

# Color feature selection for unconstrained iris recognition

Ana F. Sequeira  
afps@inescporto.pt  
Jaime S. Cardoso  
jaime.cardoso@inescporto.pt  
Samaneh Khoshrou  
skhoshrou@inescporto.pt

INESC TEC and Faculdade de Engenharia  
Universidade do Porto  
Porto, Portugal

## Abstract

In recent years many authors have recognized that the path forward, regarding iris recognition, is the development of iris recognition systems that can work independently of the conditions under which iris images are acquired. Recent works have tried to achieve robust and unconstrained iris recognition in order to develop real-world applicable methods. In this work, the problem of unconstrained iris recognition is referred and some results of an approach to the problem of fusing color information to enhance the performance of an iris authentication system are briefly presented.

## 1 Introduction

Reliable automatic recognition of persons has long been an attractive goal. In most of all daily activities, personal identification plays an important role. The most traditional techniques to achieve this goal can be divided in two kinds: knowledge-based and token-based. In one hand, token-based approaches take advantage of a personal item, like a passport, driver's license, ID card, credit card or a simple set of keys, on the other hand, knowledge-based approaches, are based on something the user knows that, theoretically, are not accessible to others, such as passwords or personal identification numbers. These approaches present obvious disadvantages: tokens may be lost, stolen, forgotten or misplaced, while passwords can easily be forgotten by a valid user or guessed by an unauthorized one [5]. In fact, all of these approaches stumble upon an obvious problem: any piece of material or knowledge can be fraudulently acquired.

Biometrics represents a return to a more natural way of identification: many physiological or behavioral characteristics are unique between different persons. Testing someone by what this someone is, instead of relying on something he owns or knows seems likely to be the way forward.

Several biological traits in humans show a considerable inter-individual variability: fingerprints and palmprints, the shape of the ears, the pattern of the iris, among others. Biometrics works by recognizing patterns within these biological traits, unique to each individual, to increase the reliability of recognition. The growing need for reliability and robustness, arise some expectations and become the focal points of attention when someone is trying to develop a new system based on a specific trait: universality, uniqueness, collectability, permanence [5].

Iris patterns become interesting as an alternative approach to reliable visual recognition of persons when imaging can be done at distances of less than a meter, and especially when there is a need to search very large databases without incurring any false matches despite a high number of possibilities. Although small (11 mm) and sometimes problematic to image, the iris has the great mathematical advantage that its pattern variability among different persons is enormous [2]. The iris presents itself as a leading candidate to become the standard biometric trait: it is universal, the variability is huge which assures the uniqueness for each individual, apart from being an organ easily accessible and very difficult to modify.

## 2 (Unconstrained) iris recognition system

The pioneer works in iris recognition set the basis of the typical iris recognition system architecture: segmentation, normalization, feature extraction and matching [3]. For an overview of the system see Fig. 1.

Currently, there are several biometric systems based on iris recognition with excellent rates of success. However, this performance is due to the constrained conditions under which iris data is acquired (infra-red illumination of the eye, user collaboration, controlled distance from the camera, etc.). Some implicit or explicit assumptions about the acquisition process are no longer valid in unconstrained acquisition scenarios. Therefore, some of the promising results reported in the literature must

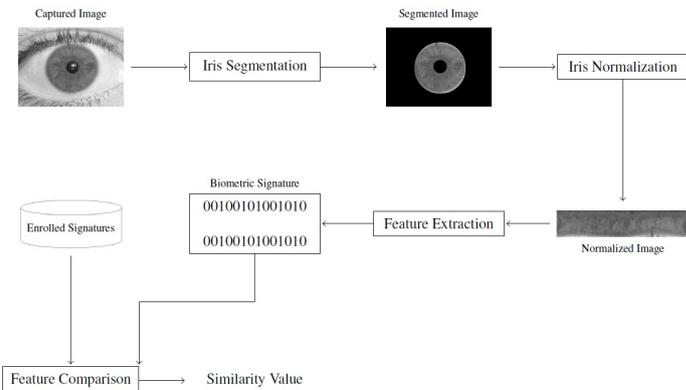


Figure 1: Iris recognition scheme, from [8]

be taken with caution and reassessed under these new, more challenging, conditions.

The new challenges for iris biometric systems arise when the attempt is made to perform iris recognition without user cooperation or under less ideal conditions. Some typical unconstrained scenarios in applications may be iris recognition with mobile phones for security such as in airports, in military applications [13] or in bank accounts [1]. It has been recognized that the path forward is the development of algorithms that can work independently of subject collaboration and proper near infrared illumination conditions, in order to achieve robust (i.e. accurate even with noisy images) and unconstrained (i.e. accurate for several sets of acquisition conditions: distance, movement, illumination, etc.) iris recognition and, in this way, become a real-world applicable method [7, 11].

