TELKOMNIKA, Vol.11, No.11, November 2013, pp. 6420~6426
e-ISSN: 2087-278X

Application of Data Fusion in Computer Facial Recognition

Wang Aiqiang*, Han Min
Department of Information Engineering, Henan Polytechnic, Zhengzhou Henan 450046, China
Corresponding author, e-mail: 578351601@qq.com

Abstract

The recognition rate of single recognition method is inefficiency in computer facial recognition. We proposed a new confluent facial recognition method using data fusion technology, a variety of recognition algorithm are combined to form the fusion-based face recognition system to improve the recognition rate in many ways. Data fusion considers three levels of data fusion, feature level fusion and decision level fusion. And the data layer uses a simple weighted average algorithm, which is easy to implement. Artificial neural network algorithm was selected in feature layer and fuzzy reasoning algorithm was used in decision layer. Finally, we compared with the BP neural network algorithm in the MATLAB experimental platform. The result shows that the recognition rate has been greatly improved after adopting data fusion technology in computer facial recognition.

Keywords: *data fusion technology, facial recognition, fuzzy reasoning, neural network*

1. Introduction

The accurate results of facial recognition play a important role in positioning facial feature and contrast of icon in video surveillance. So far, both domestic and foreign researchers have proposed a variety of algorithms for face recognition. Literature [1] proposes the algorithm for face detection in the movement of the actor, which makes it easy for video retrieval, but the recognition rate is not high for the algorithm, while the actor remains still. Literature [2] proposes to use BP neural network thinking. Although this method improves the accuracy and efficiency of recognition, the algorithm still has shortcomings that it cannot meet the real-time requirements of video retrieval. The article, based on data fusion technique, processes separately the collected original information in accordance with the type of sensor. Then, gradually increase the recognition effect according to the three-tier framework thinking.

The main purpose of this article is to solve the shortcomings that the facial recognition rate is low to use single identification method and to use data fusion technique to combine various identification methods to omnibearingly form fused facial recognition system to improve the overall performance of face recognition.

2. Data Fusion Technique Principle

The data fusion take full advantage of the data resources collected by many sensors in different time and space and uses the computer technology to make analysis, synthesis, domination and calculation under certain criteria of the data gained by many sensors in time order, as well as achieve the corresponding decisions and estimates for the objects observed [3]. The nature of the data fusion is the process of multi-source information fusion and abstract treating from low-level to high-level, which is divided into the three levels of the data level fusion, feature level fusion and decision level fusion [4].

The data fusion purpose is to try to keep the initial information. Therefore, in this level, fuse directly the original data detected by every sensor, without giving more subtle output. However, the initial data obtained by the sensor has the characteristics of instability and uncertainty, which results in the blindness defect of the data level in direct integration. The feature level in the above level is to extract the feature information and make comprehensive analysis and treatment of these data and finally, make classification, gathering and

Received May 6, 2013; Revised June 18, 2013; Accepted July 10, 2013

synthesization, in order to make it easy to treat and reduce real-time the communication traffic of the system, compress the data during the extraction. The output and the pretreated extract information in the second level is to be identified by the decision-making level, of which the task is to make full use of the input information and in accordance with the algorithm of this level, process information, mainly on the characteristic of face. In this way, the output results could keep accurate.

3. Data Fusion in Facial Recognition

The facial recognition designed in the article, makes use of the thinking of data three-level fusion and hierarchically process the original information collected. The data acquisition information is from various sensors, sensor 1, 2,…,n, maybe homogeneous or heterogeneous. Under normal circumstances, the data obtained by the homogeneous sensor, after being pretreated by the data level, will be directly taken to the feature level for fusion. However, the data by the heterogeneous sensor must go through the feature extraction process, in order to be taken to the he decision-making level to output.

