Identification and Analysis of Limb Swing Image in Short Run Training Based on Visual Signal Processing

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Abstract. In order to improve the ability of the accurate detection and recognition of the swing of the training limb of the sprinter, a method of image recognition based on the visual signal processing for the motion of the limb is proposed. The method comprises the following steps of: analyzing the motion characteristic quantity of the swing of a sprinting training limb, carrying out a sprinting training limb swinging image acquisition by adopting an infrared characteristic scanning technology, carrying out edge contour detection on the collected sprinting training limb swinging image. Carrying out contour segmentation and characteristic identification of the swinging of the limb of the sprinting training limb in combination with the image segmentation technology, constructing a gray histogram distribution structure model of a sprinting training limb swing image, and carrying out effective extraction of the motion characteristics of the limb swing and the motion characteristic of the sprinting training limb by adopting a regional block matching method, The method of multi-dimensional space reconstruction is adopted to simulate the motion of the limb, and the visual signal processing and the key feature point calibration method are adopted to calibrate and detect the characteristic points of the limb swing of the sprinting training, so as to realize the optimal recognition of the swing of the training limb of the sprinter. The simulation results show that the method of the invention has the advantages of high accuracy, good characteristic identification ability and the capability of improving the swing image recognition ability of the sprinter training limb.

Keywords: Visual signal processing · Sprinting · Training · Limb swing · Image recognition

1 Introduction

In that field of human body kinematics, it is necessary to carry out the optimization recognition of the limb swing of the sprinting training, combine the image recognition and the laser scan tracking technology, carry out the image analysis of the motion of the limb of the sprinting training, establish a laser scanning and image analysis model of the swing of the sprinting training limb [1], the method comprises the following steps of: carrying out the feature extraction and identification of the swing of the limbs of the sprinting training by adopting a laser imaging method, and improving the characteristic

Y.-D. Zhang et al. (Eds.): ICMTEL 2020, LNICST 326, pp. 247–256, 2020.
https://doi.org/10.1007/978-3-030-51100-5_22

identification ability of the sprinting training limb swing; The related sprinting training limb swinging image recognition method has an important significance in promoting the kinematics optimization of the human body, Through the characteristic recognition of the swing of the training limb of the sprinter, the human motion training is guided, and the related sprinting training limb swing image recognition method has been greatly concerned by the people [2].

The image recognition of limb swing in sprint training is based on the analysis of human kinematic image, adopts infrared feature scanning technology of human motion, carries on the image fractal processing, adopts the laser image recognition method of sprint training limb swing, realizes the image recognition of limb swing in sprint training [3]. In the traditional method, the image recognition method of limb swing in sprint training mainly includes Harris corner detection method. Moment analysis method and fuzzy information enhancement method, the dynamic fractal recognition model of limb swing information in sprint training is established, and the laser scanning and feature recognition of human motion are realized by combining scale decomposition method and multi-mode feature reconstruction method. A real-time extraction method of limb swing in sprint training based on monocular video is proposed in reference [4]. Monocular video acquisition method is used to sample and recognize the laser scanning image of limb swing in sprint training, but the calculation cost of limb swing image recognition in sprint training is large and the real-time performance is not good. In reference [5], a method of limb swing image recognition in sprint training based on video tracking is proposed. According to the law of trajectory distribution, the optimal feature extraction of human motion video is realized and the accuracy of recognition is improved. However, the ambiguity of this method is large in the recognition of limb swing image in sprint training. In order to solve the above problems, a method of limb swing image recognition for sprint training based on visual signal processing is proposed in this paper. Firstly, the laser sampling of limb swing information in sprint training is carried out, and then the gray histogram distribution structure model of limb swing image in sprint training is constructed. Combined with the feature point calibration method with large interval and nearest neighbor, the limb swing image recognition in sprint training is realized. Finally, the simulation test and analysis are carried out, and the validity conclusion is obtained [6].

