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Resampling Method with Color Image Decomposition

Gwanggil Jeon

Department of Embedded Systems Engineering, Incheon National University
119 Academy-ro, Yeonsu-gu, Incheon 406-772, Korea
gjeon@incheon.ac.kr

Abstract

The lossy compression approaches accept some loss of information and data that have been compressed using lossy methods normally cannot be restored perfectly. While accepting this error in the restoration, one can attain efficient method and obtain higher compression ratios. In this paper, we study the method to compress RGB image in YCbCr color space. By using chroma subsampling approach, we reduce data size while the loss of information is not much.

Keywords: *Sampling, color space, YCbCr image, decomposition*

1. Introduction

The data compression is necessary for digital image processing, where data compression encodes information with fewer bits that the actual representation [1-3]. There are two compression categories: lossy compression approach and lossless compression approach. The later represents information with decreased bits by distinguishing and removing redundancy [4-7]. There are three redundancy categories: spatial, temporal and statistical, and normally statistical redundancy is reduced by data compression. On the other hand, the former approach does not use data compression, and the original information is well preserved [8]. The procedure of decreasing the size of a data file is mentioned as data compression.

The lossy compression methods include some loss of information and data that have been compressed using lossy methods normally cannot be restored perfectly [9-11]. While tolerating this deformity in the reconstruction, we can achieve much higher compression ratios which is available with lossless compression. Generally speaking, the lack of perfect reconstruction is not an issue because human eyes are not very sensitive for very high-frequency information. Therefore, images are normally compressed and coded using lossy compression. The goal of image compression is to decrease redundancy of the image data. Although original information is reduced, the data compressed form is efficient for transmitting or storing [12-14].

In this paper, we study how we compress color images in YCbCr color space. Particularly, we use chroma subsampling method, which considers the fact that the human eye is more sensitive to the luminance than chrominance. Therefore, it is better to decrease chrominance information that that of luminance information.

This paper is arranged as follows. Section 2 describes the proposed method. Simulation results are shown in Section 3, where objective and subjective performance comparison are displayed. Finally, conclusion remarks are shown in Section 4.

2. Proposed Method

An RGB image can be transformed into YCbCr, where Y and CbCr are luminance and chrominance components, respectively. The luminance component shows a black and white image which includes white, black and shades of grey. The luminance component is

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shown as changing brightness. On the other hand, the chrominance component shows the color information in an image. The full RGB image can be split into YCbCr with following equation [15-17]:

$$\begin{aligned} R &= Y + 1.402(C_R - 128) \\ G &= Y - 0.34414(C_B - 128) - 0.71414(C_R - 128) \\ B &= Y + 1.772(C_B - 128) \end{aligned} \quad (1)$$

$$\begin{aligned} Y' &= 0 + (0.299R_D') + (0.587G_D') + (0.114B_D') \\ C_B &= 128 - (0.168736R_D') - (0.331264G_D') + (0.5B_D') \\ C_R &= 128 + (0.5R_D') - (0.418688G_D') - (0.081312B_D') \end{aligned} \quad (2)$$

