Performance Evaluation Model of Wushu Sanda Athletes Based on Visual Signal Processing

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Abstract. In order to improve the accuracy of the performance evaluation of Wushu Sanda athletes, the performance evaluation model of Wushu Sanda athletes was designed based on visual signal processing. First, extract the contours of Wushu Sanda athletes, then collect the performance information of Wushu Sanda athletes, and finally complete the performance evaluation through the establishment of the performance evaluation index of Wushu Sanda athletes and the index processing. Experimental results show that the evaluation model designed in this study not only improves the accuracy of evaluation, but also has a higher evaluation efficiency.

Keywords: Visual signal processing · Wushu Sanda athletes · Performance evaluation · Contour extraction · Information collection

1 Introduction

Wushu Sanda is an important part of modern competitive sports. How to improve the athletes' competitive ability in such events is very important [1–3]. The expressiveness evaluation of Wushu Sanda athletes has a certain promotion effect on improving the athletes' competitive level. Through expressiveness evaluation, it is found that the strengths and weaknesses of athletes in training are the topics of general concern in training practice [4, 5]. Therefore, in order to improve the athlete's competitive level, it is necessary to design a performance evaluation model for Wushu Sanda athletes.

In this context, some scholars put forward the evaluation method of basketball players' competitive performance ability based on the hybrid model. This method follows the idea of analytic hierarchy process, constructs the evaluation index system of competitive performance ability, and establishes the hybrid evaluation model based on AHP-FCE to scientifically evaluate and analyze the basketball players' competitive performance ability. The experimental results show that this method can fully reflect the competitive ability of basketball players, but the evaluation time is long. Some scholars put forward the comprehensive quality evaluation method of cyclists Based on support vector machine, and selected 16 influencing factors of 225 cyclists' body shape, body function, sports ability and special ability as three methods to optimize the parameters of the network model. The experimental results show that the accuracy of this method is high, but the evaluation time is long.

W. Fu et al. (Eds.): ICMTEL 2021, LNICST 388, pp. 103–116, 2021.
https://doi.org/10.1007/978-3-030-82565-2_9

Visual signal processing is an information processing department based on visual processing. It is the most natural, convenient, convenient and effective way to realize human-computer interaction. It can be used in almost any scene in the field of signal processing, which helps reduce human labor intensity and improve information processing efficiency. Therefore, the visual signal processing technology is applied to the performance evaluation of Wushu Sanda athletes. Aiming at the problems of traditional methods, this paper designs a performance evaluation model of Wushu Sanda athletes based on visual signal processing. The sports contours of Wushu Sanda athletes are extracted through visual signal processing, and the performance information of Wushu Sanda athletes is collected through visual signal processing. Finally, the performance evaluation is completed through the establishment of the performance evaluation index of Wushu Sanda athletes and the index processing. The experimental results show that the evaluation model designed in this study not only improves the accuracy of evaluation, but also has higher evaluation efficiency, which effectively improves the problems existing in traditional methods.

2 Construction of Evaluation Model of Wushu Sanda Athletes' Performance

2.1 Contour Extraction of Sanda Athletes

Before evaluating the performance of Wushu Sanda athletes, it is necessary to extract the contour data of Wushu Sanda athletes based on visual signal processing. In the process of contour extraction, the saliency of a single pixel does not provide meaningful guidance for the position of the contour, and the salient area composed of salient points is likely to correspond to the perceptual target in the image, which can be used for contour extraction based on the deformation template.

In the calculation of salient regions, the most primitive method is to divide the image into fixed rectangular regions, calculate the saliency values in each region, and select the regions with the highest values as salient regions [6, 7]. The disadvantage of this method is that it is easy to divide the perceptual object into several parts, and lose the matching and recognition meaning as a whole. Some researchers divide the image into overlapping rectangular or circular windows, and the size of the window is adjustable. The significance value of the area covered by each window is taken as the factor to compare the regional significance. The advantage of this method is that it can divide the salient region according to the actual size of the target, especially for a specific task, the given shape of the region is equivalent to providing a shape prior for finding the salient target, which can effectively improve the efficiency of target detection. However, the disadvantage of this method is that the overlapping of regions will lead to the repetition of saliency calculation and greatly increase the amount of calculation. In addition, another method is to use the segmentation algorithm to divide the image into several regions and calculate the saliency value of each region. This method avoids the increase of workload caused by repeated calculation. At the same time, the segmentation algorithm can guarantee the perceptual attributes of the region roughly, that is, the pixels in the region have the same or similar visual features, which is very helpful for extracting the perceptual object contour. Natural images are rich in brightness and texture changes, and the shape of the target is completely unknown, so we choose to use segmentation method to help build templates [8–10]. The expression is as follows:

