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A Novel Survey Based on Multiethnic Facial Semantic Web

Li Zedong*[1,2], Duan Xiaodong[2], Zhang Qingling[1]
[1]Institute of Systems Science, Northeast University, Shenyang, China, 110819.
[2] Institute of Nationality Cultural Information and Technology, Dalian Nationalities University, Dalian, China, 116600.
*Corresponding author, e-mail: lizedong2008@163.com

Abstract

The face includes a number of facial features which are various in minorities. Firstly, according to the correlations of the face parts shape semantics, multiethnic facial semantic web is proposed. It represents the relationship which belongs to the same minority and the difference of that belongs to the different minorities. Secondly, multiethnic facial semantic web is reduced by the correlations between the parts of the face. The semantic web which is reduced can maintains most available information which is belong to original semantic web, reduces the complexity and indirectly analysis the national facial features. Lastly, the effectiveness of our experiment is demonstrated by some real-word data sets.

Keywords*: facial features, correlation, shape semantics, semantic web*

1. Introduction

The multiethnic face contains rich feature information. The multiethnic facial features are various for culture, genetic, life and so on [1-2]. Generally, the research which could estimate different race has been carried out on different racial skin colors and facial features. For example, the facial features which is belong to Mongoloid, Caucasian and black people had been extracted and recognized by Satoshi Hosoi, Erina Takikawa [3]etc.; RBF neural network is used to identify gender and ethnic in FERET facial database by Gutta Srinivas and Wechsler Harry [4]; The method which is PCA plus SVM was used to extract facial features and research on Asians and non-Asians's facial features by Yongsheng Ou [5] who work in Hong Kong University of Science and Technology; According to the racial characteristics of different regions, the Gabor plus Adaboost was used to classify Asians and non-Asians by Qiu X etc. [6] who works in Chinese Academy of Sciences; With the facial features which were extracted with the way of color and wavelet, the race of yellow, white and black people is identified through SVM by LU Hu-Chuan [7] who works in Dalian University of Technology; The geometry and algebraic features of multiethnic face were analyzed with the correlation of facial features of Chinese minorities by DUAN Xiao-Dong and WANG Cun-Rui [8-11] who work in Dalian Nationality University. Deeply with the research of facial features, the face which is retrieved and estimated in face database was accomplished based on facial parts by some scholars. For example, The facial semantic retrieval system was built to retrieve face in face database through the continuous attribute of facial features by Karthik Sridharan etc. [12]; According to the discrete facial semantic features, the individual which is belong to the facial database could be recognized well by Hamido Hourani [13]. A variety of methods were used to analysis face image by many scholars who is at home or abroad, and a number of achievements were gained. However, the work which is based on the correlation of Chinese multiethnic facial parts is further necessary to develop.

In this paper, firstly, the concept of the facial semantic web [12-13][15-16] is imported. Then, the multiethnic facial semantic web is proposed based on the facial semantic web. Secondly, according to the multiethnic pedigree characteristics, the model of minorities facial features is preliminarily established. The model can analysis the facial parts shape semantics which possesses minorities characteristics, meanwhile the similarity and difference is described in facial semantic web by the minorities facial features.

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2. The Presentation of Minorities Facial Shape Semantic

Multiethnic face is a directly way to estimate the minority species by the facial features. As shown in Figure 1.

Figure 1. Parts of Multiethnic Feature Faces Figure

According to the knowledge systems of human body tectonics [18], ethnonymics [19], multiethnic features expression [20] and so on, the minorities standard face is a unique combination of facial features, meanwhile it is the most significant signs of appearance which is obviously different between minorities. There are some parts of minorities standard facial semantic features which are shown in Figure 2-Figure 4.

