



3D Human Motion Information Extraction Based on Vicon Motion Capture in Internet of Things

Ze-guo Liu^(✉)

College of Information Engineering, Xizang Minzu University,
Xianyang, China
liuzeguo316@163.com

Abstract. In order to solve the problems of unclear contour and poor geometric precision in the process of extracting human body motion information by traditional key point detection method, a 3D human motion information extraction method based on Vicon motion capture was proposed. The motion characteristics of human body were captured by Vicon motion capture technology. According to the capture results, the change characteristics of joint force and angle in the course of human motion were collected and calculated, so that the frequency of human motion wave can be accurately grasped, the distribution of frequency change and the law of change. According to the law of change, the contour features in the process of human motion were perceived and judged, and the geometric accuracy of the moving contour was optimized by using fuzzy algorithm, thus the accurate extraction of three-dimensional human motion information was realized. The simulation results show that this method can effectively extract 3D human motion information, solve the problem of unclear contour in traditional methods, and improve the geometric accuracy of 3D human motion information extraction.

Keywords: Internet of things · Motion capture · Human motion · Information extraction

1 Introduction

With the development and maturity of the Internet of things technology, in the environment of the Internet of things, the requirement of extracting three-dimensional human motion information is gradually raised. In order to extract and analyze the human motion information more accurately, scan out the movement behavior characteristics of the object accurately, extract the motion information and the structure information of the object, the method of 3D human motion information extraction based on Vicon motion capture technology is innovated [1].

2 Human Motion Information Extraction Method Based on Vicon Motion Capture

2.1 Motion Features of Human Joint Based on Vicon Motion Capture

In the process of human motion feature capture, in order to extract 3D human motion information better, combined with Vicon motion capture technology, the process of human motion feature mining is simplified, in order to carry out fast and accurate 3D human dynamic capture. The feature extraction algorithm is used to extract and calculate the change features of joint motion in the course of human motion, and the dynamic capture of the motion feature is established. The calculation process is as follows:

$$\begin{aligned} H[a] &= 1.75 \frac{\partial^2 \Omega}{\partial v^2} \\ &= - \sum_{i=1}^n \xi_{ij} \left\{ \sin[1.75\xi_i^{-1/2}] + \xi_i^{-1/2} \cos[1.75\xi_i] \right\} e^{\xi_i^{2i/2}} \end{aligned} \quad (1)$$

In formula: $H[a]$ represents that the effective use value of capturing the joint angle in the course of human motion, and it can balance angle parameters and average sharpness to a certain extent; Ω represents a set of dense vectors representing contour operators; v^2 represents time-delay parameters of motion characteristics; $\xi_i^{-1/2}$ represents interactive vector parameters, which is a differential parameter that represents a specific capture process [2]. $e^{\xi_i^{2i/2}}$ represents annotation operator; ξ_{ij} represents visual error offset. The above formula optimizes the use condition of the key angle, and also needs to optimize the motion frame frequency. The formula is as follows:

$$\begin{aligned} \beta(s + 1, n - s + 1) &= \frac{1}{(s + 1, n - s + 1)} \cdot R^S (1 - R)^{n-s} \\ \beta(s + a, n - s + b) &= \frac{1}{(s + a, n - s + b)} \cdot R^{S+1} (1 - R)^{n-s-1} \end{aligned} \quad (2)$$

In formula: $\beta(s + 1, n - s + 1)$, $\beta(s + a, n - s + b)$ represent the individual pixel starting coordinates and the terminal feature parameters of the visual moving image, respectively; $(1 - R)^{n-s}$ represents the frequency of the motion image; R^S represents the frequency hopping probability of the moving image. The distribution of wave frequency, frequency change and frequency hopping in human motion capture system is shown in Fig. 1.

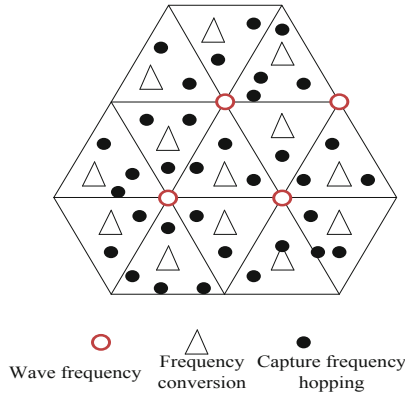


Fig. 1. Relationship between frequency of human motion wave and frequency change

According to the frequency of human motion wave and the relation of frequency change distribution, the calculation method of human joint motion characteristic is optimized. The formula is as follows:

$$cen_{it} = \ln \frac{I_{it}}{A} - \phi_{it}^2 FDI_{it} - \ln(H * FDI)_{it} \tag{3}$$

In formula, cen_{it} represents the tradeoff value of human motion characteristics, which is used to define the essential evaluation of parameters; H_{it} represents the texture set of moving point sub-pixel distribution; FDI represents valid values that can be qualified; ϕ_{it}^2 represents the local variance and is used for the coefficient defined by the weighting depth [3].

