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Digital color restoration from slide images which use the color target Kodak Q-13

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Abstract

This paper intent to collaborate with some Archive's collection, where there are color slides with necessity to restore their colors. To make the restoration, this research considers the images which has the Kodak Q-13 Color target.

The Kodak Q-13 reference color targets (Gray Scale and Color) were, at first, developed to evaluate and correct chemical color photographs and not for digital images. The purpose of this research is the development of a methodology which makes possible the restoration of colors and tones in the pictures through digital image processing. For this purpose, it was made the colorimetric study in these targets, and the development of the methodology for digital processing. The results indicate better color matching consistency for the Gray Scale target than the color one. Results obtained from the experiments using different methodologies to development, show that it is possible to accomplish color restoration of the pictures, which has used the Kodak Q-13 Gray Scale reference target.

Introduction

There are, in many Archives, a lot of color slides in their collections. Some of these slides are responsible to store the images of cultural heritage. The information stored inside each image (slide) can be much important to researches (historians, conservators, restorators, and others), and the color information generally need to be precise, but normally the color in the slide film is not trustable. There are some features into the slide film material and others related to photographic process that can damage the colors recorded in the image (slide) [3]. The constant physical and chemical modification can harm slide film material by: color fading, hogback, etc [10]; and the colors can be modified during the photographic moment (the color temperature by light source versus film write balance, and lens quality). To turn possible the color correction, the color target in the image is fundamental because the own image does not store enough information to make the color correction. This research studied the kodak Q-13, which was very useful a few years ago.

To procedure with color restoration is necessary: the digital file from slide film, the Kodak Q-13 color data, the methodologies to process the color adjustment in the digital file [2].

The first thing to be done is digitalize the slide, using very good film scanner with precise color management tools. This complete process will guarantee that the digital file will be the same as the original slide.

The second, is necessary to know what the Kodak Q-13 color is. The color data studies about Kodak Q-13 resulted in different information [5, 6, 8, 9]. To Color target, just 3 patches have color information [8, 9] (over 18), as Fig. 1 and Table 1. To Gray Scale there are information for all patches [5, 6, 8, 9], but the colorimetric information is different, Fig. 2 and Table 2. The question is: What is the real color data?

Figure 1. Color target - Kodak Q-13

Table 1. Color data for color target

Sample	Puglia, 1998	Puglia, 2004
Write	241-241-241	237-237-237
Gray (background)	101-101-101	102-102-102
Black	19-19-19	23-23-23

Figure 2. Gray Scale target - Kodak Q-13

Table 2. Color data for Gray Scale target

Sample	PUGLIA, 1998	PUGLIA, 2004	MYERS, 2006	Johnston, 2002
A	247-247-247	242-242-242	242-242-242	242-242-242
1			230-230-230	218-218-218
2			207-207-207	196-196-196
3			186-186-186	177-177-177
4			168-168-168	159-159-159
5			151-151-151	143-143-143
6			136-136-136	129-129-129
M	105-105-105	104-104-104	123-123-123	116-116-116
8			110-110-110	105-105-105
9			99-99-99	94-94-94
10			90-90-90	85-85-85
11			81-81-81	77-77-77
12			73-73-73	69-69-69
13			65-65-65	62-62-62
14			59-59-59	56-56-56
15			53-53-53	50-50-50

B		24-24-24	48-48-48	45-45-45
17			43-43-43	41-41-41
18			39-39-39	37-37-37
19	8-8-8	12-12-12	35-35-35	33-33-33

Experimental

There are two main researches on this paper, the colorimetric studies for Kodak Q-13 (Color and Gray Scale targets) and the development of a methodology to process the digital images from Kodak targets.

Colorimetric Data – Kodak Q-13

The main problem to solve is related to understand the exactly colorimetric information about Kodak Q-13 target (Color and Gray Scale).

To study these targets were used three different batches, manufactured in different years, 1977, 2000 and 2007, Color and Gray Scale target for each one. To measure the patches were used two colorimetric devices, namely, spectrophotometer i1Pro Xtreme made by X-Rite and spectrocolorimeter Datacolor 1005 made by Datacolor, computers and a lot of accessories.
The measurement process: each patch was measured in three different parts, using both colorimetric devices, as Fig. 3.

