its convergence speed is strongly correlated with the original value a^0 [7].

According to the first-order Newton iteration point list, a three-dimensional coordinate system of motion images is constructed, as shown in Fig.1.

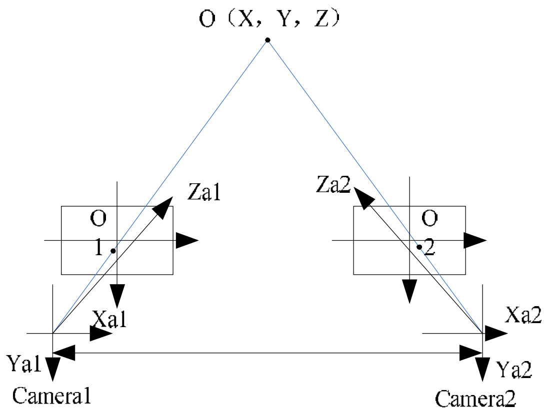

Figure 1. Motion image three-dimensional coordinate system

It can be seen from Fig.1 that the focal lengths of the two cameras are both f, along the baseline B, and the optical axis is parallel to the Z axis. The X coordinate of the image coordinate system coincides, and the Y axis is parallel to each other. Assuming that the projections of the spatial point p(X, Y, Z)) on the left and right phase planes are respectively Ol and O2, the parallax $d=|O1-O2|$ is defined. Equation (4) can be obtained from a similar triangle relationship:

$$z=\frac{f\times B}{d} \quad (4)$$

The target point depth information can be obtained by using equation (4), thereby realizing the target three-dimensional coordinate reconstruction. The MIAS3D system uses this coordinate system for 3D coordinate reconstruction [8]. After reconstruction, three-dimensional parameters such as position, distance, velocity, acceleration, angle, angular velocity, angular acceleration, angular displacement, displacement, and relative coordinate position can be measured.

2.2. Parameter measurement

The parameters are measured according to the above three-dimensional coordinate reconstruction results. The projection error method of minimizing the image sequence is used to obtain the motion parameters and structural parameter matrix of the athlete during the three-dimensional motion process, and finally the accurate analysis of the three-dimensional motion parameters is completed. First assume that the measured matrix of the athlete's feature points is m_{xy}, and the predicted moving image feature point matrix is m_{xy}. If the measurement matrix formed by the feature point $\begin{bmatrix} t_{xy} \\ e_{xy} \end{bmatrix}, i=1,...J, c=1,...,Q$ of each frame moving image is m_{xy}. Where J represents the number of moving image frames, and Q represents the number of feature points of the single-frame moving image. The ultimate goal of the matrix is to obtain the three-dimensional structure of the moving image of each frame. If the three-dimensional shape of the athlete's joint is a weighted linear set of shape bases, then:

$$F=\sum_{i=1}^{N}\delta_{xy}\lambda_x \quad (5)$$

In the formula (5): δ_{xy} represents a weighting coefficient, λ_x represents a shape base, and N represents the number of shape bases. If $N=1$, the state δ_{xy} of the key area under the weak perspective projection model is:

$$m_{xy}=\begin{bmatrix} t_{x1},...,t_{xQ} \\ e_{x1},...,e_{xQ} \end{bmatrix}=\overline{w}\left(\sum_{i=1}^{N}\delta_{xy}\lambda_x\right)+\overline{D}_x k_v^D \quad (6)$$

In formula (6): $\overline{w}$ represents the first two rows of the rotation matrix, and $\overline{D}_x$ represents the first two elements of the translation vector. In order to optimize the operation process of the algorithm, the coordinates of each moving feature image should be changed to ensure that the origin of the moving image coordinate system is at the center of the image point, and then the translation vector is filtered. The process is as shown in equation (7):

$$\begin{cases} \bar{t}_{xy}=t_{xy}-\frac{1}{Q}\sum_{y=1}^{Q}t_{xy} \\ \bar{e}_{xy}=e_{xy}-\frac{1}{Q}\sum_{y=1}^{Q}e_{xy} \end{cases} \quad (7)$$

Further processing of equation (7) yields:

$$e_{xy}=\begin{bmatrix} \bar{t}_{x1},...,\bar{t}_{xQ} \\ \bar{e}_{x1},...,\bar{e}_{xQ} \end{bmatrix}=\overline{w}\left(\sum_{i=1}^{N}\delta_{xy}\lambda_x\right) \quad (8)$$

To ensure that the projection error of m_{xy} and m_{xy} is minimized, the motion parameter matrix and the 3D structure parameter matrix can be obtained, as shown in equation (9):

$$\min\sum_{xy}\left\|m_{xy}-m'_{xy}\right\|^2=\min\sum_{x,y}\left\|m_{xy}-\left(w\sum_{i=1}^{N}\delta_{xy}\lambda_x\right)\right\|^2 \quad (9)$$

The method represents a motion parameter matrix by a quaternion path, first setting a 4×G rotation parameter, where G represents the number of frames of the overall moving image sequence. The quaternion method makes the rotation matrix not singular, and the orthogonality usually appears in four constant quads. Therefore, the quaternion method can avoid the complex orthogonal protection problem that occurs in the process of selecting matrix parameters. The quaternion method greatly improves the solution of the rotation matrix and the efficiency of solving the parameter matrix of the three-dimensional motion result. The motion parameter matrix is initialized according to the motion parameters that can reflect the motion rigid region when the athlete is exercising, which can effectively describe the large motion state of the human body. This method can solve the problem that the constraint information cannot be effectively adjusted due to the small time interval of the image sequence.

