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Piazza C. Caneva, 4
20154 Milano
C.F. 97619430156
P.IVA: 09003610962
www.gruppodelcolore.it
e-mail: segreteria@gruppodelcolore.org

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Colors documentation and processing in graphic production for architectural heritage representation

Federica Maietti[1], Andrea Zattini[1]
[1]University of Ferrara, Department of Architecture

Corresponding author: Federica Maietti, federica.maietti@unife.it

Abstract

The paper presents some preliminary outcomes of a number of research experiences focused on the one hand on the survey of colour as a specific field of architectural heritage documentation, and on the other on the representation of colour in digital views. These representations are processed through rendering software, allowing information to be transferred through digital elaborations able of rendering the chromatic features of surfaces in photorealistic visions.
Within this survey and representation process, the role of the colour is crucial, mainly regarding the approach to colour documentation, assessment, elaboration and representation. The novelty regards the inclusion of this approach within the so-called "survey of the project" as a form of investigation through sources and documents as a starting point for critical analysis and representation.
Among the main outcomes of this process, it is possible to highlight the digital reconstruction of buildings that no longer exist or have been deeply modified by interventions that have altered their original layout and chromatic configuration.

Keywords: Documentation, Survey, Architectural Heritage, Representation, Digital Colour, Photography.

Introduction

The survey of colour as a specific field of architectural heritage documentation, and the representation of colour in digital views are part of several research activities - developed within the authors' research centre focused on documentation, survey, diagnostic investigations and representation of Modernist Architecture in Latin America. These research activities carried out by the DIAPReM Centre (Development of Integrated Automatic Procedures for Restoration of Monuments, Department of Architecture, University of Ferrara), also processed at the educational level, have led to the development of a methodology called "survey of the project". This procedure is an "indirect" investigation through available sources and documents as a starting point for critical analysis and representation in BIM - Building Information Modeling, and photorealistic renderings of architecture. Among the purposes of analysis, documentation and representation, the management and reproduction of surface chromatic features is essential in the elaboration of digital views (Lukac and Plataniotis, 2018).
The paper presents some preliminary outcomes of research experiences focused on the survey of colour as a specific field of architectural heritage documentation, and specifically on the representation of colour in digital views. These representations are digitally processed, allowing information to be transferred through digital and paper elaborations able of rendering the chromatic features of surfaces of renowned architectures in photorealistic visions.
The paper deepens a sequence of steps, systematized at methodological level, which have led to the optimization of the representation through the management, correction and digital colour processing. The creation of digital photographic shootings and the processing of synthetic data sheets describing surveyed surfaces, their interaction with the environment and related schematic representations that identify the mapping of dispersions, roughness, deformations and other characteristics of the material are parts of this process. Up to the use of image corrections, by using chromatic channels and colour calibration for the transfer of the digital image on paper.

Project framework and overview

The topic of colour survey and its digital representations has been deepen by the authors in several research projects related to interdisciplinary areas.

On the one hand, the topic of colour is the focus of in-depth studies concerning in particular the documentation and survey of historical surfaces and the creation of colour databases useful both for the intervention on historical surfaces and for the conservation project (Balzani and Maietti, 2010; Balzani, 2011), up to recent experiences in international contexts (Maietti, 2019). On the other hand, colour is a research avenue - within digital representation - constantly developed and updated (Zattini, 2019).

These two areas find a point of blending and connection in the experience of the research on documentation, analysis and representation of Modernist heritage architecture in Latin America, in order to collect a database of models as support for different research directions.

Some of these architectures have been survey on site within some project of documentation and 3D survey developed by the DIAPReM Centre, including colour reliability in image-based 3D modeling of heritage architectures (Gaiani *et al.*, 2017), others have been investigate by an indirect process of documentation, analysis, investigation and digital representation.

This research field has led to the development of a methodology based on "indirect" survey, based on the analysis of the available sources and documents as a starting point for the critical analysis and representation of architecture: the "survey of the project".

The methodological process is divided into seven steps: Research and documentation, Survey of the project, Parametric modelling, Rendering, Scale model, Conceptualization process, Creation of a conceptual model (Maietti and Zattini, 2019).

Starting from a bibliographic, photographic and iconographic documentation, the building is analysed by identifying geometric and constructive relationships. The graphic representation starts from sketches aimed at analysing the main features of the building, including colour features.

