IRIS COLOR EVALUATION WITH A DIGITAL COLOR CAMERA

Jorge Herrera, Meritxell Vilaseca, Marta de Lasarte, Jochen Düll, **Jaume Pujol**
Centre for Sensors, Instruments and Systems Development (CD6).
Technical University of Catalonia (UPC). Spain.

ABSTRACT

In this work we measure and evaluate the color of irises, prostheses and cosmetic colored contact lenses with a system based on a digital RGB color camera. Using multispectral tools, the CIE L*a*b* colorimetric coordinates are computed from the RGB digital values of the acquired images. With the statistical analysis of the L*a*b* values, the color gamuts and the CIEDE2000 color differences, a comparison of the color associated to each set of samples is performed. Specifically, the samples are classified in three major groups: brown, blue and green, using a new algorithm developed for this purpose. In the same way, the irises color reproduction achieved by prostheses and contact lenses is analysed, obtaining closer results in prostheses than in contact lenses. Besides, a preliminary analysis of the color spatial distribution of the irises, prostheses and cosmetic colored contact lenses by means of an algorithm based on co-occurrence matrices is also performed. The results obtained suggest that the color spatial distribution and therefore, the texture associated to each kind of samples, is very different. This study provides useful information on the color and texture of irises and may help improving the techniques used in the manufacturing process of prostheses and colored contact lenses in order to obtain a better and more realistic appearance.

Keywords: color, multispectral, iris

CONTACT

jorge.alexis.herrera @cd6.upc.edu

INTRODUCTION

Iris color measurement is a complex task. Some studies use subjective observations[1,2] and few have attempted quantitative measurements using standard color instrumentation[3,4] and multispectral systems[5]. Irises have such variability in color and texture that make them suitable for biometric identification[6] and increasing the accuracy in its colorimetric and spectral characterization is desirable for this and other applications, such as those related with the detection or characterization of ocular pathologies[7]. Recently our group have implemented new colorimetric elements like color image processing and multispectral systems based on digital cameras with high spatial resolution to face these studies[5,8,9] . Following this tendency, in this work we analyze the color and texture corresponding to real irises, ocular prostheses and cosmetic colored lenses. First, in order to achieve the color comparison, we developed an automatic algorithm that allows the classification of samples into three different groups: brown, blue and green. This algorithm evaluates some criteria over the CIE L*a*b* coordinates of each sample. Statistical analyses, color differences and gamut comparisons are performed as a first approach to the color characterization of samples as well as the comparison of prostheses and contact lenses accounting their color characteristics with respect to irises.

On the other hand, the analysis of not only the former mean colorimetric values, but also the color spatial distribution of the samples or texture is performed by means of an algorithm based on co-occurrence matrices[10] applied over the pixels of the acquired images.

In this study, we attempt to obtain objective color data that could assist prostheses and contact lenses producers in their goal of reproducing irises, task that nowadays is performed by trial and error with subjective comparisons.

EXPERIMENTAL SETUP AND METHOD

Experimental Setup

The multispectral system used consists of a 12 bit depth cooled CCD monochrome camera with 1.4 megapixels (1392 × 1040), an objective zoom lens, and a color RGB tunable filter attached to the CCD camera. Furthermore, an illumination system composed of an adjustable halogen lamp attached to a stabilized DC power supply and a focusing lens allows lighting the analyzed iris with a 45° angle of incidence and provides a uniform luminous field over the eye. The system has been previously trained using a great amount of samples and allows the reconstruction of spectral reflectance profiles pixel by pixel using Moore-Penrose pseudoinverse based algorithms. From the computed spectra, the CIEL*a*b* values are obtained under the illuminant D65.

