Face recognition algorithm of sprinters based on sliding data camera measurement

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Abstract: In order to solve the problems of low accuracy of face key point recognition and large noise error in recognition, a sprinter face recognition algorithm based on sliding data camera measurement is designed. Firstly, the sliding data camera measurements is imported, and the camera calibration method is used to obtain the 3D points and plane projection in the athlete's running scene, which are collected into the same coordinate system through the conversion matrix to extract the taxiing data. Then, the unclear coordinate points are replaced by convolution kernel, and the image noise points are removed by bilateral filter. Finally, multiple key point coordinates are designed in the face image, and face recognition is realised by sparse approximation of the key points, and the most matched feature points in the face image combined with greedy algorithm. The results show that the proposed algorithm can recognise the six key points of human face, and the noise reduction error is less than 1.3%, which achieves the expected goal and has practical application value.

Keywords: taxi data camera measurement; sprinter; face recognition; 3D points; bilateral filtering.

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1 Introduction

In contemporary society, electronic information technology is developing continuously, and computer identification technology is also developing rapidly. As an important way of transmitting information in human daily life, facial expression reflects human psychological state (Dimov, 2020). Among them, in the field of sports, the application of face recognition technology to athletes can effectively analyse the psychological state of current athletes through face image recognition (Sampaio et al., 2019). In recent years, face image recognition technology has made great progress (Yang et al., 2021; Najafi and Mehrdad, 2020; Qian et al., 2020). It is not only applied to people's life and simplifies people's way of payment, but also applied to the field of sports (Zhu et al., 2020) to improve athletes' psychological quality. In the training of sprinters, because this type of sports is a competition requiring strong explosive ability and fast response speed, the face recognition of this type of athletes can effectively improve the effect of athlete training (Wan, 2020). Therefore, face recognition technology has been applied to this field, and relevant scholars have done a lot of research and achieved some results.

Gao et al. (2020) proposed a face image recognition method under variable illumination based on wavelet transform. Firstly, the face image is decomposed, the redundant data in the image is deleted, and the face image is transformed into a low-frequency image. Then the processed image is processed, and the face image recognition is realised by Gaussian algorithm and wavelet change method. Face image recognition is fast and has certain feasibility, but this method can not adapt to face recognition in fast movement, and has some limitations. Zhang et al. (2019) proposed a face recognition method based on deep learning and constrained sparse expression. This method is mainly designed for the problem that a single image cannot match the key point features. Firstly, the facial image features are extracted by convolution neural network, then the features are sorted, and the correlation is determined according to the different features. Finally, the obtained image is recognised. This method improves the accuracy of key point matching and can accurately identify face parts in the image, but does not consider the influence of noise in the image, resulting in poor quality of the output face image. Yu et al. (2020) proposed a face image recognition method based on discrete cosine transform basis function iteration. This method takes the image attractor as the characteristic of the face image, processes the image features with the help of discrete cosine transform technology, and then introduces the DCT basis function matrix into the image recognition. The obtained results are further Fourier transformed to complete the face image recognition. This method has high accuracy in face image recognition and can efficiently recognise face in practical application, but its operation process of this method is complex, and the noise of recognition image is high.

In order to solve the problems in the above methods, this paper designs a sprinter face recognition algorithm based on sliding data camera measurement. The main technical route of this method is:

Step 1 Sprinter face image is obtained by sliding data camera measurement. This step mainly introduces the sliding data camera measurement, and uses the camera calibration method to obtain the runner's running scene, collect it into the same coordinate system through the conversion matrix, collect the video through the camera sliding section to obtain the image frame, extract the sliding data, and complete the Sprint Athlete's face image acquisition.

Step 2 Face image preprocessing: replace the unclear coordinate points through the convolution kernel, and design the bilateral filter to remove the noise points of the sprinter's face image with the help of the bilateral filter method. This step combines convolution kernel and bilateral filtering method on the basis of sliding data camera measurement to complete image preprocessing, improve the quality of face image, and lay a foundation for face recognition.

