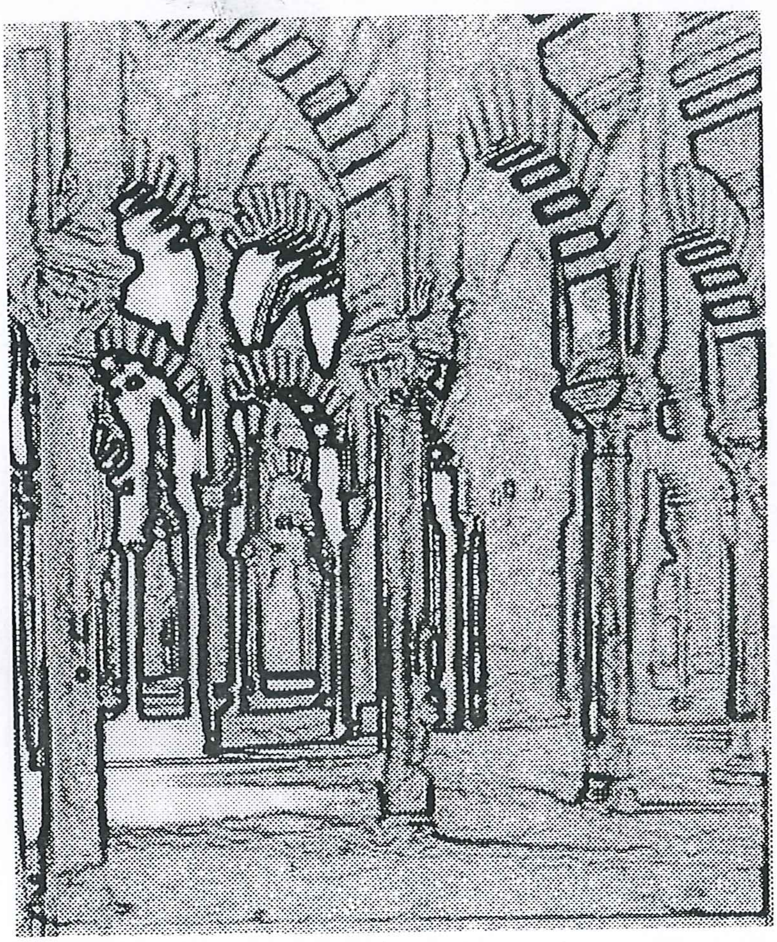
PATTERN RECOGNITION AND IMAGE ANALYSIS



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A COLOURMETRIC STUDY OF PSEUDOCOLOURATION IN DISPLAYING MEDICAL IMAGES

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1. INTRODUCTION.

It is evident that the world of medicine has been subjected to an enormous revolution as the result of the incorporation of diagnosis through the image. The provision of data which are difficult to appreciate through the senses in the physical examination of patients justifies its unquestionable value.

Our investigations are centred on the improvement of the display of medical images. Once these images are digitalised, we establish a standard for treatment and display for clininical application, which gives an objective improvement in the image obtained [5]. For this purpose we introduce pseudocolouration techniques, including in them the capacity for chronometric discrimination in the human vision system.

2. ACQUISITION AND DISPLAY OF IMAGES.

To acquire the images we used a personal computer PC-386 provided with a MATROX PIP-1024 plaque. The observed image was turned into a matrix of 512x512 sized points with a resolution of 256 levels of grey for each point of image.

In order to paint a screen point in a certain colour, one must give an appropriate combination of the intensity values to the three basic colours (red, green and blue) so that the resulting colour from the combination of these three is the desired one. This trio of values of intensity for each one of the basic colours C is called trichromatic coordinates in the RGB colourmetric space: C=(R,G,B). R, G, and B are three numbers included between 0 and 63 for a personal computer with a SVGA target, offering a total of 262.144 different colours, more than enough for a good display if we bear in mind the capacity for chromatic discrimination in the human eye [6].