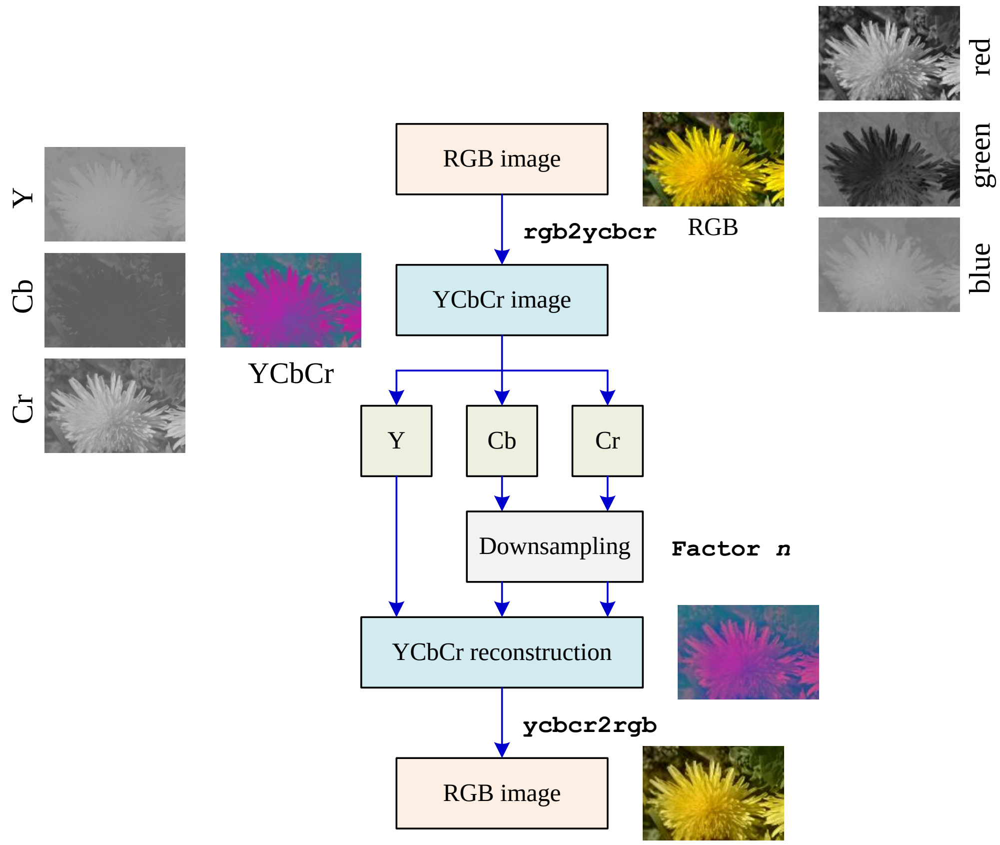


Figure 1. The Flowchart of the Presented Approach

Figure 1 shows a process of the proposed method (5 Steps). The proposed system works as follows:

Step 1

Apply gamma correction and white balance process, and obtain RGB image. The RGB image can be decomposed into three color components, red, green and blue.

Step 2:

The given RGB image is transformed into YCbCr using Eq. (2).

Step 3:

The transformed YCbCr image is decomposed into Y, Cb, and Cr. The downsampling process (with factor of n) is applied to Cb and Cr, while Y component is well preserved as human eyes are more sensitive to luminance component. The factor n is even number.

Step 4:

The processed Cb' and Cr' components are reunited with Y component, and YCbCr image is re-generated.

Step 5:

The result RGB image is obtained using Eq. (1) on YCbCr image.

Note that rgb2ycbcr and ycbcr2rgb commands were used for transforming RGB to YCbCr and YCbCr to RGB.

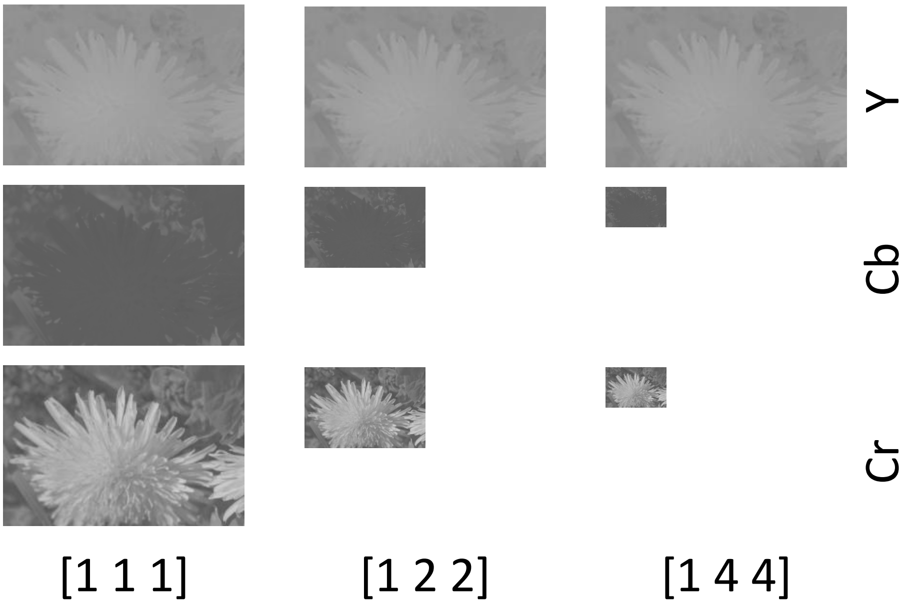
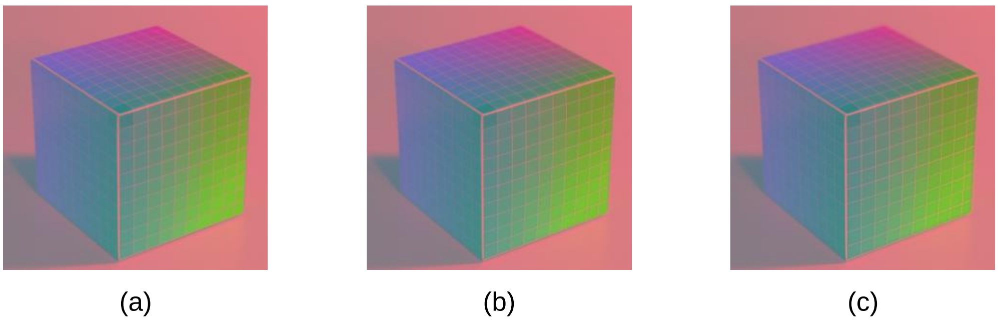
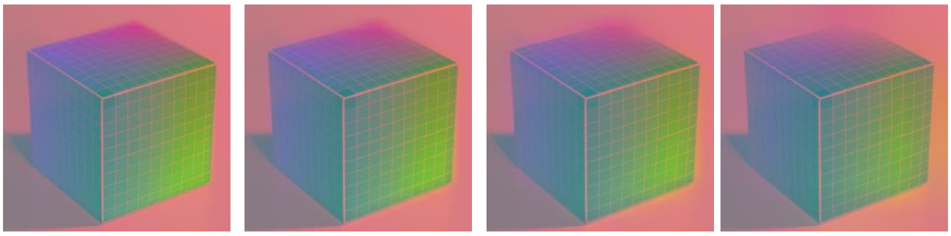


