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Research of Intelligent Stride Characteristics Analysis Inspection System

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Abstract. In order to narrow the range of suspects and clear direction of investigation quickly, a smart stride characteristics test system was designed and development. The system design concept and concrete implementation of the key technologies such as image mosaic, PCA-based stride characteristics extraction and membership test were all introduced in detail. Actual stride characteristics test experiments show the effectiveness of the system.

Introduction

A footprint series means multiple consecutive footprints which can directly reflects the relationship between the characteristics of the feet coordination. With the help of the footprint series, we can acquire suspect's personal information and tracks of the activities field, then compare to the sample in database, it can helps investigators to narrow the scope of the suspect, clear the investigate direction [1].

At present, in domestic and international field the footprint detection always use plaster casts, laser light irradiation and other means, rely on specialized equipment or professional experience, there are many disadvantages [2]. At the same time, because the handling conditions of the criminal investigation were limited, the footprint extracted from the crime scene was always a single plane footprint picture [3]. Therefore, we should make full use of image processing, data analysis and data mining and other advanced technology, research and develop process-oriented system of stride characteristics extraction, analysis, testing and comparison, then popularize the methods of stride characteristics inspection, and also further improving the efficiency of handling case by police officers [4].

In response to these problems, we designed and implemented an intelligent stride characteristics inspection system base on LabVIEW platform, the system first through improved matching algorithm for fast access to the crime scene photos spliced into the trip footprint, pretreatment and calibration of weights and measures, and then extract characteristic parameters of stride based on the use of PCA algorithm, and then analyzes the personal characteristics through the stride characteristics of the suspect, use the membership inspection Act and the make similarity comparison with the suspect's sample data, and finally confirm the suspect, provide the basis for the investigators' handling.

System design

2.1 Overall system framework

According to requirements analysis, this system can be subdivided into footprint extraction and image mosaic, image pretreatment, stride's characteristic feature extraction, personal characteristics analysis, and membership test comparison.

2.2 Introduction of system's sub-module

Each module's function describe below:

1) "Footprint extraction and photo mosaic module", mainly is a processing of taking pictures of the footprint and stitching the image into a footprint series.

2) “Image pretreatment module”, mainly is a pretreatment of the footprint series, preparing for subsequent analysis test link.

3) “Stride’s characteristic feature extraction module”, base on PCA algorithm, undertaking pre-processing module, completing the steps feature automatic extraction process.

4) “Personal characteristic analysis module”, according to projections footprint characteristics of height, weight, age, gender and other personal characteristics, be used as input to predict subsequent membership test module to narrow sample range, improve test efficiency.

5) “Membership test comparison module”, the scene stride characteristic data and screening samples for membership quantitative tests to determine the suspect roughly vest provides the basis for investigators handling the case.

Overall system flow as shown in Figure 1

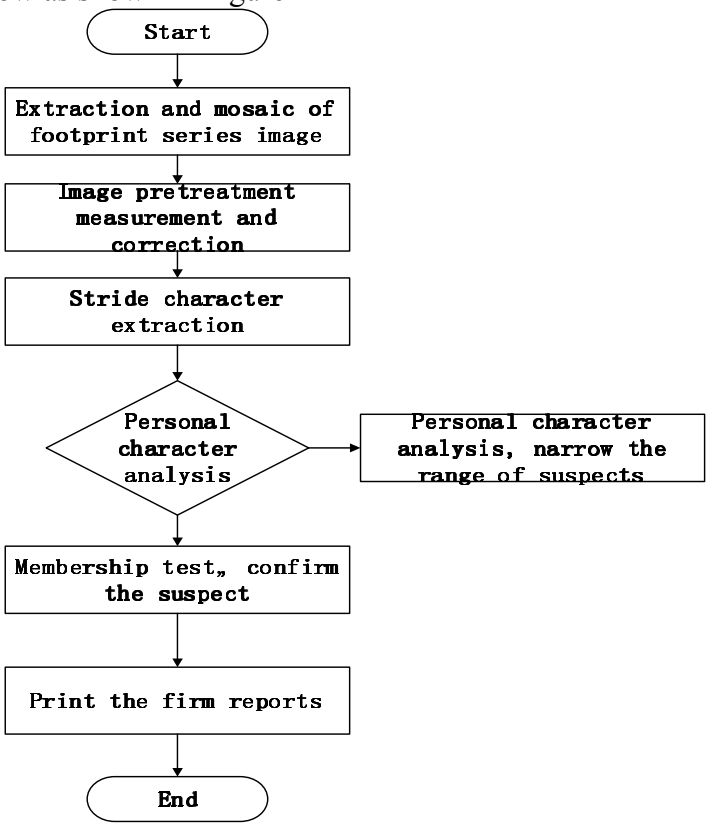

Fig.1 Overall flow chart systems

The key technology

Key technologies involved in the functional modules: fast matching algorithm based on improved a trip footprint stitching, based on pretreatment process image processing algorithm based on PCA stride characteristic parameter extraction of features based on personal characteristics stride analysis, based on the analysis and inspection of stride characteristics membership. Next, the classification of the key technologies introduced.