As part of the building digital modelling, points of view similar to the photographs of the built architecture retrieved in the research are set, defining the first rendering drafts. The photorealistic approach aims to deepen the relationship between volumes and the light and the materials used both indoors and outdoors. Each material is in fact filed and described both in terms of its physical and visual-perceptual characteristics.

This part of the research is particularly relevant for the survey of the project focused on Modernist architectures in Latin America. Part of the process has in fact been applied in order to digitally reconstruct architectures of the great masters of Modernism that have been demolished or architectures that have been modified over time, losing their original materials and chromatic characteristics.

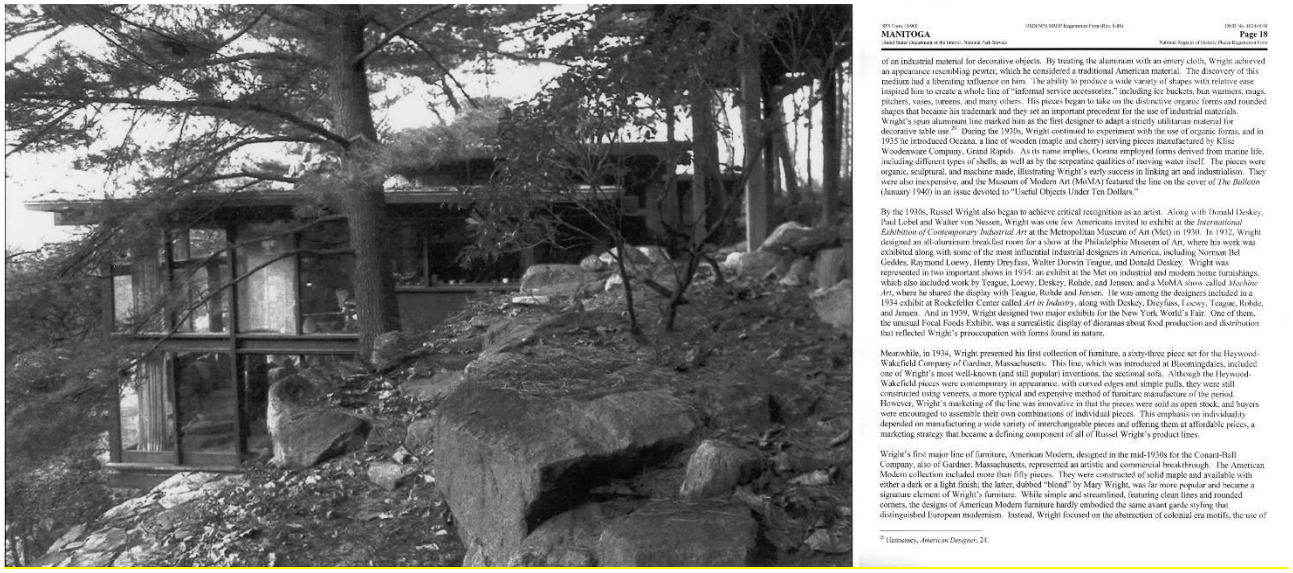
Colour management in architectural representation

The representation of colour through rendering software requires knowledge of the materials of the analysed architecture, giving a strong critical-analytical value to the whole process. Architectural surfaces are indeed heterogeneous elements for which it is not possible to render a single colour in a photorealistic vision and coherent communication of information, representing just a single colour. For instance, a grey colour related to a concrete material is strongly influenced visually by the surface finish; if the surface shows traces or grooves of any formwork or if it is porous, there will be, visually, a different and often heterogeneous perception of the colour itself.

Moreover, when the object of the representation is the architectural heritage, the chromatic characteristics are strongly influenced by the surface features in terms of state of conservation. The presence of surface degradation whether this is kept in the graphic works or removed for possible simulations, requires a basic chromatic reference and the definition of the surface appearance.

Among the main actions necessary for digital colour processing - cognitive phase, processing, and representation - photographic documentation plays an essential role (Fig. 1), whether it is found in the documentary material used for the survey of the project or produced on purpose.

Having the opportunity to make the photographic documentation directly, offers substantial usefulness, including the possibility to take advantage of suitable lighting and the support of colour atlases (or maps) for a visual determination of the reference colour.
The approach to colour assessment on photographic documentation found on paper or digital documents, often in black and white for historical buildings, requires a more critical attitude, where the main source is a bibliographic search.