3. Case Analysis

The effectiveness of the research on the image attitude parameter measurement method based on MIAS3D system is verified by computer simulation. The experimental sample database is derived from the behavioral characteristics of trampolines and hurdle athletes.

3.1. Experimental parameter setting

The time interval for the collection of experimental samples is 1.0 s, and the number of feature points collected per frame is 1000. The experiment comprehensively analyzes the characteristics of the attitude parameters of football players during the movement. The sample image in the database is shown in Fig.2.

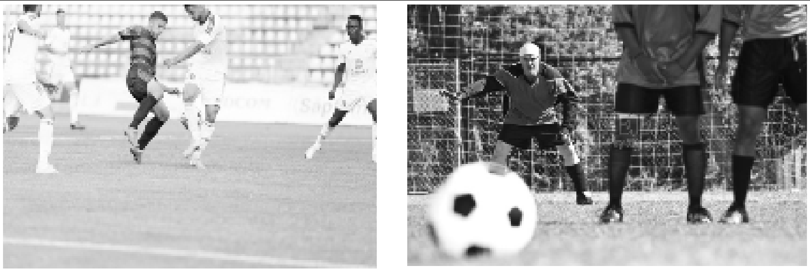

Figure 2. Sample image in the database

3.2. Experimental results and analysis

In the experimental data, the traditional research method is compared with the experimental method based on the MIAS3D system research method for the image attitude parameter measurement method. The results are shown in Fig.3.

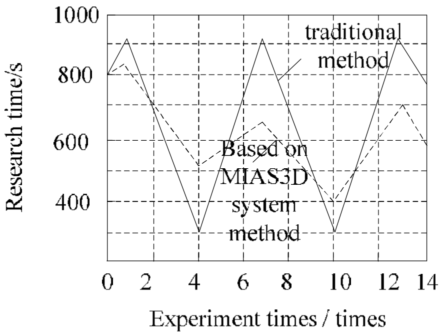

Figure 3. Two methods study time comparison results

It can be seen from Fig.3 that when the number of experiments is 2 times, the research time of the two methods is consistent. With the increase of the number of experiments, the research time of the traditional method is unstable, and the fluctuation range is large. Although there are several running times during the experiment than the MIAS3D system method, the network is unstable, resulting in the last research time of the traditional method being stable at around 760s; Based on the MIAS3D system method, the research time is relatively stable, and the fluctuation range is not large. Finally, the research time based on the MIAS3D system method is stable at around 580 s. It can be seen that the research method based on the MIAS3D system method is shorter than the traditional method.

The traditional research method is compared with the experimental research results of the image attitude parameter measurement method based on the MIAS3D system research method. The results are shown in Fig.4.

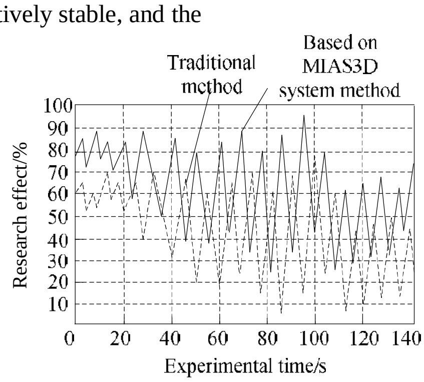

Figure 4. Comparative analysis of the effects of the two methods

It can be seen from Fig.4 that when the experimental time is 20s, the traditional method can achieve a maximum of 70%, and when the experimental time is 83s, the traditional method can achieve a minimum of 5%; When the experimental time is 95s, the research effect based on the MIAS3D system research method reaches 96%. When the experimental time is 81s, the research effect based on the MIAS3D system research method reaches a minimum of 25%. It can be seen that the experimental time has a serious impact on the research results of the research methods, especially the traditional methods. Compared with the maximum value based on the MIAS3D system research method, the difference is 26%, and the lowest value is 20%. The experimental time has little effect on the research method based on MIAS3D system.

3.3. Experimental results

According to the above experimental content, the experimental conclusion can be drawn:

The time comparison was studied for the two methods. When the number of experiments was 10, the research time based on the MIAS3D system method reached the lowest; When the experimental time was 98s, the research results based on the MIAS3D system method reached the best, 96%. It can be seen that the research based on the MIAS3D system image attitude parameter measurement method is effective.

4. Conclusion

A three-dimensional motion attitude measurement method for athletes is proposed. By optimizing the human motion parameters, the constraint optimization problem of motion parameters can be seen as a problem of minimizing nonlinear solutions. Using the motion constraint parameters to provide a fast convergence regularization method, the motion parameters and structural parameter matrix of the non-rigid body 3D motion are obtained, and the motion 3D parameter measurement is completed. The experimental results show that the method can have good measurement results, accurately control the motion posture, and is useful for retrieving athletes' injuries and further protecting athletes.

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