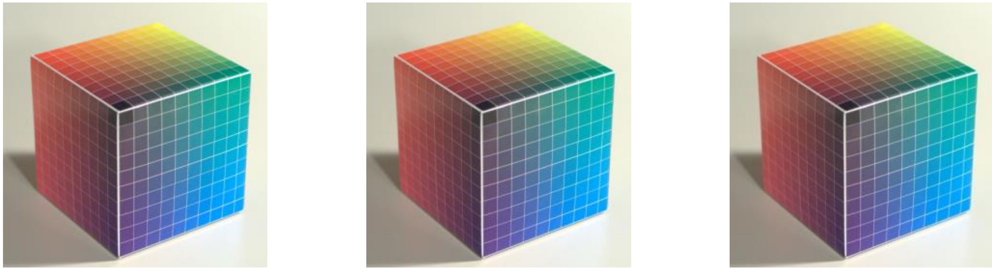
Figure 2. [1 *n n*] Configuration for YCbCr Image



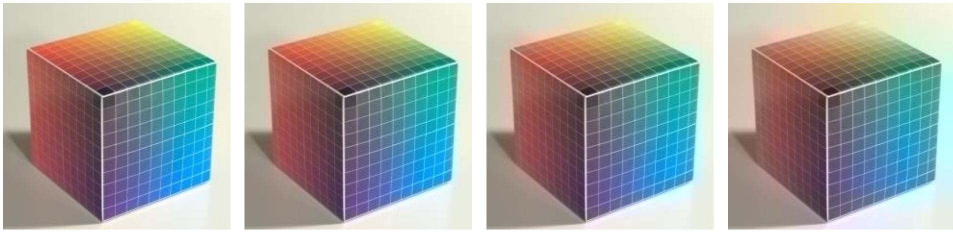


(d) (e) (f) (g)

Figure 2. YCbCr Image on 22nd Test Image: (a) Original, (b) *n*=2, (c) *n*=4, (d) *n*=8, (e) *n*=16, (f) *n*=32, and (g) *n*=64.



(a) (b) (c)



(d) (e) (f) (g)

Figure 3. RGB Image on 22nd Test Image: (a) Original, (b) *n*=2, (c) *n*=4, (d) *n*=8, (e) *n*=16, (f) *n*=32, and (g) *n*=64.

We used [1 *n n*] configuration, where Cb and Cr images are halved or quartered when *n*=2 or *n*=4.

Figure 2 shows YCbCr images of 22^{nd} test image. Figure 2(a) is the original YCbCr image and we changed *n* as 2, 4, 8, 16, 32, and 64, respectively, and they are shown in Figs. 2(b-g). From Figure 3, it can be found that color information is faded away as *n* is increasing. For example, Figure 2(g) is the result of *n*=64 and its corresponding RGB image is shown in Figure 3. Color in Figure 3(g) is much vivid than Figure 3(b), which used *n*=2.

