Chapter 2
New Color Features for Pattern Recognition

Chengjun Liu

Abstract. This chapter presents a pattern recognition framework that applies new color features, which are derived from both the primary color (the red component) and the subtraction of the primary colors (the red minus green component, the blue minus green component). In particular, feature extraction from the three color components consists of the following processes: Discrete Cosine Transform (DCT) for dimensionality reduction for each of the three color components, concatenation of the DCT features to form an augmented feature vector, and discriminant analysis of the augmented feature vector with enhanced generalization performance. A new similarity measure is presented to further improve pattern recognition performance of the pattern recognition framework. Experiments using a large scale, grand challenge pattern recognition problem, the Face Recognition Grand Challenge (FRGC), show the feasibility of the proposed framework. Specifically, the experimental results on the most challenging FRGC version 2 Experiment 4 with 36,818 color images reveal that the proposed framework helps improve face recognition performance, and the proposed new similarity measure consistently performs better than other popular similarity measures.

2.1 Introduction

Color provides powerful information for pattern recognition, such as in object detection, in image and video indexing and retrieval, and in pattern classification [31], [8], [2], [28], [5], [34], [33], [27], [9], [3], [6], [10], [32], [12], [30]. One commonly used tristimulus space for color image representation is the RGB color space, whose three component images correspond to the primary colors: red, green, and blue. While the RGB color space has broad applications in color image representation such as for color monitors and video cameras, it might not be the ideal one

Chengjun Liu
New Jersey Institute of Technology, Newark, NJ 07102, USA
e-mail: chengjun.liu@njit.edu

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for color image classification. Recent research reveals that some color spaces transformed from the $RGB$ color space can indeed improve pattern recognition performance, such as the Uncorrelated Color Space (UCS), the Independent Color Space (ICS), and the Discriminating Color Space (DCS) \cite{13}. The UCS applies Principal Component Analysis (PCA) \cite{4} to decorrelate the red, green, and blue component images of the $RGB$ color space and derives three new color component images that are statistically uncorrelated. The ICS exploits a blind source separation procedure, such as the Independent Component Analysis (ICA) \cite{1}, \cite{13}, to obtain three new color component images that are statistically independent. The DCS utilizes discriminant analysis \cite{4} to acquire three new color component images that are most discriminatory in terms of class separability. One common characteristic among the new ICS, UCS, and DCS is that they all contain component images that are defined by the weighted subtraction of the primary colors.

The motivation of this research thus is to investigate innovative color features that are derived from both the primary and the subtraction of the primary colors in order to enhance pattern recognition performance. Towards that end, we present in this chapter a new pattern recognition framework that applies effective color features and a new similarity measure. First, innovative color features, which are derived from both the primary color (the red component) and the subtraction of the primary colors (the red minus green component, the blue minus green component), are applied for effective color image classification. Second, the dimensionality of the three new color components, namely, the red, the red minus green, and the blue minus green components, is reduced by means of the Discrete Cosine Transform (DCT). Third, the DCT features of the color components are then concatenated to form an augmented pattern vector to represent the color image in a compact way. Fourth, the augmented pattern vector is further processed by discriminant analysis for deriving the effective color features for pattern recognition. Discriminant analysis, which extracts features based on a criterion for class separability, is implemented through the simultaneous diagonalization of the within-class and between-class scatter matrices. Simultaneous diagonalization reveals that some small valued trailing eigenvalues of the within-class scatter matrix can cause overfitting, as they appear in the denominator of the overall transformation matrix of discriminant analysis. To enhance the generalization performance, discriminant analysis should be preceded by a dimensionality reduction process in order to get rid of the small valued trailing eigenvalues from the eigenvalue spectrum of the within-class scatter matrix. Finally, the effective color features apply a new similarity measure for further improving pattern recognition performance. The new similarity measure, which integrates both the angular measure and the distance measure in terms of the $L_p$ norm, is able to improve upon the commonly used similarity measures in pattern recognition.

The effectiveness of the proposed new framework is assessed using a large scale, grand challenge problem. Specifically, the most challenging Face Recognition Grand Challenge (FRGC) \cite{24}, \cite{21}, \cite{35}, \cite{20}, version 2 Experiment 4, which contains 12,776 training images, 16,028 controlled target images, and 8,014 uncontrolled query images, is applied to evaluate the proposed framework. The experimental results show that the proposed framework helps improve face recognition