CS 448I Project Proposal
Exploring and Comparing Methods of Demosaicing
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Overview and Motivation

Most commercial cameras utilize color filter arrays (CFAs), which in turn require demosaicing. Linear methods of demosaicing images are not robust against color artifacts. This was apparent in our second assignment, when linear methods of demosaicing the Kodak dataset's lighthouse image still left intense color artifacts in the fence, and wall, as well as some smaller artifacts in the bricks of the lighthouse.

In an effort to see how other methods that might resolve these kinds of artifacts, we will implement three others' approaches to demosaicing and compare them to a localized baseline — high-quality linear interpolation, as outlined in Malvar et al. 2004. We will then stress test these methods by finding or generating our own images to analyze weaknesses in these non-local approaches. Finally, time-permitting, we will take our own approach or put a twist on an existing approach to try to correct for weaknesses that we encounter.

Related Work

In "Color image demosaicking: An overview" Menon et al. 2011 presented current demosaicing techniques: (1) heuristic methods, such a adaptive interpolation, pattern matching, and weighted sums, (2) directional interpolations, (3) frequency domain approaches, (4) wavelet-based methods, (4) reconstruction approaches, and (5) joint approaches with denoising, zooming, and super-resolution. Some of these techniques are mentioned later in this section. Menon additionally mentions issues with the Kodak dataset itself, noting that the images are outdated and expressing the need to evaluate methods on RAW images. In Andriani et al. 2013, a new set of images were proposed to better represent modern photographic needs. In Bonanomi et al. 2018, another set of images were proposed as well.

Buades et al. 2009, "Self-similarity driven color demosaicking," presents an algorithm that first fills in missing colors through assessing similarity of non-local neighborhoods. They then perform a chromatic regularization step. This process is repeated multiple times with a resolution parameter. This method was found to work reasonably well at reducing color artifacts through relying on self-similarity.

Another non-local demosaicing approach is "Color demosaicking by local directional interpolation and nonlocal adaptive thresholding" by Zhang et al. 2011, which describes local directional interpolation in the green channel followed by non-local adaptive thresholding. They then do a local directional interpolation of the red and blue channels using the green channel, and then apply not local adaptive thresholding again. They additionally suggest a method using non-local means instead of non-local adaptive thresholding.

Finally, "Demosaicing by successive approximation" by Li et al. 2005, suggests a method of iteratively updating the red/blue channel and then the green channel, only stopping when a criterion has been satisfied. The update is determined by a 3x3 grid, while the criterion is based on correction color misregistration and zipper artifacts. The criterion adapts to areas with low and high aliasing, focusing on classifying pixels as high or low aliased regions, calculating the difference between pixel colors between iterations, and terminating if the threshold reaches a specific threshold.

Project Overview

We plan to implement and compare the performance of several different demosaicing algorithms on the images of both the Kodak dataset as well as either the Bonanomi or Andriani dataset, although we are having difficulty accessing the latter. Each method will be evaluated qualitatively and quantitatively, using the PSNR as our quantitative measurement.

We will implement three different methods of demosaicing:

- Self-similarity (Baudes et al. 2009)
- Local directional interpolation and nonlocal adaptive thresholding (Zhang et al. 2011)
- Demosaicing by successive approximation (Li et al. 2005)

If needed, we will try to derive our own images to stress-test these algorithms or pull them from other image sets mentioned in other papers. Finally, time permitting, we will then either tweak an existing approach or implement our own approach to try to counter the weaknesses we find in these other approaches. We are particularly interested in iterative techniques involving non-local similarity, as well as possible probabilistic graph-based approaches, although we're uncertain if these will be tractable or feasible in our timeframe.

Milestones and Timeline

1. **Week 0-1:** Simulate bayer patterning for all images in the Kodak and/or Andriani datasets. Generate baseline images using Matlab's Demosaicing function. Calculate PSNR for each image.
2. **Week 1-2:** Implement three algorithms mentioned in project overview. Qualitatively and quantitatively compare performance to the baseline.
3. **Week 2-3:** Find and/or take photos to stress-test the algorithms, comparing performance of implemented algorithms with the baseline.
4. **Week 3-4:** Inspiration and time-permitting, implement our own demosaicing algorithm or alter another approach to better resolve any found weaknesses.

References

Andriani, S., Brendel, H., Seybold, T., & Goldstone, J. (2013, September). Beyond the Kodak image set: A new reference set of color image sequences. In 2013 IEEE International Conference on Image Processing (pp. 2289-2293). IEEE.

Bonanomi, C., Balletti, S., Lecca, M., Anisetti, M., Rizzi, A., & Damiani, E. (2018). I3D: a new dataset for testing denoising and demosaicing algorithms. Multimedia Tools and Applications, 1-28.

Buades, A., Coll, B., Morel, J. M., & Sbert, C. (2009). Self-similarity driven color demosaicking. IEEE Transactions on Image Processing, 18(6), 1192-1202.

Li, X. (2005). Demosaicing by successive approximation. IEEE Transactions on Image Processing, 14(3), 370-379.

Malvar, H. S., He, L. W., & Cutler, R. (2004, May). High-quality linear interpolation for demosaicing of bayer-patterned color images. In 2004 IEEE International Conference on Acoustics, Speech, and Signal Processing (Vol. 3, pp. iii-485). IEEE.

Menon, D., & Calvagno, G. (2011). Color image demosaicking: An overview. Signal Processing: Image Communication, 26(8-9), 518-533.

Wang, G. G., Zhu, X. C., & Gan, Z. L. (2012, October). Image demosaicing by non-local similarity and local correlation. In 2012 IEEE 11th International Conference on Signal Processing (Vol. 2, pp. 806-810). IEEE.

Zhang, L., Wu, X., Buades, A., & Li, X. (2011). Color demosaicking by local directional interpolation and nonlocal adaptive thresholding. J. Electronic Imaging, 20, 023016.