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Method of Quantifying and Analyzing the Characteristics of Sports Action

Caizhen Song*, Lifang Zhang
Department of Physical Education, Changsha Normal University, Changsha, 410100, China

Abstract: In order to improve the ability of quantitative analysis and pattern recognition of sports movement features, a method of sports movement feature quantization and pattern analysis based on computer vision image analysis is proposed. Based on wavelet multilayer decomposition and feature transformation, a model of feature extraction and quantization pattern recognition of sports action image is constructed. The method of one-dimensional wavelet transform is used to decompose the motion feature of sports action image visually. Combined with edge pixel reconstruction and Harris corner detection method, the sports action image is segmented, and the feature quantization analysis and pattern recognition of the sub-block pixel of the sports action image are carried out to achieve image enhancement. The wavelet multilayer decomposition and feature transformation are used to reconstruct the 3D feature of sports action image, and the multi-scale Retinex algorithm is used to extract the feature points of sports action, and to realize the quantization pattern recognition of sports action image. The simulation results show that the algorithm has higher accuracy and better ability of quantization and pattern analysis of sports action image. The ability of dynamic recognition and planning analysis of sports action is improved.

Keywords: Sports; Feature analysis; Image; Pattern recognition; Wavelet analysis; Computer vision image

1. Introduction

In recent years, computer technology can be found in all kinds of international and domestic sports competitions, and the vigorous development of sports cannot be separated from the computer technology, which is always at the forefront of the times. It can be said that the competition in the contemporary sports field is in a sense the competition of science and technology, and computer technology plays an increasingly important role in competitive sports. The application of computer technology in competitive sports is quite extensive, and the prospect of development is very considerable. Nowadays, competitive sports with the Chinese national spirit have developed into a symbol of a country's comprehensive national strength, and computer technology has been widely used in the field of competitive sports. To a great extent, it promotes the improvement of the overall level of competitive sports in our country, and at the same time, it also promotes the overall national strength of our country. The quantitative analysis and pattern recognition of sports movements by computer vision image analysis method can improve the ability of quantitative analysis of sports movements and thus promote the correction of sports movements. It has great significance to analyze the sports movement characteristics with computer vision image analysis method.

Traditionally, motion quantization pattern recognition of sports images takes optical projection technology to reconstruct digital information. Image feature distribution and 3D radiation characteristics are used, the region segmentation of 3D reconstruction image of sports action is carried out by using digital image reconstruction, and direct volume rendering technology is taken in sports movement characteristic quantization analysis. The 3D holographic projection is realized by simulating the point distribution and edge contour distribution of the image, and the feature extraction and motion quantization pattern recognition are carried out in the holographic projection. The movement quantization pattern recognition uses the texture segmentation method, in the large-scale sports action image processing the real-time performance is not good, it cannot realize the batch image adaptive screening.

Aiming at the above problems, a method of sports movement feature quantization and pattern analysis is proposed based on computer vision image analysis. Based on wavelet multilayer decomposition and feature transformation, a model of feature extraction and quantization pattern recognition of sports action image is constructed. The method of one-dimensional wavelet transform is used to decompose the motion feature of sports action image visually. Combined with edge pixel reconstruction and Harris corner detection method, the sports action image is segmented, and the feature quantization analysis and pattern recognition of the sub-block pixel of the sports action image are carried out to achieve image enhancement. The wavelet multilayer decomposition and feature transformation are used to reconstruct the 3D

feature of sports action image, and the multi-scale Retinex algorithm is used to extract the feature points of sports action. Finally, the performance test is carried out through the simulation experiment, which shows the superior performance of this method in improving the quantitative analysis of sports movement characteristics and the ability of pattern recognition.

