

Assignment 5

Color Image Processing

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This report examines the results of demosaicing Bayer patterns by bilinear interpolation and examines an algorithm for removing redeye from images.

Technical Discussion

Bayer Pattern

In the first part of this project, I implemented a demosaicing algorithm for a Bayer pattern. Bayer patterns allow color images to be captured on a single layer IC by capturing only one color channel per pixel, with half of the pixels containing green values, one quarter containing red values, and one quarter containing blue values. This is because the human eye has roughly twice as many green light receptors as red or blue light receptors. There are many methods of demosaicing (combining) Bayer patterns into color images. In this project, I implemented a bilinear method.

First, the pixels must be masked into the correct color channel. The masks are generated using the modulus operator to create alternating patterns of zeros and ones. Multiplying the original image by the masks results in three color channels, but each pixel only has a value for one channel. In order to fill in the missing values, bilinear smoothing was used. The bilinear method, as described in (1), can be implemented using three filtering kernels, one each for the red, green and blue channels. These filter kernels are shown in Figure 1.

1	2	1
0	4	0
1	2	1

0	1	0
1	4	1
0	1	0

1	0	1
2	4	2
1	0	1

Figure 1: Bilinear Filtering Kernels for Red (l), Green (m), and Blue(r) channels (each kernel is divided by 4 to scale values).

Redeye Correction

Redeye is a common problem in images taken with flash. The blood vessels in the back of the pupil make reflect the flash back red, making the eye appear red. Microsoft (2) developed a method for correcting redeye using two aligned images, one taken with flash and one without. I implemented a variant on this method.

First, the two images are converted to YCbCr color space. Then the Cr (chroma) channel of the no-flash image is subtracted from that of the flash image to give a grayscale image representing the difference in "redness" between the two images. Using the YCbCr color space allows a simple comparison of "redness" to be made independent of brightness. This would be very difficult in HSI color space, but could probably be accomplished in RGB color space if the red channel of each image were first normalized by the overall brightness of the image.

Performing a threshold operation on the difference image results in a mask that shows only the pupils in the image. Once the mask is created, the color of the pupils is replaced using the method described in (3). The color is removed from the area identified by the mask, leaving only a grayscale image of the pupil, which is then darkened.

Results

Bayer Pattern



Figure 2: Result of Bayer pattern demosaicing (left) and true image (right)

As shown in Figure 2, the result of the Bayer algorithm is a color image that looks similar to the original. However, there are artifacts of the conversion process visible throughout the image. Figure 3 shows a close-up of these artifacts, a series of green dots in a regular pattern through the image. Although I checked my algorithm many times, I cannot find a cause for these dots, and have concluded that they are a normal artifact of bilinear demosaicing of Bayer patterns. I noticed that these artifacts only appear in the red and blue channels, which would be consistent with an error in the way I implemented bilinear interpolation, but I cannot seem to find the error.



Figure 3: Linear interpolation artifacts (errors?)

Redeye Correction

The redeye correction algorithm took a small amount of tuning to get right. The Microsoft paper uses a threshold of .05 to segment the chroma difference, but I found that adjusting the threshold to .12 would directly give me a mask (at least for my test images). I also found that attenuating the grayscale values for the pupils by a factor of .8 was not enough--the eyes looked too washed out. Instead, I used a factor of .5 to get darker pupils. The results of the algorithm can be seen in figure 4.



Figure 4: An image taken with flash, before (left) and after (right) redeye correction.

Appendix

Scripts

`demosaic.m` - Performs demosaicking of Bayer pattern in `bayerimg.mat` by linear interpolation and outputs result to `output/demosaic_result.png`.

`redeye.m` - Performs redeye removal by a variant on the method described in Petschnigg et al. and outputs result to `output/redeye_result.png`.

Images

`bayerimg.mat`

`flash.jpg`

`noflash.jpg`

Output directory – Outputs of both scripts

Works Cited

1. *Demosaicking methods for Bayer color arrays*. **Ramanath, Rajeev, et al.** 3, s.l. : Journal of Electronic Imaging, 2002, Vol. 11.
2. *Digital Photography with Flash and No-Flash Image Pairs*. **Petschnigg, Georg, et al.** s.l. : ACM Transactions on Graphics, 2004.
3. *Automatic Digital Redeye Reduction*. **Patti, Andrew, et al.** s.l. : IEEE International Conference on Image Processing, 1998.