

Qualitative Measurement of Colour Based on Human Perception

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Abstract

With the development of the media and with the competition of the marketing, the colour became a differential, such for the recognition of a commercial mark as for the sensation of a good product (example: oranges, apples, French fries, soft drinks). In this context we observe the need of expressing properly products colour. Industries and companies must assure the quality of their products and services. Among the several items to be controlled we can remark the quality of the colour product and consequently the appropriate perception of this for the consumer. In fact, in many cases we notice a great difference between the projected colours, the produced ones and the colours perceived by the final users. The industry should be capable to assist to the consumers' expectations guaranteeing the constancy of the colour of their products. This subject affects several industrial sectors like: automobiles, manufacturing, textile, urban and domestic furniture, food, design, scenic and graphic arts, paints, cosmetics, etc. The proposal of this article is present a methodology to study how the human being perceives and express the characteristic of product colours in realistic conditions. This work deals with different colour hues, submitted to different lighting. Acquiring those quantitative measurements, it will be possible to reproduce human-like colour perception of commercial product. In this context, this paper presents some results of a research in colour vision. We consider specially the colour perception in different illuminations. The presented results may help designers to adjust their product colour according to human colour difference perception.

Introduction

Generally the colour classification of the objects is made through instruments in laboratory-controlled experiments. It is known that the colour classification and their grouping involve subjective evaluations that the colour provides. Aspects as clearer, darkness, more yellow, have an ambiguity that the deterministic operations don't presuppose. In terms of results, the used colour formulas today don't contemplate that language kind. Some colour

grouping software approach is classifying neighboring colours that maintain minimum colour difference.

The illumination has a fundamental paper in the analysis of the colour. That can be observed in daily situations, as when buying a cloth in a store (with specific illumination) the consumer notices a colour and when leaving with the cloth he perceives a new colour hue.

The human being ambiguity to express if a colour is clearer, darker, more greenish, turns unreal the use of a deterministic process for colour classification. In this context, gradations are used for the colours in order to turn more realistic the modelling of the perception and classification of them. An interesting approach to operate with this consists in the use of Fuzzy Logic (Leta and Araújo, 2000). Lotfi Zadeh introduced the concept of fuzzy logic. Initially presented as an extension of the traditional logic, a fuzzy system is based on that a logical proposition is not necessarily true or false, but it possesses, in fact, truth degrees (Cox, 1994). When we say that the time is "sunny", we don't want to say that there are not clouds. In the same way, in a cloudy time we can have sun. We usually accept as sunny a sky with up to 20% or 30% of clouds. How then we can define the limits of our propositions? It can be said that, when the human being uses such terms he infers a truth degree. The values that define the truth degree of a proposition cannot be conscious, but in some way defined by the context social, linguistic, or a base of experimental reference.

This paper presents a colour vision methodology to assess colour under different lighting. This methodology involves a qualitative assessment based on subjective human perception. The main goal of this research is to study the way a selected group of people perceives the colour of an object and how they describe it verbally. In a previous paper we presented a methodology based on fuzzy colour. Now the aim is to make a broader application, in order to use later fuzzy logic to classify the qualitative obtained results. Our approach consists in present a number of different samples previously chosen to chosen observers. These samples are submitted to different illuminations. In this paper we selected a specific group (young university students). Afterwards the observers will be classified in new distinct groups,

according to their age, gender, knowledge level and social-economic situation.

The study of colour perception is an important subject in colour vision segment, especially if we evaluate the influence of commercial illuminations. Thus, the result assessment can be used in many industrial applications.

Colour Models and Perception

The colour formulas are always associated to a call colour model. To prove the ambiguity due to the colour phenomenon, it can be said that there are at least 15 colour models scientifically accepted. The colour can be measured through a solid where brightness, chroma and hue are the coordinated axes. Such disposition presents people a form of representing colour differences.

In the course of time, it was verified that the human beings notice the colour in a non-linear manner. So scientists tried to approximate the practical models (colour models and colour difference formulae) through solids not so linear, as the elliptic form. Those formulas continue to be tested and it is still not able to one to say that the colour difference formulas contemplate 100% of the cases.

Some colour difference formulae, such as the called CMC, take into account the proportionality between scales of brightness and chroma of the colour. These formulas still adjust some of their coefficients with the current variations of sharpness, obtained by the observation of the experimental data and of characteristics of the colour. Although it is possible to obtain good uniformity for the measurement of small colour differences, it persists the ambiguity of expressing a perceptual colour model for relating widely differing colours (Jackson et al., 1994). Unhappily, the traditional metric doesn't distinguish those perceptual differences.