2 Image Sampling and Edge Contour Detection of Limb Swing in Sprint Training

2.1 Image Acquisition of the Motion of the Limbs in the Sprint Training

In order to realize the recognition of limb swinging image in sprint training, firstly, infrared feature scanning technology is used to collect the wobble image of sprint training limb, and the edge outline of the collected sprint training limb wobble image is detected [7]. Assuming that the gray pixel set of sprint training limb swinging laser scanning image is (i,j), as the pixel center, the method of profile compensation is used to combine the sharpening template into blocks. At any level of the 3D surface model of laser imaging, the matching set of pixel imaging template for sprint training limb swinging laser scanning image is as follows:

$$W_u = \frac{1}{\sqrt{a}T}(\frac{T}{2} + \frac{a}{2} - b_m) \tag{1}$$

Where, T represents the ratio of flexion to extension acceleration, a represents the maximum acceleration of oscillation, and b_m represents the oscillation frequency. The level set function reconstruction method is used to reconstruct the laser scanning image of limb wobble in sprint training. The error matching function of swinging laser scanning image of sprint training limb is established by using single frame scanning technology. Combined with pixel reconstruction method, the action feature distribution pixel set of laser scanning tracking of sprint training limb wobble is obtained.

$$s(k) = \phi \cdot s(k - 1) + w(k) \tag{2}$$

Where

$$\phi = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 1 \\ 0 & 0 & 0 & 0 & 1 \end{pmatrix}, w(k) = \begin{pmatrix} N(0, \sigma_{\theta(k)}) \\ 0 \\ N(0, \sigma_{x(k)}) \\ 0 \\ N(0, \sigma_{y(k)}) \end{pmatrix} \tag{3}$$

s stands for high frequency persistence. The R, G, B components of sprint training limb swing laser scanning image W are extracted, and the 3D template matching values A_R, A_G, $A_{\mathbf{B}}$ and W_R, W_G, W_B, of the corresponding sprint training limb swing laser scanning image are extracted during the evolution of the outline curve. According to the above analysis, the laser scanning image acquisition model of sprint training limb swing is constructed, and the feature extraction of sprint training limb swing is carried out taking into account the regional information of the image [8].

2.2 Image Edge Contour Detection

The method comprises the following steps of: carrying out edge contour detection on the collected dash training limb swinging image, carrying out contour segmentation and characteristic identification of the motion of the limb swing by combining the image segmentation technology, calculating the visual characteristic distribution of the swinging laser scanning image of the sprinting training limb to the quantification set [9], the segmentation threshold of the swing laser scanning image of the sprinting training limb is as follows:

$$w(i, j) = \frac{1}{Z(i)}\exp(-\frac{d(i, j)}{h^2}) \tag{4}$$

Where, $Z(i)$ is the template matching value of the sub-region feature matching region, defines the Gibbs prior energy function of the sprint training limb swing laser scanning image, through the edge ambiguity identification method, carries on the edge and the region information combination processing, in the feature mark area, obtains the image gradient information dynamic fusion result, obtains the sprint training limb swing laser scanning image template characteristic distribution:

$$w(d_{ij}) = f(|x_i - x_j|) = \frac{1}{\sqrt{2\pi}} \exp\left\{ \frac{(x_i - x_j)^2}{2} \right\} \tag{5}$$

Using the edge gradient information of the image to carry on the sprint training limb swing laser scanning and the image vision tracking, obtains the image block area size is $M \times N$, according to the sprint training limb swing laser scanning image vision RGB value carries on the pixel characteristic separation, the output is:

$$\beta_i = \exp\left\{ -\frac{|x_i - x_j|^2}{2\sigma^2} \right\} \frac{1}{\text{dist}(x_i, x_j)} \tag{6}$$

The method comprises the following steps of: constructing an active contour model of a sprinting training limb swing, carrying out correlation characteristic matching on the extracted sprinting training limb swinging infrared scanning image, carrying out information fusion and feature extraction at the edge of the sprinting training limb swinging target, The edge contour detection model of the swing image of the training limb of the sprinter is constructed, and the motion attitude recognition is carried out according to the edge contour detection result [10–12].

3 Image Recognition and Optimization of Swing Training Limb Swing

3.1 Visual Signal Processing and Calibration of Key Feature Points

In that method, an infrared characteristic scanning technique is adopted to carry out the image acquisition of the swing training limb, and on the basis of the edge contour detection of the collected dash training limb swing image, the motion of the limb swing image recognition is carried out, In this paper, a method of image recognition based on visual signal processing is presented. a gray histogram distribution structure model of a sprinting training limb swing image is constructed [13], and a regional block matching method is adopted to perform effective extraction of the swing and motion characteristics of the limb swing and motion of the sprinting training limb, and the template matching function $f(g_i)$ of the sprinting training limb swing image is as follows:

$$f(g_i) = c_1 \tilde{\lambda}_i \sum_{j=0}^{N_{np}} \frac{\rho_j \vec{v}_{ij}}{|\vec{v}_{ij}|^{\sigma_1} + \varepsilon} \Big/ \sum_{j=0}^{N_{np}} \frac{\rho_j}{|\vec{v}_{ij}|^{\sigma_1} + \varepsilon} \tag{7}$$