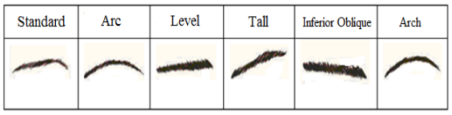

Figure 2. Semantic Description of Brows

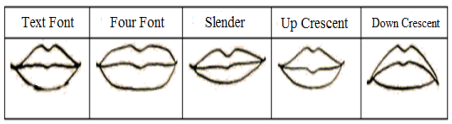

Figure 3. Semantic Description of Mouths

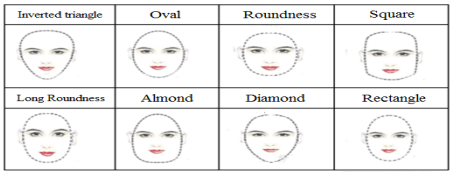

Figure 4. Semantic Description of Face Shape

Some reprots by anthropology scholars in China show that, “Square face” and “convex cheek” which simultaneously appeared has a higher frequent in the Tibetan; “deep nest eye” and” peak nose” are similar in Uighur, and ; the frequency between "slender eyes" and "rectangle face" also is similar in Zhuang [8-9][17] and so on. It shows that, in the same national groups, different facial features semantics has different occurrence frequency and different correlations in facial semantics. Therefore, the problems about the correlations of facial semantics in same minority and the diversities in different minority is need to be further quantitative analysis and research.

3. The Analysis of Facial Semantic Web

The facial semantic web which is proposed is a tool for describing facial parts shape semantic features and correlations, in this paper. It analysis the differences of minorities with facial semantic features.

3.1. The Description of Facial Parts Semantic Correlation

Due to a various of frequencies, the correlations of facial semantics is diverse in their ethnic groups. Thus, The facial semantic web is processed in accordance with node way, but

the correlations of nodes also are introduced. In this web, nodes represent a number of facial parts semantics and the sides represent an associated probability.

With a general minority as an example. The total number of face image sample is recorded as N. According to the minorities standard face, the number of minorities standard facial semantic features is supposed as γ. The i-th part semantic feature is supposed as γ_i and its probability which is presented in face database is defined as $p(\gamma_i)$. The correlation probability between the i-th and the j-th facial part semantic features is defined as $p(\gamma_i\gamma_j)$. then the correlation probability of any two facial semantic feature is shown as formula (1).

$$p(\gamma_i\gamma_j) = \frac{\#(\gamma_i)\bigcap\#(\gamma_j)}{N} \tag{1}$$

In formula (1), $\#(\gamma_i)$ represents the number of appearance of the i-th facial semantic in face images; when $i = j$, formula(1) represents the probability which is the frequency of the i-th facial semantics in this minority.

In order to research conveniently, the association relationship of facial semantics is converted to a matrix. It is shown as formula (2).

$$\Phi = \begin{bmatrix} p_{1,1} & p_{1,2} & \cdots & p_{1,\gamma-1} & p_{1,\gamma} \\ p_{1,2} & p_{2,2} & \ddots & \ddots & p_{2,\gamma} \\ \vdots & \ddots & \ddots & \ddots & \vdots \\ p_{1,\gamma-1} & \ddots & \ddots & \ddots & p_{\gamma-1,\gamma} \\ p_{1,\gamma} & p_{2,\gamma} & \cdots & p_{\gamma-1,\gamma} & p_{\gamma,\gamma} \end{bmatrix} \tag{2}$$

In formula (2), $p_{ij} = p_{ji}$. The element p_{ij} of the incidence matrix Φ which is γ order represents the association probability between the i-th and the j-th facial semantic feature. Especially, the value of p_{ij} is smaller, the association probability of facial semantic features is lesser. Otherwise, if the value of p_{ij} is bigger, it shows that the probability of facial semantics between i-th and the j-th is bigger, simultaneously

3.2. The Reduction of Multiethnic Facial Semantic Web

The multiethnic facial semantic web contains various features of facial parts. It is a disadvantage to express the difference between different groups due to the correlation which is unclear between facial part semantic. Therefore, it is necessary to deeply analysis the multiethnic facial semantic web for keeping the semantic features which is presented frequently.

Our aim is to find a group of unit orthogonal vectors as an optimal vector basis in the space of facial semantics. These orthogonal vectors which are used to reconstruct original samples can make the error minimum.

The column vector $\mathrm{P} = [p_{i,1}, p_{i,2}, \cdots, p_{i,\gamma}]^T \in \mathrm{R}^D$ is a random variable, $\alpha = [\alpha_1, \alpha_2, \cdots, \alpha_D]$ is an orthogonal normalized coordinate system in D-dimensional space. Thus, the random vector P can be represented with α as formula (3) shown.

$$\mathrm{P} = \sum_{i=1}^{D} y_i \alpha_i \tag{3}$$

In formula (3), If P is estimated with the previous d items, there will generate a mean square error ε about $\hat{\mathrm{P}} = \sum_{i=1}^{d} y_i \alpha_i$.