$$\bar{S} = \frac{1}{n}\sum_{i=1}^{n}\bar{S}_{Ai} \tag{1}$$

In the formula (1), $\bar{S}$ represents the segmentation value, $\bar{S}_{Ai}$ represents the mean value of the regional average significant value, and n represents the number of general regions.

When the overall brightness of the target in it is dark, it is likely to be ignored or divided into non-significant areas. In order to avoid this situation, add position information to the template, assume that the target is located in the middle of the image, and define the connected area whose point coordinates are mostly in the middle of the image as the target area. In order to make the resulting template smoother, reduce the impact of repeated changes in local gray levels on the movement of the model, and obtain a template that stably predicts the direction of the curve's movement, the resulting template can be removed from isolated points and areas with smaller areas, and fill holes in the target area. And use median filter for smoothing operation, the expression is:

$$F = M(K) - k\frac{e}{m} \tag{2}$$

In formula (2), k represents the image force coefficient, m represents the parameter when the curve passes through the edge, e represents the external constraint coefficient, and M represents the background parameter.

On this basis, for closed contour extraction, curvature is an important invariant of the curve, which can remain unchanged in the translation and rotation of the image:

$$M(K) = (b - a)|Kn(s)| + a \tag{3}$$

In formula (3), K represents the image force coefficient, b represents a continuous monotonous non-decreasing function, and a represents the magnitude parameter of the external force.

This traditional method only uses the low-level feature of the image gray level, which is very sensitive to noise. It may take the small texture with great difference in gray level as the real edge. Moreover, this definition method loses the rich regional and structural information in the image, which can make the results of edge extraction process more robust and provide more reliable input for more advanced visual tasks.

Therefore, the following calculation method is adopted for further processing

$$\begin{cases} E_{snake} = E_{int}(v(s)) + E_{ev}(v(s)) \\ E_{im}(v(s)) = \int_0^1 \frac{1}{2}\left(\alpha\left|v'(s)\right| + \beta\left|v''(s)\right|\right)ds \\ E_{ext} = \int\limits_0 M(K)\vec{n}(s) - k\frac{\nabla E_{SBP}}{\nabla E_{SBP}}d \end{cases} \tag{4}$$

In formula (4), E_{SBP} represents the image energy term, α represents the variance, and E_{int} represents the scalar function of the image surface.

The above process takes into account the changes of the dual features of grayscale and texture near the edge, can provide a clear and concise input image for contour extraction, and effectively improve the accuracy of the active contour model for contour extraction.

2.2 Information Extraction of Wushu Sanda Athletes' Expressive Force

The Fourier transform is used to achieve target detection through frequency filtering. The meaning of the frequency component is the change in the value (color, brightness, etc.) between adjacent pixels, which means that the faster the image changes in space, the corresponding in the frequency domain. The greater the value. The Fourier transform of an image is a method of observing the characteristics of the image from the gray-scale distribution to the frequency distribution. The frequency of the image is an index that characterizes the intensity of the gray-scale change in the image, and it is also the gradient of the gray-scale in the plane space. According to the characteristics of high frequency reflecting the details and low frequency reflecting the general situation of the scene, the edge with strong transformation of visual attributes is a region with dramatic changes in the spectrum, and the corresponding frequency value is higher. In general, there are differences between foreground objects and background images in the regions with high visual saliency. This difference is mainly manifested in the large change of gray gradient. Therefore, in the frequency spectrum after Fourier transform, the abrupt part of the image is represented by high-frequency component, which includes not only image contour features, but also noise and interference. In addition, in some cases, the change of the image inside the salient region is relatively gentle. The low-frequency component of the spectrum is used to obtain the image. The low-frequency component determines the overall image of the image, including the contour information of the object.

The discrete two-dimensional Fourier transform formula of the image is as follows:

$$F(u, v) = \frac{1}{N}\left(-j2\pi\left(\frac{mu}{N} + \frac{nv}{N}\right)\right) \tag{5}$$

In formula (5), $F(u, v)$ represents the gray value of the image.