The background difference component of limb swing image in sprint training is obtained [14]. The reconstruction model of three-dimensional feature distribution region is established by using difference information fusion method. Combined with Gaussian process and deformation model, the dynamic fusion of human motion is carried out. The gray pixel fusion model of infrared information of limb swing in sprint training is established, and the fusion results are satisfied.

$$\partial = arccos\left\{ max\left[\frac{\overrightarrow{W_iS_k} \times \overrightarrow{W_iW_j}}{\left\|\overrightarrow{W_iS_k}\right\| \times \left\|\overrightarrow{W_iW_j}\right\|} \right] \right\} \tag{8}$$

Where, $k = 1, \ldots, M$, $i,j \in \{1, , N\}, i < j$, calculates the quantitative set of regional feature distribution of the swinging infrared scanning image of the sprint training limb. $S_i(i = 1, 2, \ldots, M)$, uses the sub-regional feature matching method to fuse the pose information of the two-dimensional outline feature distribution point M $(x_i + \frac{1}{2}, y_{i+1})$, pixel PE1, and constructs the gray edge feature quantity of the swinging infrared scanning image of the sprint training limb.

$$\min_c\left(\min_{y\in\Omega(x)}\left(\frac{I^c(y)}{A^c}\right)\right) = \widetilde{t}(x)\min_c\left(\min_{y\in\Omega(x)}\left(\frac{J^c(y)}{A^c}\right)\right) + (1 - \widetilde{t}(x)) \tag{9}$$

Where, $\widetilde{t}(x)$ is the spatial region pixel of the infrared scanning image of sprint training limb swing, A^c is the gray information component of infrared scanning image, $I^c(y)$ is the transmission intensity of sprint training limb swing under infrared scanning, and the adaptive fusion output of the image is obtained by using the method of region block matching:

$$bnr_\beta(X) = R_\beta X - R_\beta X_1 \tag{10}$$

The image adaptive fusion model of unmarked human motion video is constructed. Multi-dimensional phase space reconstruction method is used to simulate the limb swing of sprint training, and dynamic block matching technology is combined to segment the texture of infrared scanning image of human motion. The super-resolution fusion model of the image is obtained as follows:

$$J(x, y, \sigma) = \begin{pmatrix} \frac{\partial P}{\partial x} \\ \frac{\partial P}{\partial y} \end{pmatrix} = \begin{pmatrix} 1 & 0 & L_x(x, y, \sigma) \\ 0 & 1 & L_y(x, y, \sigma) \end{pmatrix} \tag{11}$$

Different threshold t is used to segment the infrared scanning image $L_x(x, y, \sigma)$ of human motion, and the fractal estimation and information fusion of the image are realized.

3.2 Feature Extraction and Recognition of Limb Swing in Sprint Training

The 3D reconstruction image of the original human motion infrared scanning image is set as F, the outline of the object in the infrared scanning image of human motion is G, and the block matching is carried out in the affine invariant region. The volume motion attitude transformation analysis is carried out by Kalman filtering method [15]. The attitude transformation matrix is obtained as follows:

$$K_{ab} = \begin{bmatrix} sx & 0 & 0 \\ 0 & sy & 0 \\ 0 & 0 & 1 \end{bmatrix} \tag{12}$$

By adopting the characteristic matching method of the deformation model, the attitude analysis and the deformation characteristic analysis of the human body motion are carried out, and the self-adaptive blocking of the human motion infrared scanning image is carried out on the basis of the combined morphological segmentation method, so that the edge pixel value of the human body motion infrared scanning image is obtained:

$$E_{ext}(V(i)) = \gamma(i)E_{image}(V(i)) + \delta(i)E_{con}(V(i)) \tag{13}$$

Where, E_{image} represents the information component of human motion infrared scanning, combined with wavelet transform method, the fusion filtering of human motion infrared scanning image is carried out, the fractal dimension statistical analysis model of human motion infrared scanning image is established, and the visual signal processing and key feature point calibration methods are used to calibrate the feature points of limb swing in sprint training. The results of super-pixel region reconstruction of human motion infrared scanning image are obtained:

$$P(x_{w_3}, y_{w_3}|\Theta) = \prod_{x_i \in w_3} \prod_{k=1}^{K} \alpha_k g(x_{ij}, y_{ij} \mid \mu_k, \sigma_k^2) \tag{14}$$