$$\varepsilon = E\left[\left(\mathrm{P} - \hat{\mathrm{P}}\right)^T \left(\mathrm{P} - \hat{\mathrm{P}}\right)\right] = E\left[\sum_{i=d+1}^{D} (y_i^2)\right] = \sum_{i=d+1}^{D} \alpha_i^{\mathrm{T}} E(\mathrm{P}\mathrm{P}^{\mathrm{T}})\alpha_i = \sum_{i=d+1}^{D} \alpha_i^{\mathrm{T}} \mathrm{S}\, \alpha_i \quad (4)$$

Where, $y_i = \alpha_i^{\mathrm{T}}\mathrm{P}, (i = 1, \cdots, D), \mathrm{S}$ represents the covariance matrix of P. The extremum coordinate system of ε is obtained by lagrangian multiplier.

$$g = \sum_{i=d+1}^{n} \alpha_i^{\mathrm{T}} \mathrm{S}\, \alpha_i - \sum_{i=d+1}^{n} \lambda_i (\alpha_i^{\mathrm{T}} \alpha_i - 1) \quad (5)$$

According to the extreme conditions of formula (5), it is facility to obtain the eigenvalues and eigenvectors of S. When P is expanded by the coordinate system which is based on the eigenvectors of S. The ε can be presented as $\varepsilon = \sum_{i=d+1}^{D} \lambda_i$. The smaller the sum of $\lambda_{d+1}, \lambda_{d+2}, \cdots, \lambda_D$, the less information that of P is loss. So it is only necessary to remain the vectors which is corresponding to the bigger eigenvalues as axis to record the information extremely.

In the process of multiethnic facial semantic statistical, it is found that the correlations of multiethnic is various. It is shown that the matrix of multiethnic facial semantics can describe the features itself. Hence, it can achieve indirectly analysis on facial semantic web through Φ.

The covariance S^* of the incidence matrix Φ can be shown as formula (6).

$$\mathrm{S}^* = (\Phi - \mathrm{m}_i)(\Phi - \mathrm{m}_i)^T = \mathrm{U} \sum \mathrm{U}^T \quad (6)$$

SVM is used to solve the equation. Where, m_i represents the mean value of Φ. Σ is a diagonal matrix and values of $\lambda_1^*, \lambda_2^*, \cdots, \lambda_n^*$ on the diagonal are eigenvalues of S^*. U_i is the eigenvector corresponding to λ_i^*. $\lambda_1^*, \lambda_2^*, \cdots, \lambda_n^*$ presents all of the facial semantics in mapping space which takes U as the projection axis. When the proportion of ε^* is less, the information of original facial semantics will be remained extremely

4. Results and Analysis

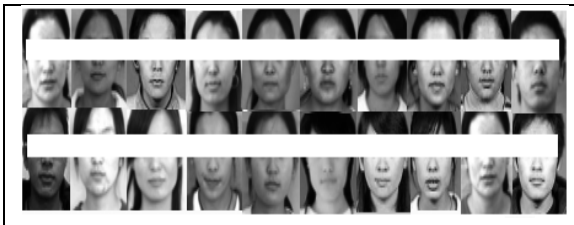

Figure 5. Parts of Training Figures of Tibetan

Figure 6. Parts of Training Figures of Uygur

Figure 7. Parts of Training Figures of Zhuang

A group images of the Tibetan, Uygur, Zhuang are chosen from the multiethnic face database (Multiethnic Facial Database V1.0(MFD V1.0)) [8-10]. These face images are used as a group of training samples. Primarily, the characteristic method of algebraic and geometric is used to recognize the facial parts of minorities standard face. There are seven facial semantic features which includes forehead, eyebrows, eyes, nose, mouth, face and cheek are extracted from face database. Then, the facial semantic web which is made up of seven facial semantics is cut. Lastly, the attribute of the unknown test is verified with the facial semantic web. The test images of minorities face database is shown in Figure 5-Figure 7.

4.1. Semantic Association Analysis of the Multi-ethnic Facial Parts

According to multiethnic standard face, make statistics of the semantic feature of seven facial parts incidence matrix Φ in the selection of facial images of Tibetan, Uygur, Zhuang.

