PRINCIPLE COMPONENT ANALYSIS FOR FACIAL IMAGES

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ABSTRACT

Principle component analysis (PCA) bas been widely used for analyzing the statistics of data. When applied to facial images, PCA meets certain challenges. In this paper, we present a number of modifications to PCA in order to meet these challenges. Using face recognition as an example, we show that eigenflow, PCA applied to optical flow, enables us to measure the difference between two facial images while allowing expression changes and registration error. We show how PCA can be updated to model time-varying statistics, for example in a video sequence of facial images. We also show that PCA can be used to model the surface reflectance of human faces and thus reduces illumination variation that troubles most face recognition algorithms. Finally, we demonstrate that PCA can be used for facial animation as well.

INTRODUCTION

Principle component analysis has been widely used in modeling the statistics of a set of data. In a vector space, PCA identifies the major directions, and the corresponding strengths, of variation in the data. PCA achieves this by computing the eigenvectors and eigenvalues of the covariance matrix of the data. Keeping only a few eigenvectors corresponding to the largest eigenvalues, PCA can be used as a tool to reduce the dimensions of the data while retaining the major variation. Both the variation modeling aspect and the dimension reduction aspect of PCA have been used in many applications. In face recognition, one of the most well-known results is the eigenfaces [1]. In practice, PCA-based face recognition is challenged by variations in facial expressions, poses, and illuminations. In addition, PCA is known to be sensitive to any offset in the images, i.e., registration error. Face recognition is also difficult in general when the subject has grown facial hair, is wearing a bat or glasses, or simply aging. We would like to present a number of new approaches to using PCA to accomplish robust facial image analysis.

We will present eigenflow [2] that aims to make face recognition robust to expression changes and registration error. We will present PCA updating [3] in order to enhance face recognition over time. We will use PCA to model surface reflectance and make face recognition robust to illumination changes [4]. Finally, we will show how PCA can be used to analyze facial motion for creating realistically-looking facial animation [5].

REFERENCES

[1] M. Turk, A. Pentland, "Eigenfaces for recognition," *Journal of Cognitive Neuroscience*. no. 3, vol.1, pp. 71-86, 1991.

[2] X. Liu, T. Chen and B.V.K. Vijaya Kumar, "Face authentication for multiple subjects using eigenflow," *Pattern Recognition*, Special Issue on Biometric, Volume 36, Issue 2, February 2003, pp. 313-328.

[3] X. Liu, T. Chen and S. M. Thornton, "Eigenspace updating for non-stationary process and its application to face recognition," *Pattern Recognition*, Special issue on Kernel and Subspace Methods for Computer Vision. September, 2002.

[4] T. Chen, Y.J. Hsu, X. Liu, and W. Zhang, "Principle component analysis and its variants for biometrics," Intl. Conf. on Image Processing, Rochester, NY, USA, September 2002.

[5] K. Goudeaux, T. Chen, S.-W. Wang and J.-D. Liu, "Principal component analysis for facial animation," IEEE Intl. Conf. on Acoustics, Speech, and Signal Processing, Salt Lake City, Utah, May 2001.