Step 3 Design of face recognition algorithm for sprinters. The coordinates of multiple key points are designed in the sprinter's face image, and the key point coordinate reference points are transformed into European distance. The greedy algorithm is used to sparse approximate the key points and the most matching feature points in the face image, so as to realise the design of sprinter's face image recognition algorithm.

Step 4 Experimental analysis.

Step 5 Conclusion: highly summarise the methods and results of this study.

2 Face recognition algorithm of sprinters based on sliding data camera measurement

2.1 Acquisition of sprinter's face image by sliding data camera measurement

In the face recognition of sprinters, due to the fast speed of sprinters, their facial expressions continue to produce subtle and complex expressions with the speed of sprinters. Therefore, in order to achieve the effect of Sprinter's face recognition, this paper uses the sliding data camera measurement method to obtain the sprinter's face image, so as to provide accurate face image for subsequent recognition (Otani and Ogawa, 2021).

Camera calibration is a key step to obtain the face image of Sprinters in taxiing data camera measurement. Camera calibration is an important part of obtaining accurate information. The relationship between world coordinates and face image coordinates is obtained by camera calibration method, and then the face image of sprinters is extracted. Sliding data camera measurement refers to establishing a certain correlation between the pixel coordinates of the camera image and the position of the scene points (Irak et al., 2020). Through the sliding in the process of camera shooting, the coordinates of the feature points of the obtained sprinter's face image are obtained to obtain the sliding data camera measurement data, so as to realise the extraction of Sprinter's face image.

In the measurement of sprinters' sliding data camera, the image of the research object is collected through the camera model in the scene of sprinters' fast running. According to the needs of collection accuracy, the linear relationship between the projection of 3D points and planes in the scene where athletes run during collection is determined in this paper. This relationship can be represented by a matrix, that is:

$$A\begin{bmatrix} a \\ b \\ c \end{bmatrix} = \begin{bmatrix} f_{11}, f_{12}, f_{13}, f_{14} \\ f_{21}, f_{22}, f_{23}, f_{24} \\ f_{31}, f_{32}, f_{33}, f_{34} \end{bmatrix} \begin{bmatrix} X_i \\ Y_i \\ Z_i \\ c \end{bmatrix} \tag{1}$$

In the formula for, (a, b) represents the pixel coordinate point in the camera slide, (X_i, Y_i, Z_i) represents the world coordinate system, and c represents the change factor of the facial fibre when the athlete is running (Wang et al., 2020).

According to the linear relationship between the set projections, without considering the distortion of the sprinter's face image obtained in the shooting, convert the relationship between the shooting projections, and converge the points of all sprinter's face images into a coordinate system, where the set conversion matrix is:

$$A' = \begin{bmatrix} f_{11}, f_{12}, f_{13}, f_{14} \\ f_{21}, f_{22}, f_{23}, f_{24} \\ f_{31}, f_{32}, f_{33}, C \end{bmatrix} \tag{2}$$

In formula, A′ 'represents the transformation matrix of the sprinter facial image points.

Considering that in the process of collecting sprinters' movement, the face image points of sprinters in the world coordinate system are transformed to obtain:

$$\begin{bmatrix} X_i, Y_i, c, O, O, O - X_i a, -Y_i a, -a \\ O, O, O, X_i, Y_i, -X_i b, -b \end{bmatrix} = A' \tag{3}$$

After collecting the face coordinate points of sprinters and transforming them to a plane, it is also necessary to process the sliding data in the collection process. The emergence of sliding data affects the accurate collection of face image points, which can ensure the accurate collection of face image points of sprinters (Zaman, 2020).

The first frame of the athlete's face image is obtained from the video collected by the camera sliding section, and n sliding data are obtained from this frame, namely:

$$H = (h_1, h_2, \ldots, h_n) \quad (4)$$

In formula, h_1, h_2, …, h_n represents the gliding data composition.

Build a background template for obtaining sprinters for taxiing data, which is:

$$K = [k_1, k_2, \ldots, k_d] \quad (5)$$

In formula, *K* represents the unit matrix of the gliding data.

Integrate the sliding data with the set background template to further obtain the face image points of sprinters during running, namely:

$$G = [H, K], \qquad G \in r^{d(n+d)} \quad (6)$$

In formula, r represents the result value after fusion, from which a comprehensive acquisition of image points is achieved.