Table 1. Incidence Matrix of Facial Parts Semantic Features of Tibetan

	forehead	brows	eyes	nose	mouth	face shape	cheek
forehead	0.1471	0.0441	0.1029	0.0588	0.0294	0.1324	0.1471
brows	0.0441	0.1618	0.0735	0.0735	0.0735	0.1471	0.1618
eyes	0.1029	0.0735	0.3971	0.1176	0.0735	0.2647	0.3824
nose	0.0588	0.0735	0.1176	0.1912	0.0735	0.1324	0.1765
mouth	0.0294	0.0735	0.0735	0.0735	0.1029	0.0735	0.1029
face shape	0.1324	0.1471	0.2647	0.1324	0.0735	0.7059	0.7059
cheek	0.1471	0.1618	0.3824	0.1765	0.1765	0.7059	0.9706

Table 2. Incidence Matrix of Facial Parts Semantic Features of Uyghur

	forehead	brows	eyes	nose	mouth	face shape	cheek
forehead	0.1000	0.0500	0.1000	0.1000	0.0333	0.0833	0.0583
brows	0.0500	0.4083	0.3333	0.3250	0.0667	0.1083	0.0750
eyes	0.1000	0.3333	0.8500	0.7667	0.1250	0.2333	0.1083
nose	0.1000	0.3250	0.7667	0.8417	0.1250	0.2250	0.1000
mouth	0.0333	0.0667	0.1250	0.1250	0.1250	0.0667	0.0583
face shape	0.0833	0.1083	0.2333	0.2250	0.0667	0.2750	0.0750
cheek	0.0583	0.0750	0.1083	0.1000	0.0583	0.0750	0.1167

Table 3. Incidence Matrix of Facial Parts Semantic Features of Zhuang

	forehead	brows	eyes	nose	mouth	face shape	cheek
forehead	0.0917	0.0500	0.0917	0.0500	0.0417	0.0667	0.0250
brows	0.0500	0.1833	0.1833	0.0667	0.0917	0.0583	0.0583
eyes	0.0917	0.1833	0.9083	0.2917	0.2750	0.7583	0.1500
nose	0.0500	0.0667	0.2917	0.3000	0.1167	0.2500	0.0750
mouth	0.0417	0.0917	0.2750	0.1167	0.2833	0.2417	0.1000
face shape	0.0667	0.0583	0.7583	0.2500	0.2417	0.8417	0.1417
cheek	0.0250	0.0583	0.1500	0.0750	0.1000	0.1417	0.1667

As Table 1-Table 3 shown, because, the correlations of the seven facial semantic features are unclear, it is unable to explicit the minority features. It is necessary to cut the facial semantic web for remaining the semantic features whose correlation is stronger.

4.2. The Multiethnic Facial Semantic Web Cut

The facial semantic web of Tibetan, Uygur, Zhuang is analysized by PCA. For the invariance of facial semantic features, the nodes which lie in mapping space can indirectly represent the relation of that of original space. The proportion of nodes which lie in mapping is analyzed. As shown in Figure 8.

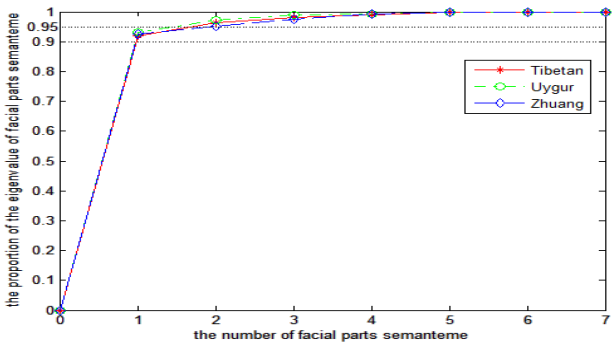

Figure 8. Proportion of the Facial Parts Semanteme

From the Figure 8, the curve proportion of eigenvalues is shown, in the incidence matrix of Tibetan, Uygur, Zhuang, the largest eigenvalue has the largest proportion, and its rate of change is the most obvious. When the number of eigenvalues reaches to 2, the rate of curve becomes slow and the proportion reached the threshold. When the number reaches 3 or above, the rate approaches 0 gradually and the proportion of sum of eigenvalues tends to 1. So, the eigenvalues of test incidence matrix is remained. As shown in Table 4.

