



Optical features of old books paper

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Abstract

Three volumes of a book in possession of the National and University library in Zagreb (RIIF-4- 358- sv.1, RIIF-4- 358- sv.2, RIIF-4- 358- sv.3) were preliminary observed by image analysis and by spectrophotometric method. Regarding the optical features of these old books paper, these books were analyzed through watermarks characteristics and reflectance spectra. Obtained reflectance spectra for title page and random page of first volume show the highest values compared to second and third volumes, but these differences are insignificant. From the measurements results of all printed map paper reflectance spectra, we can conclude that printed map paper of third volume has been made from different type of paper. The image analysis results pointed out that watermarks characteristics of third volume are significantly different to the first and second volumes.

Key words: Optical features, reflectance values, old book papers, watermarks, paper grid

Introduction

Watermarks are European invention. They are not found in old Chinese or Arabian paper. This can be also explained by the fact that papermakers in Europe began to use rigid paper moulds to which wire figures could be attached. [1] Watermarks are produced by thinning out of the fibres in the required shape and area. When the light passes through the paper the watermark is more translucent than the surrounding area and creates effect of the appearance of the image. The watermark provides information on the origin of the paper and high security paper and graphic product. [2] Today's use of watermarks is to determine where the paper was produced and to understand its distribution. Watermark research differentiates between identical watermarks and variants. Watermarks that are considered identical are the same in all details. Both the impression of the wire figure and the placement on the mould and so are perfectly congruent, which can be tested by laying transparent copies one above the other. In contrast, watermarks that are classified as variants, as the term is used today, were clearly made with the same wire figure, but during the production process the shape of the figure changed, creating watermarks that are different from one another. [1]

The aim of this paper is to preliminary observe old book's paper comparing data measured by spectrophotometric method and image analysed watermarks relevant to papers reflectance values. According to this task it was extremely important to treat watermarks as typographic logos because typeface constructions and deletions through three volumes of a book in possession of National and University library in Zagreb reveals development of the same initials through time.

Experimental part

Experimental samples for optical features analysis were old book's paper in possession of the National and University library in Zagreb (RIIF-4- 358- sv.1, RIIF-4- 358- sv.2, RIIF-4- 358- sv.3). Thickness of paper is measured with micrometer eleven times on different places. Front pages, random pages and map papers of each volume were preliminary observed by spectrophotometric method, measured twenty times on different places with white background so average reflectance spectra are presented and compared through image analysed watermarks characteristics. Papers reflectance measurements were processed using X-rite SpectroEye spectrophotometer in the interval of the wavelengths from 380 nm to 730 nm for every 10 nm, with standard illuminant D65 and 2 degree of observer. These measurements were analysed by Technical Graphic Origin 6.0 Professional. Lightness (L), hue (H) and chroma (C) the color difference (ΔE) was calculated according to Equation 2. [3]

$$\left(\frac{\Delta L'}{k_L S_L}\right)^2 + \left(\frac{\Delta C'}{k_C S_C}\right)^2 + \left(\frac{\Delta H'}{k_H S_H}\right)^2 + R_T \frac{\Delta C'}{k_C S_C} \frac{\Delta H'}{k_H S_H}$$

Equation 2

Where:

$\Delta L'$ is the transformed lightness difference between old papers

$\Delta C'$ is the transformed chroma difference between old papers

$\Delta H'$ is the transformed hue difference between old papers

R_T is the rotation function

k_L, k_C, k_H is the parametric factors for variation in the experimental conditions

S_L, S_C, S_H is the weighting functions.

Acceptable values of color difference (ΔE) are given in table 1, from which it can be concluded about paper optical features.

Table 1 Color difference tolerance [4]

ΔE values	Tolerance
<1	The colour difference is not visible to the naked eye
1-2	Slightly colour difference, optimal colour difference
2-3,5	Moderately colour difference
3,5-5	Noticeable colour differences
>5	Significant colour difference