2. Image Acquisition and Block Preprocessing

The research of motion quantization pattern recognition of sports action image is based on the feature acquisition and block processing of the image. The digital device Nikon D7200 is used for image acquisition. The sensitivity is set to 100. Radon scale transform is used to construct the 4 × 4 mesh region of the image, and one-dimensional wavelet transform is used to decompose the angle and frequency of the sports action image. Using sparse prior information of image to detect sports action corner, using one-dimensional wavelet transform of image to segment super-pixel, pixel feature acquisition of image is realized, the collection results are extracted by wavelet multilayer decomposition and feature transformation to realize the recognition of sports action features. According to the above design principle, the overall framework of motion quantization pattern recognition of sports action images is obtained, as shown in figure 1.

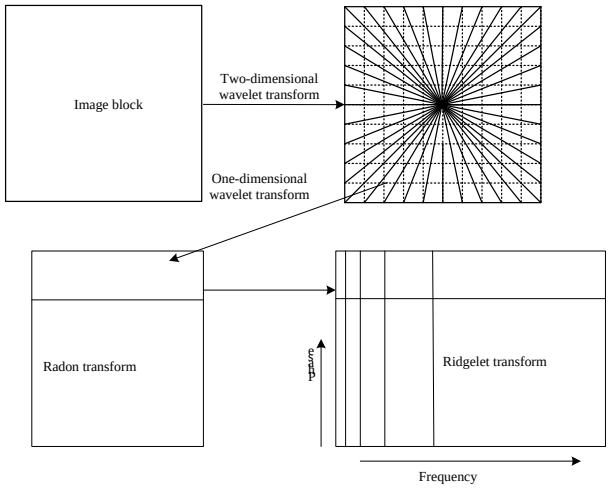


Figure 1. Realization process of feature quantization pattern recognition of sports action image

According to the overall structure block diagram constructed in figure 1, the algorithm of quantization pattern recognition of sports action feature is designed, and the corner detection of the collected sports action image is carried out. The three-dimensional feature values of the pixel position in the distribution of sports action feature points can be written as follows:

$$\begin{aligned} Kr_1(W) &= \sum_{r=1}^{t}\sum_{p=1}^{k_1}\left\|W_i^T x_{ir} - W_i^T x_{irp}^{'}\right\|^2 A_{irp} \\ &= \sum_{r=1}^{t}\sum_{p=1}^{k_1} tr(W_i^T x_{ir} - W_i^T x_{irp}^{'})(W_i^T x_{ir} - W_i^T x_{irp}^{'})^T A_{irp} \\ &= \sum_{r=1}^{t}\sum_{p=1}^{k_1} tr(W_i^T[(x_{ir} - x_{irp}^{'})(x_{ir} - x_{irp}^{'})^T A_{irp}]W_i) \qquad (1) \\ &= tr(W_i^T[\sum_{r=1}^{t}\sum_{p=1}^{k_1}(x_{ir} - x_{irp}^{'})(x_{ir} - x_{irp}^{'})^T A_{irp}]W_i) \\ &= tr(W_i^T H_1 W_i) \end{aligned}$$

$$H_1 = \sum_{r=1}^{t}\sum_{p=1}^{k_1}(x_{ir} - x_{irp}^{'})(x_{ir} - x_{irp}^{'})^T A_{irp} \qquad (2)$$

Where, H_1 denotes the prior information component of sports action image, $tr(.)$ indicates that the track of sports action feature distribution, A_{irp} is the measurement error amplitude of image pixel acquisition. In the 4 × 4 sub-region of the image, the sub-pixel feature matching of the sports action image is carried out, and the sub-block pixel feature distribution of the sports action image is obtained as follows:

$$\begin{aligned} Kr_2(W_i) &= \sum_{r=1}^{t}\sum_{q=1}^{k_2}\left\|W_i^T x_{ir} - W_i^T x_{irq}\right\|^2 B_{irq} \\ &= tr(W_i^T[\sum_{r=1}^{t}\sum_{q=1}^{k_2}(x_{ir} - x_{irq})(x_{ir} - x_{irq})^T B_{irq}]W_i) \qquad (3) \\ &= tr(W_i^T H_2 W_i) \end{aligned}$$

$$H_2 = \sum_{r=1}^{t}\sum_{q=1}^{k_2}(x_{ir} - x_{irq})(x_{ir} - x_{irq})^T B_{irq} \qquad (4)$$

Where, H_2 is the high frequency feature output of sports action image, x_{ir} is the principal component feature component, x_{irq} is the image binarization kernel function, B_{irq} is the edge contour feature quantity of sampled pixel points, W is the frame number, $tr(.)$ represents the pixel trace of the sub-block image.