Among the colour formulas, today known, stand out CIELAB, CIELUV, CIELCH and CMC. Each one has specific strips of application and use. Some companies edited its own models, based on the consecrated formulas. They developed their own methodologies and trained observers. Examples of that are the formulas of colour difference of J & P Coats (Linhas Corrente in Brazil) and Marks&Spencer (department store of England).

The evaluation of the colour difference, as done by the industries, accepts the linearity between the measured colour differences and the perceptible scales. In the case of very small differences, tenuous tones, it is very difficult to apply this linear relationship in a satisfactory way.

An important factor of the perception of the colour consists of the observer's memory. Our memory for certain colours is very poor, unless two similar colours are presented side by side, we will have difficulty in saying if it is the same colour or not. When we put together different objects, we will also have a different perception from the colour. We interpreted the colour in an image in agreement with our experiences and memories. For this reason when we give a name to a colour in many times we remind some object with similar colour. It is common hear denominations as: blue of the sea, blue of the sky, swimming pool green, gold yellow, etc.

The sensation of the colour involves besides the light and the human vision system, the individual's background, which can induce distinguished understandings of the observed objects. A paper can be considered white, independent of the type of illumination; even the colour, for instance, tends to yellow. In some cases, the variation of the light source alters significantly the reading of the colour.

There are countless characteristics that can be associated to the colours. One given colour can be vivid, beautiful, strong, classic, fashionable, tranquil, intense, etc. According to the observer the same colour may have different attributes. We cannot expect the same answer of children and adults, of people with low and high education degree, of men and women. We can notice the complexity involved in the evaluation of the colour perception by the human being. If we associate to this subject the variation of light source, we will have increased the evaluation difficulty; especially if the objects are commercial ones and not colour patterns as used in laboratories.

Methodology

The adopted methodology involved the choice of a group of colour samples (commercial objects). Instruments previously measured those samples in order to obtain a first notion of the type of substratum structure. Later these samples were introduced to the observers, under varied conditions of illumination, in order to obtain data for a new colour classification.

The tests were accomplished at a double cabin with two different light sources, with different colour reproduction index. These cabins are controlled environments; the only illumination that affects the samples came from the selected lamps. In the top of the box we also present the samples submitted to a non-controlled illumination (ambient light). In figure 1 and 2 we present, respectively, the experiments and a schematic top view of the test cabin.



Figure 1. Experiments.

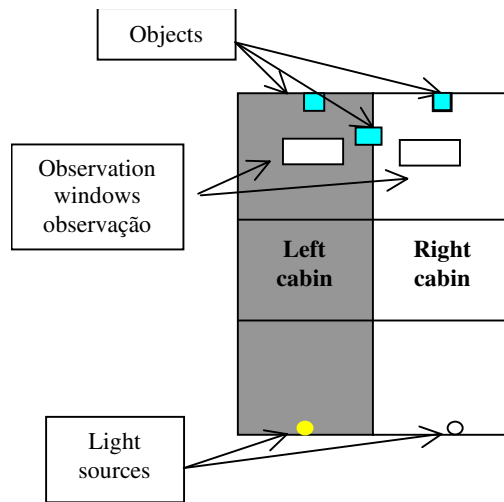


Figure 2. Schematic top view of the cabin.

The kind of linguistic variables are endless. To help this evaluation we present many common words usually adopted to describe colours (Kobayashi, 1990). The observers assess a questionnaire of evaluation, containing those words. We present a language to classify the characteristics of a colour. It is important to note that the used words are non-technical ones, but are ordinary words. The chosen characteristics were defined by a group of 7 students, 2 professors and laboratory technical staff. The group discussed the common used words in colour industry and selected sixteen colour attributes: vivid, intense, chic, soft, neutral, extinguished, dazzling, romantic, tranquil, clear, strong, feminine, dark, old-fashioned, beautiful and modern. The intention was to present a great variety of terms and to analyze how people attribute the colour characteristics. Some of these attributes have similar interpretation and others have opposite interpretation. The obtained answers correspond to colour perception of the selected group.

In future works we will apply fuzzy logic to compute those results, inserting the uncertainty of the natural world into the field of rational, exact numbers. We will also evaluate the sensation that colour induces in different individual groups.

The conditions that we see the colours in the real world, in our day by day, are very different from the established conditions for the system CIE. In laboratorial conditions a cabin is constructed with specific and standard light source and a set of colour test patterns. In the real world we have a variety of objects, in sizes and different forms, submitted to a variety of light sources. There are many factors that affect the appearance of the colour in an image. The environmental conditions and the own complexity of the image can influence this appearance significantly.