## 3 Color feature selection for an unconstrained iris recognition system

In this work, we consider the problem of fusing multiple color channels to enhance the performance of an iris authentication system. The verification process is based on open-source implementation made by Masek [6] (available in open source<sup>1</sup> and tested with near infrared images).

### 3.1 Fusion Methods

Multiple expert fusion aims to make use of many different classifiers to improve the classification performance. Different color channels show different performance in various applications. So, it is expected that better performance could be obtained by fusing classifiers based on different color channels. Among the possibilities, we choose two simple approaches, "Averaging" and "Product", in addition to a sequential search approach. An adopted version of the sequential search approach [10], "Plus L and take away R" works based on finding the best "L" features in the beginning and then, try to find "R" worse features from our latest optimum subset. This method finds the best set leading to the best result generally. For all the cases we consider the same features [12].

### 3.2 Method

We convert the images from RGB to other color spaces. It is common to describe color as a set of three primary colors (Red, Green and Blue) but there are different color spaces that can be used. We use opponent color channels given by  $RG = R - G$ ,  $RB = R - B$ ,  $GB = G - B$ , *Intensity* and also *HSV* (for more details see [4]).

<sup>1</sup><http://www.csse.uwa.edu.au/pk/studentprojects/libor/sourcecode.html>

Table 1: Results (%) using SVM for different color spaces considering EER

	R	G	B	Intensity	H	S	V	RG	RB	GB
FARE	24	22.5	30.2	19.9	45.8	31.9	23.8	34.5	26.2	36.5
FRRE	24	22.7	30.6	19.9	44.9	31.6	23.6	33.9	26.3	36.8
TERE	48	45.2	60.8	39.8	90.7	63.5	47.4	68.4	52.5	73.3
FART	17.8	20.3	27.5	17.3	45.1	33.1	16.9	30.8	23.4	36.3
FRRT	22.7	19.7	27.4	18.2	39.7	22.6	24	35.8	28.6	33.7
TERT	40.5	40	54.9	<b>35.5</b>	84.8	55.7	40.9	66.6	52	70

An histogram equalization is applied for photometric normalization of images. The segmentation of the iris region was done manually (due to the difficulty of applying the segmentation part of the method of Masek [6] to the noisy images of the database chosen (UBIRIS.v2 [9]) and consisted of selecting three points: the center of pupil and iris, one point in the border of pupil and one point in the border of iris. In this process two “major” assumptions were made: the coincidence of the centers of pupil and iris and the circular shape of both regions 2. Also the noise mask that should be obtained with the information of the occluded regions was considered to be empty, so the iris image used in the posterior process had some noise that was considered as iris regions. After the manual segmentation we used Masek’s code for normalization of the iris image, for the extraction of features and matching. Once the raw scores in different color spaces were extracted then we could start the fusion part of the method. We worked on the prediction using a support vector machine (SVM) and

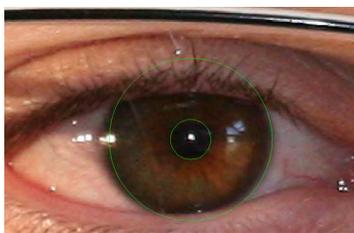


Figure 2: Manual Segmentation

tried to apply sequential search method on this new set of features. The sequential search algorithm, “Plus 2 and Take away 1” (“+2 – 1”), was applied for selecting an optimum subset of the color channels. The system uses the prediction of SVM, which is trained based on hamming distances of client and impostor classes, as input. The selection procedure keeps adding or taking away features (color channels in our case) until the best evaluation performance is achieved. The optimum set found is applied to evaluate the performance of the system in the test step. Two different approaches (averaging and product) are also employed to give a critical view on differences between various fusion methods.

## 4 Experimental Setup

### 4.1 Dataset

We used 10 images of each of the 40 different subjects selected from the UBIRIS.v2 database [9]. The major purpose of the UBIRIS.v2 database is to constitute a new tool to evaluate the feasibility of visible wavelength iris recognition under far from ideal imaging conditions.

### 4.2 Experimental Results and Discussion

In the following tables, for each different color spaces, the results are shown using: FARE, FRRE and TERE (False Acceptance, False Rejection and Total Error, respectively); FART, FRRT and TERT (False Acceptance, False Rejection and Total Error, respectively, Rate for Test). Also the boundary surface for SVM was displaced for minimizing the difference between the FAR and FRR for training (Equal Error Rate, EER).

