RESIDUAL INTERPOLATION FOR COLOR IMAGE DEMOSAICKING

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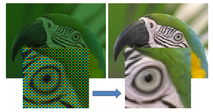
Source code is available!
http://www.ok.ctrl.titech.ac.jp/res/DM/RI.html

Introduction

- A **demosaicking** process plays a crucial role to acquire a high-quality color image.
- Researches on the demosaicking algorithm for the **Bayer CFA** have a long history.

Bayer CFA.



Demosaicking process.

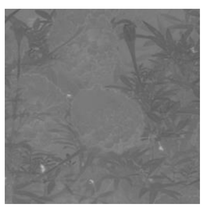
- A **color difference interpolation** technique is widely used.

We propose **residual interpolation** instead of color difference interpolation.

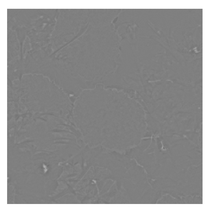
Main idea

- **Observation of the color difference**
  - The color difference image is likely to be flat since all color bands have very similar image structures.
    → This makes the interpolation process easy.
- **Motivation**
  - **A flatter image than the color difference image makes the interpolation easy.**
    → We generate a **residual image**, which is flatter than the standard color difference image.

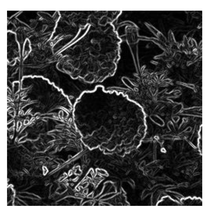
R band image



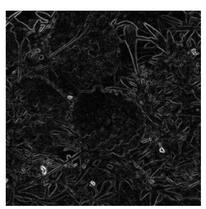
Color difference (R-G) image*



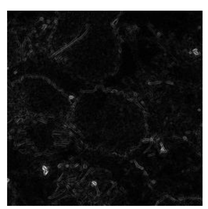
Residual (R-$\check{R}$) image*



R band gradient image



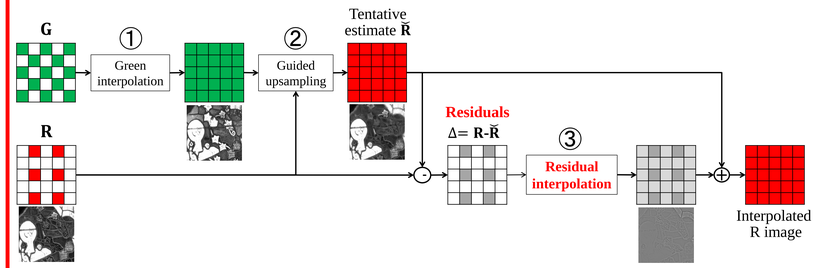
Color difference gradient image



Residual gradient image

* Normalized for visual comparison.

Proposed algorithm



The outline of our proposed algorithm.

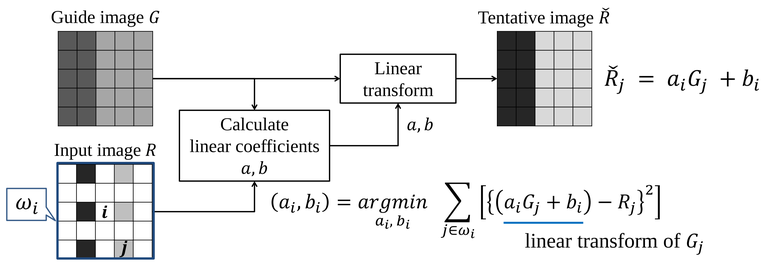
① Green interpolation

- We incorporate the residual interpolation into the GBTF [1] algorithm.
- The GBTF algorithm uses the Hamilton and Adam's interpolation, which is a color difference interpolation.

→ We replace the color difference interpolation with the residual interpolation.

② Guided upsampling

- We generate the tentative estimate by using the guided filter [2].
- For each local window, the tentative estimate is represented by a linear transform of the interpolated G image [3].



(a_i, b_i) are the linear coefficients, a_i is a gain component, b_i is a DC component.

Generation of the tentative estimate $\check{R}$ by the guided filter.

③ Residual interpolation

- We interpolate the residuals by bilinear interpolation.

References

[1] I. Pekkucuksen and Y. Altunbasak, "Gradient based threshold free color filter array interpolation," *ICIP*, 2010.
[2] K. He, J. Sun, and X. Tang, "Guided image filtering," *ECCV*, 2010.
[3] Y. Monno, M. Tanaka, and M. Okutomi, "Multispectral demosaicking using guided filter," *Proc. of SPIE*, 2012.
[4] X. Li, B. Gunturk, and L. Zhang, "Image demosaicing: a systematic survey," *Proc. of SPIE*, 2008.

Experimental results

- Algorithms : AHD, DLMMSE, LPA, LDI-NAT, GBTF, Proposed
- Datasets : IMAX 18 images, Kodak 12 images [4]

PSNR and CPSNR comparison

IMAX 18 images

Algorithms	PSNR [dB] R	PSNR [dB] G	PSNR [dB] B	CPSNR [dB]
AHD	33.00	36.98	32.16	33.49
DLMMSE	34.03	37.99	33.04	34.47
LPA	34.36	37.88	33.30	34.72
LDI-NAT	**36.28**	39.76	34.39	36.20
GBTF	33.48	36.59	32.71	33.89
Proposed	36.09	**40.01**	**35.38**	**36.49**

Kodak 12 images

Algorithms	PSNR [dB] R	PSNR [dB] G	PSNR [dB] B	CPSNR [dB]
AHD	38.81	40.84	38.42	39.22
DLMMSE	41.17	43.94	40.51	41.62
LPA	41.66	44.46	41.00	42.12
LDI-NAT	38.30	40.49	37.94	38.77
GBTF	**41.71**	**44.85**	**41.01**	**42.21**
Proposed	39.74	42.21	38.90	40.05

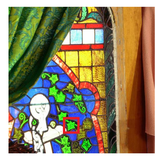
IMAX+Kodak 30 images

Algorithms	PSNR [dB] R	PSNR [dB] G	PSNR [dB] B	CPSNR [dB]
AHD	35.32	38.52	34.66	35.78
DLMMSE	36.89	40.37	36.02	37.33
LPA	37.28	40.51	36.38	37.68
LDI-NAT	37.09	40.05	35.81	37.23
GBTF	36.77	39.89	36.03	37.22
Proposed	**37.55**	**40.89**	**36.79**	**37.92**

Running time per one image

Algorithms	Running time [s] 500*500 (IMAX)	Running time [s] 768*512 (Kodak)
AHD	30.10	45.60
DLMMSE	23.94	37.73
LPA	1.51	3.46
LDI-NAT	1387.66	2172.51
GBTF	0.11	0.17
Proposed	1.22	2.01

Visual comparison



IMAX

Original

AHD : 31.28dB

DLMMSE : 32.19dB

LPA : 32.33dB

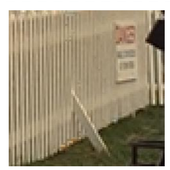
LDI-NAT : 33.22dB

GBTF : 32.09dB

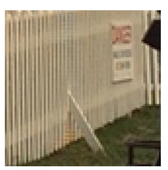
Proposed : 33.26dB

Lighthouse of Kodak

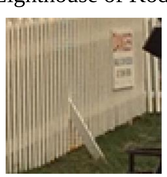
Original



AHD : 41.12dB



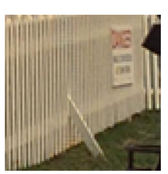
DLMMSE : 42.14dB



LPA : 42.97dB

LDI-NAT : 35.38dB

GBTF : 42.81dB



Proposed : 41.57dB