The method comprises the following steps of: converting a feature matching method into a one-dimensional sequence $NF_c = \{n : c - k \leq n \leq c + k\}$ with a size of $1 * WN$, combining a two-dimensional spatial feature distribution fusion method, performing visual signal processing and a key feature point calibration of an image, and realizing saliency area feature extraction of the human moving infrared scanning image, The result of the optimized identification of the output of the sprinting training limb is as follows:

$$\begin{aligned} R(x,y) &= \frac{\det(M)}{\det(H)} \\ &= \frac{L_{xx}(x,y,\sigma)L_{yy}(x,y,\sigma) - L_{xy}(x,y,\sigma)L_{xy}(x,y,\sigma)}{1 + L_x^2(x,y,\sigma) + L_y^2(x,y,\sigma)} \\ &= \sigma^2 \frac{L_{xx}(x,y,\sigma)L_{yy}(x,y,\sigma) - L_{xy}(x,y,\sigma)L_{xy}(x,y,\sigma)}{1 + L_x^2(x,y,\sigma) + L_y^2(x,y,\sigma)} \end{aligned} \tag{15}$$

As above, a multi-dimensional space reconstruction method is used to simulate the motion of the limb, and the visual signal processing and the key feature point calibration method are used for the calibration and detection of the characteristic points of the limb swing of the sprinting training, and the optimal recognition of the swing of the training limb of the sprinter is realized.

4 Simulation Test Analysis

In order to verify the application performance of this method in the recognition of limb swing image in sprint training, the simulation experiment is carried out. In the experiment, the fractal dimension of infrared scanning image of human motion is

(a) frame=110

(b) frame=240

(c) frame=280

(d) frame=360

Fig. 1. Sampling results of the swing data of the training limb of the sprinter

estimated to be 5, the hidden variable data X = [2, 5, 6, 8], the sample training scale is 20, and the edge information adjustment parameter of 3DStudio MAX, infrared scanning image of human motion is 1.45. The feature segmentation coefficient is 0.65, and the sampling results of sprint training limb swing data under different sampling frames are shown in Fig. 1.

Taking the sampling result of Fig. 1 as an input, combining the image segmentation technique to carry out the contour segmentation and the characteristic identification of the swing of the limb of the sprinting training, and the characteristic point of the swing of the sprinting training limb is extracted, and the result is shown in Fig. 2.

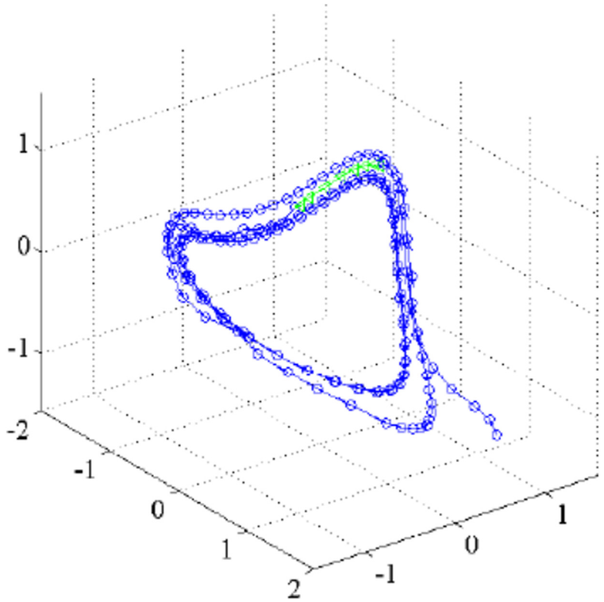
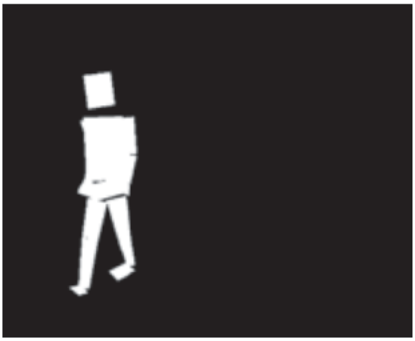


Fig. 2. Extraction results of the swing feature points of the training limb of the sprinter

According to the extraction results of feature points, the motion shape is 43 frames. According to the calibration results of large interval nearest neighbors, the body swing images of sprint training are recognized from different sides, and the recognition results are shown in Fig. 3.

