NEW METHODOLOGY OF LIGHT SOURCE SPECTRAL DISTRIBUTION SELECTION AND DESIGN FOR USE IN MUSEUMS TO PROPERLY EXHIBIT AND PRESERVE ARTWORK.

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Abstract:

A new methodology to select light source spectral distribution for use in museums is presented. It is based upon obtaining the Representative Spectral Reflectance Curve (RSRC) for each artwork and then lighting it with a light source which spectral power distribution is coincident in shape with the object´s R.S.R.C. This should cause minimum damage due to radiation on the object, given that object deterioration due to radiation is an effect of absorbed energy. In order to evaluate presentation quality, colour differences were calculated for the three primal colours present in an artwork sample, illuminated under Illuminants D65 and under a simulated illuminant which spectral power distribution matches the R.S.R.C. of the illuminated object. Results are in general lower than 3 CIELAB units, considered the limit for strict tolerance in normal colour reproduction.

Keywords: methodology, spectral reflectance, Illuminants, presentation, preservation

I. INTRODUCTION.

The current protocol for exhibition object preservation in museum lighting is based upon the combined use of a dual criteria: object classification according to their risk of deterioration due to radiation and the standards for total accumulated exposition [1];[2]. Considering a certain degree of object deterioration is inevitable when exposing an exhibiting object to radiation, due to the physic phenomena that causes it [3], it becomes necessary to rely on more precise information about object´s vulnerability to deterioration due to radiation, particularly on those dealing with their material qualities and those dealing with methods capable of predicting their performance under visible and non-visible radiation.

The hypothesis under this ongoing project is explained by the following propositions: a) It is possible to obtain a reflectance curve of an artwork or an exhibition object which is sufficiently representative of its surface area [4]. b) Lighting an artwork or an exhibition object, under a light source which spectral emission power matches the object's representative reflectance curve, allows for minimum object damage caused by light incidence, given that object deterioration due to radiation is an effect of absorbed energy [3]. Visual stimulus resulting from interaction between an artwork representative spectral reflectance curve

(R.S.R.C.) and a light source which spectral emission power matches the RSRC, allows for adequate and acceptable performances in terms of exhibition standards.

II. METHODOLOGY.

During the development of a methodology for spectral curve acquisition, a criteria was adopted: to consider a reflectance curve as representative of an artwork or an exhibiting object when it contains within itself, not only the spectral information of the different parts of the objects and artwork, but also all their variations in a proportional manner at the final integration of the curve [5].

When characterizing artwork- more precisely painting reproductions in the process of deducting their reflectance curves - they were considered as randomly distributed color on a surface. Thus, factors of such characterization are essentially: the amount of measurements on a surface to sufficiently inform of all its sectors, and the proportion in which all the sectors information is represented into the final spectral curve [5].

1. SAMPLE. Definition and processing.

Four artwork reproductions have been selected as the sample, considering them as colour displayed on a surface, progressively from a discriminated and plain form, as in the work of Piet Mondrian “Composition in Red, Yellow and Blue 1921” named M1, to other three more randomly colour-displayed artworks by Paul Klee: “Farbtafel 1930”, “Arkitecturder” and ” Highway”, respectively named M2, M3 and M4 (Fig. 1).

Figure 1 – Artwork reproductions sample (M1, M2, M3, M4).

2. Reflectance data from the reproductions was acquired with a photo-spectrometer Spectrascan PR 715,in order to construct a representative spectral reflectance curve R.S.R.C. for each sample. The light source used for these measurements was incandescent lamps operated with continuous electrical current, regulated to 45 Amps., in a specially built cabinet of white non-textured internal walls. The criteria for data acquisition was to take a significant amount of one-sized measurements of the surface previously divided into quadrants, which sufficiently described every colour present on the surface and all its transition and change areas [6].

3. A procedure to characterize the spectral curve for each sample was obtained. It consisted in weighing up each measurement, each colour and each colour zone into the resulting overall spectral curve.

The procedure includes finding both a ratio between each measurement and the total surface, and an average ratio between every colour surface and the total surface area. This is done first in the divided quadrants of the surface and then in the total surface area. The obtained curve was considered to be the R.S.R.C. (Representative Spectral Reflectance Curve) for the specific artwork reproduction sample.