In the acquisition of sprinter's face image by taxing data camera measurement, the linear relationship between 3D points and plane projection in the athlete's running scene is obtained by camera calibration method, and it is collected into the same coordinate system through the conversion matrix. The image frame is obtained by collecting video from the camera taxiing section, and it is fused with the constructed sprinter's background template, extract the sliding data and complete the face image acquisition of sprinters.

2.2 *Face image preprocessing*

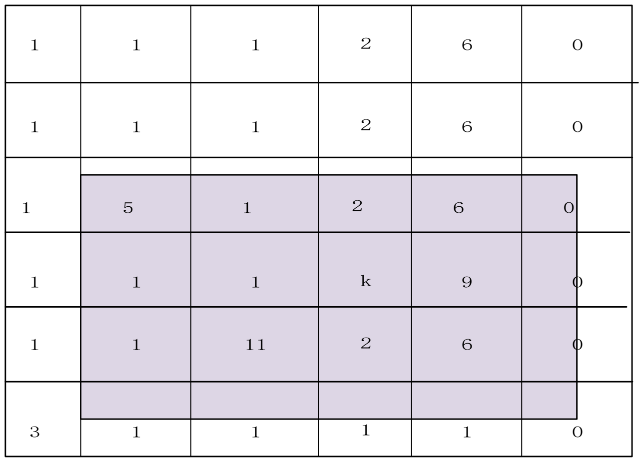
In the above collected sprinter face images, due to the influence of camera, background environment and other factors, it is easy to lead to a variety of influencing factors such as noise and illumination in the athlete face images, which affect the final recognition results (Liang, 2021). Therefore, it is necessary to preprocess the face image of sprinters to ensure that the abnormal difference of the image is small and the authenticity of image recognition is good. The ambiguity of the collected sprinter face images were preprocessed.In this preprocessing, the convolutional kernel is distributed in the sprinter face image, matching the coordinate point of each image, and replacing the unclear coordinate point through the convolutional kernel, when the size of the convolutional kernel is generally set to odd.In the study of this paper, the convolution core is set to 1, which conforms to the format of the camera device. Set the central coordinate of the convolutional kernel to (x, y), the pixel of the fuzzy face image is convolved, and the schematic diagram is shown in Figure 1.

The fuzzy coordinate points are replaced according to the set pixel values, and the result is:

$$R_x^y = \frac{1}{m} \sum\nolimits_i^n R_{x+i}^{y+i} \quad (7)$$

In formula, R_x^y represents the result of the sprinter, *R* is the convolutional nuclear sliding value and *m* is the filling boundary value.

Figure 1 Convolutional kernel processing of fuzzy face images (see online version for colours)



Based on this result, the noise points in the sprinter face image were further removed. This paper performs noise reduction processing by using bilateral filtering (Chambino et al., 2021).When the image boundary of the sprinter's face is clear, the spatial characteristics of its pixels are filtered geometrically, the two filters are weighted, and the new image noise filter is designed as:

$$\varphi(x, y, e, l) = \frac{1^{\sigma}}{\sqrt{2\pi\sigma^2}} \quad (8)$$

In formula, φ(x, y, e, l) represents the two-sided geometric filtered nuclear points and *σ* is the noise point values in the sprinter face image.

In the preprocessing of sprinter's face image, the unclear coordinate points are replaced by convolution kernel, and the bilateral filter is used to remove the noise points of sprinter's face image under the condition of ensuring the clear boundary of sprinter's face image.

2.3 *Design of the face recognition algorithm for sprinters*

After the face image preprocessing is completed, greedy algorithm is introduced to match and track the key points of the face to realise the face recognition of sprinters. In the face recognition of sprinters, it is very important to recognise the key points of their face image. Through the recognition of the key points in the face of sprinters, we can recognise their face. The key point in the face image of sprinters is the important information to realise recognition (Liu et al., 2020). Accurately locate the key points of the sprinter's face, and extract the features of the key points of the sprinter's face image. Firstly, the coordinates of multiple key points are designed in the face image of sprinters. The coordinates of these key points are essentially a multi-dimensional vector, namely:

$$V = \left[v_1, t_1, v_2, t_2, \ldots, v_n, t_n \right]^T \quad (9)$$

In Ev, (v, t) represents the coordinates of the key points of the sprinter face image, n represents the number of keys, and T represents the transposed symbol.