3. Simulation Results

We used 25 Zahra dataset for our experiments. We used two metrics, PSNR and S-CIELAB to evaluate objective performance. In addition, we provide result images to assess subjective performance.

Figure 4 has four graphs, each of them indicates red component, green component, blue component, and color PSNR results. It can be found that smaller *n* provides higher PSNR and lower S-CIELAB results throughout all red, green and blue components.

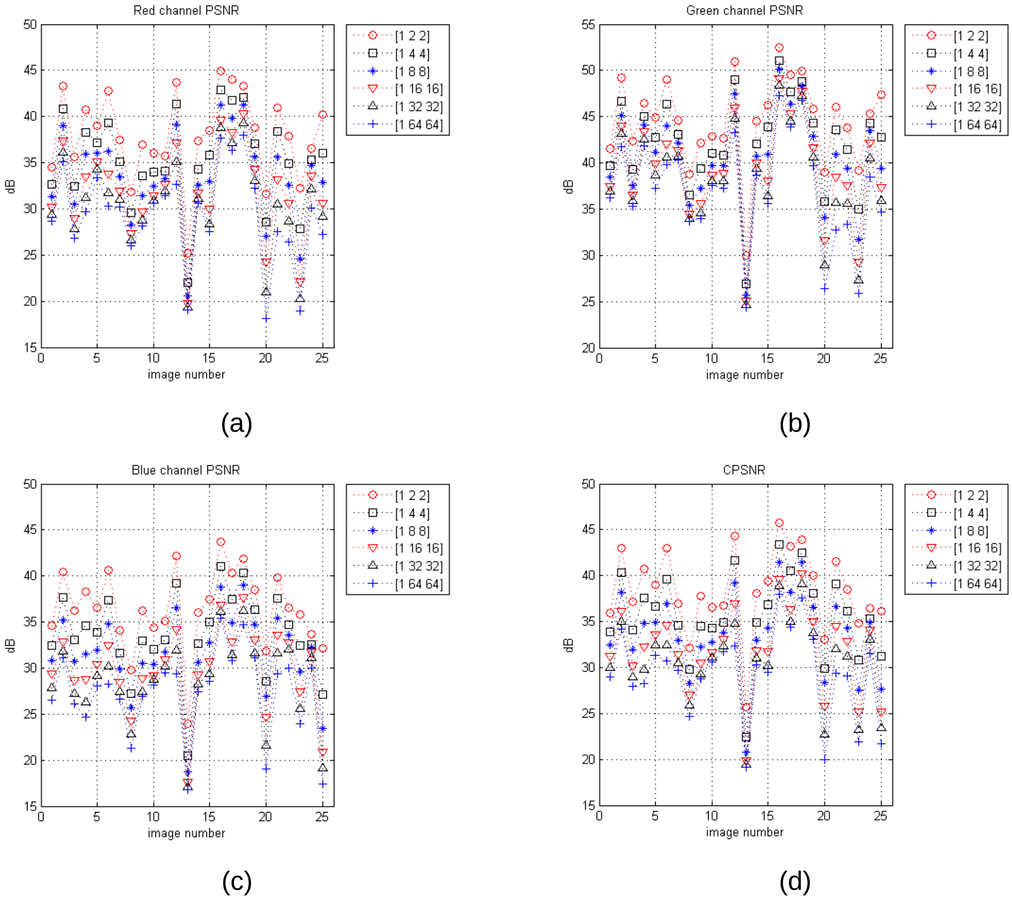


Figure 4. PSNR Evaluation for different Configurations: (a) Red Channel, (b) Green Channel, (c) Blue Channel, and (d) Color Image.

Tables 1 and 2 show numerated PSNR and S-CIELAB results. As we can see, smaller *n* gives higher PSNR and lower S-CIELAB values.

