

Image analysis course SICOM 3A - Project report

Problem Statement

The project revolves around the concept of image demosaicking, a process that is integral to digital imaging. Many commercial RGB cameras employ a technology known as Color Filter Array (CFA). This technology overlays an array of red, green, or blue filters over the sensors, typically arranged in periodic patterns. As a result, the incident light is filtered by each filter before being captured by the sensor. The pixels on the sensor will only acquire one color (red, green, or blue), leading to a raw acquisition that is a grayscale image.

The challenge posed by this project is to perform demosaicking, i.e., to recover all the missing colors for each pixel and thereby reconstruct the full RGB image. The task is to reconstruct four images using only the raw acquisition (grayscale image) and the forward operator that models the effect of a CFA camera with two different CFA patterns: Bayer or Quad Bayer pattern.

Proposed Solution

To address this problem, I decided to employ an iterative residual interpolation technique. This method is a powerful tool in image processing and has been successfully applied in various image reconstruction tasks.

This solution is described in the 2014 Wei Ye and Kai-Kuang Ma's paper for their method called "IMAGE DEMOSAICING BY USING ITERATIVE RESIDUAL INTERPOLATION" [1].

Iterative residual interpolation is a two-step process. The first step involves an initial interpolation of the missing pixels in the CFA image. The second step is an iterative process where the residuals between the original and the interpolated images are computed and then used to correct the initial interpolation. This process is repeated until the residuals are minimized, or a certain number of iterations have been reached.

The strength of this method lies in its iterative nature, which allows it to progressively refine the image and fill in the missing color information. This approach is particularly suitable for our task as it can effectively recover the full RGB image from the grayscale image acquired from the CFA camera.

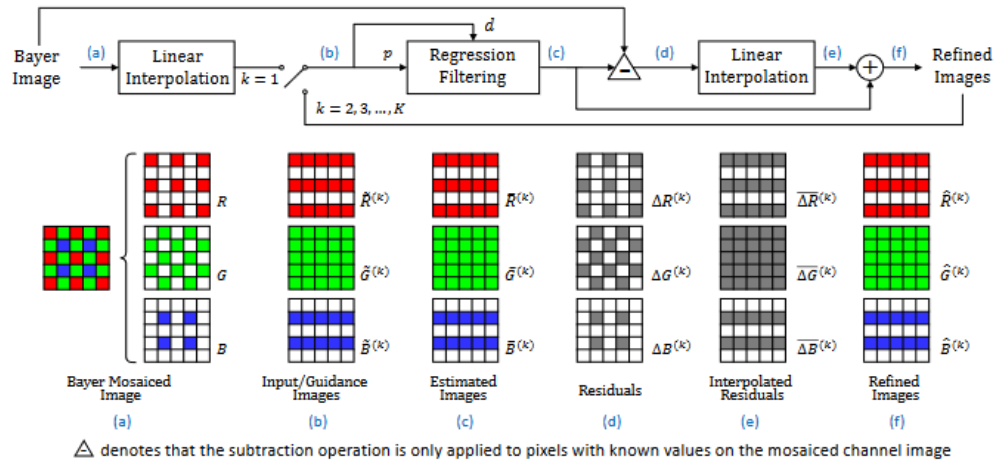


Figure 1 : Principle of the method for the horizontal treatment. [1]

Solution

We can see through the different steps the work of the method on a crop of the image :

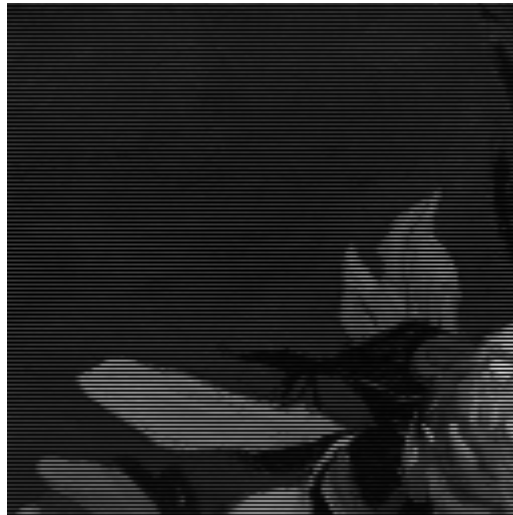


Figure 2 : Red component of the horizontal interpolated image, also the input image for the horizontal pipe. (b)



Figure 3 : Red component of the estimated image in the horizontal pipe. (c)

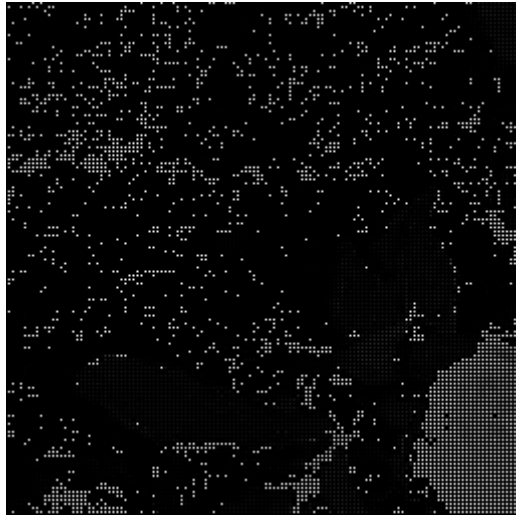


Figure 4 : Red component of the residuals in the horizontal pipe. (d)



figure 5 : Red component of the refined image. (f)



Figure 6 : Complete output after combining horizontal and vertical images.

So I implemented the method of the paper [1] as best I could. The ending method for combining the vertical and horizontal component is not well described in the paper so I just used an average for the common pixels and an interpolation of the four neighboring pixels for the missing ones. Same for the stopping criterion so I used only one iteration because running more times added some artifacts.

To understand how the method works, we can see on figure 4 that there are some residuals, meaning that there is some difference between the green spatial behavior and what we know of the red one. So then we correct with the interpolated residuals.

Results

	PNSR	SSIM
img_1	34.70315595208797	0.9489487822565587
img_2	30.83190248655848	0.8410090656352537
img_3	32.18434640883621	0.89198211247641
img_4	30.39997730730247	0.8122187328552791



Figure 7 : Result on img_1

Conclusion

The system works well because we have significantly better results compared to the baseline solution in the project; but doing the process multiple times as it is told in the paper [1] should improve the result, but it was not the case for my tests, so there is probably something I misunderstood in the method that I implemented badly.

More generally what could be improved could be the speed of the process because it is interesting to put this process inside a camera and have instantaneously the result when taking the picture not in raw format.

References :

[1] Wei Ye and Kai-Kuang Ma, "IMAGE DEMOSAICING BY USING ITERATIVE RESIDUAL INTERPOLATION", IEEE 2014. [Here is a link](#)