Application of PCA and LDA methods on gloss recognition research in TCM complexion inspection

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Abstract—In TCM theory, gloss and moisture are recognized as the Qi; blue, red, yellow, white and black are recognized as the color, the five colors governs blood, the gloss governs sprit and Qi. We may estimate the overabundance or insufficiency of the viscera's essence by observing the changes of face gloss, which is a very important way to judge the condition and extrapolate the prognosis. However, because of lacking of objective data, the traditional way of observing face gloss mainly depends on clinicians' subjective appraises, which becomes one of the most important factors that hamper TCM's development. As a grope and study for the objective TCM, we utilize the computer vision skills and apply the feature extraction methods, like PCA, 2DPCA and $(2D)^2PCA$, LDA to the face samples under 4 color spaces as facial gloss extraction methods. The result indicates that 4 methods have a positive effect on extracting gloss information, LDA may reach to the rate of 88.69% in the HSV color space. This article attempts to explore informatization intellectualization of TCM , and attains positive experimental results. It provides a new method for the TCM observation of gloss quantification examination.

KeyWords-TCM complexion; Gloss; PCA; 2DPCA; $(2D)^2PCA$; LDA

I. INTRODUCTION

Observing the color and gloss on the face is one of characteristics of TCM examines methods. TCM always pays much attention on observing, mainly on observing color and gloss. *Miraculous Pivot* says, "The blood and Qi of 12 meridians and 365 collaterals are all transformed upwards face through hollow orifices". Three hand and foot Yang meridians walks upon face, therefore, watching the color on the face may diagnose the overabundance and insufficiency in internal organs and meridians. *Plain Questions – Mai Yao Jing Wei Lun* says, "Essence-Brightness of the eyes and the five colors reflect the splendor of Qi". Essence of Qi and blood which reaches walk upward to head and walk outside to flesh, may display the different gloss. The five colors belong to blood, the gloss represents spirit and Qi; Its appearance belongs to blood, and its utilization belongs to Qi.

As the development of modern color and optics theory and the innovation of color-testing instruments, many experts and scholars were trying to apply the color optics theory and

modern instruments, such as color difference meter, spectrophotometer to the research of modern diagnosis of TCM. However, most of these measures are limited because it observing "color" rather than "gloss". For instance, we use the color difference meter according to "red and yellow faintly with brightness and luster reserved", but it fails to manifest the color and gloss like wearing a piece of sick. Therefore, a more advanced measure which suits for five color inspection of TCM should be developed, in order to offer technological supply for TCM diagnostic detect system.

In recent years, increasingly active research have been carried out to detect human face with computer technology which is advanced and scientific and lays a foundation for the objective auto-observing of TCM face inspection, as well as pioneering a prospect for its research. In 2006, we firstly did the research on the computer auto-observing for the face inspection information, we discussed the calculating method of complexion, and we initially developed TCM complexion analysis system and set up 3600 cases database of complexion from clinical patients[1-3]. This subject attempts to extract face gloss feature with PCA, 2DPCA, (2D)^{2}PCA, and LDA according to TCM fundamental theory and clinical practice.

II. THE ESTABLISHMENT OF CLINICAL COMPLEXION OBSERVATION TABLE

Firstly, we referred TCM classic literature and articles related to complexion inspection in recent 20 years, and designed TCM complexion observing table based on TCM diagnostics theory and clinical practice. Secondly, we invited 13 experts from Shanghai University of TCM and affiliated hospitals to judge the five color division and selected the items one by one in the table. Thirdly, we adopted most experts' suggestions to select clinical complexion observing table. Therefore, gloss is classified into 3 levels: glossy，less-glossy，and non-glossy[4]. These TCM experts observed complexion comprehensively analyzed, selected by quantified table correctly, which realized classification of complexion effectively and briefly and supported computer recognize face information with TCM theory.

III. THE INTRODUCTION OF COMPLEXION COLLECTION INSTRUMENT

The compatible complexion collecting instrument includes LED(the light source),and camera（the photographing medium）. It adopts plane instead of traditional bar or spot, which has the feature of soft and even, stable, with low voltage power and security , the photography dark box. We've taken over 3600 face samples of diseased patients with various systems disease in affiliated hospital of Shanghai University of TCM, such as Longhua Hospital, Shuguang Hospital, Yueyang Hospital and Renji Hospital. In this article, we selected 160 pictures, including 80 pictures of gloss and 80 of non-gloss to extract the gloss information.

IV. CALCULATING METHODS OF FEATURE EXTRACTION

As the feature extraction methods, PCA, 2DPCA, (2D)^{2}PCA LDA are widely used in the field of human face recognition. We are trying to use these 4 methods in extracting gloss during TCM face inspection.