Table 1. CPSNR Results with Different Configuration (in dB)

	[1 2 2]	[1 4 4]	[1 8 8]	[1 16 16]	[1 32 32]	[1 64 64]
1	35.898	33.903	32.418	31.179	29.978	28.953
2	43.023	40.349	38.141	36.091	34.974	34.159
3	37.179	34.055	31.930	30.202	28.954	27.943
4	40.723	37.540	34.814	32.198	29.742	28.211
5	38.995	36.643	34.935	33.582	32.418	31.333
6	42.944	39.637	36.943	34.563	32.444	30.711
7	36.956	34.602	32.922	31.474	30.457	29.679
8	32.130	29.737	28.247	27.033	25.876	24.634
9	37.766	34.514	32.209	30.514	29.321	28.792
10	36.572	34.316	32.769	31.633	31.163	30.631

11	36.787	34.915	33.802	33.030	32.358	31.697
12	44.287	41.614	39.202	36.957	34.839	32.315
13	25.715	22.408	20.804	19.846	19.404	19.111
14	38.037	34.854	32.960	31.885	31.038	30.291
15	39.418	36.846	34.288	31.762	30.223	29.434
16	45.706	43.350	41.441	39.635	38.865	37.960
17	43.231	40.562	38.224	36.362	35.012	34.373
18	43.902	42.514	41.435	40.276	39.086	37.575
19	40.037	38.101	36.512	35.034	33.755	33.045
20	33.085	29.935	28.315	25.818	22.712	19.964
21	41.589	39.118	36.680	34.499	32.080	29.406
22	38.470	36.121	34.329	32.818	31.192	29.065
23	34.836	30.763	27.564	25.184	23.285	21.931
24	36.430	35.284	34.859	34.117	33.066	31.502
25	36.154	31.239	27.640	25.177	23.419	21.724
Average	38.395	35.717	33.736	32.035	30.626	29.377

Table 2. S-CIELAB Results with different Configuration

	[1 2 2]	[1 4 4]	[1 8 8]	[1 16 16]	[1 32 32]	[1 64 64]
1	0.9640	1.5796	2.3063	3.2415	4.3838	5.7846
2	0.3767	0.6505	1.0647	1.7055	2.3230	2.8804
3	0.7137	1.3144	2.1265	3.3207	4.5638	5.5856
4	0.5114	0.8843	1.4590	2.4726	4.0072	5.7303
5	0.8258	1.5051	2.3844	3.5818	5.0911	6.6578
6	0.4271	0.8010	1.3505	2.2586	3.3554	4.5217
7	1.1068	1.6356	2.2045	2.9832	3.8433	4.7024
8	1.0404	1.8895	3.0888	5.2005	8.2978	11.4948
9	0.8444	1.5092	2.4064	3.5675	4.9260	5.8240
10	1.0769	1.6432	2.1649	2.7711	3.3174	4.0885
11	0.8966	1.4412	2.0114	2.7152	3.5725	4.5378
12	0.4327	0.7541	1.1963	1.8475	2.8035	4.3022
13	4.8825	8.4421	11.5021	14.7243	17.0780	18.9101
14	0.8720	1.5544	2.3471	3.2805	4.4588	5.7668
15	0.5139	0.9559	1.7204	2.9261	4.1311	4.9846
16	0.1864	0.3123	0.4769	0.7355	0.9601	1.3104

17	0.4931	0.8363	1.3170	1.9559	2.6732	3.1311
18	0.2471	0.3879	0.5491	0.8161	1.1982	1.7001
19	0.5349	0.8942	1.4183	2.1749	2.9371	3.3380
20	0.9279	1.6545	2.8586	5.4636	9.6268	15.5739
21	0.4612	0.8288	1.4793	2.5660	4.4804	7.9702
22	0.6487	1.0795	1.6011	2.3377	3.5192	6.1465
23	0.9881	1.9495	3.5577	6.1109	9.5117	13.8350
24	0.5235	0.7679	1.0258	1.5221	2.3393	3.4060
25	0.8254	1.6697	2.8587	4.1415	5.5199	7.4666
Average	0.8529	1.4776	2.2590	3.3768	4.7567	6.3860