Method

In order to perform the color comparison, we analyzed the obtained CIE L*a*b* coordinates for 106 human irises, 68 prostheses and 17 cosmetic colored contact lenses, corresponding to two square areas of approximately 1cm^2 on the iris, which presented a rather uniform coloration. A statistical analysis of these coordinates was performed over the three sets of samples obtaining the corresponding mean, standard deviation, minimum and maximum values. After that, an automatic algorithm based on statistical descriptors extracted from their CIE L*a*b* values was applied over them in order to classify each set into brown, blue and green groups, what allowed an easier analysis of the colors associated to each kind of samples color by color.

Besides, as a first approach to the analysis of not only mean colorimetric values, but also the analysis of color spatial distribution, that is, texture, we have implemented an algorithm based on co-occurrence matrixes. The algorithm uses the CIE L*a*b* values computed for each pixel, in order to study the distribution of these values over the L*a*b* image of each sample. Thus, extracting contrast and entropy[10] values from those matrices, we have achieved an algorithm that allows automatically establishing whether a sample, without any previous information about it, corresponds to a real iris, an ocular prosthesis or to a cosmetic colored contact lens.

RESULTS

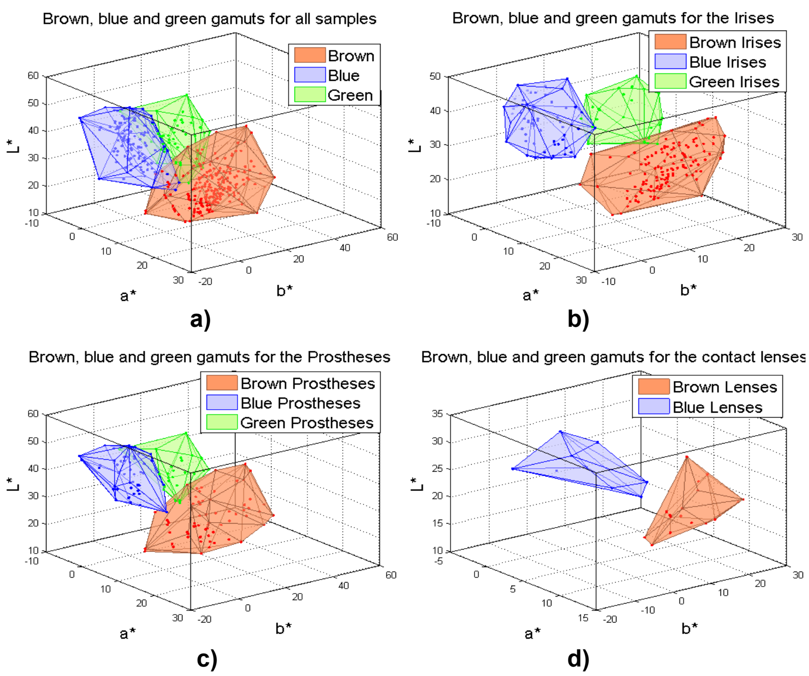

Fig 1. Classification of samples in brown, blue and green color groups.
a) Classification for the whole set of samples, **b)** Classification for the real irises set, **c)** Classification for the Prostheses set and **d)** Classification for the contact lenses set.

We built boundaries in the CIE L*a*b* color space that produced the classification shown in the Fig. 1. This separation evidences the brown group as the largest and most numerous, both for the whole samples set (Fig. 1a) and for each kind of samples separately (Fig. 1b, 1c and 1d). Noteworthy that in contact lenses classification (Fig. 1d), there are not enough elements in the green color group for generating a volume.

This classification allowed the comparison of the samples by color and the analysis of the iris color reproduction achieved by prostheses and colored contact lenses taking into account how volumes overlap (Fig. 2).