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of an industrial material for decorative objects. By treating the aluminum with an emery cloth, Wright achieved an appearance resembling pewter, which he considered a traditional American material. The discovery of this medium had a liberating influence on him. The ability to produce a wide variety of shapes with relative ease inspired him to create a whole line of "informal service accessories," including ice buckets, bun warmers, mugs, pitchers, vases, tureens, and many others. His pieces began to take on the distinctive organic forms and rounded shapes that became his trademark and they set an important precedent for the use of industrial materials. Wright's spun aluminum line marked him as the first designer to adapt a strictly utilitarian material for decorative table use.[2] During the 1930s, Wright continued to experiment with the use of organic forms, and in 1935 he introduced Oceana, a line of wooden (maple and cherry) serving pieces manufactured by Kline Woodenware Company, Grand Rapids. As its name implies, Oceana employed forms derived from marine life, including different types of shells, as well as by the serpentine qualities of moving water itself. The pieces were organic, sculptural, and machine made, illustrating Wright's early success in linking art and industrialism. They were also inexpensive, and the Museum of Modern Art (MoMA) featured the line on the cover of *The Bulletin* (January 1940) in an issue devoted to "Useful Objects Under Ten Dollars."

By the 1930s, Russel Wright also began to achieve critical recognition as an artist. Along with Donald Deskey, Paul Lobel and Walter von Nessen, Wright was one few Americans invited to exhibit at the *International Exhibition of Contemporary Industrial Art* at the Metropolitan Museum of Art (Met) in 1930. In 1932, Wright designed an all-aluminum breakfast room for a show at the Philadelphia Museum of Art, where his work was exhibited along with some of the most influential industrial designers in America, including Norman Bel Geddes, Raymond Loewy, Henry Dreyfuss, Walter Dorwin Teague, and Donald Deskey. Wright was represented in two important shows in 1934: an exhibit at the Met on industrial and modern home furnishings, which also included work by Teague, Loewy, Deskey, Rohde, and Jensen, and a MoMA show called *Machine Art*, where he shared the display with Teague, Rohde and Jensen. He was among the designers included in a 1934 exhibit at Rockefeller Center called *Art in Industry*, along with Deskey, Dreyfuss, Loewy, Teague, Rohde, and Jensen. And in 1939, Wright designed two major exhibits for the New York World's Fair. One of them, the unusual Focal Foods Exhibit, was a surrealistic display of dioramas about food production and distribution that reflected Wright's preoccupation with forms found in nature.

Meanwhile, in 1934, Wright presented his first collection of furniture, a sixty-three piece set for the Heywood-Wakefield Company of Gardner, Massachusetts. This line, which was introduced at Bloomingdales, included one of Wright's most well-known (and still popular) inventions, the sectional sofa. Although the Heywood-Wakefield pieces were contemporary in appearance, with curved edges and simple pulls, they were still constructed using veneers, a more typical and expensive method of furniture manufacture of the period. However, Wright's marketing of the line was innovative in that the pieces were sold as open stock, and buyers were encouraged to assemble their own combinations of individual pieces. This emphasis on individuality depended on manufacturing a wide variety of interchangeable pieces and offering them at affordable prices, a marketing strategy that became a defining component of all of Russel Wright's product lines.

Wright's first major line of furniture, American Modern, designed in the mid-1930s for the Conart-Ball Company, also of Gardner, Massachusetts, represented an artistic and commercial breakthrough. The American Modern collection included more than fifty pieces. They were constructed of solid maple and available with either a dark or a light finish; the latter, dubbed "blond" by Mary Wright, was far more popular and became a signature element of Wright's furniture. While simple and streamlined, featuring clean lines and rounded corners, the designs of American Modern furniture hardly embodied the same avant garde styling that distinguished European modernism. Instead, Wright focused on the abstraction of colonial era motifs, the use of

[2] Hennessey, *American Designer*, 24.