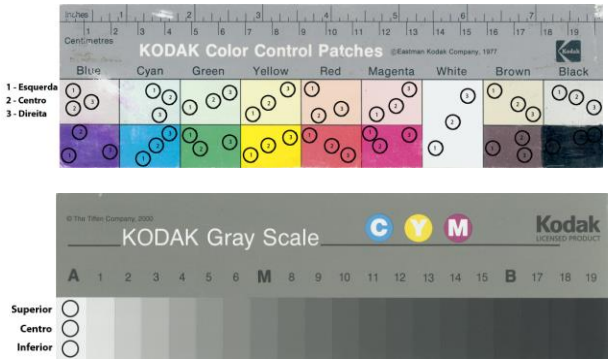

Figure 3: *Color Measurement for Kodak K-13 targets (Color and Gray Scale)*

The methodology to get the best color values from these targets from two different colorimetric devices was plot in a spreadsheet and the procedures were divided in three main steps. The step 1 was to get the colorimetric information to each patch according to the year (1977, 2000 and 2007), Fig 4. In the step 2 the result was the average of these three different years which has the less ΔE^*_{ab}, Fig 5. The step 3 was to compare the colorimetric results from two different colorimetric devices. The result is the average of these devices, in terms of colorimetric data, Fig 6.

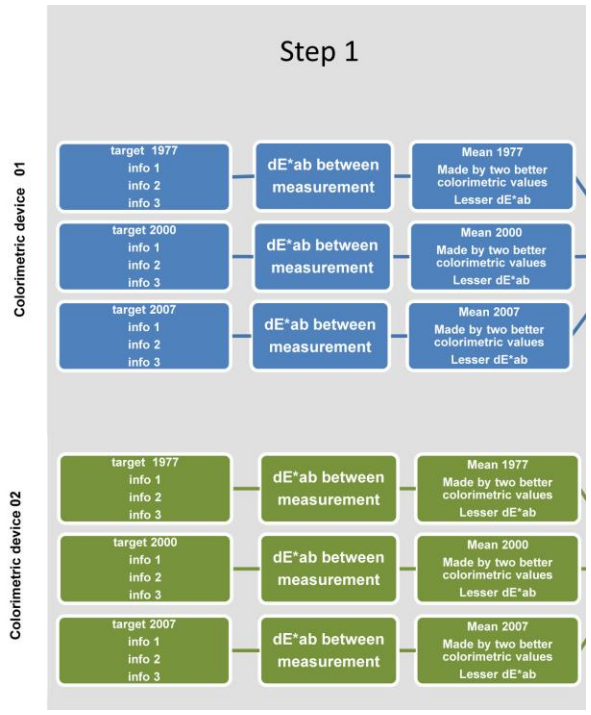

Figure 4: Step 1 – Methodology for colorimetric information

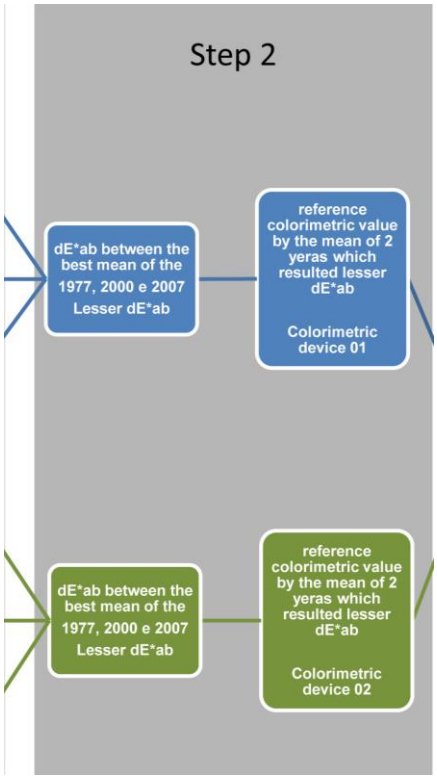

Figure 5: Step 2 – Colorimetric Information by Color Data Average

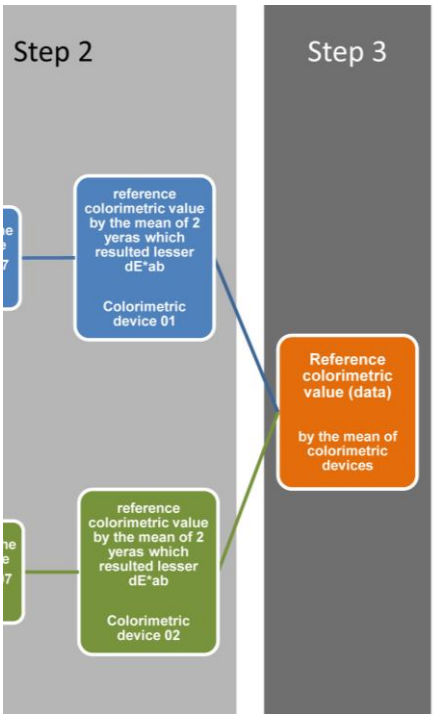

Figure 6: Step 3 – Colorimetric result by devices

To calculate the color difference in all steps and procedures was used the ΔE^*_{ab} , as show in Equation 1. The limit was considered under 5 or less [1, 7]

$$\Delta E^*_{ab} = \sqrt{(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2}$$

The reference colorimetric value to Kodak Q-13 (Color and Gray Scale) was obtained using ΔE^*_{ab} under 5.

Methodology for Image Processing

The digital file to process is coming from the slide image, which had been digitalized by a professional scanner with color management. The file format must be RAW or TIFF to allow good quality images. The color correction was made by photoshop software. The procedure involved some tools in photoshop, for example: eyedropper with sample size 11x11 pixels (to produce average by color information), adjustments by curves (RGB and Lab modes).
This research developed four different methodologies to make color correction in the digital image, each one using different procedures in photoshop. The best procedure is described below:

- select the "eyedropper" tool with sample size 11x11 pixels or another value that can be necessary.
- The image must be in RGB mode, but is important set the color info to L*a*b*. The colors to be selected must have a difference in L* axis of at least 10 points (on a scale of 0 to 100).