The block preprocessing of the result of the sports action image acquisition and output is carried out, the sampling pixel is $\nabla_x = [1,-1]$, $\nabla_y = [1,-1]^T$, and the block matching function of the single frame sports action image is obtained as follows:

$$s(k) = [s_1(k), s_2(k), \cdots, s_m(k)]^T \qquad (5)$$

The edge contour feature points are sampled in the gradient direction. The following wavelet multilayer decomposition and feature transformation are used for block segmentation:

$$\begin{aligned} x(n) &= s(n) + v(n) \\ &= \sum_{i=1}^{L} A_i \cos(\omega_i n + \varphi_i) + \sum_{j=0}^{\infty} h(j) w(n-j) \end{aligned} \qquad (6)$$

In the sub-block, the sports action texture feature of the image is subspace sampled, and the energy function E_i of the sports action distribution region is calculated by LHA operator, and the edge contour feature vector of the image is extracted, and the image information fusion is carried out. The output matrix of image fusion is expressed as follows:

$$X' = \begin{pmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{(n-1)1} & x_{(n-1)2} & \cdots & x_{(n-1)n} \end{pmatrix} \tag{7}$$

Where, $r(t)$ F is approximate to the sports action distribution contour $S(t)$ of the sports action image. The multi-scale wavelet decomposition is used to realize the same square superposition of the human sports action information and to improve the intensity of the sports movement feature output.

3. Quantitative Pattern Recognition of Movement Characteristics

3.1. Quantitative analysis and pattern recognition of sports action image

On the basis of the acquisition and preprocessing of sports action images, the quantization pattern recognition of sports action images is optimized. In this paper, a new method based on wavelet multilayer decomposition and feature transformation is proposed for feature extraction and quantization pattern recognition of sports action images[11]. One dimensional wavelet transform method is used to decompose the motion feature of sports action image by visual quantization. The characteristic decomposition equation is described as follows:

$$\begin{cases} p_{th}^{(b_{int})} = C_i \sum_{x_i \in w} k(\|x_i\|)\delta(h(x_i) - b_{int}) \\ p_{te}^{(b_{ine})} = C_e \sum_{x_i \in w} k(\|x_i\|^2) his_{x_i} \delta(v_{x_i} - b_{ine}) \end{cases} \tag{8}$$

Where, $C_i = C_e = \dfrac{1}{\sum_{x_i \in w} k(\|x_i\|^2)}$, in the sports action feature distribution region $M \times M$, combining edge pixel reconstruction and Harris corner detection method to segment the sports action image, the difference value of the key information points of the image is obtained as follows:

$$\min_{c\in\{r,g,b\}} (\min_{y\in\Omega(x)} (\frac{I^c(y)}{A})) = \tilde{t}(x) \min_{c\in\{r,g,b\}} (\min_{y\in\Omega(x)} (\frac{J^c(y)}{A})) + (1-\tilde{t}(x)) \tag{9}$$

The sports action image is collected as a pair of gray image, the threshold segmentation method is used to detect the key information points of sports action, the iterative $s(k) = [\theta(k), \Delta x(k), \Delta y(k)]$ is updated, the pixel value of the sports action image tends to be zero, and the pixel value of the sports action image tends to be zero through the ruler[13]. The normalized pixel values of the image are obtained by wavelet decomposition:

$$P(i,j)(i \in [0, \text{int}(W/2)-1], j \in [0, \text{int}(H/2)-1]) \tag{10}$$

The characteristic difference value is obtained from the gray value marking line of the image. Combining edge pixel reconstruction and Harris corner detection method, the sports action image segmentation is carried out. The state equation of the Secant line is expressed as follows:

$$\begin{aligned} &E_{image}(Vi) = \\ &-|I(x_{i-1}, y_{i+1}) + 2I(x_i, y_{i+1}) + I(x_{i+1}, y_{i+1}) \\ &-I(x_{i-1}, y_{i-1}) - 2I(x_i, y_{i-1}) - I(x_{i+1}, y_{i-1})| \\ &+|I(x_{i+1}, y_{i-1}) + 2I(x_{i+1}, y_i) + I(x_{i+1}, y_{i-1}) \\ &-I(x_{i-1}, y_{i-1}) - 2I(x_{i-1}, y_i) - I(x_{i-1}, y_{i+1})| \end{aligned} \tag{11}$$