Typeface and paper grid results and discussion

For better understanding reflectance values results it is necessary to point out development of watermarks typeface. Figure 1a shows typographic watermark detected in the first volume, including the map paper, observed according to watermarks shape and paper grid. This watermark can be split in four letters- IVIB or three letters- IVB, therefore deconstruction of typeface disables unique meaning. Another watermark (Figure 1b) detected in the second volume, observed according to watermarks shape and its grid, can be split in two or four letters- MB or IVIB. Watermarks characteristics of third volume are significantly different to the first and second volumes (Figures c and d). Although watermark presented in Figure 1c seems to be made from three letters- JVB which may look different from previous watermarks, Bernstein- the memory of paper [5] data base of watermarks equals

letters I and J, therefor watermark detected on front page and random page of the third volume can be split in three letters- IVB or four letters IVIB. Finally, watermark detected in third volume, Figure 1d, solved diversity of watermarks initials because it is made from absolutely separated three letters- IMB, which means that all previous watermarks were just typeface stylization for initials IMB. That means that all front pages and random pages for all volumes was made by the same papermakers, including map paper from the first volume, or was made for the same client.

Table 2 shows watermarks appearance through three volumes

	First volume	Second volume	Third volume
Front page	IVIB, IVB (IMB)	MB, IVIB (IMB)	JVB (IMB)
Random page	IVIB, IVB (IMB)	MB, IVIB (IMB)	JVB and IMB (IMB)
Map paper	IVIB, IVB (IMB)		

Table 3 Characteristic of paper production grid on front pages

Label	1 - 2	2 - 3	3 - 4	4 - 5	5 - 6	6 - 7
First volume	2,66	2,91	2,88	2,76	2,98	2,61
Second volume	2,66	3,08	2,88	2,74	2,81	2,95
Third volume	2,98	3,00	2,91	3,10	2,86	2,95

Distances between paper grids measured on front pages of three volumes showed frequently appearance of similar results, especially between front pages of first and second volume, therefor further research might reveal its potential benefits of providing information about paper production process without watermarks.

Figure 1: Development of Watermarks initials IMB through time.



Figure 1a: Watermarks from the first volume, top- photography of watermark, middle- idealized visualization of watermarks typographic development, bottom- vectorized example from the first volume

Figure 1b: Watermarks from the second volume, top- photography of watermark, middle- idealized visualization of watermarks typographic development, bottom- vectorized example from the second volume

Figure 1c: Watermarks from the third volume, top- photography of watermark, middle- idealized visualization of watermarks typographic development, bottom- vectorized example from the third volume

Figure 1d: Watermarks from the third volume, top- photography of watermark, middle- idealized visualization of watermarks typographic development, bottom- vectorized example from the third volume