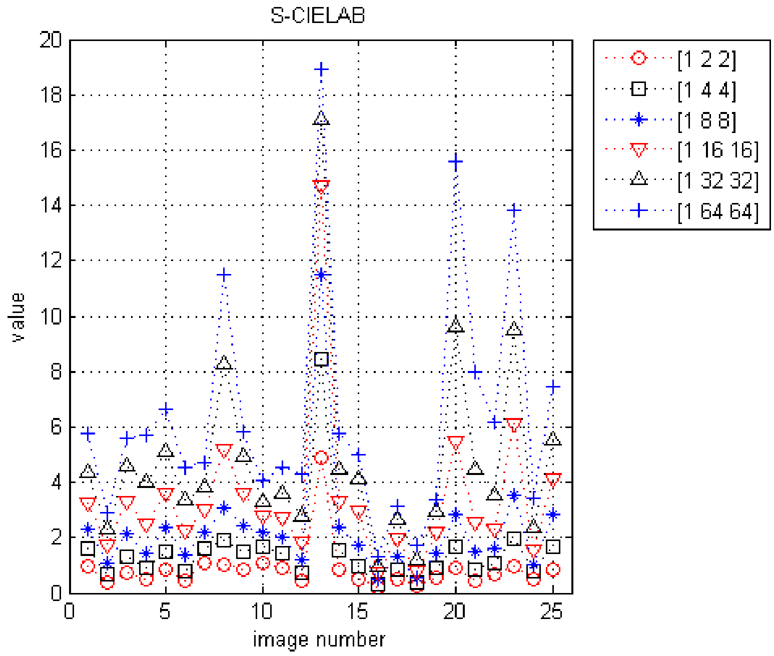


Figure 5. S-CIELAB Evaluation for different Configurations

The visual performance comparison results are displayed in Figs. 6-8. We used three Zahra test images, #13, #14, and #20. All images located in the left side are RGB images, and all image shown in the right side are YCbCr images. Due to the space, we only displayed four configurations: [1 4 4], [1 16 16], and [1 64 64]. As we have bigger parameter *n*, result images lose color information.

4. Conclusion

The lossy compression methods tolerate some loss of information and data that have been compressed using lossy methods which cannot be reconstructed. In this paper, we studied image compression method which reduced the size of image by downsampling chrominance channels. Subjective and objective performance comparisons were provided.

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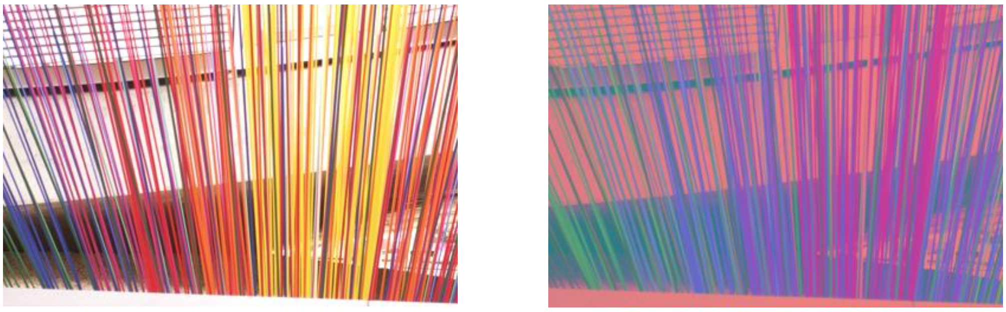
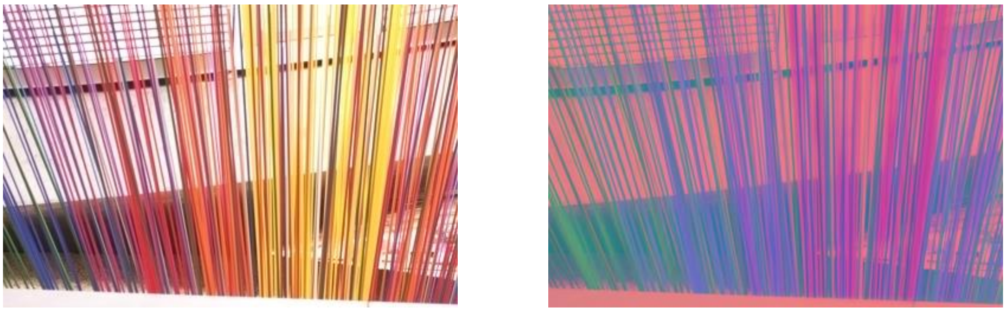
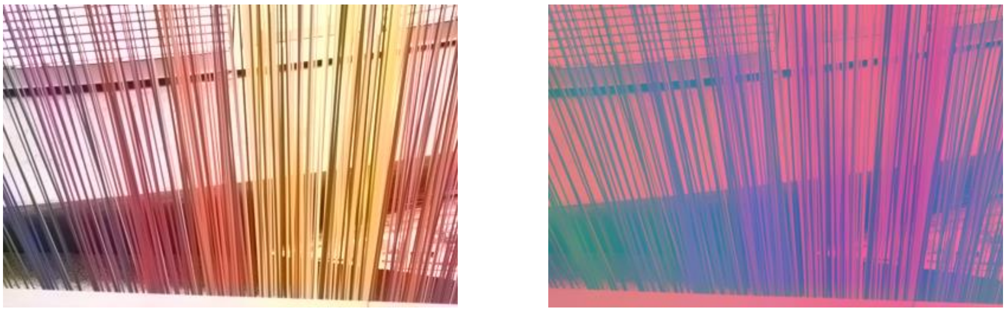


