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Guest Editorial

Color image processing

1. Background and motivation

The perception of color is of paramount importance in applications areas such as multimedia, computer vision, graphics, biomedical signal processing, and industrial inspection. Humans routinely use color features to sense the environment, identify and recognize objects of interest, and convey information. Color image processing and analysis deal with the manipulation of digital color images through the utilization of signal processing techniques. Like most advanced signal processing techniques, color image processing was, until the last decade, confined to academic institutions and research laboratories that could afford the expensive image processing hardware needed to handle the processing overhead required to process large volumes of visual data.

However, with the advent of powerful computing devices, and the proliferation of consumer electronics such as digital cameras, smart phones, color scanners and printers, color image processing techniques are now within the grasp of the general public. Image processing practitioners and end-users routinely use color image processing solutions in applications such as transmission of consumer images and videos in wireless networks, indexing and archiving of personal photo collections, web-based processing of color images and videos, virtual restoration of artworks, multimedia information mining, and color management for peripheral devices such as printers and scanners. It is also not surprising that more versatile visual sensors and more efficient image processors replace their predecessors in various consumer electronic and computing devices to allow better understanding and reproduction of the visual scene and higher processing rates. Thus, new solutions are permanently needed to enhance performance of today's digital imaging systems, to enable real-time processing and analysis of high-resolution color visual data, and to solve challenging problems in emerging applications of color image processing.

This special issue provides an overview of color image processing solutions for computer vision and visual data analysis applications. It is aimed at researchers and practitioners who work in the area of color image processing. Its purpose is to fill an existing gap in the scientific literature by presenting the state of the art research in the area. By its nature, a special issue cannot cover all important developments in such a dynamic and fast expanding area. However, it can provide a good starting point for researchers and practicing engineers willing to address the technical challenges and take advantage of the opportunities in the area of color image processing and analysis.

2. Quick facts about the special issue

The guest editors suggested putting together this special issue on color image processing to the editor-in-chief in September 2005. In October 2005, the guest editors and the editor-in-chief established the outline and schedule of the special issue, and the first call for papers was distributed through the Internet.

Between March and May 2006, 34 manuscripts were submitted for review and possible inclusion in the special issue. Each of the submitted manuscripts was reviewed by experts in the field of color image processing. Between April and July 2006, the first rigorous review round was completed, and 24 papers were removed from consideration for the special issue. However, the guest editors recommended several best papers from this set of rejected papers to the editor-in-chief for inclusion in the regular issue.

Papers selected for the inclusion in the special issue underwent additional two review rounds before their definite acceptance. It is our hope that the 10 accepted papers illustrate relevant solutions to fundamental challenges in color image processing research and will prove useful to researchers and practitioners in the area of digital color imaging.

3. Scanning the special issue

This special issue attempts to provide a comprehensive overview of the most recent trends in color image processing. The papers included in the issue focus on various top-

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ics central to developments in the field. Accepted papers cover both theoretical and practical aspects of the digital color imaging pipeline, including color image acquisition, processing, and analysis.

The special issue opens with two papers on single-sensor digital color imaging. In their paper "Practical Implementation of LMMSE Demosaicing Using Luminance and Chrominance Spaces," Brice Chaix de Lavarène, David Alleysson, and Jeanny Hérault propose to restore the color information from the gray-scale, mosaic-like data captured by a single-sensor digital camera. An effective calculation of linear minimum mean square error (LMMSE) estimates in their solution results from the decomposition of the acquired sensor data into the luminance and chrominance terms. In another paper on single-sensor imaging, "A Joint Demosaicking-Zooming Scheme for Single Chip Digital Color Cameras," Lei Zhang and David Zhang propose a solution that integrates both demosaicking and zooming operations to transform the mosaic sensor data to a full-color image with the increased spatial resolution in a single processing step.

The next part of the special issue is focused on image filtering and restoration. Zhonghua Ma, Hong Ren Wu, and Dagan Feng, in "Fuzzy Vector Partition Filtering Technique for Color Image Restoration," describe the use of adaptive fuzzy similarity functions and fuzzy ranking techniques in vector partition filtering to effectively suppress different types of noise while preserving the underlying image structures such as edges and fine details. In the paper "Graph Regularization for Color Image Processing," O. Lezoray, A. Elmoataz, and S. Bougleux propose a new framework suitable for color image denoising, restoration, and simplification. The framework is based on general discrete regularization defined on weighted graphs of arbitrary topologies and allows fast and simple anisotropic linear and nonlinear filters which do not involve partial differential equation calculations.

The special issue continues with two articles on color data preprocessing for image analysis. In the paper titled "Morphological Colour Operators in Totally Ordered Lattices Based on Distances," Jesús Angulo generalizes distance-based and lexicographical-based approaches and extends morphological operators to color images. The application of the proposed framework to color feature extraction, image segmentation, denoising, and enhancement is shown and commented upon. In their work "Spatial and Spectral Quaternionic Approaches for Color Images," Patrice Denis, Philippe Carre, and Christine Fernandez-Maloigne constrain the discrete quaternionic Fourier transform to avoid information loss during processing and define new spatial and frequency operators suitable for edge detection in color images.

The next part of the special issue is devoted to color image analysis solutions. In the paper titled "Quaternion Color Texture Segmentation," Lilong Shi and Brian Funt show that the quaternion representation of color can be efficiently used for segmenting color images. The power of the proposed quaternion color texture representation is demonstrated by its use in an unsupervised segmentation algorithm that successfully divides an image into regions on basis of texture. Operating on the RGB color domain of digital images, Céline Mancas-Thillou and Bernard Gosselin, in the second work on color image analysis, "Color Text Extraction with Selective Metric-Based Clustering," use several metrics to merge pixels with similar color together. In addition, they use intensity and spatial information extracted using log-Gabor filters to enable precise character segmentation. They show that the proposed selective metric-based clustering solution is suitable for text extraction and character segmentation in complex natural scene images.

The special issue concludes with two papers on color image enhancement. Nikoletta Bassiou and Constantine Kotropoulos, in "Color Image Histogram Equalization by Absolute Discounting Back-off," propose solutions that exploit the correlation between color components and enhance color images using multi-level smoothing and hue preserving nonlinear transformation to deal efficiently with the problem of unseen color values and eliminate the gamut problem, respectively. Finally, in the paper titled "Automated Colour Grading Using Color Distribution Transfer," F. Pitié, A.C. Kokaram, and R. Dahyot propose first to find a one-to-one color mapping that transfers the palette of an example target picture to the original picture and then to reduce grain artifacts introduced during the color transfer process through an efficient post-processing algorithm that intends to preserve the gradient field of the original picture.

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