Since most of the energy in the image is concentrated on low-frequency components, the amplitude values of the four corners of the spectrogram are relatively large. However, in the actual image spectrum analysis process, because the low-frequency components are small and scattered in the four corners, it is not conducive to analyze them. At this time, the coordinates of the spectrogram can be shifted according to the periodicity and conjugate symmetry of the image spectrum. Therefore, the following formula is used to concentrate all the low-frequency components in the center of the spectrogram, while the high-frequency components are scattered around:

$$A(f) = |F(u, v)| = \sqrt{R(u, v)^2 + I(u, v)^2} \tag{6}$$

For image $f(x, y)$, if there are r_k kinds of gray values in the image, then the probability density function is as follows:

$$P(r_i) = \frac{N_r}{N}(\mathrm{i} = 0, 1, 2..., k - 1) \tag{7}$$

$$\sum_{i=0}^{k-1} P(r_i) = 1 \tag{8}$$

In the above formula, r_i represents the number of pixels, and N is the total number of pixels.

On this basis, the gray histogram method is used to segment the image:

1) The number of pixels on each gray level;
2) The dynamic range of image grayscale;
3) The overall brightness and contrast of the image.

Histogram is a very useful decision and evaluation tool in image processing. The commonly used histogram operation methods include: image brightness adjustment, contrast adjustment, gray level correction and dynamic range adjustment. Infrared image is different from visible light image in imaging, and its spatial resolution and contrast are worse than that of visible image:

1) The overall gray scale of the image is excessively smooth, and most pixels are concentrated in some adjacent gray scale ranges;
2) There are obvious peaks and valleys in the gray histogram, among which there are more single peaks or double peaks.

Each image has a unique histogram. If the interior of the foreground object has a uniform gray value, and the background is evenly distributed on another gray value, and the difference between the two gray levels is far, then the gray histogram of the image presents a bimodal state. One peak corresponds to the center gray level of the target, and the other peak corresponds to the center gray level of the background. The valley point between the two peaks corresponds to the gray level of the boundary, and the gray value of the valley point is often used as the threshold value in image segmentation. However, the actual infrared image background is complex and changeable, which makes the valley or peak in the gray histogram not obvious, so the bimodal method is difficult to play its advantages. To solve this problem, the basic idea of the method is to calculate a certain gray level in the histogram, which divides the histogram into left and right parts, and makes the distance between the gray mean of these two parts and the overall gray mean value of the image maximum, then the gray level is the segmentation threshold. The expression is as follows:

$$N = \sum_{i=0}^{L-1} n_l \tag{9}$$

In formula (9), L represents the gray level.

In this way, the image segmentation is completed through the above process.

On this basis, a region with significant visual difference is generated. The Fourier spectrum shape of each image in the same image is similar, and the frequency range is similar. In visual selective attention, similar redundant information is allocated less computing resources, and more attention resources are allocated for information unique to each image. Finding out the unique information of each image is the key to discovering visually significant areas. Its expression is:

$$E_{L,ab} = \sqrt{(L_2 - L_1)^2 + (a_2 - a_1)^2 + (b_2 - b_1)^2} \tag{10}$$

In formula (10), L_2, L_1, a_2, a_1, b_2 and b_1 represent image parameters respectively.

In this way, the performance information extraction of Wushu Sanda athletes is completed through the above process, which provides a basis for the performance evaluation of Wushu Sanda athletes.

2.3 Construction of the Evaluation System of Wushu Sanda Athletes' Performance

The power transaction evaluation model is divided into the target layer, the criterion layer and the scheme layer. The corresponding three parts are the evaluation object, the evaluation module and the evaluation element. Among them, the indicators in the evaluation module are sub-indices, and the indicators in the evaluation elements are Sun indicators. The overall evaluation model framework is shown in Fig. 1.