Pseudocolouration is the technique through which an image in levels of grey is represented on a colour monitor, assigning a different colour to each one of the 256 levels of grey. The use of this technique in the display of medical images is justified because the human eye is capable of discriminating between thousands of colours while, in levels of grey, it is only capable of distinguishing between one and two dozen levels, depending on the visual training of the human observer [2]. Bearing in mind that most medical images are monochromatic, the use of this technique can offer an improvement in the appreciation of different tones which exist in the images used for medical diagnosis.

The assignment of pseudocoloration for medical imaging should be made pursuing certain objectives: uniformity in the assignment, cold or warm colours for certain bands of intensity of grey, the inclusion of a wider range of chromatic tones, not very bright colours for the lowest levels of grey, a bigger variation of tones for some predetermined bands of intensity of grey and so forth.

We investigated this colourmetric assignment thoronghly, studying the reaction of the human eye to the colour chosen to display each level of grey of the initial image.

3. COLORIMETRIC STUDY.

For this study, we digitalised images of photographs of cataracts to which we applied the pseudocoloration technique and two additional treatments: shading for intensity and normalisation in scale of greys based on a linear modification of the histogram [5].

Prior to assigning colours to the levels of grey, we carried out tests with colour tables (luts) proposed in the bibliography [2,3,4] and performed a colourmetric study of the perception of the assigned colours which permited us to objectively measure the quality of the range of colours chosen. Since the use of these colour tables did not satisfy the medical observers, we designed our own range of colours to fulfil the following visual and colourmetric requirements of the observers: 1) to assign the colour black to the darkest tone in the scale of greys (R=G=B=O) and evolve towards blue, 2) a progression from cold tones to warm tones as the luminosity in the image increases, 3) a progression from less to more luminous colours for more luminous tones in scale of greys.

We also made a graphic representation of the 256 colours using a space of colour perceptually uniform, the colourmetric space CIELAB [1], to objectively judge the quality of the range chosen.

4. RESULTS.

We developed the pseudocolour table shown in Figure 1. The assignment of colours to levels of grey was made in a progressive way, starting from black, going through blue, then green, then red and finishing with yellow. For displaying the degree of opacity in the crystalline lens, this distribution resulted in the darkest tones showing a smaller degree of opacity and the brightest tones showing the greater degree of opacity. With this assignment we also achieved to emboss the biggest range of opacity of the cataracts with warm colours.

We also represented the 256 colours chosen from each table in a uniform space of colour (CIELAB) to determine which of the 17 tables of colour offered a better discrimination between the colours used. This colour space has an associated formula for colour difference, which is:

$$\Delta E^*_{a,b} = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}$$

The graph in Figure 2 shows the distribution of the 256 colours used and represents the colour table we designed in this perceptually uniform space.

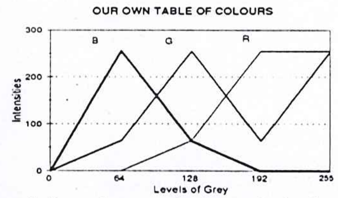

Figure 1. Our assignment of colous to the levels of grey.

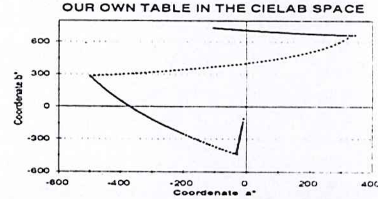

Figure 2. Our own pseudocolour table in CIELAB colour uniform space.

To obtain a quantative measure of the chromatic discrimination of each of the tables used, we calculated which was the mid point between the two adjacent colours, (based on ΔE). The ΔE in our table (11.69) resulted superior to the rest of the 17 tables of colour except for two (Levine, 13.19 and Niblack, 18.85).

6. CONCLUSIONS.

Our table of colours, designed to fulfil the visual requirements for medical diagnosis, also offered a very good chromatic discrimination. Although this average value was not higher than those of Levine and Niblack, it was sufficiently high to permit an excellent discrimination between two adjacent colours. Beyond, we found that the tables of Levine and Niblack did not meet the features that medical diagnostic imaging demand.

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