Fig. 1 - Above: example of indirect photographic analysis with documentary support relating to the analysis of the building in its context and the used materials; information then compared with other more recent photographic data (Manitoga house, from National Historic Landmark Nomination, npgallery.nps.gov, pp. 18, 43). Below: example of exterior rendering with representation of the context and the building, where materials are sourced by photographic comparison and document analysis of Manitoga house

In the analysis of a "complex" surface, such as a stone floor, tile or wall paneling, a synthetic form is filled in. This sheet includes a significant area of the reference photograph, the definition of the material, a description of the surface appearance and a functional description of how the material interacts within the environment according to the light sources and other nearby materials.
Then, always within the sheet, the map elaborated for the definition of the feature is reported together with other grayscale maps for the definition of the different surface characteristics, such as the mapping of dispersions in the case of reflective elements, roughness or possible deformations (Fig. 2).

This procedure leads to certain visual and perceptual focuses that are essential for the representation, through digital software, of the materials (Thompson *et al.*, 2011). The result expressed in a photorealistic representation will therefore not deviate from the real perception of the material, thus preserving its formal and chromatic features. The latter in fact are adjusted following the result obtained, compared with the original photographic data.

Fig. 2 - Example of filing carried out for a material which describes the surface appearance and behaviour within the environment in which it is placed. Inside the sheet, image elaborations that express the surface aspect, the behaviour of the reflections, the relief factor and any other characteristics for the management of the material in a 3D environment for rendering and realistic graphic simulation purposes are included

For the adjustment or correction, therefore, a "trial and error" process is applied starting from the use of the acquired photographic data, corrected from time to time, especially at a chromatic level, according to the result obtained, by comparing the reference photo with the digital processing of the same simulated environment. For the correction of the starting chromatic digital data, a decomposition by elements according to the type of surface is performed, going to isolate, for instance, wooden boards, tiles or stone inserts. This process of "decomposition" is useful in order to better understand the interaction between the elements of complex surfaces and to enrich their information, especially in the definition of the different colour maps (Fig. 3).
A surface as complex as a stone face is then broken down into binding mortar and stone blocks, allowing the two types of element to be handled separately, cleaning up any shadows or imperfections. Afterwards, it is possible to make a further distinction even on the single stone elements, dividing them by shade or even forcing a chromatic variation if the surface on which the representation work is focused is not acquired by the reference building but by a similar surface in terms of morphology.
Once the corrections have been made, the image obtained in grayscale is checked for its balance in terms of contrast with the colour data (Sharma and Bala, 2017). Again, on the basis of grayscale, by using the subdivision of the compositional elements, it is therefore possible to elaborate the maps

that concern the mortar rather than the stone elements or both, changing the gradient according to the intensity of application of the effect.
With regard to simpler surfaces but characterised by reflection effects, such as treated wood or ceramics, the trial and error procedure is essential in understanding which effect is predominant compared to the others and for the variation in saturation and contrast of the colours and drawings as a result of the influence of light. Plastered surfaces, which have a minimum light dispersion factor, although they are distinguished by a single colour, still contain information that interferes with the perception of the appearance such as porosity and any deformations given by the substrate.

Fig. 3 - Above: reference photo of the playroom of Frank Lloyd Wright's home and studio in Oak Park (left, A. Abernathy, *The Oak Park Home and Studio of Frank Lloyd Wright*, 1988, pp. 24, 25) and rendering of the room modeled in 3D (right). Below: internal view of Manitoga's studio (left, by Lilit Marcus, cntraveler.com) and its photorealistic rendering (right) where the realized materials have always taken place on the comparison of the photographic and documentary data

Fig. 4 - From left to right: reference photo (A. Abernathy, *The Oak Park Home and Studio of Frank Lloyd Wright*, 1988, p.21), example of mapping for the material's surface and example of mapping of the glossiness characteristic of the same surface

