Alexandria Engineering Journal (2016) xxx, xxx–xxx

HOSTED BY

Alexandria University

Alexandria Engineering Journal

www.elsevier.com/locate/aej
www.sciencedirect.com

ORIGINAL ARTICLE

Color image demosaicing using sparse based radial basis function network

V.N.V. Satya Prakash [a,*], K. Satya Prasad [a], T. Jaya Chandra Prasad [b]

[a] Department of E.C.E., JNTUK, Kakinada 533003, Andhra Pradesh, India
[b] Department of E.C.E., RGM College of Engineering &Technology, Nandyal 518501, Andhra Pradesh, India

Received 26 July 2016; accepted 29 August 2016

KEYWORDS

Demosaicing;
Bayer pattern;
CPSNR;
RBF network

Abstract Images contain three primary colors at each pixel, but single sensor digital cameras capture only one of the primary channels. Process of color image reconstruction by finding the missing color component is called color image demosaicing. Various approaches have been proposed in this field of image demosaicing such as interpolation based and frequency based approaches due to sharp image edge and higher color saturation, and these techniques fail to reconstruct image efficiently. To overcome this, in this work we propose a new approach, sparse based RBF network for color image demosaicing. According to this approach a sparse model is constructed first and based on that weights are computed which are used to minimize the reconstruction error. To improve this we use optimal weight computation and RBF training for missing color component value prediction. Proposed method is implemented using MATLAB tool and experimental results show the efficiency of the proposed work in terms of color peak signal to noise ratio (CPSNR). Simulation results show 16.20% improvement in the performance in terms of CPSNR.

1. Introduction

In last decade, uses of images and videos have been grown rapidly in daily life scenarios. These images are captured using digital cameras. Since mid-1990s, digital cameras being used for consumer level applications. In today's scenario various cameras are available such as point-and-shoot which have capacity over 8 million pixels; similarly, other commercial cameras also present with capacity more than 12 million pixels. Image quality of these cameras depends on resolution, sensor's dynamic range and sensitivity of light. Various operations are performed during capturing the image such as focus adjustment, adjustment of white balance, and image compression. During the image capturing intensity of the light is sampled by using a single CMOS sensor and similarly color images are acquired in the same way but the intensity variations of light are measured in different band of colors which are red band, green band and blue band. In color image capturing process splitting of beam can be implemented which helps to measure each color at each value of image pixel, but due to computational complexity and cost raising issues it is difficult to implement for commercial and general purpose.

* Corresponding author.
E-mail addresses: prakashvnv@gmail.com (V.N.V. Satya Prakash), prasad_kodati@yahoo.co.in (K. Satya Prasad), jp.talari@gmail.com (T. Jaya Chandra Prasad).
Peer review under responsibility of Faculty of Engineering, Alexandria University.

http://dx.doi.org/10.1016/j.aej.2016.08.032

This becomes a challenging task for the researchers, and to overcome this color filter array (CFA) is proposed which captures color images using single sensor. This is a process of reconstruction of full-resolution by using data of CFA. It is defined as the combinational array of alternate color filters which performs sampling on a single color band at location of each pixel. Widely used CFA pattern is displayed in Fig. 1 which is called Bayer pattern. According to this pattern red and blue filters are placed in an alternate location of pixel in horizontal and vertical directions whereas green filters are placed in quincunx way at the remaining location of the pixels.

These patterns are used to reconstruct the color image. The process of estimation of missing two values is denoted as image demosaicing. Due to the presence of single color channel, interpolation of channels must be performed with the help of spectral correlation of neighboring color components [1]. Color image reconstruction quality depends on the used template for CFA and approach for demosaicing. In this context of color image reconstruction, various approaches have been proposed by the researchers to improve the color image reconstruction quality. Demosaicing approaches are classified into the following sub-categories: (a) Spatial domain approaches [2], (b) frequency domain based demosaicing [3], (c) chrominance channel interpolation [4] and (d) post-processing technique [5].