Therefore, the article adopts two ways to process the pretreated output information from the data level. The data from the homogeneous sensor will be directly taken to the feature level, the other data will directly go through feature extraction and will not participate in the fusion in the feature level. In theory, this method will have better recognition effects than to use single factor to process the data obtained by sensor. The facial recognition process designed in the article is shown in the figure below:

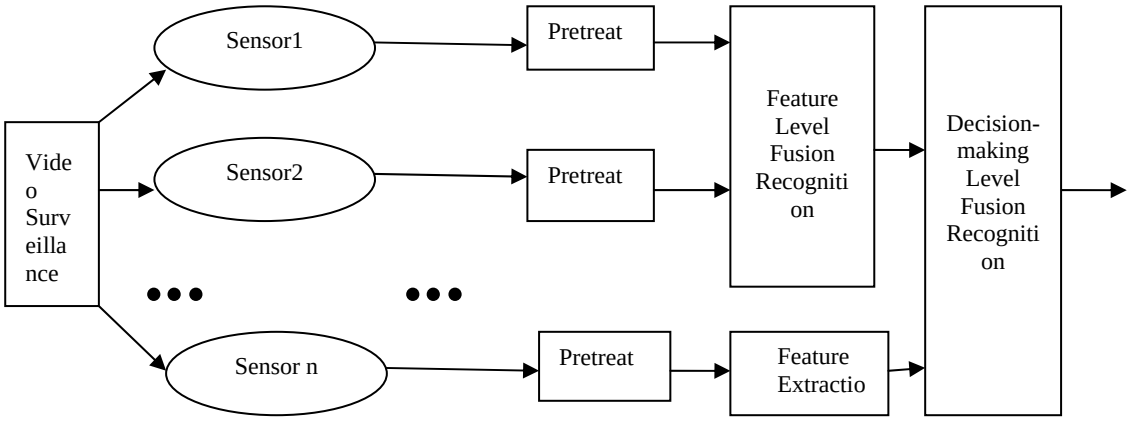

Figure 1. Facial Recognition Process

The appropriate algorithm not only can reduce the computational complexity, but also improve the accuracy. Therefore, we must select several algorithms out of many that could give full play to the effect of data fusion in the article. After the research and comparison of various fusion algorithm principles and the advantages and disadvantages, it was found that the weighted average algorithm is simple and easy to conduct and meet the requirements of data layer pretreatment. The BP neural network is the algorithm based on training, which can give play to its strong points in the feature level. The decision-making level of the last level, adopts the fuzzy reasoning to achieve the final output result of human face.

3.1. Data Level Fusion

In the computer facial recognition, we must first get the data. If the original data is obtained by the camera, based on the consideration about their characteristic of unstability, it needs to preprocess and extract the feature values. The main goal of preprocess is to reduce or eliminate image noise. In order to make it easy to extract the human face from the background, it needs the edge detection. When the computer is processing the image, the grayscale image is considered to reduce the calculation complexity and resource consumption. Therefore, it still needs the grayscale processing.

The feature point should be first determined for the feature extraction. The differences could be finally found on the face of the different actors. Select the lips, nose, eyes, eyebrow human facial feature points, order O as pixel,, δ_o the point within the neighborhood $q(q \in \delta_o)$, σ_q in the following formula is presented as the grayscale of q, the number of pixels of neighbourhood δ_o is presented as n_o。The feature weight calculation designed in this paper is divided into three steps. The weight value brings us great convenience to extract feature. The weight calculation is as follows:

Step 1: Request mean square error of grayscale

$$\phi_{oq} = \sqrt{\frac{\sum_{q \in \delta_o} (\sigma'_q - \sigma_q)^2}{n_o - 1}} \quad (1)$$

Step 2: Project into nuclear space

$$\pi_{oq} = \exp\left(-\left(\phi_{oq} - \frac{\sum_{r \in \delta_o} \phi_{oq}}{n_o}\right)\right) \quad (2)$$