For traditional PCA, transforming the sample variables into vectors is necessary when we covariance matrix[5-7].

$$\mathbf{C} = \frac{1}{M}\sum_{K=1}^{M}(\mathbf{x}_K - \overline{\mathbf{x}})^T(\mathbf{x}_K - \overline{\mathbf{x}})$$

2DPCA is similar to PCA, while it builds the covariance matrix directly on the matrix form images in row direction.[8]

$$\begin{aligned}\mathbf{G} &= \frac{1}{M}\sum_{K=1}^{M}(\mathbf{A}_K - \overline{\mathbf{A}})^T(\mathbf{A}_K - \overline{\mathbf{A}}) \\ &= \frac{1}{M}\sum_{K=1}^{M}\sum_{i=1}^{m}(\mathbf{A}_K^{(i)} - \overline{\mathbf{A}}^{(i)})^T(\mathbf{A}_K^{(i)} - \overline{\mathbf{A}}^{(i)})\end{aligned}$$

$(2D)^2PCA$ builds the covariance matrix not only on the row direction as 2DPCA, but also builds the covariance matrix in the column direction of the images[9].

$$G = \frac{1}{M} \sum_{K=1}^{M} (A_K - \overline{A})(A_K - \overline{A})^T$$

$$= \frac{1}{M} \sum_{K=1}^{M} \sum_{i=1}^{m} (A_K^{(j)} - \overline{A}^{(j)})^T (A_K^{(j)} - \overline{A}^{(j)})^T$$

LDA uses the label information. It builds the between-class and with-class scatter matrix based on the training data[10],

$$S_B = \sum_{i=1}^{L} N_i (\overline{x}_i - \overline{x})^t (\overline{x}_i - \overline{x})$$

$$S_W = \sum_{i=1}^{L} \sum_{j=1}^{N_i} (x_j - \overline{x}_i)^t (x_j - \overline{x}_i)$$

Learning from principle in face recognition , we will promote and apply these feature extraction' methods in face gloss information extraction.

V. EXPERIMENT AND RESULTS

We selected 160 cases during this experiment, including 80 human face image of "gloss" and 80 "non-gloss" recognized by TCM experts. According to TCM theory, we extracted the same square area of every right cheek, and zoom with the size 100*100 for experiment.

To make the best of the limited samples, we applied 10-fold cross-validation method, so that we used 90% samples for training and the rest 10% for testing. The evidence of reducing dimension is to reserve 95% the largest eigenvalue of the eigenvectors corresponding to the load as the projection，and the classification method is to use Euclidean distance as a criterion. As gloss information has close relationship to the color information of image itself, we intended to compare the recognition effect of all image in different color space with each other. The specific index included the correct rate and calculation time consumption(table 1, table 2,)

TABLE1. THE CORRECT OF RECOGNITION

	PCA	2DPCA	$(2D)^2PCA$	LDA
Gray	0.6194	0.6419	0.6594	0.7494
RGB	0.7975	0.8113	0.8144	0.8713
HSV	0.8575	0.8675	0.8700	0.8869
Lab	0.8481	0.8419	0.8438	0.8794

TABLE2. THE TIME CONSUMPTION(SEC)

	PCA	2DPCA	$(2D)^2PCA$	LDA
Gray	50.43	15.73	16.45	50.49
RGB	215.56	49.13	50.45	221.20
HSV	216.36	47.00	51.04	225.01
Lab	217.51	47.19	51.16	223.94

According to the data above, Generally speaking, it is showed

1.In Gray, RGB, and HSV color space, the results of PCA, 2DPCA, $(2D)^2PCA$ are accordance with that of expected. The highest correct rate is showed in 87.00% of HSV color space. The reason may lie in the data which reserved the original data more completely.

2. As the main advantages of 2DPCA and $(2D)^2PCA$ in effective feature extraction is available when there's a small amount of training samples, it is non-effective in this experiment, for they are 100 training samples. The main advantage is that they improved the time consumption calculating significantly compared with PCA.

3. The highest testing correct rate in this experiment is showed in 88.69% of HSV color space when using LDA, it is advised that training data may have a positive effect relationship with facial gloss extraction.

4. The correct rate of recognition after feature extracted was unstable or even decreased

in Lab color channels, It is suggested that the information included in these color space may have no relationship with the gloss of face.

VI. CONCLUSION

In this experiment, we extracted the gloss feature of TCM face inspection by PCA，2DPCA (2D)^{2}PCA and LDA, classified and recognized the gloss feature in different color space. The results shows that the 4 methods are useful in extracting information of face gloss during TCM complexion inspection, especially HSV which has a better performance in the recognition of color. And the correct rate of recognition of LDA can reach 88.69% in HSV color space. It provides a new method and thought for the quantitative and test technology research of gloss about "Spirit" inspection in TCM theory. The next step of research is to set up data collection more reasonably and effectively based on original image guided by the concept of face gloss, as well as to search training data relationship with facial gloss.

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