According to spatial domain demosaicing, missing values in green channels are interpolated using heuristic approach. This approach uses computation window such as 3×3 or 5×5 with second order gradient of chrominance value. According to frequency domain approach, in order to reconstruct G channel, a low pass filter is applied. In interpolation based approaches, pixel values of G channel are interpolated in an iterative way along with horizontal and vertical directions. In post-processing techniques, median filtering based approach is implemented to compute the difference between color pixel values to estimate the missing color component. But these approaches face challenges in terms of image reconstruction quality which is evaluated by computing CPSR.

To overcome all these issues related to image demosaicing, here in this work we propose sparse based RBF network construction to perform the demosaicing. According to this approach, input image is downsampled or normalized, and this downsampled image is used to construct the sparse image model. Furthermore to optimize this, we use RBF network construction by applying optimal weight prediction and computation.

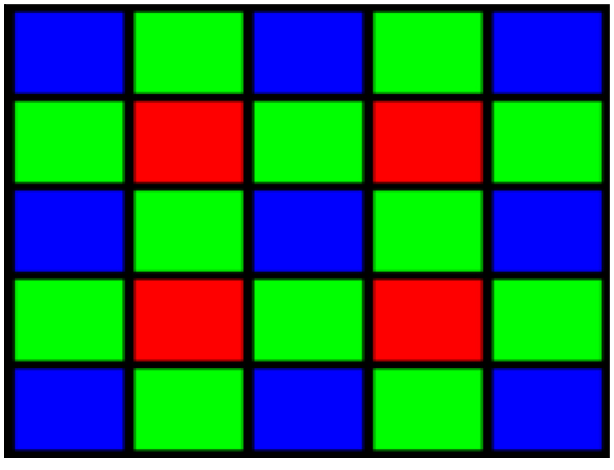

Figure 1 Bayer pattern.

Remainder of this manuscript is organized as follows: Section 2 describes the most recent related works in this field; proposed model is described in Section 2.1. Experimental study of proposed work is presented in Section 2.2 and finally conclusion is explained in Section 4.

2. Related work

This section describes about the other approaches which have been proposed by other researchers for color image demosaicing. As previous section describes about the interpolation based scheme for image demosaicing, based on this approach, Ye et al. [24] proposed a new approach based on the iterative method of residual interpolation. This approach shows more efficient outcomes when compared to residual based approach. One of the promising technique was proposed in [6] by Khashabi. This demosaicing is based on the machine learning technique. Performance of this was carried out by applying this on a publicly available dataset with ground truth. In this approach image modeling is introduced such a way that it performs better when noise is present in the image. This modeling is completed using machine learning methods which improve the performance in terms of PSNR and structural similarity. Another approach based on machine learning is presented in [7]. In this technique wavelet sub-band theory is used which improves the quality of color filter array (CFA).

Several Color image demosaicing algorithms have been proposed which require a reference image or ground-truth image. In [10,11], reference image based methods are discussed for image demosaicing. Lu et al. [9] proposed interpolation based scheme for demosaicing which consists of two steps. First step is to perform interpolation and second step is to perform post-processing. In order to overcome this, a new approach has been proposed in [8]. This work concentrates on two algorithms, in first algorithm, edge slope measurement, image sharpness and edge reconstruction accuracies are measured, in second algorithm, false color measurement, deviation estimation, color difference models and reconstruction for each channel is estimated. Lukac et al. [12], proposed an approach for image demosaicing using *PCA* (Principal Component Analysis). According to this approach, input image is zoomed first and then demosaicing is carried out. At this stage of processing, other algorithms for zooming and demosaicing can be utilized directly, but this approach faces challenge during zooming or demosaicing when performed separately, and at this time raw sensor data cannot be used effectively which results in low reconstructed image. According to CFA pattern, more information of image is stored in green channel of input image compared to other channels; half of the pixels in Bayer pattern are allocated in green channel. Detailed information can be extracted from the channel without aliasing effect on image. Main challenge is related to alignment of the pixels based on the regular distance which affects the correlation between channels [13]. Simplest method for image demosaicing is to fill the missing pixel values of each channel by applying bilinear or bicubic interpolation method [14]. Another approach based on interpolation scheme is presented by Dai-

Please cite this article in press as: V.N.V. Satya Prakash et al., Color image demosaicing using sparse based radial basis function network, Alexandria Eng. J. (2016), http://dx.doi.org/10.1016/j.aej.2016.08.032