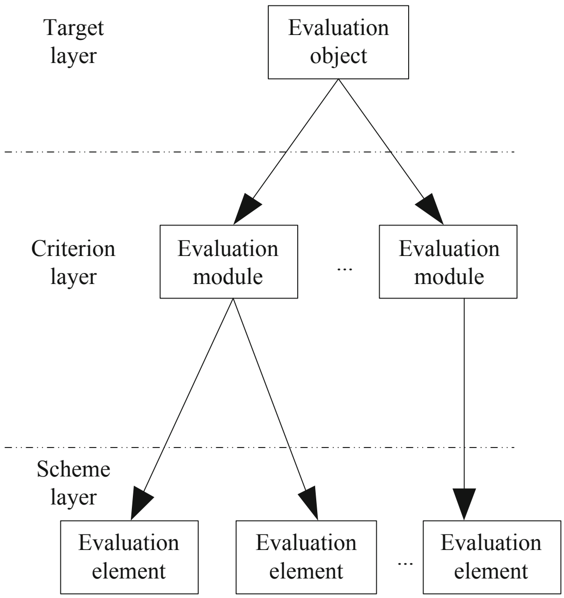

Fig. 1. Framework of evaluation model

Figure 2 shows the construction process of the comprehensive evaluation index system.

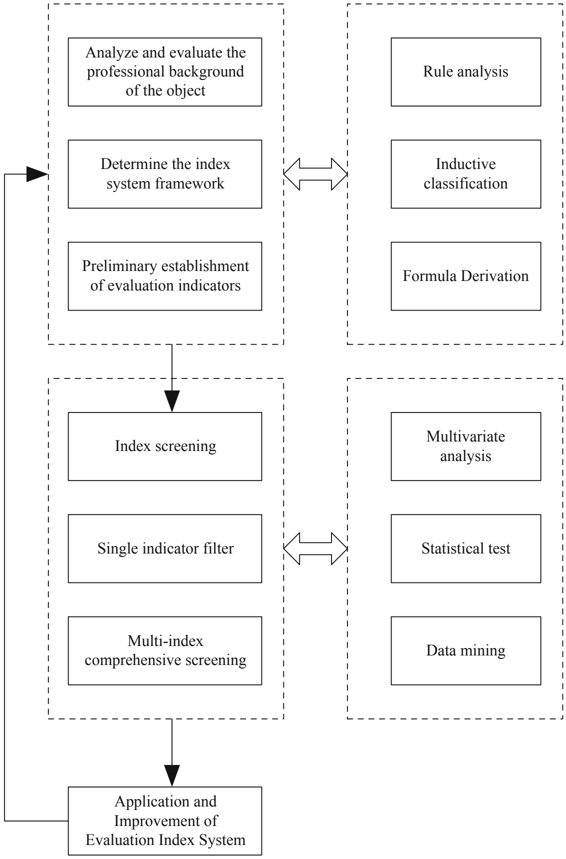

Fig. 2. Construction process of comprehensive evaluation index system

Analyzing the above figure, it can be seen that in qualitative analysis and calculation, the professional background of the evaluation object is analyzed through the methods of rule analysis, inductive classification and formula derivation to determine the index system, and the evaluation index is initially established.

The index system includes physical fitness and skills of athletes. These two parts include several elements, each of which can be decomposed into many specific indicators. In order to establish a perfect evaluation system of athletes' core competitive ability, it must include three parts: evaluation index, index weight and evaluation standard.

The methods and procedures for establishing indicators are as follows. For the selection of an effective indicator system, the following steps are generally followed:

(1) The determination of primary selection index must be supported by theoretical logic analysis;
(2) The primary selection indexes should be screened by the experience of relevant experts (the first round of screening);

(3) The second round of statistical screening (commonly used stepwise regression analysis or principal component analysis) was carried out on the measurement results of the final indicators (expert screening results indicators). According to this method, the establishment of the index system of this study has gone through three procedures: primary selection, expert evaluation and statistical optimization. The confirmation flow chart of indicator system is shown in Fig. 3.

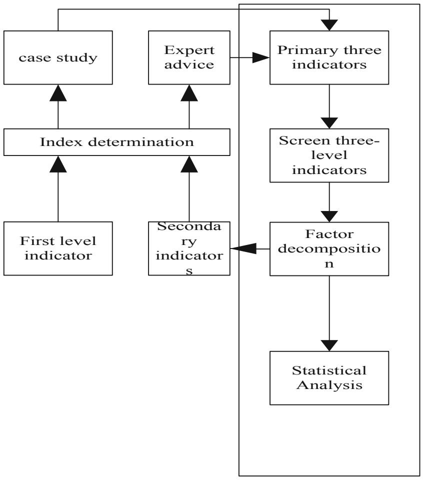

Fig. 3. Confirmation flow chart of indicator system

(1) Through the primary selection of indicators to determine the first level indicators. The first step is to decompose the first level evaluation index according to the objective and quantitative factors. The first level index should be determined according to the main requirements of Sanda competition for athletes' physical skills, and at the same time, it should also consider the principle requirements of establishing evaluation index system, as well as the situation of evaluation organization and implementation. According to the above discussion on the theoretical basis of the core competitive ability of athletes, this study designed four first-class indicators: body shape, body function, sports quality and technical quality.