The position coordinates of key points in the sprinter face identified as above, because these points contain the boundary areas of their faces, these points may tilt rotation, so the key point coordinates on each face are European distance conversion to avoid the influence of these factors, this process is as follows:

$$O = \left[o_1, o_2, o_3, \ldots, o_n \right]^T, o_i = \sqrt{(o_i - l_i)^2 + c_u - l_i} \quad (10)$$

In the formula, o_1, o_2, o_3, …, o_n represents the boundary influence point in the key point, and l_i represents the Euclidean distance.

After removing the key points at the boundary of the key points in the sprinter's face image, the features of the key points need to be matched and tracked to realise the sprinter's face recognition. In this process, the greedy algorithm is used to sparse approximate the key points and the most matching feature points in the face image. After a certain iteration, the key point feature extraction and matching tracking are completed. Set the feature dictionary of the key point feature in the sprinter's face image as:

$$D = \left\{ W_k ; K = 1, 2, \ldots, N \right\} \quad (11)$$

Assuming that the norm of all key point features in the sprinter face image in the dictionary is 1 that is:

$$\left\| W_k \right\|^2 = 1 \quad (12)$$

Initialising the norm of its key point features, is :

$$W_0 = \left\langle W_{R0}, W_0 \right\rangle W_{R0} + W_1 \quad (13)$$

In formula, W_{R0} represents the minimum residual value in the key feature dictionary.

The initialised face key eigenvalue is equivalent to the projection value in the photography, maximising the minimum residual value as far as possible (Xu et al., 2020), and extracting the key features of the sprinter face image, that is:

$$P = \left\langle W_1, W_0 \right\rangle W_{R0} + W_2 \quad (14)$$

In formula, P represents the eigenvalue of the face image key.

The face-key point match tracking was performed based on the determined sprinter face eigenpoint values. The key to the algorithm is to reconstruct the lowest rank feature point in the key point.The lowest rank of the key point features of the reconstructed sprinter face image is:

$$\overline{\text{MINRANK}}(z)s \cdot tS = AS \quad (15)$$

In the formula, S representing sample key feature data, A represents the key values in the dictionary, $\overrightarrow{\text{MINRANK}}(z)$ represents the final lowest rank.

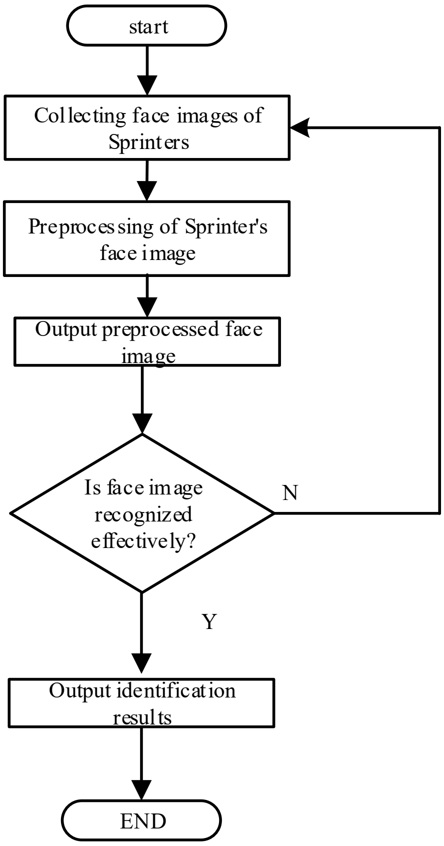
Based on the lowest rank of the key points in the face image obtained as described above, the effective recognition of the sprinter face image in this irrelevant space is obtained:

$$z_i = \|AS\| \sum \overline{\text{MINRANK}}(z) \quad (16)$$

In formula, z_i is the lowest value of key features represents the result, ||AS|| representing the lowest value of face image recognition.