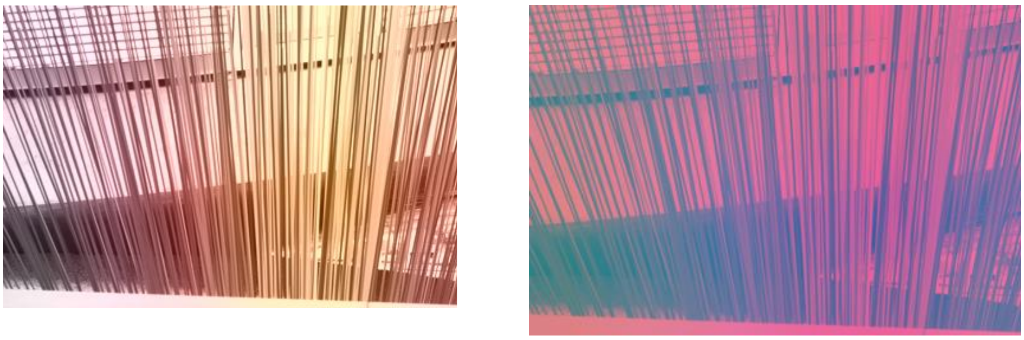
(a)



(b)



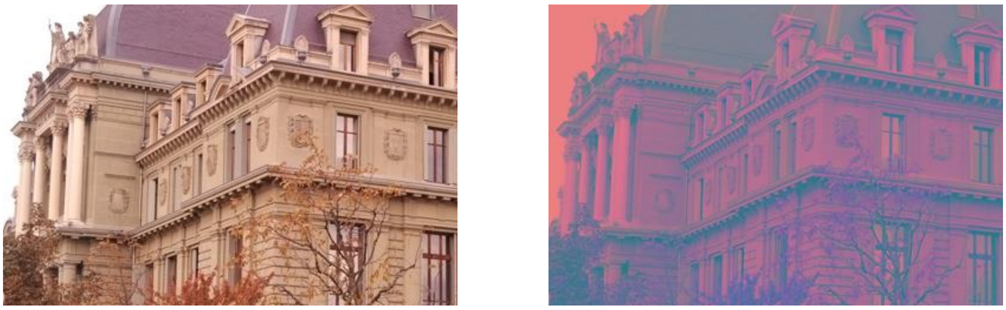
(c)



(d)

Figure 6. 13th RGB and YCbCr Images: (a) Original, (b) [1 4 4] Configuration, (c) [1 16 16] Configuration, and (d) [1 64 64] Configuration

(a)

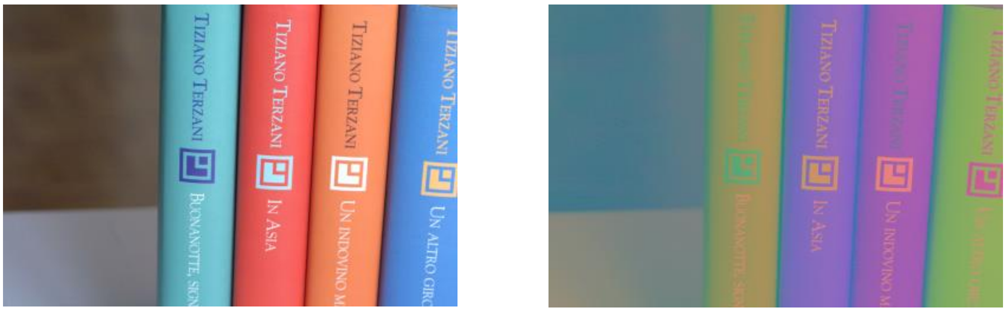


(b)