- open the "curve" by adjustments tab and modify the RGB channels until the values of the selected samples match the reference values, or at least get very close.
- select samples 1, 5, 10 and 19 from kodak Q-13 Gray Scale target and adjust the RGB channels individually according to the reference.
- evaluate the lightest and darkest tone which values of a* and b* axis are furthest from "0" and correct the "curve" by RGB color channels individually.
- perform a new Gray Scale evaluation to verify the samples with the highest deviation in a* and b* color channels, and if necessary make another correction.
- select samples 1, 5, 10 and 19 again to adjust, firstly, the extremes samples (1 and 19) and after that make the RGB adjusts by "curves" to check the reference values. At now, if necessary, can be set another tone that has a deviation in channels a* and b*.

Results

Colorimetric Data – Kodak Q-13

The results are available in terms of color consistency in each patch. The values available are: the average of each area measured, the target's manufactured year; finally comparing the difference between colorimetric devices.

The review of each target (Color and Gray Scale), in terms of accuracy, on the color target, just 3 patches (out of 18) were approved, considering ΔE^*_{ab} limited in 5, as Fig. 7. These colors are "yellow A" (yellow light), "red A" (red light) and white, from all three targets (1977, 2000 and 2007). The color data for these colors are presented in Table 3. "A" represent the first line and "B" the second line of the color target. In terms of accuracy, on the Gray Scale target, 17 patches (out of 21) were approved, considering ΔE^*_{ab} limited in 3, excepting when the number is very close to three (as the color number 6 and 12). These colors are the samples 1, 2, 4, 5, M, 8, 9, 10, 11, 13, 14, 15, B, 17, 18 and 19, as Fig. 8. The color data to these colors are presented in Table 4.

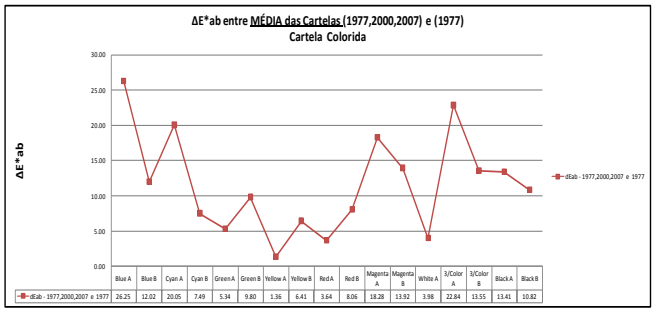

Figure 7: Kodak Q-13 ΔE^*_{ab} Color target

Table 3 – Kodak Q-13 colorimetric data / color target

SAMPLE	L	a	b	R	G	B
Blue A						
Blue B						
Cyan A						
Cyan B						
Green A						
Green B						
Yellow A	92,71	-2,77	37,83	229	229	157
Yellow B						
Red A	82,07	15,09	21,47	209	186	157
Red B						
Magenta A						
Magenta B						
White A	96,39	0,62	3,45	243	242	235
3/Color A						
3/Color B						
Black A						
Black B						
Background grey						