The process of sprinter face image recognition is shown in Figure 2:

Figure 2 Process of face image recognition for sprinters



In the sprinter face image recognition, design multiple key coordinates in the sprinter face image, and the key point coordinate benchmark point for European distance conversion, using the greedy algorithm in the face image and the most matching feature points of sparse approach, and determine the face key features according to the low-rank algorithm, to realise the sprinter face image recognition algorithm design. Design method compared with traditional methods, this article introduces the main methods of sliding camera measurement data, and through the camera calibration method to get the 3D point and plane projection, slide to extract data, and combined with the neural network algorithm of convolution kernels, bilateral filter and greedy algorithm, the sprinter face image noise reduction processing, face recognition. This method combines several algorithms, so that the sprinter face recognition method has the advantages of high precision of sliding data camera measurement, and has the simple and efficient characteristics of greedy algorithm.

3 Experimental analysis

3.1 Design of experimental protocol

In order to verify that the proposed method can accurately complete the face image recognition of sprinters, experimental tests are carried out. Firstly, the research object is determined, the experimental parameters are explained, and the face image is preprocessed. Secondly, the experimental performance index is designed to verify the performance of the design method. Finally, the performance of the performance index is analysed. According to the above steps, complete the experimental analysis in turn to verify the effectiveness and feasibility of the design method.

Figure 3 Face images of sprinters used for the experiment (see online version for colours)

3.2 Experimental parameter design and pretreatment

The face images of real sprinters were obtained in this experiment. These collected face images of sprinters were integrated into an image dataset, and the collected images were converted into input format with pixel value set as [0.255]. Experimental dataset of a sprinter facial images including 100 of the 2,000 training samples and testing samples, the first 100 training samples for training, the training sample input recognition algorithm, the input fuzzy degree of face image preprocessing, in pretreatment, the convolution kernel distribution in sprinters face image, every image matching the coordinates of the point, At this time, the size of the convolution kernel is generally set to odd. In the experiment, the convolution kernel is set to 1. After the above operations are completed, the pixels of the face image are blurred by the convolution processing to complete data preprocessing. The characteristic parameters are set in the system software and hardware respectively. To ensure the effectiveness of the experiment, the threshold value of the energy ratio of the image was set as 0.95, and the threshold value of the membership degree of the simulation of a single facial expression feature was set as 0.80. A face image of a medium sprinter was randomly selected from 2,000 test samples as the specific research object, as shown in Figure 3.

According to the experimental scheme set above, comparative method, method of Gao et al. (2020) and method of Yu et al. (2020) were adopted.

3.3 Experimental performance indicators

In order to verify the performance of the design method, it is necessary to design the performance index, with performance indicators reflect the performance of the method, the experimental design for two experimental performance index, index respectively, the key points face recognition and face image noise error, and the face recognition is to identify the key players face number, the key point of the original image set up six key points, Verify whether the method detects all the key points, and identify all the key points in the expected target; The noise error of face image is the difference between the expected noise reduction value of the denoising processing image and the actual noise reduction value, the expected target noise error is below 2.0%, the calculation formula is as follows:

$$L = \frac{|l_1 - l_2|}{l_1} \tag{17}$$

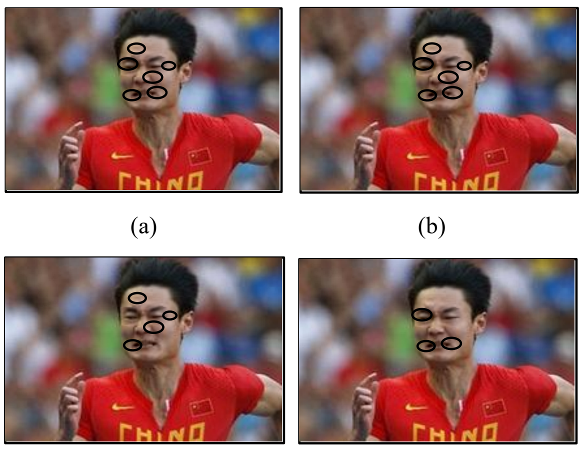
In formula, l_1 represents the expected noise reduction value, and l_2 represents the actual noise reduction value. The lower the value of the performance index, the better the performance of the recognition method.