Set up the coverage area $F: E \to R^3$ of sports action, set $\mathbf{T}: E \to \text{PDS}(2)$, in triangulation the image pixel (x, y), the template matching function of the sports movement characteristics is obtained as:

$$\begin{cases} t = \mu\cos\alpha - \nu\sin\alpha \\ \omega = \mu\sin\alpha + \nu\cos\alpha \end{cases} \tag{12}$$

The edge pixel values of the sports action distribution region are extracted. The results are expressed as follows:

$$\lim_{P\to+\infty} \kappa_B^P(f)(x,y) = \max_{(s,t)\in B(x,y)} f(s,t) = \delta_B(f)(x,y) \tag{13}$$

$$\lim_{P\to-\infty} \kappa_B^P(f)(x,y) = \min_{(s,t)\in B(x,y)} f(s,t) = \varepsilon_B(f)(x,y) \tag{14}$$

The feature quantization analysis and pattern recognition of the sub-block pixels of the sports action image are carried out. The filter function is expressed as follows:

$$t(x) = 1 - \min_{c\in\{r,g,b\}} (\min_{y\in\Omega(x)} (\frac{I^c(y)}{A})) \tag{15}$$

$$\tilde{U}(x) = 1 - \tilde{t}(x) = \min_{c\in\{r,g,b\}} (\min_{y\in\Omega(x)} (\frac{I^c(y)}{A})) \tag{16}$$

In the 4 × 4 sub-block model, the image feature quantification analysis and pattern recognition are carried out to achieve image enhancement, thus improving the feature identification ability of sports action image.

3.2. Feature point information enhancement for image identification

In the 4 3 × 3 sub-block models, wavelet multilayer decomposition and feature transformation are used to reconstruct the 3D feature of sports action image. The texture feature set of sports action distribution in the image is described as follows:

$$e = \frac{1}{|\nabla u|}(\frac{\partial u}{\partial y} i - \frac{\partial u}{\partial x} j),\ f = \frac{1}{|\nabla u|}(\frac{\partial u}{\partial x} i + \frac{\partial u}{\partial y} j) \tag{17}$$

The wavelet multilayer decomposition and feature transformation equation are constructed by introducing the edge joint distribution feature of sports action image:

$$\frac{\partial u(x,y;t)}{\partial t} = \frac{\partial^2 u(x,y;t)}{\partial \xi^2} + c^2 \frac{\partial^2 u(x,y;t)}{\partial \eta^2} \tag{18}$$

In the texture distribution subspace, the sports movement distribution position in the image is marked, and the multi-scale Retinex information enhancement output of the sports action image is obtained as follows:

$$\begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} \cos\alpha & -\sin\alpha \\ \sin\alpha & \cos\alpha \end{bmatrix} \begin{bmatrix} p \\ q \end{bmatrix}, \alpha = \arctan(\frac{\partial u}{\partial y} \Big/ \frac{\partial u}{\partial x}) \quad (19)$$

The characteristic functional for estimating the location information of sports movement distribution is described as follows:

$$\min_{x,k} \lambda \left\| x \otimes k - y \right\|_2^2 + \frac{\left\| x \right\|_1}{\left\| x \right\|_2} + \beta \left\| k \right\|_1 \quad (20)$$