Fig. 2a shows how volumes of brown color of each kind of samples overlap and it can be stated that almost every volume is contained into the volume given by the brown color prostheses. Fig. 2b shows that for blue subsets, prothesis and irises are much more overlapped than contact lenses and irises. Finally, it can be seen in Fig. 2c that for green samples, irises and prostheses have a similar gamut. This shows that in general terms, prostheses are a better representation of irises than colored contact lenses according to mean colorimetric values. Taking into account how the gamuts of each color group are represented by the prostheses and contact lenses, it can be stated that prostheses cover almost completely the irises gamuts for each color group, hence is very likely to find any close representation for a specific iris in the prosthesis set, at least regarding to its color appearance. Besides, there must be stated that in the case of contact lenses, the influence of the eye used in the measurement procedure is important, so it can be necessary a different treatment for its complete characterization.

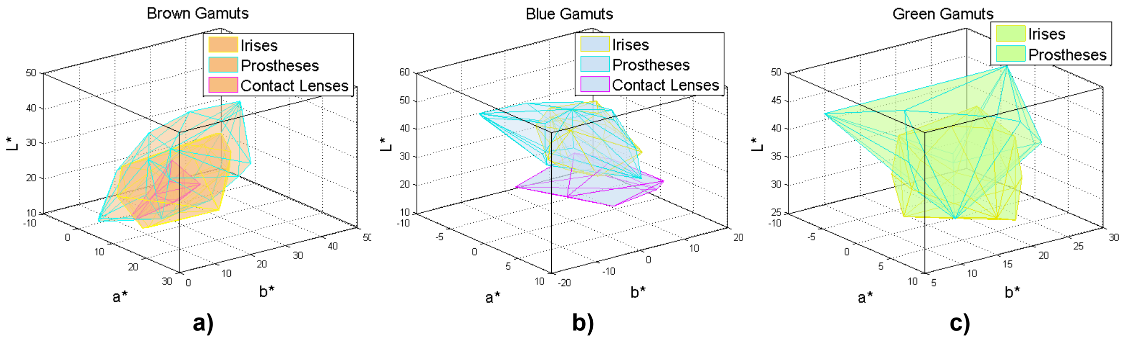

Fig 2. Gamuts for each color group separated by sample sets. **a)** Brown gamuts, **b)** Blue Gamuts and **c)** Green Gamuts

Applying the CIEDE2000 formula we calculate color differences and find the partners with the minimum color difference between each iris and the other two sets of samples, i. e. prostheses and contact lenses. We extract mean values and standard deviations for these minimum differences (Table 1). Color differences between prostheses and real irises are still important and the values obtained between samples corresponding to contact lenses and irises are in general greater than those obtained between prothesis and irises.

Table 1. Analysis of CIEDE2000 minimum color differences. Standard Deviation and Mean values of minimum color differences between irises, prostheses and contact lenses.

	Brown Group		**Blue Group**		**Green Group**	
	Irises-Prostheses	Irises-Lenses	Irises-Prostheses	Irises-Lenses	Irises-Prostheses	Irises-Lenses
Mean	2.3375	2.3162	2.3070	8.2706	2.5056	11.4587
Standard Deviation	1.1464	1.6163	0.7638	3.8684	1.1073	4.3867

The former discussion sets the necessity of a more accurate color analysis, not only including mean colorimetric values for some specific regions, but taking into account the spatial color characteristics of the samples. In this work, this issue can be addressed taking advantage from the data obtained by means of the multispectral system, which provides high spatial resolution images. In this context, we have developed an algorithm based on co-occurrence matrices for the separation of the samples. The algorithm extracts information that looks for spatial colorimetric differences among samples and allows obtaining a classification. The obtained results suggest that changes of spatial texture allow associating each sample with a specific spatial structure, and therefore, this method allows classifying the samples in different groups depending on these features. In our case it was enough to take into account values of contrast and entropy extracted from co-occurrence matrices to have a criterion to distinguish the samples from each subset with a 100% of accuracy.

The application of this algorithm over the analyzed samples highlights that there is a different spatial structure in each kind of samples; in consequence, the appearance of the prostheses and contact lenses can be improved changing their spatial structure in order to make them more similar to the irises.