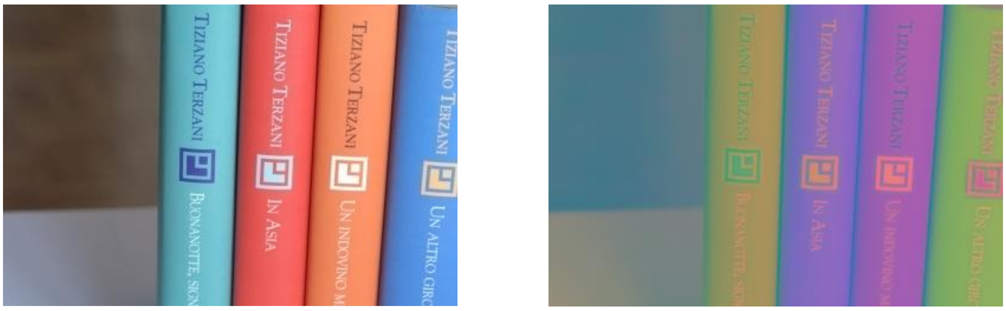
(c)

(d)

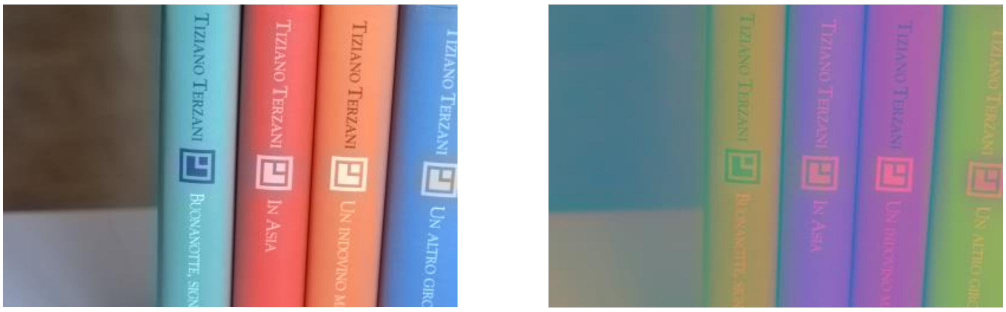
Figure 7. 14th RGB and YCbCr Images: (a) Original, (b) [1 4 4] Configuration, (c) [1 16 16] Configuration, and (d) [1 64 64] Configuration



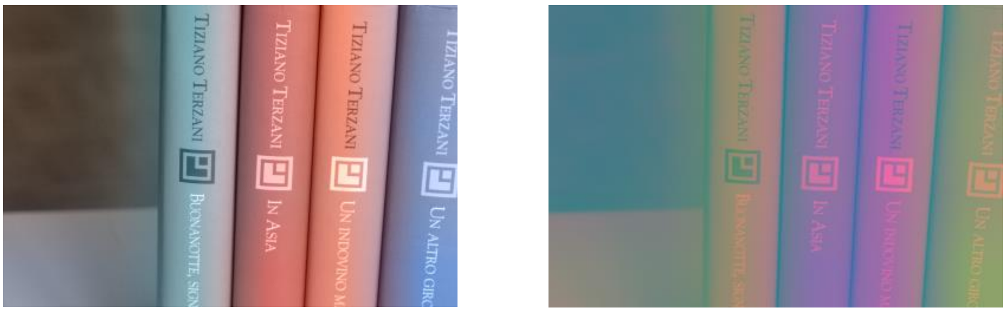
(a)



(b)



(c)



(d)

Figure 8. 20th RGB and YCbCr Images: (a) Original, (b) [1 4 4] Configuration, (c) [1 16 16] Configuration, and (d) [1 64 64] Configuration

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Author

Gwanggil Jeon received the BS, MS, and PhD (summa cum laude) degrees in Department of Electronics and Computer Engineering from Hanyang University, Seoul, Korea, in 2003, 2005, and 2008, respectively.

From 2008 to 2009, he was with the Department of Electronics and Computer Engineering, Hanyang University, from 2009 to 2011, he was with the School of Information Technology and Engineering (SITE), University of Ottawa, as a postdoctoral fellow, and from 2011 to 2012, he was with the Graduate School of Science & Technology, Niigata University, as an assistant professor. He is currently an assistant professor with the Department of Embedded Systems Engineering, Incheon National University, Incheon, Korea. His research interests fall under the umbrella of image processing, particularly image compression, motion estimation, demosaicking, and image enhancement as well as computational intelligence such as fuzzy and rough sets theories.

He was the recipient of the IEEE Chester Sall Award in 2007 and the 2008 ETRI Journal Paper Award.