CFA Demosaicking project intermediate report

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1 Introduction

Each pixel in a color image has a red, green, and a blue component. A camera can capture these RGB values for each pixel using beamsplitters to separate the light into red, green, and blue components while capturing the color intensities with 3 different CCDs as in the case with 3CCD, or by using layered photodiodes that are each sensitive to only one of the red, green, or blue components as in the Foveon X3 sensor. Many high-end cameras will employ one of those technologies, but the rest of the cameras use a single CCD sensor in conjunction with a color filter array (CFA). CCD sensors are not sensitive to specific wavelengths and will therefore require a filter to obtain the intensity of the wavelength of interest. There are many different CFA patterns that can be used, the most common of which is the Bayer filter, which has twice as many green filters as blue and red, mimicking the human eye response. Since each element of the CCD will capture the intensity of only one wavelength, we need a way to determine the two missing color values for each element. This process is called demosaicing. Basic methods for demosaicing involve using an interpolation filter, while more sophisticated methods will take advantage of spatial and spectral correlations of the pixels. When a picture is taken by a digital camera, a raw image file is produced, and a demosaicing algorithm stored in the camera's firmware will process the image.

For our project, we will implement the following algorithms: edge-directed interpolation, homogeneity-directed interpolation, and a linear minimum mean square error (LMMSE) based method. Each of these are what are called heuristic approaches. These approaches make certain assumptions about an image to simplify the filtering operations, as opposed to other approaches that involve solving optimization problems. Each approach is also adaptive; each method has control flow statements that direct the interpolation process. The original images we will use are Kodak PhotoCD images, high quality digital images that were scanned from film photographs, which are considered a benchmark in demosaicing images. These images did not need to be interpolated as the camera that captured them did not have a CFA. We will first need to downsample these images to a produce a Bayer filtered image, and then apply the demosaicing algorithms. The final results will be compared to the original images using metrics such as MSE, PSNR, and SSIM.

2 Methods

2.1 Edge-directed interpolation

The edge-directed method we will use first interpolates each of the missing green pixels. The vertical and horizontal luminance gradients are determined by the neighboring green pixel values. The size of the vertical or horizontal gradient tells us whether there is an edge in either direction. If there is a large gradient horizontally for example, then we infer there is a vertical edge, and therefore we interpolate based on the vertical neighbors. Once the green channel has been filled in, the second part of the method estimates the R and B values. It is assumed that there is a interchannel correlation such that the ratio or difference in two colors within in object is roughly constant. This constant-hue based approach will allow us to interpolate the R and B colors.

2.2 Homogeneity-directed interpolation

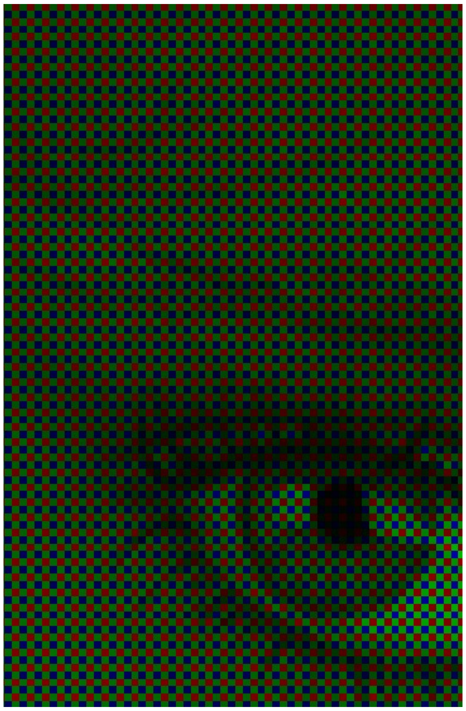
In homogeneity-directed interpolation, two separate images are produced by interpolating along either direction, i.e., horizontally and vertically. Each image is converted to a perceptually uniform color space such as CIELAB. Within this space, the pixels at each location in both copies are compared with their neighbors. A decision is then made between the two pixels, determined by which of the two has greater local homogeneity.

2.3 LMMSE

The LMMSE method estimates of a missing primary color sample in both horizontal and vertical directions then combines the two to reconstruct the channels, we can use any interpolation method to interpolate the missing green samples at red and blue pixel (in this case we used second-order Laplacian interpolation filter), then interpolate the missing red and blue samples at green samples, for details, please check LMMSE description

3 Experimental results

To demosaic an image, we first need an image with a mosaic pattern. We have created a function to downsample an input image to a Bayer mosaic pattern, as shown in the picture below. Feiyu is currently working on the LMMSE code and Steven is currently working on the edge-directed interpolation code in MATLAB.



Code

All code for this project can be found on our GitHub page:

https://github.com/tcswp/debayer

Division of Labor

The LMMSE method will be implemented and demonstrated by Feiyu Wang.

The edge- and homogeneity-directed methods will be implemented by Steven Hastings.