In our experiments, five colours were presented, denominated by the observers as: rose, orange, yellow, blue and cyan. Some observers had attributed other names to these colours like: blue swimming pool, clear blue, dark blue, coral, marine blue, etc. Intentionally the chosen colours were not basic ones, because we didn't intend to induce the denomination of the colour. Decision of

colours was taken randomly, trying to get some of the universe of colours in daily life. The objects were also chosen in a way that the observers didn't make any colour association, which could happen if we introduced, for instance, an apple that naturally would be associated to the red colour.

The observer should read each selected colour group, separately, and attribute a scale that varied from 1 to 5 to the inquired characteristics. This scale increases from "it is not really" to "it is exactly".

Besides observe the characteristic attributed to the colours, this research had the intention of evaluating colour, as its quality change when we alter the illumination. The objects were presented in three different situations, the first one in the ambient light (with variable illumination), the second one consists in *Croma 50* lamp (GE 20W, 5000K, CRI 92) and the last one called *Duramax Super Light of the Day* (GE 20W, 5250K, CRI 68). These light sources were chosen because, visually, they have similar colour temperature, however they have different colour reproduction index and both are ordinary commercial lamps.

The observers group consisted of 82 university students with ages from 18 to 25 years old (belonging to this total we have 14 women). In this group there are 1 colour vision deficient and 2 that didn't distinguish soft tones.

Results

In the external sample, we notice that there is the following colour evaluation tendency, most of the answers was "it seems", with a symmetric distribution between "it is not" and "it is". The exceptions were for these characteristics: extinguished (62, 3), dazzling (42, 13), romantic (41, 12), modern (9, 46), dark (61, 11) and old fashioned (59, 6), where the pair (a, b) means ("it is not", "it is").

In table 1, 2 and 3 we can observe a comparison of the results obtained in both controlled light source.

Table 1. Colour Perception - Light Source Comparison

	Vivid	Intense	Soft
Croma 50	52 "it is not"	51 "it is not"	30 "it is not"
Duramax	53 "it is"	55 "it is"	30 "it is"

Table 2. Colour perception - Light Source Comparison

	Extinguished	Beautiful	Dark	Old fashioned
Croma 50	48 "it is not"	42 "it is"	45 "it is not"	59 "it is not"
Duramax	69 "it is not"	54 "it is"	60 "it is not"	70 "it is not"

Table 3. Colour perception - Light Source Comparison

	Dazzling	Romantic	Feminine
Croma 50	67 "it is not"	52 "it is not"	46 "it is not"
Duramax	43 "it is not"	45 "it is not"	42 "it is not"

While analyzing the 16 colour characteristics it was observed that the following attributes have no predominance in the controlled artificial light source: neutral, tranquil and clear. The modern (10, 47) and strong (11, 54) characteristics were attributed only for *Duramax* lamp.

Conclusions

Assessing colour difference is still a very hard task to fulfill. It must take into account not only the readings of a spectrophotometer but as well some personal feelings and understanding (Leta and Araújo, 2000).

In this paper we presented the preliminary results of experiments performed in colour vision area. We proposed a methodology to test consumer colour perception. The results show a colour vocabulary tendency adopted by young university students.

We note that the observers didn't perceive difference between the two controlled light sources, until observing the products submitted to those sources. They didn't understand also the reason of this difference. The experiments help them to be conscious of a common problem that consumers suffer. The colour vision area is still non-accessible to the ordinary people and for that reason it denotes the necessity of extended research.

Although the colour reproduction index be commonly used by industries, it is relevant that the commerce and consumers perceive its importance. The consumer may be induced to buy products in a wrong manner because of inadequate lighting.

In addition, in this experiment we note that the consumers didn't use the same characteristic words for colours, as CIE or industry models. That also justifies more investigation in this area, exploring other observers groups and lighting sources.

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Biography

Fabiana R. Leta is a professor at Universidade Federal Fluminense at the Mechanical Engineering Department since 1989. She has got a D.Sc. in Mechanical Engineering (Computer Graphics and Bioengineering). Researcher of the post graduation program in Mechanical Engineering. She is responsible for the Laboratory of Metrology. She has several works published including engineering teaching, metrology, computer vision, fuzzy logic and biomechanics engineering.

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Márcia P. Velloso is Physics, D.Sc. Professor of Universidade Federal Fluminense, researcher of the post graduation program in Civil Engineering. Several works published along 30 years, including physics teaching, the free software (linux), the interaction of the radiation, ionizing or no, with the matter, optical of Fourier, optical metrology, lightning and colour.