Step 3: Weight calculation formula

$$\varphi_{oq} = \frac{\pi_{oq}}{\sum_{q \in \delta o} \pi_{oq}} \quad (3)$$

After the grey Processing of face image in the above steps, the influence of noise point on the center point of the gray-value could be eliminated. In addition, use anti-sharpen membrane to enhance edges, fold image and high-pass filter with the impact response P, the marginal information can be obtained. The final image processing results are as follows

$$Q = (L - P) * Q + P * Q \quad (4)$$

Order L as identity operator. Add a factor $\lambda(\lambda \succ 1)$, which is used to enhance the high-frequency part:

$$Q_{sh} = (L - P) * Q + \lambda P * Q \quad (5)$$

Define anti-sharpen mask filter:

$$I = L + (\lambda - 1) P \quad (6)$$

After filtering of anti-sharpen mask, the ultimate ideal image can be obtained. Then undertake fusion processing of the image of different sensor through every level. Presently, the algorithms applicable to the level such as weighted average method and wavelet transform method could all be used for the fusion calculation. For the simple and convenient calculation is considered, adopt the weighted average fusion algorithm. For the sensors that the original images are from are different, the differences could be caused in the matching. This article abandons these considerations and integrates the redundant information of the original image to obtain the better signal-to-noise ratio.

Oder $\psi(x,y)$ to be presented as result function after fusion, order $A_1(x,y)$、$A_2(x,y)$、$A_3(x,y)$ to be presented as the image from the sensor, of which (x,y) is the coordinate position of certain point in the image. The image fusion function to be used is as follows:

$$\psi(x,y)=aA_1(x,y)+bA_2(x,y)+cA_3(x,y) \qquad 0\le a、b、c\le 1 \tag{7}$$

Of which $a、b、c$ is weighting coefficient, The size of the weighting coefficient can be determined according to the quality of the image, but it should meet $a+b+c=1$。, When $a=b=c=1/3$, it is presented as the average fusion.

In the system design, three images of the face of the same actor are to be collected, after the location, character segmentation and normalization, three samples of the same face could be obtained. It is different from the past that only considers single-frame algorithm, because this frame taken may have quality problem. The article undertakes averaged fusion of pixels of the three samples, the obtained results saved and special level input are from here.

3.2. Feature Level Fusion

The second level of data fusion, the feature level, the work is rather difficult. It forms the fusion vector and conducts the nonlinear operation on the data from different sensors and well solves the defects of the linear operation. There are also many fusion algorithms in feature level. The algorithms often used are the parameter template algorithm, BP neural network, RBF neural network algorithm and so on. The neural network can be used in non-linear mapping system that demands self-learning and self-organization. Its ability to learn is strong and it conducts linear processing on the information output by different sensors, which meets the nonlinear need. The commonly used neural network algorithms are the data fusion and classification of BP neural network and RBF neural network. The article chooses BP neural network that is based on the training, because the BP training is convenient.

The input level of BP neural network receives the output after pretreatment by data level or sensor, then sends the information to the intermediate level and finally transmits the information to every neuron of the output level. Use sigmoid function as the excitation function, its expression is as follows:

$$\zeta(t)=\frac{1}{1+\exp(-\chi t)} \tag{8}$$

In addition, this function can also be used as the excitation function of the output node. The slope of the function is presented as parameter χ, The slope of the function will change will the value of χ。When χ decreases, the slope of the function will also decrease, when $\chi\to\infty$, the Sigmoid function becomes the jump function.

The input vector of each neuron is set to be $u\in R^{n_1}, u=(u_1,u_2,\ldots u_{n_1})^T$, and is with n_2 outputs $v\in R^{n_2}, v=(v_1,v_2,\ldots v_{n_2})^T$.

$$\eta_j=\sum_{i=1}^{n_1}\rho_i u_i-\xi_j \tag{9}$$

$$\kappa_j=\zeta(\eta_j)=\frac{1}{1+\exp(-\varepsilon\eta_j)} \tag{10}$$

Do derivation:

$$\kappa_j' = \zeta'(\eta_j) = \frac{1}{1+\exp(-\varepsilon\eta_j)} \frac{\varepsilon \exp(-\varepsilon\eta_j)}{1+\exp(-\varepsilon\eta_j)} = \lambda\left[1-\zeta(\eta_j)\right]\zeta(\eta_j) \quad (11)$$