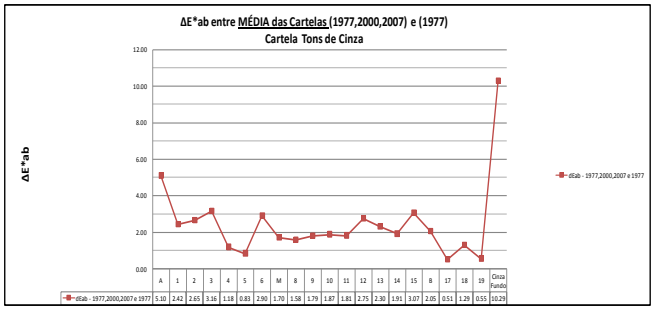

Figure 8: Kodak Q-13 ΔE^*_{ab} Gray Scale target

Table 4 – Kodak Q-13 colorimetric data / Gray Scale target

SAMPLE	L	a	b	R	G	B
A						
1	86,61	1,15	2,54	209	207	203
2	78,64	1,35	1,47	183	181	179
3						
4	65,40	1,09	0,38	142	141	141
5	58,97	0,78	0,34	124	123	123
6						
M	48,47	0,24	-0,45	96	96	96
8	43,58	0,26	-0,68	84	84	85
9	39,22	0,17	-0,76	74	74	75
10	35,59	0,25	-0,78	66	66	67
11	31,70	0,10	-0,79	58	58	59
12						
13	24,79	-0,03	-1,17	45	45	46
14	22,36	0,17	-1,08	40	40	41
15						
B	17,25	0,13	-1,00	32	32	33
17	14,61	0,13	-0,54	28	28	28
18	12,87	-0,05	-0,97	25	25	26
19	10,56	-0,29	-0,71	22	22	22
Background grey						

Methodology for Image Processing

The methodologies were applied in two different images, just to verificafy the methodology. The image had been digitalized and processed using the color data and methodology developed in this research.

The results by Color target were not acceptable, because just three patches could be used to make color correction. The color inconsistency in this target turns unavailable to be used as a Color target to correct the colors by digital processing.

The results by Gray Scale target were considered acceptable because after the digital processing by the methodology presented in this paper. The ΔE^*_{ab}, between the kodak Q-13 Gray Scale color data and the Gray Scale info into the image after color correction methodology, was 1,96, Fig. 9.

Methodology 4				
By: Alexandre Leão				
SAMPLE	L	a	b	
A				dEab
1	86,00	1,00	2,00	0,83
2	81,00	2,00	2,00	2,51
3				
4	66,00	1,00	0,00	0,72
5	59,00	1,00	1,00	0,69
6				
M	49,00	0,00	0,00	0,73
8	45,00	0,00	0,00	1,60
9	40,00	0,00	-1,00	0,83
10	36,00	0,00	-1,00	0,53
11	30,00	0,00	-1,00	1,72
12				
13	21,00	0,00	0,00	3,97
14	18,00	0,00	0,00	4,49
15				
B	13,00	1,00	-1,00	4,34
17	11,00	0,00	-1,00	3,64
18	11,00	0,00	-1,00	1,87
19	11,00	0,00	0,00	0,89
Background gray				
			average=	1,96

Figure 9 – Gray Scale target - ΔE^*_{ab} between colorimetric reference data and color after processed by methodology.

Conclusion

The Gray Scale Kodak Q-13 target is much better than Color target in terms of color consistency and color fading. The manufacturing process is different, because the Gray Scale target was made by silver photographic process, it means, without dye.

The colorimetric information provided by this research can help other researches, once at this moment just some patches were used as reference information. Other great contribution can be considered to restore the "original" color image in slide film. The "original" means the color information when the picture was made.

A lot of institutions around the world have problems with their slide collections and this research present one possibility to restore the color/tonality to original image.

The research about color fading in these kind of Color targets could be done using a wide group of targets, that can be collected in different institutions around the world.

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