Figure 1: Multispectral experimental setup

CONCLUSION

This work shows the results of the application of an automatic algorithm to classify a set of samples composed by 106 real irises, 68 prostheses and 17 colored contact lenses in three color groups: brown, blue and green. This classification allows us to perform a deeper analysis of the irises color reproduction through the representation of gamuts in each color group and the observation of their overlapping zones. This analysis shows that prostheses are very similar to irises regarding their mean colorimetric values; meanwhile this is not true for colored contact lenses. Moreover, with the analysis of the color differences utilizing the CIEDE2000 formula, the same behaviour is observed, although these color differences are still noticeable. Finally, we set out the use of the analysis over the entire iris surface taking advantage of the pixelwise information acquired through the multiespectral system. The application of the developed algorithm for this purpose demonstrates that the spatial structure of real irises, prostheses and cosmetic contact lenses is distinguishable, and therefore a strategy for improving the industrial reproduction of the spatial structure of prostheses and contact lenses to make them more resembling to irises can be of great importance.

ACKNOWLEDGMENTS

This work has been supported by the Ministry of Science and Innovation of Spain through the project DPI2008-06455-C02-01. Jorge Herrera thanks the support from the Commissioner for Universities and Research of the Department of Innovation, Universities and Enterprises of the Catalonian Government and also the European Social Fund.

REFERENCES

[1] W. E. Budde, I. M. Velten and J. B. Jonas, "Optics disc size and iris color", *Arch. Ophthalmol*, Vol. 116, pp. 545, 1998.

[2] M. Seddon, C. R. Sahagian, R. J. Glynn, R. D. Sperduto and E. S. Gragoudas, "Evaluation of an iris color classification system. The eye disorders case-control study group", *Invest. Ophthalmol. Visual Sci.*, Vol. 31, pp. 1592-1598, 1990.

[3] E. J. German, M. A. Hurst, D. Wood and J. Gilchrist, "A novel system for the objective classification of iris colour and its correlation with response to 1% tropica-mide", *Ophthalmic Physiol. Opt.*, Vol. 18, pp. 103-110, 1998.

[4] M. Melgosa, M. J. Rivas, L. G. Mez and E. Hita, "Towards a colorimetric characterization of the human iris", *Ophtal. Physiol. Opt.*, Vol. 20, pp. 252, 2000.

[5] M. Vilaseca, R. Mercadal, J. Pujol, M. Arjona, M. de-Lasarte, R. Huertas, M. Melgosa and F. H. Imai, "Characterization of the human iris spectral reflectance with a multispectral imaging system", *Appl. Opt.*, Vol. 47, pp. 5622-5630, 2008.

[6] J. Daughman, 1994, U.S. Patent 5,291,560, Biometric personal identification system based on iris analysis, March 1, 1994:March 1, 1994

[7] E. Pascal, E. Gooding and L. Hannan, "Is the albino iris worse than no iris?" *Ophthalmic Physiol. Opt.*, Vol. 18, pp. 383, 1998.

[8] M. Vilaseca, M. de-Lasarte, J. Pujol, M. Arjona and F. H. Imai, "Estimation Of Human Iris Spectral Reflectance Using A Multi-Spectral Imaging System", *Proceedings of the Third European Conference on Colour in Graphics, Imaging and Vision (CGIV 2006)*, pp. 232-236, 2006.

[9] M. Vilaseca, M. de-Lasarte, J. Pujol, M. Arjona, R. Huertas, M. Melgosa and F. H. Imai, "Measuring and Analyzing the Colour of the Iris with a Multi-Spectral Imaging System", *Proceedings of the Fourth European Conference on Colour in Graphics, Imaging and Vision (CGIV 2008)*, pp. 427-431, 2008.

[10] R. M. Haralick, K. Shanmugam and I. Dinstein, "Textural Features for Image Classification", *IEEE Trans. on Systems, Man and Cibernetics*, Vol. 3, pp. 610-621, 1973.