3.1 Footprint series mosaic based on fast matching algorithm

Footprints extraction and image mosaic module work steps are mainly:

1) First set the number of shots N and contrast, brightness and other shooting parameters;

2) The motor control system is moved to a first specified position until the motor has been completed and the focus stable image capture;

3) Continue to move to the next position to shoot, stop when shooting the N images;

4) Finally, doing the image mosaic, if the result satisfied, then put the footprint series photos into an image pretreatment module, otherwise, re-shooting and stitching.

According to the characteristics of the footprint series order taking pictures, very small rotation error between images, the implementation of registration can be neglected and only consider the translation. Fast matching algorithm of traditional translation thoughts is to select the first image

overlapping part of the column as a template, in the second image of the area to search for the best matching columns, thus realizing the two-image mosaic. Such a large amount of calculation matching results are susceptible to illumination and other external factors [5]. In order to overcome the influence, combined with the template to improve fast registration algorithm, then doing the image mosaic, the steps are as follows:

1) In the first picture taken with the order of the second image in the overlapping area of three consecutive columns of pixels, then select X intervals of three consecutive columns of pixels, with its corresponding ratio as a template a;

2) In the second picture in the first row of pixels is selected from the beginning, according to 1) the method steps of a calculated ratio of template;

3) To calculate the difference between the template a and b_1, get squared template c, find the column vector and subsequently obtained $sum1$ by adding the three and values;

4) Remove the template in the second picture to the 1 column, to calculate $sum2$ in step 3), and then continue to move until the completion of the search;

5) After the search is complete by a group of $sum1, sum2, sum3$ through comparing the minimum value is sum_{min}, its corresponding value is the pixel matching with the pixel point choosing the first picture of column values

6) This completes the stitching of two images, repeat the above steps to complete the loop stitching on all pictures. The actual mosaic effect shown in Figure 4.

Fig 2 Footprints left at the scene after a reverse effect stitching

3.2 Image pretreatment process

The image pretreatment module main work steps are:

1) First, a trip to the original footprint of the binary image processing and inverted to highlight the characteristics of component footprints

2) Then calculate the scale length and the pixel ratio, metrology calibration performed to ensure the follow-up measurements were converted to metric units, to ensure their accuracy

3) If satisfied with the results of pretreatment, then the image preprocessing and metrology parameters into stride's characteristic feature extraction module, or re-pretreatment.

3.3 Calculated weight based on the forefoot pressure surface

The main steps are as follow:

1) Weight were measured forefoot surface length (mm), weight forefoot Width W_{fp} (mm) and forefoot width W_f (mm), weight width accounted forefoot width 1/2 or less of lean body, 1/2-4/5 is medium body, 4/5 or more is overweight body.

2) By formula (3.1) to calculate the weight，

$$Weight\ （kg）= 2\times(W_{fp} + W_f + Body\_factor) \quad (1)$$

Body factor based on body can divide in: slim body (10mm), medium body (20mm), overweight body (30mm).

Front, back palm pressure surface and calculate weight based on front palm pressure surface process is shown in Figure 3.

Figure 3 Front, back Palm pressure surface

Experimental verification

In order to verify the practicality and effectiveness of the system, we set up a footprint series extraction inspection platform in the laboratory for actual test experiments, specifically shown in Figure 4.

Fig.4 Actual stride character extraction experiment

1) Taking pictures of the footprint on the scene and stitching the image into a footprint series by using Fast matching algorithm.

2) Perform calibration of weights and measures, find the actual length (unit: cm) and the pixel values rio, thus, accurate length measurements can be carried out directly on the picture;

3) By adjusting the two values, such as color inversion parameters after stitching color image preprocessing, to highlight its morphological characteristics;

4) Then acquired the stride's characteristic feature, obtain the mean, , the mean of the scene left stride characteristic parameters are as following: left step length X_{01}: 78.4cm, the right step X_{02}: 80.8cm, left step width X_{03}: 6.5cm, the right step width X_{04}: 2.1cm, left step angle X_{05}: 2.2 °, the right step angle X_{06}: 4.8 °

5) By checking the stride features and analyzing the personal characteristics, we could narrow the scope of the suspect, After projections, the personal characteristics of the footprints at the scene are as following: height about 171.7cm, weight about 66.75kg, age about 22 years old, medium body.

6) Joint sample data by comparing the similarity of the membership test method and screening, and ultimately determine the value of the highest degree of membership suspects belonging. The mean of the scene left stride characteristic parameters are as following: left step length X_{01}: 78.6cm, the right step X_{02}: 81.1cm, left step width X_{03}: 6.3cm, the right step width X_{04}: 6cm, step left angle X_{05}: 4.8 °, the right step angle X_{06}: 4.5 °. Calculated the membership degree U is 0.796, so it can judge whether the suspect has the significant crime suspicion.

Conclusion

This paper based on improved fast matching algorithm, PCA algorithm, stride character analysis inspection algorithm and membership test algorithm, design and implement a intelligent stride characteristics analysis inspection system.

Experimental results demonstrate the usefulness and accuracy of the system, but also temporarily unable to completely replace the footprint reconnaissance expert conclusions, mainly because the following problems need to be improved:

1) Need to establish a perfect footprint series sample database, unified inspection standards, and promote the building of a trip to stride characteristics quantitative test grading basis.

2) Increase more variety of comparison function similarity test algorithm, for users to search directly in the database, improve the testing efficiency and accuracy.

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