Set the number of neurons in the hidden level of the first level to be n, the output is $x' \in R^n, x = (x_1', x_2', ...x_n')^T$, The second level has m neurons, the output is $x'' \in R^m, x = (x_1'', x_2'', ...x_m'')^T$. Set ρ_{ij} as the weight from the input level to the hidden level of the first level, the threshold value is ξ_j , order ρ_{jk}'' as the weight from the input level to the hidden level of the second level ξ_j' is set to be the threshold value; the weight from the hidden level of the second level to the output level is w_{ij}' , the threshold value is ξ_j'' . So the neurons outputs of the two levels are respectively:

$$\begin{cases} x_j' = \zeta(\sum_{i=0}^{n} \rho_{ij} x_i - \xi_j), j = 0,1,2,...,n \\ x_k'' = \zeta(\sum_{j=0}^{m} \rho_{jk}' x_j' - \xi_k'), k = 0,1,2,...,m \\ y_1 = \zeta(\sum_{k=0}^{m} \rho_{kl}'' x'' - \xi_l''), l = 0,1,2,...n_2 - 1 \end{cases} \quad (12)$$

After setting the network parameters according to the needs of the recognition system, conduct training for the neural network, and constantly adjust parameters during the training to achieve good convergence effect, finally, conduct identification on face image.

3.3. Decision-making Level Fusion

The higher level of system fusion is the fusion of decision-making level. The final decision-making basis is the output result of the decision-making level fusion. Therefore, regardless of the output from the feature level or the directly requested output of the characteristics of the data of the sensor as well as the auxiliary information data, the decision-making level must take full advantage of them and starts from the specific issues, and finally output the accurate results. The decision-making and judgement basis is the interrelation of each factor. First, it needs the transmission bandwidth with lower sensor information, second, the strong anti-interference ability, then it is effective to reflect on different information. But the factor has fuzziness, so in the article, we use the fuzzy reasoning technique. The unstructured data processing is taken as the output of the neural network. The fuzzy reasoning technique is suitable for the computation of the results structured knowledge.

During the fuzzy reasoning, the schematic diagram we use is as follows:

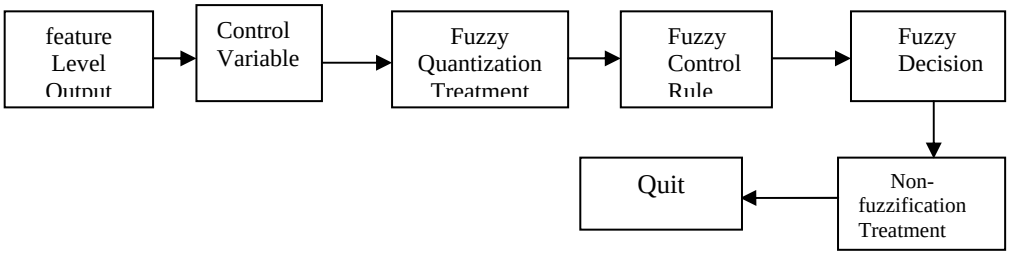

Figure 2. Fuzzy Reasoning System Schematic Diagram

The fuzzy reasoning methods include: Take maximum and minimum compositional operation as the Mamdani inference method of compositional rule. When request, do reasoning

or fusion of incentive intensity, use product operation Larsen reasoning method. Zadeh reasoning method defined by using different fuzzy relations. The article adopts Mamdani reasoning method, of which the emphasis is on the selection of subordinating degree function.

The article chooses fuzzy statistical method in the determination of membership function, as the method is based on the number of tests and has certain practical basis. First determine a domain of discourse U, variable clear set A, total number of tests n, confirming factor a, so the request formula of membership frequency is as follows:

$$f = a \in A / n \tag{13}$$

When n is gradually increasing, f will become stabilized. The stable value is the membership value of a to A.