A sensitive part of the procedure is finding out the proportion of every measurement and of every colour zone into the total integration of the spectral reflectance curve. In order to do so, a dual criteria has been adopted: the first method has been finding an area proportion index (A.P.I.), considered as the one expressing the weighed value of each measurement in terms of the total area of the sample. It comes from dividing the area of each colour zone and of each measurement over the total area of the sample. The A.P.I. obtained is then multiplied by the spectral data of its correspondent measurement, which is considered as the weighed value of every measurement into the final integration of the representative spectral reflectance curve (R.S.R.C.)

The second method for weighing the value of each measurement and each color zone in the R.S.R.C. has been developed by analyzing histograms of the digital image for every sample. The criteria has been to relate the RGB pixel distribution present in the histogram of every measurement and of every colour zone, to the RGB pixel distribution of the entire sample digital image. A proportion of that relationship is found as a ratio of both partial and total RGB pixel distributions, named Píxel Quoeficient (P.Q.) which is then multiplied by the spectral information of the correspondent measurements resulting in every case the weighed value of each measurement and colour zone.

Comparison between the two R.S.R.C. obtained with the above mentioned methods allows for mutual confirmation of the representative spectral reflectance curve for all members of the sample. (Fig.2)

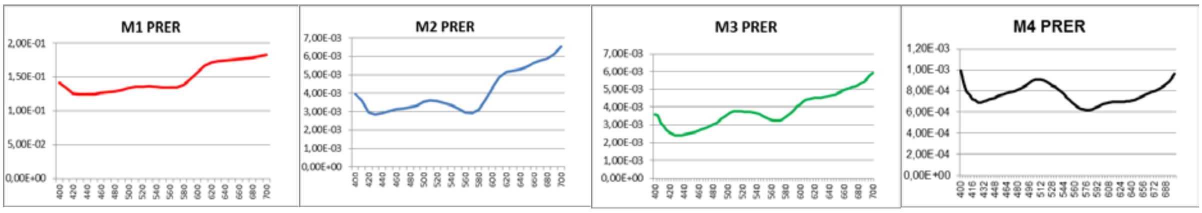

Fig.2. Representative Spectral Reflectance Curves (R.S.R.C.) for the Samples.

The obtained curves, which are considered to be the R.S.R.C. (Representative Spectral Reflectance Curve) for each specific artwork reproduction sample, have been used in designing the spectral emission of a light source, which coincides with the R.S.R.C.´s shape, called MATCH 1,2,3 and 4 according to the sample from which they derive. They have also been used for selecting and evaluating spectral power emissions of CIE illuminants according to the preservation and presentation parameters stated in the hypothesis.

III. EVALUATING ILLUMINANTS AND SOURCES ACCORDING TO PRESENTATION AND PRESERVATION.

One of the goals of this work is to develop a method for selecting and evaluating CIE illuminants in terms of presentation and preservation, susceptible of being inserted into a controllable emission Illuminator to acceptably comply those important aspects of the museum mission.

A criteria to evaluate C.I.E. illuminants has been applied, consisting in : a) to select C.I.E. illuminant spectral curves more closely coincident in shape to the representative spectral reflectance curve (R.S.R.C) of the reproduction sample which is to be illuminated under the given illuminant in the simulation. In order to do so, a calculation method has been developed to establish the existing power gap between every C.I.E. illuminant and the R.S.R.C. of the sample to be illuminated. The power gap calculated for an illuminant and a given sample reflectance curve is called the deteriorating factor. The lesser the deteriorating factor -power gap- between the two curves, the better expected preservation performance for the C.I.E. illuminant. Deteriorating factor calculation results are shown in tables 1-4.

RESULTS: Deteriorating Factor - ILLUMINANTS CIE and MATCH 1 for M1

	ILUMINANT CIE	DETERIORATING FACTOR- M1 R.S.R.C.
1	**MATCH 1**	**0,00**
2	B	10,16
3	D 50	12,64
4	E	13,58
5	A	14,47
6	F11	14,52
7	F2	15,80
8	D65	26,27
9	C	29,02
10	F7	32,22
11	D75	36,67