(2) Decompose secondary indicators. In accordance with the principles of design indicators and the usual mode of establishing an indicator system, the indicators that can be set for each layer are listed item by item and level by level according to the first-level indicators determined above. The listed indicators are mainly based on their own evaluation requirements and management experience, and then refer to the collected evaluation indicator system. The above-identified first-level indicators are decomposed one by one, and a total of 16 second-level indicators have been established, as shown in Table 1.

Table 1. Evaluation index of core competitive ability of Sanda Athletes

Serial number	Primary indicators	Secondary indicators
1	Body shape	Length
		Dimension
		Fullness
		Body type
2	Body function	Circulation function
		Respiratory function
		Nerve function
3	Athleticism	Speed
		Power
		Endurance
		Flexible
		Sensitive
		Coordination
4	Technical quality	Technical quality
		Stability

In the comprehensive evaluation, in order to accurately and reasonably reflect the different importance of each evaluation index in the evaluation system, it is very important to work out the "weight" of each index as accurately as possible.

This study uses the index ranking method in the expert consultation method to determine the weight of the first-level indicators. The steps are:

According to their own opinions, the four first-class indexes of body shape, physical function, sports quality and technical quality, which reflect the core competitive ability of Sanda athletes, are asked to rank their importance according to their own opinions. The most important number is 1, the second is 2, and so on.

According to the above selected evaluation indicators, understand the relationship between each evaluation index, and establish a hierarchical structure model. According to the relationship between the indicators, the evaluation index is constructed as an evaluation index set composed of a target layer and multiple index layers. The judgment matrix is constructed by 1–9 scale method, as shown in Table 2.

Use the least square method to sort the indicators, the calculation formula is:

$$\varphi = \frac{q}{\prod_{i} q} / t \tag{11}$$

Table 2. 9-scale method content

Serial number	Scale	Meaning
1	1	The two indicators are equally important
2	3	One indicator is slightly more important than the other
3	5	One indicator is obviously more important than the other
4	7	One indicator is more important than the other
5	9	One indicator is more important than the other
6	2, 4, 6, 8	The median value of the above two adjacent judgments

In formula (11), φ represents the number of indicators at this level, $\prod_i q$ represents the number of indicators evaluated, q represents the relative importance of indicators, and t represents the comprehensive weight of the underlying indicators.

However, the score of each single index only reflects the level of an athlete's ability in a certain aspect. If we want to make a comprehensive evaluation of the core competitive ability of the athletes, we must calculate the comprehensive score according to the weight of each index on the basis of the single score evaluation, and then evaluate it. The formula of comprehensive score is as follows:

$$Y_d = \sum_{i=1}^{n} Y_i W_i \tag{12}$$

In formula (12), Y_i represents the standard score of each sub-indicator, and W_i represents the weight of each sub-indicator.

The comprehensive score only reflects the overall development level and situation of the core competitive ability of athletes. Although the individual scores can reflect the differences of all aspects of athletes' abilities to a certain extent, they can not reflect this imbalance quantitatively. In order to evaluate the core competitive ability of athletes objectively and concretely, and reflect the balance degree of all aspects of athletes' ability development quantitatively, it is necessary to introduce discrete score to evaluate. The calculation method of reflecting the balance index is as follows:

$$\mathrm{S} \cdot \mathrm{D} = \sqrt{\sum_{i=1}^{n} \left(Y_i - Y_j\right)^2 / n} \tag{13}$$

In formula (13), $\mathrm{S} \cdot \mathrm{D}$ is the discrete score; Y_j is the mean score, that is, the average of the standard scores of each indicator. The calculation formula is:

$$\mathrm{Y}_j = \left(\sum_{i=1}^{n} Y_i\right) / n \tag{14}$$

Through the single scoring table and the comprehensive score of the core competitive ability of athletes, we can directly determine the score of each index of athletes.