Through the above process, the optimization of the human motion feature operation is completed, and the optimized joint angle operation can capture the human body action.

2.2 Feature Processing of Human Motion Contour

Based on the human body motion feature mining algorithm based on Vicon, the preliminary results of motion feature estimation are obtained. In order to eliminate the errors in feature extraction process, and the human local motion capture is inaccurate, etc. Image edge features are recognized and analyzed with 3D shape algorithm in order to provide corresponding data support for Vicon action capture [4].

Set the collected 3D image as Y , image feature points are n , the set of data made up of feature points is $\{z_1, z_2, z_3, \dots, z_n\}$, the set of image data is $\{x_1, x_2, x_3, \dots, x_n\}$. The feature complexity coefficient is S , the perceptual time of action capture is m , the number of data samples is P , the shape of the database is described by l [5, 6].

Suppose that the initial edge of the 3D human motion image in the process of Vicon action capture is $G_t(h, l)$, the characteristic parameters of human motion contour obtained by different structures are represented by $F_a(m, n)$, and the gradient values of human motion contour can be calculated by the following formula:

$$F_a(m, n) = \sum_{a=1} UG_t(h, l) \quad (4)$$

According to the above exposition, we can more accurately extract and collect the human body motion contour features, and detect and analyze the human body motion contour region, which is conducive to more accurate recognition of three-dimensional human motion image feature data. It is beneficial to accurate extraction of 3D human motion information [7, 8].

2.3 Realization of Human Motion Information Extraction

In order to improve the timeliness and accuracy of motion feature extraction, the information extraction is greatly affected by the surrounding environment, and the resolution and edge blur of the extracted image are easy to appear in the process of motion extraction, so as to improve the timeliness and accuracy of motion feature extraction, a fuzzy algorithm is used to calculate the gradient change of salient joint motion angle in the process of human motion.

$$f_n(a, b) = \frac{a}{\delta b} n[f(a+1, b-1) - f(a-1, b+1)] \quad (6)$$

In formula: δ represents the rate of change in the angle of the joint, a, b represent the characteristic parameter of motion initiation and n is the direction of motion. According to the above algorithm, the force change of 3D human body is calculated. The algorithm is as follows:

$$P = \frac{\sum (a_n - b_n)}{n\sqrt{n^2 + 1}} \quad (6)$$

Because the traditional algorithm for extracting the global feature of human body motion consumes a relatively large proportion of time, it is difficult to extract the detailed features effectively [9, 10]. Combined with the previous algorithm, the accuracy of 3D human motion information processing is standardized and recorded as the standard data for feature extraction, which is used for comparison and reference. The data are as follows.

Table 1. Accuracy of 3D human motion information processing.

Resolution ratio	Standard for accuracy of edge contour feature extraction	Joint change precision standard	Kinematic trend precision standard	Force variation precision standard
-10	0.845	0.774	0.891	0.945
-20	0.945	0.798	0.885	0.912
-30	0.874	0.805	0.798	0.915
-40	0.768	0.854	0.791	0.857
-50	0.778	0.901	0.918	0.905
-60	0.748	0.872	0.926	0.984
-70	0.742	0.831	0.873	0.945
-80	0.757	0.846	0.744	0.901
-90	0.875	0.798	0.854	0.891

Combined with the high scale algorithm of Vicon motion capture technology, the feature of human body motion contour is extracted, thus avoiding the problem of extraction error and so on [11]. Combining with the mapping function, the extraction accuracy of human motion edge parameter information is optimized, and the edge feature can be accurately extracted and displayed in the process of human body motion, so as to improve the accuracy of feature information extraction. Reduce the error of motion feature extraction. Combined with fuzzy algorithm and gray mapping method, human motion information can be extracted more accurately. Combined with the data in Table 1 and the gray mapping function algorithm, the motion feature accuracy detection system is extracted and decomposed and analyzed. Suppose that the decomposition process of 3D human motion feature is shown in Fig. 2. C represents the analysis and extraction of 3D human motion feature information from S and P of the same sample.