RESULTS: Deteriorating Factor - ILLUMINANTS CIE and MATCH 2 for M2

	ILUMINANT CIE	DETERIORATING FACTOR- M2 R.S.R.C.
1	**MATCH 2**	**0,00**
2	A	15,20
3	F11	15,73
4	B	22,36
5	D 50	23,72
6	F2	26,50
7	E	29,73
8	D65	41,37
9	C	43,66
10	F7	44,57
11	D75	52,10

RESULTS: Deteriorating Factor - ILLUMINANTS CIE and MATCH 3 for M3

	ILUMINANT CIE	DETERIORATING FACTOR- M3 R.S.R.C.
1	**MATCH 3**	**0,00**
2	A	13,09
3	F11	15,63
4	B	19,61
5	D 50	20,06
6	F2	25,45
7	E	28,17
8	D65	39,71
9	C	41,59
10	F7	41,64
11	D75	51,09

RESULTS: Deteriorating Factor - ILLUMINANTS CIE and MATCH 4 for M4

	ILUMINANT CIE	DETERIORATING FACTOR - M4 P.R.E.R.
1	**MATCH 4**	**0,00**
2	E	7,82
3	B	8,43
4	D 50	8,49
5	F11	14,46
6	D65	15,66
7	C	20,33
8	A	20,69
9	F2	23,07
10	F7	23,86
11	D75	24,09

TABLES 1-4

b) To design four Illuminant curves based upon the representative spectral reflectance (R.S.R.C.) of the each sample (M1,M2,M3,M4) which shapes are coincident to the corresponding sample and are endowed with an amount of emission power. Such designed illuminants are named MATCH 1, 2, 3 and 4, according to the sample from which they originate.

c) Given that the hypothesis of this work implies adequate comply of presentation, quality presentation of the sample colours have been evaluated as follows: CIEL*a*b* colour differences [8] have been calculated for the colours present in each sample under all C.I.E. and MATCH illuminants in comparison under C.I.E. illuminant D65, taken as reference illuminant for colour rendering measurements.

IV. RESULTS.

After L*a*b* colour differences were calculated for the colour present in the samples under curves MATCH 1,2,3 and 4 compared against C.I.E. D65 illuminant. Curves MATCH 1 through 4 were then inserted into a regulable emission Illuminator and spectral measurements of their resulting emissions were performed. The outputs were used for a new L*a*b* calculation for the same colours present in the samples and the same comparison to C.I.E D65 illuminant, obtaining a set of both calculation and experimental results, shown in Table 5.

SAMPLE M1	**M1**	**M4**	**M14**	
	🟥	🟨	🟦	
Calculation	3,22	2,24	1,27	
Experimental	3,64	2,69	1,38	
SAMPLE M2	**M2 19**	**M2-47**	**M2b-20**	**M2c-12**
	🟥	🟨	🟩	🟦
Calculation	2,30	2,13	1,30	1,19
Experimental	3,07	2,56	1,89	1,39
SAMPLE M3	**M3 c8**	**M3 45**	**M3 b6**	**M3 d5**
Calculation	2,17	2,98	0,24	0,33
Experimental	2,19	2,98	0,25	0,33
SAMPLE M4	**M4 a50**	**M4 e33**	**M4 g40**	**M4 c50**
Calculation	0,22	0,11	0,44	0,06
Experimental	0,22	0,11	0,44	0,06

TABLE 5. Results of color difference CIE L*a*b* (1976) for samples M1-4 under MATCH 1-4 and D65.

V. CONCLUSIONS.

A new methodology has been developed to select and design light source spectral distribution for use in Museums to properly exhibit and preserve artwork. The methodology has been tested in a sample of artwork reproduction, for presentation and preservation. On presentation, L*a*b* colour difference results, both calculated and experimental fall generally under 3 C.I.E. L*a*b*units. On preservation, C.I.E. illuminants and sample-designed illuminants have been evaluated and ranked according to a deterioration factor originated in the gap between each R.S.R.C. and the given illuminant.

Curves of spectral information can be used in the described manner in a lighting system capable of regulating its spectral emission to be used in museum lighting. To achieve a controlled between spectral information from the illuminated object and the visible radiation emitted by a source, would imply an important advance in the precision with which object deterioration is administered, along with an adequate fulfilment of the presentation aspect of the museum mission. Further studies may include experimenting with human observers as well as conducting damage measurements and other assessments to corroborate results in the preservation mission of the museum.

VI. REFERENCES.

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VII. BIOGRAPHIES.

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