Therefore, an evaluation model is proposed based on the completion of evaluation index construction. The calculation process of the model is shown in Fig. 4.

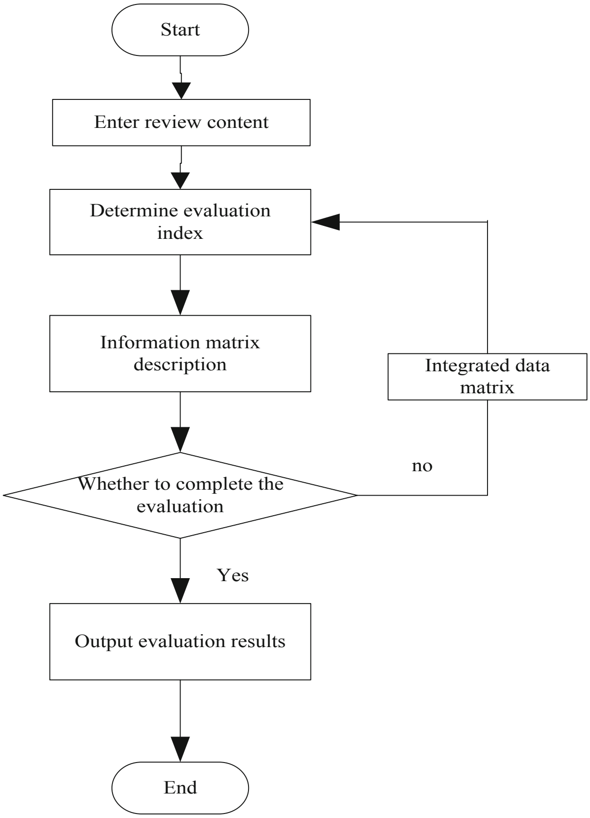

Fig. 4. Evaluation process

On this basis, normalization was carried out:

$$C = R_c/f \tag{15}$$

In formula (15), C represents a specific index, R_x represents the R value of the index, and f represents the weight coefficient.

In this way, through the above process, the performance evaluation of Wushu Sanda athletes based on visual signal processing is completed.

3 Experimental Comparison

In order to verify the effectiveness of the performance evaluation model of Wushu Sanda athletes based on visual signal processing designed in this study, the following experiments are designed. In order to ensure the rigor of the experiment, the traditional model is compared with the model in this paper, and the evaluation time and evaluation error of the two models are compared.

3.1 Comparison of Evaluation Time

The traditional model and the model in this paper are used to evaluate the performance of athletes. The evaluation time is shown in Fig. 5.

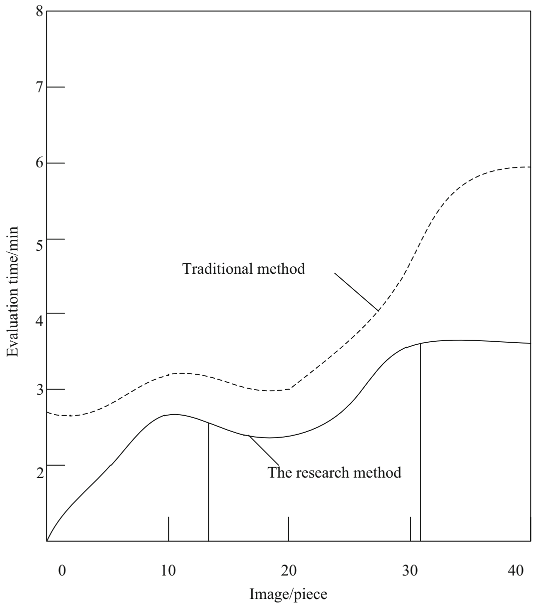

Fig. 5. Comparison of evaluation time

Analyzing Fig. 5, it can be seen that in the process of target evaluation, the performance evaluation model of Wushu Sanda athletes based on visual signal processing takes less time than the traditional model, which proves that the model can quickly evaluate the target.

3.2 Comparison of Evaluation Errors

Comparing the evaluation error of the traditional model and this model, the comparison result is shown in Fig. 6.

According to Fig. 6, the maximum evaluation error of the model in this paper is only 20%, while the maximum evaluation error of the traditional model is 98%. It can be seen from Fig. 6 that the evaluation error of the traditional model is relatively high, which is much higher than the performance evaluation model of Wushu Sanda athletes based on visual signal processing in this study.