When the diffusion coefficient of the sports action image in the edge pixel region satisfies the constraint condition: $k > 0, \sum_i k_i = 1$, the joint feature function of the edge contour feature point of the image is introduced:

$$S_\alpha(x)_i = \max(\left| x_i \right| - \alpha, 0) sign(x_i) \quad (21)$$

Combining edge pixel reconstruction and Harris corner detection method, the problem of motion quantization pattern recognition in sports action image is transformed into:

$$\min_k \lambda \left\| x \otimes k - y \right\|_2^2 + \beta \left\| k \right\|_1 \quad (22)$$

When the constraint condition $k > 0, \sum_i k_i = 1$ is satisfied, the multi-scale Retinex information is used to enhance, and the result is as follows:

$$m_{pq} = \sum_{m=1}^{M} \sum_{n=1}^{N} x^p y^q f(x, y) \quad (23)$$

In the formula, x^p is the horizontal coordinate of the distribution position of the sports action, and the y^q expresses the ordinate of the distribution position of the sports action. Thus, the identification feature points of the image are reconstructed to realize the pattern recognition of the movement of the sports action image.

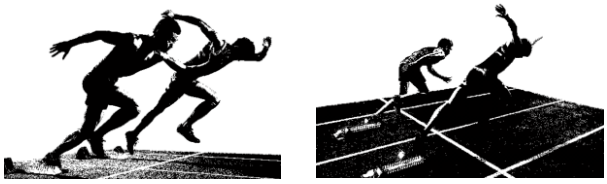
4. Analysis of simulation experiment

The running platform of simulation test is windows 7 system, Pentium (R) 4 CPU 3.00 GHz. The image processing algorithm is programmed with Matlab image processing software. Two groups of samples are selected as training set and test set in Database DDL. The size of sports action image is 2000 × 2000 pixels, the duration of sports action image acquisition is 0.23, and the result of original sports action image acquisition is shown in figure 2

(a) Frontal image (b) Back image

Figure 2. Sample set of sports movements

Taking the above sports action samples as the research object, a group of samples is taken for testing, and different methods are used for motion quantization pattern recognition and feature extraction. The recognition results are shown in figure 3. The result of analyzing figure 3 shows that the method of this paper is used to recognize the sports action, the pixel value of the output image is higher, the imaging quality is better, and the precision of the sports motion recognition is improved.



(a) Frontal image (b) Back image

Figure 3. Comparison of results of sports movement quantification pattern recognition

Different methods are used to compare the accuracy of sports action feature quantization pattern recognition, and the result is shown in figure 4. The analysis shows that the method of this paper has better accuracy for sports action feature quantification recognition. The accuracy of motion pattern recognition is higher than traditional method.

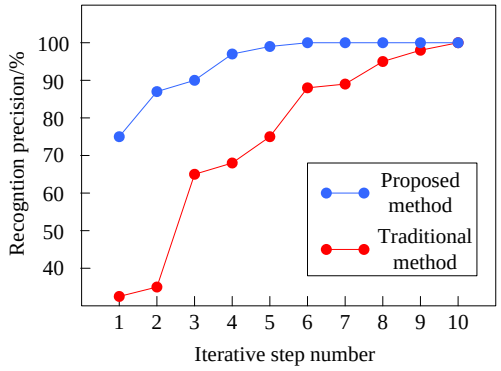


Figure 4. Performance comparison of quantitative recognition of sports action features

5. Conclusions

In this paper, a method of sports movement feature quantization and pattern analysis based on computer vision image analysis is proposed. A model of feature extraction and quantization pattern recognition of sports action image is constructed. The method of one-dimensional wavelet transform is used to decompose the motion feature of sports action image visually. Combined with edge pixel reconstruction and Harris corner detection method, the sports action image is segmented, and the feature quantization analysis and pattern recognition of the sub-block pixel of the sports action image are carried out to achieve image enhancement. The wavelet multilayer decomposition and feature transformation are used to reconstruct the 3D feature of sports action image, the quantization pattern recognition of sports action image is realized. The simulation results show that the algorithm has higher accuracy and better ability of quantization and pattern analysis of sports action image. The ability of dynamic recognition and planning analysis of sports action is improved. This method has theoretical value in the standardization and guidance of sports training.

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