Iris Texture Recovery by Independent Component Analysis and Multi-Spectral Imaging

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***Abstract*—Iris recognition has proven its accuracy and gained importance in biometric recognition. However, the presence of contact lens, particularly the cosmetic lens, has been proved to deteriorate the iris pattern and the accuracy of recognition. In this study, we propose a blind source separation method by multi-spectral imaging to separate the pattern of iris and cosmetic lens.**

***Index Terms*—independent component analysis, blind source separation, multispectral image.**

I. Introduction

Biometric recognition, such as fingerprint, face, or iris, has been widely research in recent years. Iris recognition has the highest accuracy among all [2] due to the uniqueness of pattern [3], stability throughout an individual's lifetime [3], and the non-intrusive measurement. Iris recognition has been used on places requiring high-level security such as UAE port of entry and World Trade Center's reconstruction site. Though iris pattern is considered to be unique, recent research results suggest that iris recognition accuracy could be affected by the presence of contact lens, particularly cosmetic lens. Cosmetic lens obviously changes the texture of iris and leads the recognition result to be misclassified . Researches such as using feature extraction and machine learning technique to differentiate an individual is wearing a contact lens or not has been developing. There are increasing number in users of cosmetic lens in worldwide. The users need to remove the cosmetic lens because of the existing algorithms fail to recognize authentic individual in the presence of cosmetic lenses, and the removing action breaks the significant properties of non-intrusive. Therefore we use a blind source separation technique called independent component analysis (ICA) [4] and multi-spectral image to separate texture of iris and cosmetic lens.

II. Theory

A. Independent Component Analysis

In signal processing, independent component analysis (ICA) is a computational method for separating a multivariate signal into additive subcomponents. This is done by assuming that the subcomponents are non-Gaussian signals and that they are statistically independent from each other.

Let us assume that the data vector $\boldsymbol{x}$ is formed by random vectors following certain distribution, i.e., it is a mixture of independent components $\boldsymbol{s}$:

$$\mathbf{x} = \mathbf{A}\mathbf{s}\,. \tag{1}$$

Where **A** is the mixing matrix. The independent components can be estimated by finding the linear combinations of the mixture variables, since we can invert the mixing as

$$\mathbf{s} = \mathbf{A}^{-1}\mathbf{x} \tag{2}$$

Thus, to estimate one of the independent components, we can consider a linear combination of the x_i. Let us denote this by q

$$\mathbf{y} = \mathbf{b}^{\mathbf{T}}\mathbf{x} = \mathbf{q}^{\mathbf{T}}\mathbf{s} = \sum_{\mathbf{i}} \mathbf{q_i s_i} \tag{3}$$

if b were one of the rows of the inverse of mixing matrix **A**, this linear combination $b^T x$ would actually equal one of the independent component. We can establish a good approximation by finding an estimator based on central limit theory (CLT), which states that, given certain conditions, the arithmetic mean of a sufficiently large number of iterates of independent random variables will be approximate normal distribution

B. Multi-spectral Image

The iris image are captured in two different spectrum: near infrared (850 nm) and visible (400-700 nm). The selection of these two different range of spectrum is due to the following reason: the iris texture can be easily observed under near infrared,while under visible light iris texture less noticable and cosmetic lens pattern is much obervable.

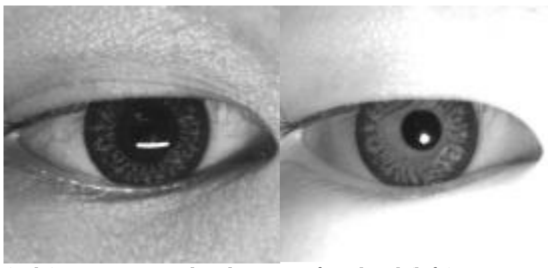

Fig. 1. (right) Image captured under near infrared and (leftt) image captured under visible light.

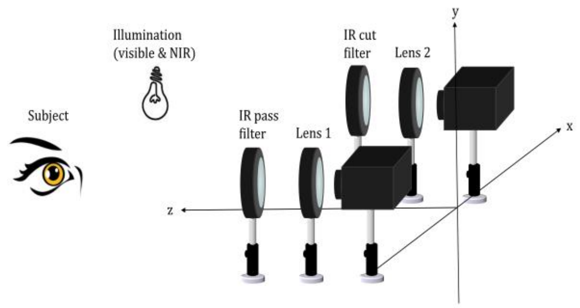

Fig. 2. Image aqusition system setup.