Figure 2: Reflectance values

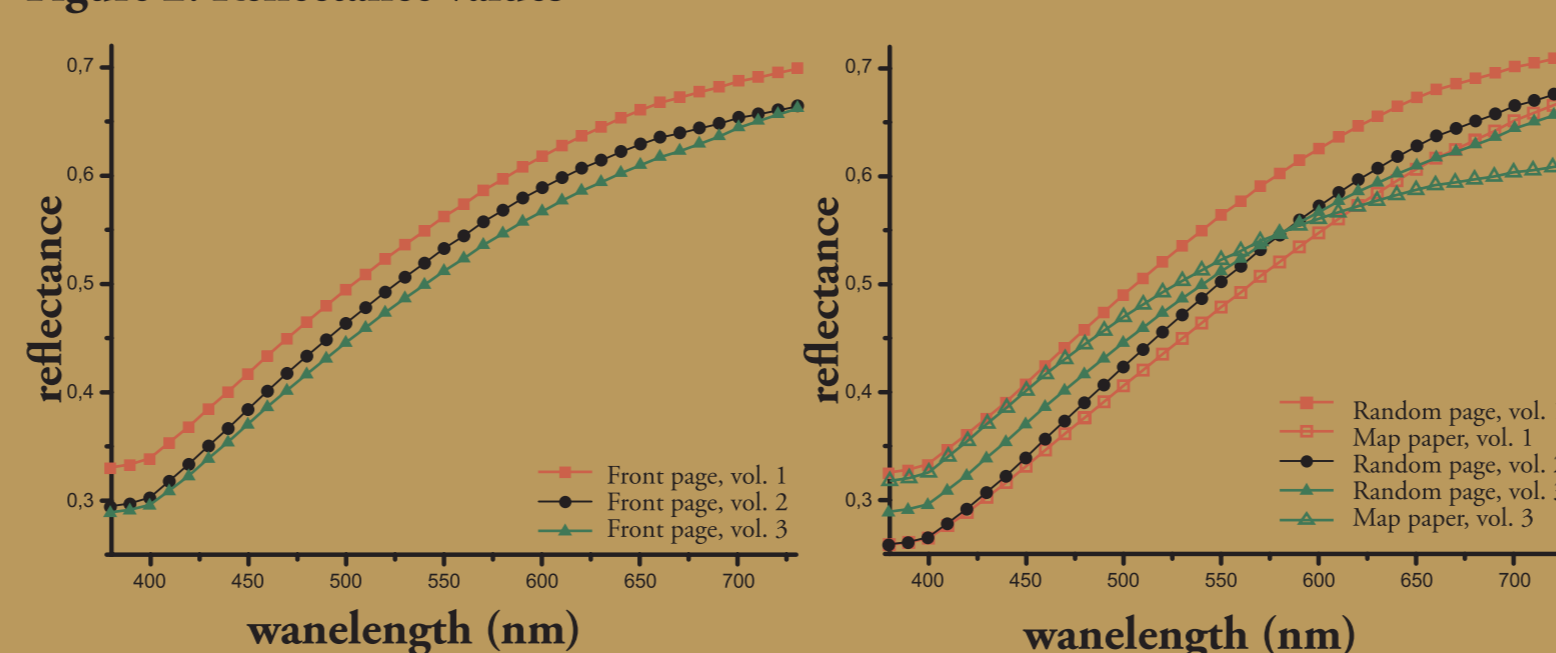


Figure 2a: Reflectance values of front pages for three volumes

Figure 2b: Reflectance values of random pages for three volumes and map paper from first and second volume

Reflectance values results and discussion

Reflectance values of front pages for three volumes are presented in Figure 2a. Results of this similar reflectance values shows that renovated front page in third volume has the lowest reflectance values, but the color difference between second and third renovated front page is not visible to the naked eye, while the color difference between front page of the first volume and renovated front page from the third volume is in optimal range (Table 4). Paper thickness of renovated front page is improved for 30-35% (Table 5) compared to first and second volume. Although reflectance values (Figure 2b) measured on equally watermarked random page and map paper of the first volume look similar they are quite lower for 10% ticker (Table 5) maps paper, and the color difference between these two papers are considered to be noticeable to the naked eye (Table 4). Monotony of the reflectance values measured on random page papers in first and second volume with just 5% tickness differences between them (Table 5), and both characterised with the same watermarks, results moderately color difference (Table 4). Reflectance values of map papers from first and third volumes with noticeable color difference between them are crossing at 620 nm, which indicates diversity of 23 % ticker (Table 5) map paper measured by spectrophotometric method in the third volume marked with different watermark (Figure 1e).

Table 4 shows Euclidean colour difference (ΔE_{00}) of measured papers

Paper color	Paper color	ΔE_{00}
Maps paper (1 volume)	Maps Paper (3 volume)	4,29
Front page (1 volume)	Front page (2 volume)	1,30
Front page (1 volume)	Front page (3 volume)	2,05
Front page (2 volume)	Front page (3 volume)	0,90
Random page (1 volume)	Random page (2 volume)	3,01
Random page (1 volume)	Random page (3 volume)	2,15
Random page (2 volume)	Random page (3 volume)	2,06
Random page (1 volume)	Maps paper (1 volume)	3,83

Table 5 Paper thickness

	Vol 1 Front page	Vol 2 Front page	Vol 3 Front page	Vol 1 Random page	Vol 2 Random page	Vol 3 Random page	Vol 1 Map paper	Vol 2 Map paper
Median (N)	11	11	11	11	11	11	11	11
9,0 μ m	9,0 μ m	8,5 μ m	13,5 μ m	9,0 μ m	9,0 μ m	10,0 μ m	10,0 μ m	13,0 μ m
Std. dev.	0,4	0,4	1,6	0,8	0,7	0,9	0,9	0,7

Conclusion

This preliminary research has provided several conclusions:

- Watermarks should be treated as typographic logos since papermakers were developing visual identity through time.
- According to watermarks all front pages and random pages were made for the same client, or made by the same papermakers, including map paper from the first volume.
- Similarity of reflectance values measured on front pages and random pages for all volumes supported by the same watermarks reveals monotonous paper production.
- Restoration of the front page of the third volume improved thickness of the paper therefor reflectance values are lower.
- Printed map paper of third volume has been made from different type of paper according to reflectance values and diversity of watermarks.

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