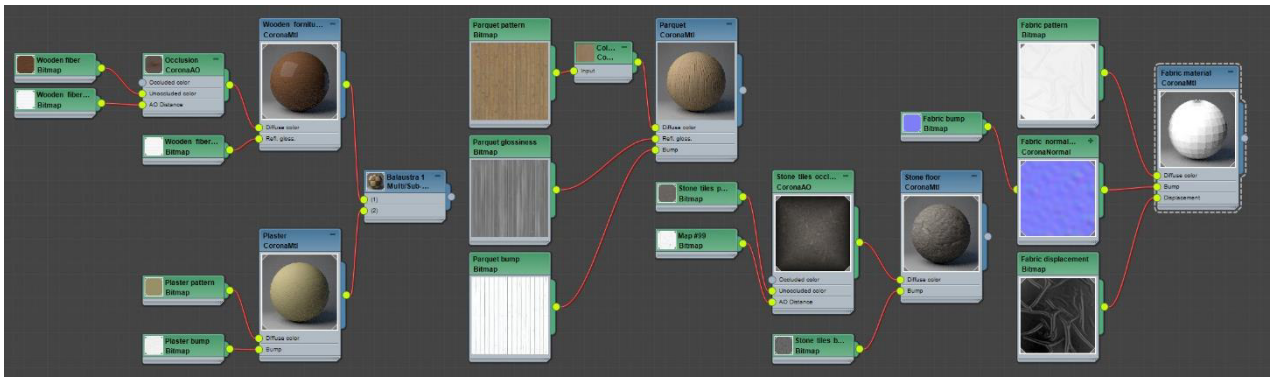

Fig. 5 - Example of material management inside Autodesk - 3ds Max, where each graphic component (properly renamed) is applied to one or more materials, with reference to the specific characteristic

The approach to surfaces featuring significant decorative elements such as frescoes, wall paintings or graffiti is different. In this case, it is not a decomposition of elements but rather a mapping of the entire surface concerned. In this way the effects that characterize the surface will be localized only where they are present (reflections of gold leaf or stucco, relief of edges, differentiated porosity and so on), proceeding with the chromatic correction always based on the objective verification of the simulated result (Figure 4). The same order must also be reflected in the management of materials within the software editor with the correlation of all the maps generated as a result of the perceptual analysis, previously outlined within the sheets, for the definition of the material properties (Figure 5). Although existing buildings have different characteristics from each other, this procedure allows to create material libraries related to a specific historical or stylistic period (Gerhard and Harper, 2010), where the material component becomes the basis on which to attribute specific chromatic information. This rigorousness is crucial when dealing with the built heritage not only for the representative aspects but also for the appropriate passage of information.

Fig. 6 - Above: black and white photo of the Cuadra San Cristobál complex by Luis Barragan (De Anda Alanis, E. X., Luis Barragán, Clasico del Silencio, Collecion Somosur, 1989, p. 169) and recoloured photo (Rispa, R., Aguanza, M. J., *Barragán, Opera Completa*, Logos Impex, 1996), p.188). Above: frame of the same shot dated 2012 (Jqrstate, Barragán: La Cuadra San Cristobal, YouTube.com, 18 April 2012) and 3D rendering with colours based on critical analysis of the various photographic representations and historical documentation

Conclusion

The proposed methodological approach is conceived as an integrated and multifaceted process according to different levels of knowledge. On the one hand, it is linked to the field of colour digitization, including colour reproduction and management, digital colour correction, image processing, photography and artificial vision. On the other hand, it is related to the topic of lighting, considering steps related to colour rendering, adaptation, constancy and memory of original chromatic features of analysed architectures.

The topic of architectural syntax is also covered, since the overall research is related to the digital documentation and conservation of heritage buildings often no longer existing or severely modified by interventions that have changed their original chromatic pattern (Figure 6) (Carpiceci, Marco, and Fabio Colonnese, 2014).

The results obtained are managed entirely digitally and consequently all the chromatic changes processed take place within the RGB additive method, which is the reason why the processed image is closely related to the hardware support with which it is interfaced and, for this reason, the comparison between processed data and photographic data is made on the same screen. As a final step, for the printing of the processed data, the result is checked on paper, calibrating any corrections on the CMYK subtractive method. Having initially taken care of the entire digitizing process by comparison, the main corrective operations concern the brightness and contrast of the image and the saturation of the colours that come too close to the purity of the three channels that describe the composition in RGB.

This last step is carried out through printing tests on heavy paper with a weight between 120 and 140 grams, in order to increase ink absorption, and a white point sufficient to avoid possible chromatic alterations. Each print test consists of the print of critical areas of the processed images to which different corrections of brightness and contrast and saturation are applied, in order to optimize the final representation.

The research is also an opportunity to open new scenarios and to experiment new digital process to digitally manage colour features (Nnolim, 2018).

The described procedure leads to a critical approach in the architecture analysis, deepening the degree of knowledge of the different surfaces. The digital elaborations display a chromatic data evaluated and interpreted together with information regarding the features of the reference material.

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