3.4 Analysis of experimental results

3.4.1 Precision analysis of identifying key points of sprinter face images by different methods

In the experimental test, the key points of method of Gao et al. (2020) and method of Yu et al. (2020) are analysed, and the results are shown in Figure 4.

Figure 4 Face key point recognition results for different methods, (a) ideal key recognition location (b) this paper's method (c) Gao et al.'s (2020) method (d) Yu et al.'s (2020) method (see online version for colours)



(a) (b) (c) (d)

As we can see in Figure 4, the six key points in the face of the sample sprinters were mainly identified to verify the identification effect of the paper method, the method of Gao et al. (2020) and the method of Yu et al. (2020). As can be seen in Figure 3, the method identification matches the ideal key identification effect, which can effectively identify the six key points; method of Gao et al. (2020) can only identify four key points in sample face image identification, and only three key points in sample face image identification, the method is more comprehensive. This is due to the identification of this method that improves the effectiveness of this method by analysing the low-rank information on the facial expression of sprinters and determining the key point coordinates for many times.

3.4.2 The noise error analysis of sprinter face images by different methods

Based on the above key points experiments identifying the sample athletes, the noise reduction error of this method, method of Gao et al. (2020) and method of Yu et al. (2020) is further analysed, and the results are shown in Table 1.

Table 1 Analysis of noise error of sprinter face images (%) by different methods

Number of noise reduction/times	*The method of this paper*	*Method of Gao et al. (2020)*	*Method of Yu et al. (2020)*
10	1.2	2.3	2.2
20	1.1	2.5	2.6
30	1.1	2.5	2.7
40	1.2	2.8	2.5
50	1.2	2.6	2.6
60	1.1	2.5	2.5
70	1.2	2.9	2.5
80	1.3	2.8	2.6
90	1.2	2.7	2.5
100	1.2	2.8	2.9

By analysing the experimental data in Table 1, it can be seen that there are some differences in the noise reduction errors of sample images using the methods in this paper, method of Gao et al. (2020) and method of Yu et al. (2020). Among them, the noise processing error of this method is low, up to about 1.3%. Although the noise reduction error of the other two methods is within a reasonable range, however, its errors reach 2.8% and 2.9% respectively. Compared with the three methods, the noise reduction errors of the proposed method are reduced by 1.5% and 1.6%. Therefore, experimental results show that the noise reduction effect of the proposed method is superior to the other two methods, and the effectiveness of the proposed method is verified. This is because the method in this paper adopts sliding data camera measurement, combines convolution kernel and bilateral filtering to effectively reduce the noise of the sprinter's face image, and achieves the expected goal.

4 Conclusions

In order to improve the recognition effect of sprint face image, a new face recognition algorithm based on sliding data camera is proposed in this paper.

1. Slide data camera measurements were introduced, and the camera calibration method is used to obtain the linear relationship between 3D points and plane projection in the athlete's running scene, which is collected into the same coordinate system through the conversion matrix. The video is collected through the camera sliding section to obtain the image frame, which is fused with the constructed sprinter background template to extract the sliding data to complete the sprinter's face image acquisition. Through the convolution kernel to replace the unclear coordinate points, and with the help of bilateral filtering method, under the condition of ensuring the clear boundary of Sprinter's face image, the bilateral filter is designed to remove the noise points of Sprinter's face image. In the face image of sprinters, the coordinates of multiple key points are designed, and the coordinate reference points of key points are transformed into European distance. The greedy algorithm is used to sparse approximate the key points and the most matching feature points in the face image, so as to realise face image recognition. Compared with traditional methods, it has the following advantages:
2. After experimental analysis, the method in this paper recognised six key points in the set face image, which reached the expectation, while the comparison method did not recognise all six key points. Compared with the comparison method, the recognition effect of this method is better and has the feasibility.
3. Validate the method performance, analysis the sprinter face image of the face recognition method of noise error, the method of noise error is only 1.3%, the highest this value has reached the expected goals, compared with the contrast method, the noise error was reduced by 1.5% and 1.6%, as a result, the output of a sprinter face higher image quality.

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