In addition, during obfuscation, the theory to determine the membership function is: arrange m fuzzy subsets in lunyu $B_1, B_2, \ldots B_m$, moreover, for every B_i it has subordinating degree function $\mu B_i(x)$, for any $x_0 \in U$, if:

$$\mu B_i(x_0) = \max\left[\mu B_1(x_0), \mu B_2(x_0), \ldots \mu B_m(x_0)\right] \tag{14}$$

It can judge that x_0 belongs to A_i。

It needs to analyze information on the detection region, the environment and the target object and make reasonable and correct decision-making output, thus get the accurate identification of human faces. First, determine the decision-making factor. Use the feature value from the feature level output or extracted from sensor as a basis for facial recognition. Finally, the decision fusion structure to design facial recognition is as follows:

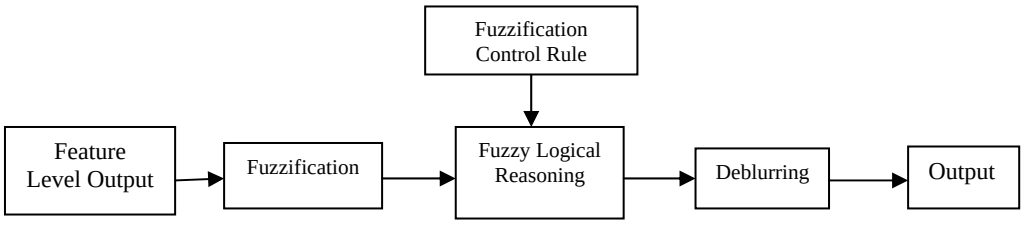

Figure 3. Facial Recognition Decision-making Level Model

After the neural network is based on training, extract the different features of human face. As the parameters set may change during training in each network, it lead to the different output and the recognition rate of the same face by different neural network, so it need to consider this to determine the membership function. After every neural network has identified the same image, it forms a matrix M. After figure out the recognition rate of each neural network, normalize it into matrix N. Membership function is determined as the product of two matrices:

$$Q = N * M \tag{15}$$

Finally, figure out the maximum value corresponding to the human face as the final results of the fuzzy decision:

$$\mu A_i(x) = \max Q = \max\left\{N * M\right\} \tag{16}$$

4. Simulation Results and Analysis

The article uses MATLAB software. MATLAB can be easily used in experiment and its starting point of learning is not that high as other software. The article conducts simulation totally three times. The previous two times are directed at BP neural network. The last time is for simulation data fusion algorithm flow. Collect 144 sets of images from the video surveillance. Taking into account that the neural network is the network based on training, we select 90 sets of them as the samples to be used in training network. The training is conducted for better test, then the remaining images are used for test. Through facial recognition and simulation in the article, the following results statistics could be obtained.

Table 1. Facial Recognition Statisticss

Classification Model	Sample（90）			Test（54）		
	Correct Identification	Wrong Identification	Correct Identification rate/%	Correct Identification	Wrong Identification	Correct Identification rate /%
BP network1	88	2	97.8	45	9	83.3
BP network2	90	0	100	48	6	88.9
Fusion System	90	0	100	52	2	96.3

From the table, it can be figured out that after the data fusion, the facial recognition rate has greatly improved.

5. Summary and Outlook

For data fusion, it takes advantage of a variety of recognition algorithms, level by level to improve the ability of recognition. It is an emerging research direction. In the article, after reading a lot of literature, I am deeply inspired to apply the idea of data fusion to the computer facial recognition system. It needs to consider their-own characteristics and purposes. Finally, determine the appropriate fusion algorithm that use the weighted average algorithm in the data level, select BP neural network in feature level and use fuzzy reasoning algorithm in the decision-making level. Finally, the experiments show that the method proposed in the article is effective. To test on the MATLAB simulation platform, analyze the experimental results and through comparison, finally find that accuracy of facial recognition gained by applying data fusion technique can be over 90%.Compared with only BP neural network process, in the article, we can get better recognition results.

Forecast the application of data fusion technique in face recognition. The future work includes two aspects: first, develop and improve data fusion theory and the theory is practical guidance, the data fusion requires more authoritative theoretical support, in order to go further in science. Second, the excellent system often has strong learning and adaptive capabilities, the three level processing algorithms of the current data fusion have certain adaptivity. But the applicable range is not wide enough and the algorithm of the decision-making level often has to rely on people's experience to set.

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