The analysis of Fig. 3 shows that the method can effectively realize the image recognition of limb swing in sprint training, and the feature recognition ability is good. The recognition error is tested and the comparison results are shown in Table 1. The analysis Table 1 shows that the error of human motion feature recognition by this method is low.

(a) Back



(b) Left side

Fig. 3. Results of image recognition of the swing training limb

Table 1. Error comparison

Iterations	Proposed method	Reference [3]	Reference [4]
100	0.025	0.075	0.176
200	0.012	0.057	0.164
300	0.004	0.045	0.123
400	0.001	0.043	0.087

5 Conclusions

The invention relates to an infrared scanning and image analysis model for establishing sprinting training limb swing, and an image recognition method based on visual signal processing is proposed in this paper. Build a sprint training body active contour model, relevant feature matching body swinging infrared scanning image, extraction of sprint training building block body swinging infrared scanning image fusion model of sprint training, adopt the method of visual signal processing, calibration and the key feature points, the motion of the body for sprint training for the calibration and testing feature points, realized the optimization of sprint training body swinging identification. The results show that this method has the advantages of small error, good recognition effect, high accuracy, strong feature recognition ability, and can improve the image recognition ability of sprinter training body swing, and improve the accurate detection and recognition ability of sprinter training body swing.

References

1. Dan, F., Tobias, S.N., Karl, O., et al.: Skeletal muscle and performance adaptations to high-intensity training in elite male soccer players: speed endurance runs versus small-sided game training. Eur. J. Appl. Physiol. **118**(2), 111–121 (2017)
2. Kim, W., Kim, C.: Spatiotemporal saliency detection using textural contrast and its applications. IEEE Trans. Circ. Syst. Video Technol. **24**(4), 646–659 (2014)
3. Alice, M., Oliver, F., Henner, H., et al.: Sprint interval training (SIT) substantially reduces depressive symptoms in major depressive disorder (MDD): a randomized controlled trial. Psychiatry Res. **1**(12), 265–268 (2018)
4. Li, S., Jia, Y., Guo, Y., et al.: Moving target tracking algorithm based on improved Camshift for through-wall-radar imaging. J. Comput. Appl. **38**(2), 528–532 (2018)
5. Tan, Q.Y., Leung, H., Song, Y., et al.: Multipath ghost suppression for through-the-wall-radar. IEEE Trans. Aerosp. Electron. Syst. **50**(3), 2284–2292 (2014)
6. Gennarelli, G., Soldovieri, F.: Multipath ghosts in radar imaging: physical insight and mitigation strategies. IEEE J. Sel. Top. Appl. Earth Obs. Remote Sens. **8**(3), 1078–1086 (2014)
7. Xiu, C., Ba, F.: Target tracking based on the improved Camshift method. In: CCDC 2016: Proceedings of the 2016 Chinese Control and Decision Conference, pp. 3600–3604. IEEE, Piscataway (2016)
8. Fang, H., Zhou, Y., Lin, M.: Speckle suppression algorithm for ultrasound image based on Bayesian nonlocal means filtering. J. Comput. Appl. **38**(3), 848–853 (2018)
9. Ramos-Llorden, G., Vegas-Sanchez-ferrero, G., Martin-Fernandez, M., et al.: Anisotropic diffusion filter with memory based on speckle statistics for ultrasound images. IEEE Trans. Image Process. **24**(1), 345–358 (2015)
10. Zhou, Y.Y., Zang, H.B., Zhao, J.K., et al.: Image recovering algorithm for impulse noise based on nonlocal means filter. Appl. Res. Comput. **33**(11), 3489–3494 (2016)
11. Peng, X., Gong, G., Liao, X., et al.: Modeling and model identification of micro-position-control hydraulic system. J. Mech. Eng. **53**(22), 206–211 (2017)
12. MA, Z., Chen, W.: Friction torque calculation method of ball bearings based on rolling creepage theory. J. Mech. Eng. **53**(22), 219–224 (2017)
13. Tian, G.H., Yin, J.Q., Han, X., et al.: A new method of human behavior recognition based on joint information. Robot **36**(3), 285–292 (2014)
14. Emmet, C., Andrew, J.H., Mark, L.: The Impact of resistance training on swimming performance: a systematic review. Sports Med. **47**(11), 2285–2307 (2017)
15. Amor, B.B., Su, J., Srivastava, A.: Action recognition using rate-invariant analysis, of skeletal shape trajectories. IEEE Trans. Pattern Anal. Mach. Intell. **38**(1), 1–13 (2016)