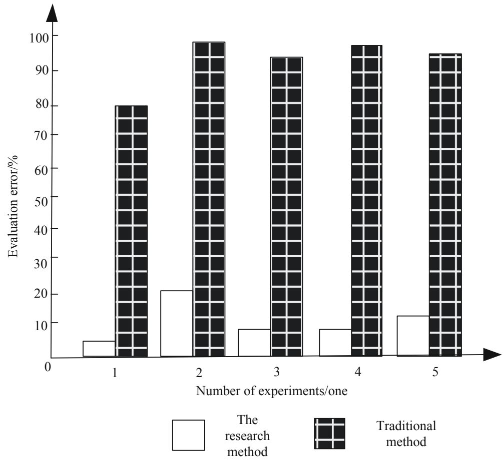

Fig. 6. Comparison of evaluation errors

3.3 Comparison of Rationality of Evaluation Results

The traditional model and this model are used to compare the performance evaluation results of the athletes with the human subjective evaluation results. The comparison results are shown in Table 3. The 5 athletes are divided equally, and the evaluation results are expressed by specific scores, specifically 0–100 points. The higher the score, the higher the evaluation of the athlete's performance.

Table 3. Comparison of rationality of evaluation results

Athlete number	Human subjective evaluation results	Paper model	Traditional model
1	87	87	75
2	75	74	70
3	69	69	73
4	90	89	80
5	73	73	67

Analyzing the data in Table 3, can see that there is no significant gap between the evaluation results obtained by this model and the human subjective evaluation results, and the equal splits of 1, 3, and 5 of the remote mobilization are completely consistent. The experiment shows that this model is highly consistent with the human subjective perception results. It shows that the evaluation results of this model are more reliable.

In summary, the evaluation model designed in this study has shorter evaluation time and lower evaluation error than the traditional model, which proves the effectiveness of the model.

4 Conclusion

This study designed a performance evaluation model for Wushu Sanda athletes based on the process of visual signal processing, and verified the effectiveness of the model through experiments. However, due to the limitation of the research time, the evaluation model of this study still has certain shortcomings. For this reason, in the follow-up study, the method of this study will be further optimized to continuously improve the accuracy of the performance evaluation of athletes.

References

1. Shi, H., Sun, G., Wang, Y., et al.: Adaptive image-based visual servoing with temporary loss of the visual signal. IEEE Trans. Industr. Inf. **15**(4), 1956–1965 (2019)
2. Peng, X.B., Abbeel, P., Levine, S., et al.: DeepMimic: example-guided deep reinforcement learning of physics-based character skills. ACM Trans. Graph. **37**(4), 1–14 (2018)
3. Dretsch, M.N., Fauth, J., Moya, M.M., et al.: Modest utility of brief oculomotor test for concussion screening in military mixed-martial arts training. Brain Inj. **33**(14), 1646–1651 (2019)
4. Sirisena, D., Leong, C.R., See, P., et al.: Popliteal artery entrapment syndrome in a Singaporean mixed martial arts fighter. Singapore Med. J. **59**(2), 114–115 (2018)
5. Bezodis, I.N., Cowburn, J., Brazil, A., et al.: A biomechanical comparison of initial sprint acceleration performance and technique in an elite athlete with cerebral palsy and able-bodied sprinters. Sports Biomech. **19**(2), 189–200 (2020)
6. Liu, S., Li, Z., Zhang, Y., et al.: Introduction of key problems in long-distance learning and training. Mob. Netw. Appl. **24**(1), 1–4 (2019)
7. Fu, W., Liu, S., Srivastava, G.: Optimization of big data scheduling in social networks. Entropy **21**(9), 902–918 (2019)
8. Liu, S., Liu, D., Srivastava, G., et al.: Overview and methods of correlation filter algorithms in object tracking. Compl. Intell. Syst. (3) (2020)
9. Boraita, A., Miriam, V., Sánchez-Testal, M.D., Diaz-Gonzalez, L., et al.: Apparent ventricular dysfunction in elite young athletes: another form of cardiac adaptation of the athlete's heart. J. Am. Soc. Echocardiogr. **32**(8), 987–996 (2019)
10. Hams, A.H., Evans, K., Adams, R., et al.: Throwing performance in water polo is related to in-water shoulder proprioception. J. Sports Sci. **37**(22), 1–8 (2019)