The results of Table 1 were obtained using a SVM considering EER in the individual color channels shown in the table. The best performance is obtained in intensity color space. The results of Table 2 were obtained using SVM considering EER in three different fusion methods. The best performance is obtained for “Plus 2 and take away 1” method.

In this experiments, the results obtained by adapted “Plus 2 and take away 1” algorithm outperforms “Averaging” and “Product”. The best result in individual subspaces was 35.5% for intensity space (see Table 1) and for the fusion methods we had obtained a result of 30.8% for “+2 – 1” method. So, as expected the results improved considerably.

Table 2: Results (%) for Fusion methods using SVM considering EER

	+2-1	Averaging	Product
FARE	16.7	19.4	19.8
FRRE	16.9	19.4	19.8
TERE	33.6	38.8	39.6
FART	14.6	15.7	16.3
FRRT	16.2	18.1	18.1
TERT	<b>30.8</b>	33.8	34.4

## 4.3 Conclusions

We addressed the problem of using colour information in an iris recognition system. We concluded that, fusing the colour information improves our system. Even using a more intelligent method, sequential search plus SVM method outperforms the blind fusion algorithms such as product and averaging.

This preliminary results encourage further work, but one important aspect to take in account is to use a segmentation method that is suitable for an unconstrained scenario in order to overcome the difficulty observed in applying Masek’s implementation. Also, more color channels are too be tested.

## Acknowledgements

This work is financed by the ERDF European Regional Development Fund through the COMPETE Programme (operational programme for competitiveness) and by National Funds through the FCT-Fundação para a Ciência e Tecnologia (Portuguese Foundation for Science and Technology) within project FCOMP - 01-0124-FEDER-022701 and PhD grant with reference SFRH/BD/74263/2010.

## References

- [1] Dal Ho Cho, Kang Ryoung Park, Dae Woong Rhee, Yanggon Kim, and Jonghoon Yang. Pupil and iris localization for iris recognition in mobile phones. In *Seventh ACIS International Conference on Software Engineering, Artificial Intelligence, Networking, and Parallel/Distributed Computing, 2006. SNPD 2006.*, pages 197–201, june 2006.
- [2] J. Daugman. How iris recognition works. In *Proceedings of the International Conference on Image Processing*, volume 1, pages I–33 – I–36, 2002.
- [3] J.G. Daugman. High confidence visual recognition of persons by a test of statistical independence. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, 15(11):1148–1161, 1993.
- [4] J D Foley, A Van Dam, S K Feiner, and J F Hughes. *Computer Graphics: Principles and Practice*, volume 2nd. Addison-Wesley, 1990.
- [5] Anil Jain, Lin Hong, and Sharath Pankanti. Biometric identification. *Commun. ACM*, 43(2):90–98, 2000.
- [6] L. Masek. Recognition of human iris patterns for biometric identification. towards non-cooperative biometric iris recognition. In *Measurement*, 2003.
- [7] H. Proenca. Iris recognition: On the segmentation of degraded images acquired in the visible wavelength. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, 32(8):1502–1516, 2010.
- [8] Hugo Proenca. Towards non-cooperative biometric iris recognition. 2006.
- [9] Hugo Proença, S. Filipe, R. Santos, J. Oliveira, and L. A. Alexandre. The ubiris.v2: A database of visible wavelength iris images captured on-the-move and at-a-distance. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, 32(8):1529–1535, 2010.
- [10] P. Pudil, J. Novovičová, and J. Kittler. Floating search methods in feature selection. *Pattern Recogn. Lett.*, 15:1119–1125, November 1994. ISSN 0167-8655. doi: [http://dx.doi.org/10.1016/0167-8655\(94\)90127-9](http://dx.doi.org/10.1016/0167-8655(94)90127-9). URL [http://dx.doi.org/10.1016/0167-8655\(94\)90127-9](http://dx.doi.org/10.1016/0167-8655(94)90127-9).
- [11] A. Ross. Iris recognition: The path forward. *Computer*, 43(2):30–35, 2010.
- [12] Mohammad Sadeghi, Samaneh Khoshrou, and Josef Kittler. Svm-based selection of colour space experts for face authentication. In *ICB’07*, pages 907–916, 2007.
- [13] Zhi Zhou, Yingzi Du, and C. Belcher. Transforming traditional iris recognition systems to work in nonideal situations. *IEEE Transactions on Industrial Electronics*, 56(8):3203–3213, aug. 2009. ISSN 0278-0046.