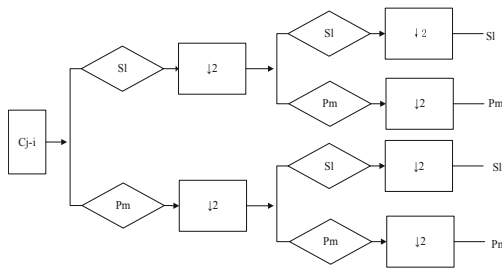


Fig. 2. 3D discrete wavelet transform

Based on the method of extracting variance of 3D human motion feature captured by Vicon, the threshold value of human motion is calculated. According to the result, the information is converted to the three-dimensional image of human motion blur, and

the fuzzy membership value C of each pixel is obtained. The mean value of 3×3 neighborhood is calculated by the previous formula. Using derivative C and image convolution, the gradient of image horizontal and vertical direction is calculated accurately to determine the value of C_{j-i} , and the edge feature is judged according to the threshold value. The gradient larger than the threshold is the contour feature of human body. The second derivative of the image is calculated by the same principle, the corresponding negative points are selected, and the largest adjacent points are extracted from the negative points. If this point is positive, the difference between this point and the negative point is obtained, and the other points are set to zero. In this case, according to the statistical characteristics of the second derivative, the threshold value can be judged to obtain the joint motion angle characteristic information of the zero crossing point, and the human body motion feature can be accurately extracted according to the joint angle and motion contour feature.

3 Experimental Results and Analysis

In order to verify the validity of 3D human motion information extraction method based on Vicon motion capture in the Internet of things, a comparative simulation experiment was designed. Take a sporting event as an example. In order to ensure the effectiveness of the experiment, the movement of the same contestant at the same time cut point is selected to detect the movement. In order to ensure the validity of human body action feature extraction in the course of motion, the relevant data are set up. Data y_i after batch Operation of the balance index within the range of [68.5 to 78.6]; Set the set of indicators $K(x_i, x_j)$ within the assessment area to 15.85; In order to ensure that the human motion capture system can accurately capture and set up the $H[a]$, $e^{\xi 2i/2}$, $N(t)$, $(2x + 1)\omega\pi$ are 5.28/4163.5/66.32/400; Set the test parameters as shown in the Table 2.

Table 2. Experimental parameters.

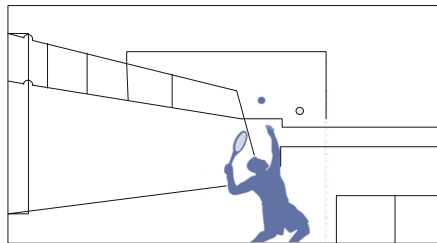
Experiment number	Range of movement/CM	Capture image frame code/PB	Correction parameter
1	20	2.5	10^{-4}
2	30	3.0	10^{-4}
3	40	3.5	10^{-4}
4	50	4.0	10^{-4}
5	60	4.5	10^{-4}
6	70	5.0	10^{-4}
7	80	5.5	10^{-4}
8	90	6.0	10^{-4}
9	100	6.5	10^{-4}

According to the parameters of the above simulation and contrast experiment, the results of the traditional method and the method in this paper are recorded in the course of the experiment, and the concrete results are shown in the Table 3.

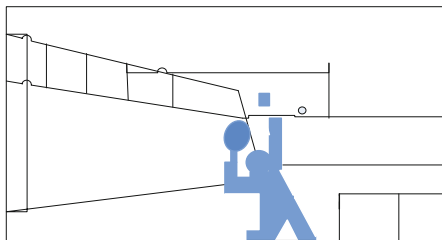
Table 3. Comparison of experimental results.

	Moving contour	Contour feature parameter	Contour definition	Background filtering rate	Fitting degree	Identification degree
Traditional method	-2	-4	3	20	0.85	4
Paper method	7	2	7	15	1.36	9

The results of the analysis table show that the motion profile of the motion information extraction method designed in this paper is much stronger than that of the traditional method, and the definition of the contour curve is much stronger than that of the traditional method. The results show that the accuracy of the extraction of motion contour features is higher in the process of capturing motion features, and the fitting degree and identification degree are also slightly better than the traditional methods. In order to detect the geometric accuracy of the method more intuitively, the actual test results are displayed, as shown in the Fig. 3 below.



(a)Paper method



(b)Traditional method

Fig. 3. Comparison of experiment results

According to the above image, it is not difficult to find that the proposed method is obviously superior to the traditional method in extracting and displaying human motion information in the process of detection, and can perform high resolution, high definition action feature capture.

4 Conclusions

A method of extracting 3D human motion information based on Vicon motion capture in the Internet of things was proposed. The joint angle in the human motion process is calculated by using the human motion feature mining algorithm. According to the joint changing angle, the shape of the moving object is obtained, and the useful data features that accurately reflect the characteristics of the human body's motion behavior are obtained. The feature information of the original point cloud is preserved to effectively extract the human body motion information. The experimental results show that compared with the traditional method, this method has high geometric accuracy, good fit and superior performance, which fully meets the research requirements.

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