III. Experiment

The ICA model is established by the assumption that the pattern of iris and cosmetic lens were two independent components s_1 and s_2 based on the obsevation of section II.B. We hypothesize that the iris texture and the pattern were being superimposed with unknow ratios each under different sprectrum of light.

A. Segmentation & Normalization

First, using the image observed under near infrared as reference to locate the boundary of pupil and cosmetic lens. Then transfer the ‘strip’ region from Cartesian coordinate to polar coordinate or the so-called normalization for the convenience of further processing.

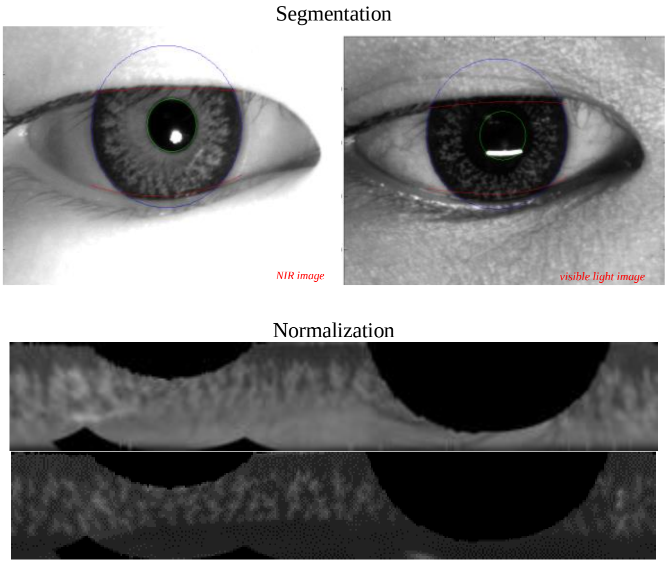

Fig. 3. These are the images of same individual’s eye obeserved under NIR and visibile light, we can observed that NIR images have more texture than visible light. However, the iris and cosmetic lens exist no clear boundary. And the black region are eyelid and specular which are masked.

B. Vectorization

ICA is easier to deal with one dimensional signal, so we pull the rubber sheet model of both near infrared and visible light image into each one dimensional vector.

C. Maximum nonguassianity

A measurment for nonguassianity is *Kutosis*

$$kurt(y) = E\{y^4\} - 3(E\{y^2\})^2 . \qquad (4)$$

Kutosis is a moment which equals to zero when the distribution of y is gaussian. An ICA algorithm called ‘fast ICA’ use *Kutosis* as an estimator to optimize the estimated s_1 and s_2 where the algorithm stop when the Kurtosis is maximized.

IV. Experimental Results

We demonstrate the potential of ICA to solve the iris image degradation cause by cosmetic lens. In Fig.4, one of the estimated independent component is the cometic lens pattern, and the other is the iris texture, this could be validate by calculating Hamming distance with authentic user.

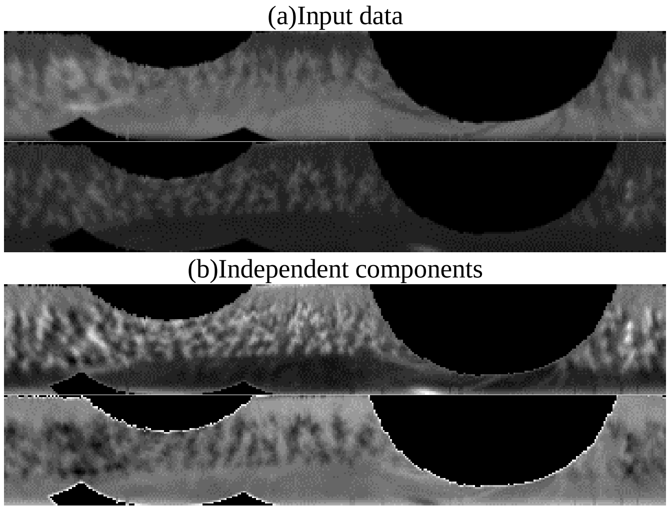

Fig. 4. The comparison of (a) original data and the (b) estimated independent components. The (upper row) s_1 components unveil texture detail that have the potential to be used on recogniotion, and (lower row) s_2 is the component of cosmetic lens pattern.

Acknowledgment

This research is supported by Ministry of Science and Technology, NSC102-2221-E-009-155-MY3.

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