Table 4. Facial Semantic Features of Minorities

	λ_1^*	λ_2^*
Tibetan	1.1805	0.0555
Uygur	1.3220	0.0603
Zhuang	1.3231	0.0372

Seen from Table 4, λ_1^* and λ_2^* are the lager eigenvalue in the incidence matrix of Tibetan, Uygur, Zhuang. They which correspond to the eigenvectors contain a major of information of the facial semantic web. So, the two bigger eigenvalues is remained. But finishing the cut of facial semantic web, also describing the correlations between different semantic features clearly

4.3. The Unknown Attribute Estimation based on the Facial Semantic Web

In mapping space, the PCA is used to analyze attribute of the unknown test set by Frobenius norm as the similarity discriminant function for Tibetan, Uygur and Zhuang. Then, the estimation of minority attribute of unknown test set will be accomplished.

Table 5. Unknown Test Set 1

	forehead	brows	eyes	nose	mouth	face shape	cheek
forehead	0.1238	0.0314	0.1035	0.0588	0.0264	0.1156	0.1238
brows	0.0314	0.1776	0.0635	0.0635	0.0685	0.1471	0.1776
eyes	0.1035	0.0635	0.4259	0.1304	0.0536	0.2647	0.3824
nose	0.0588	0.0635	0.1304	0.2016	0.0819	0.1022	0.1665
mouth	0.0264	0.0685	0.0536	0.0819	0.1174	0.0735	0.1065
face shape	0.1156	0.1471	0.2647	0.1022	0.0735	0.7322	0.7022
cheek	0.1238	0.1776	0.3824	0.1665	0.1065	0.7022	0.9176

Table 6. Unknown Test Set 2

	forehead	brows	eyes	nose	mouth	face shape	cheek
forehead	0.0833	0.0521	0.0625	0.0625	0.0104	0.0729	0.0208
brows	0.0521	0.3299	0.2604	0.2604	0.0417	0.1146	0.0208
eyes	0.0625	0.2604	0.8542	0.6875	0.1042	0.2500	0.0938
nose	0.0625	0.2604	0.6875	0.7813	0.1042	0.2188	0.0833
mouth	0.0104	0.0417	0.1042	0.1042	0.1042	0.0729	0.0625
face shape	0.0729	0.1146	0.2500	0.2188	0.0729	0.2917	0.0729
cheek	0.0208	0.0208	0.0938	0.0833	0.0625	0.0729	0.0938

Table 7. Unknown Test Set 3

	forehead	brows	eyes	nose	mouth	face shape	cheek
forehead	0.0714	0.0446	0.0714	0.0357	0.0179	0.0714	0.0446
brows	0.0446	0.1518	0.1518	0.0536	0.0179	0.1429	0.0714
eyes	0.0714	0.1518	0.9196	0.2857	0.2500	0.8214	0.1696
nose	0.0357	0.0536	0.2857	0.2857	0.0982	0.2411	0.1071
mouth	0.0179	0.0179	0.2500	0.0982	0.2589	0.2411	0.0446
face shape	0.0714	0.1429	0.8214	0.2411	0.2411	0.8929	0.1518
cheek	0.0446	0.0714	0.1696	0.1071	0.0446	0.1518	0.1696

Seen the unknown test set above, it is the incidence matrix of minority facial semantic features for unknown test set. The test database is mapping to the space of facial semantics of Tibetan, Uygur and Zhuang. The similarity function is used to estimate minorities attribute. As shown in Table 8.

Table 8. Species Recognition of the Unknown Minorities

test set	similarity	
unknown test set 1	Tibetan	0.0144
	Uygur	1.3919
	Zhuang	0.9329
unknown test set 2	Tibetan	1.4891
	Uygur	0.0156
	Zhuang	0.5196
unknown test set 3	Tibetan	0.7771
	Uygur	0.7837
	Zhuang	0.0214

Seen database from Table 8, the multiethnic facial semantic web better characterized the similarities and differences of minorities. According to the similarity function, the attributes of unknown test set is estimated. Meanwhile, the data base exploits the differences of minorities. For example, the difference of semantic features between Tibetan and Uygur is larger, but, of that between Uygur and Zhuang is smaller.

5. Conclusion

In order to exploit the similarities and differences, the multiethnic facial semantic web which is based on minorities is proposed in this paper. And the PCA is used to analyze the web deeply. As the result of the experiment, the analysis of correlations among the facial semantic features is effectively finished. Meanwhile, the attributes of unknown test set is well recognized. Then the differences of minorities is clearly described. Extremely, it represents a new method to research the similarity between minorities.

However, the communication of minorities is gradually promoted by the development of society and causes a varieties in minority feature. In future, it is one important research fields on membership and emotion of face.

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