DOCTORAL THESIS

Statistical histogram characterization and modeling: theory and applications

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Date of Award:
2008

Statistical Histogram Characterization and Modeling: Theory and Applications

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A thesis submitted in partial fulfillment of the requirements
for the degree of
Doctor of Philosophy

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Hong Kong Baptist University

June 2008

ABSTRACT

Efficient representation of visual information is the basis of many computer vision tasks. Of those effective representations for practical applications such as image classification and retrieval, histogram may be the most important and useful feature, and has been widely used with promising results. However, it is known that histogram should not be used directly as an image descriptor since the computation and dimensionality impose prohibitive computational resources for real time applications. Hence, there is a strong motivation to seek a more powerful representation in lieu of histogram while preserving the nice properties of the original histogram.

In this thesis, we shall explore the use of statistical model and histogram-based image signature for computer vision applications. The emphasis is on the characterization and modeling for the histogram of image variations that can lead to fast algorithmic implementations. We first propose a characterization of the state-of-the-art generalized Gaussian densities, namely, the Characteristic Generalized Gaussian Density (CGGD), for the wavelet high frequency subband histograms by sound optimization technique. The proposed CGGD provides an effective characterization of generalized Gaussian densities that can be learned from a set of training GGD estimators. Experimental results on supervised texture classification reveal the effectiveness of the CGGD compared with other existing texture characterization methods. Second, we study a statistical framework of a novel probability model based on bit-plane representation. We shall investigate an existing bit-plane-based model and apply extensive statistical analyses to such model. Based on the statistical analyses results, we propose a so-called 1^{st} order nonhomogeneous Markov bit-plane probability model for the observed histograms. Numerical experiments show that the proposed model is sufficient to represent the histogram of image variations compared with other existing bit-plane-based models. Then the image signature is constructed by concatenating the parameters of the proposed model which can be extracted very efficiently via bit-plane extraction. Finally, the bit-plane-based image signature is employed to several applications including texture classification, Chinese Materia Medica starch grains classification, and histogram-based color image retrieval.

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