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# Avatar Facial Biometric Authentication

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**Abstract:** With the increasing use of Internet technologies, the impressive evolution of digital media and the emergence of electronic commerce, a need for securing virtual worlds remains a significant challenge because of incessant criminal acts (verbal harassment, fraud and money laundry, theft or data piracy, etc).

In order to fill the gaps in information security, we propose, in this paper, an approach for facial recognition applied in the virtual world on the so called "avatars" based on the exploration of wavelet transforms for the characterization and on Support Vector Machines (SVM) for the classification.

Various experiments were carried out on a dataset of 1800 images collected from popular virtual worlds representing various facial expressions of avatars. Recorded tests have shown promising and encouraging results for such first contribution within the framework of this new research direction.

**Key words:** Face recognition, Avatar, Virtual world, Support Vector Machines, Wavelet transforms.

## I. INTRODUCTION

Biometric authentication is a popular approach which saw a great expansion especially during the last two decades. It provides an interesting solution to the multiple vulnerabilities of information security [1].

In fact, several applications and biometric technologies have been developed based practically on biological characteristics (saliva, blood, DNA), physiological characteristics (face, voice, iris, fingerprints) and behavioral characteristics (signature, gait, typing on keyboard) [2].

Biometric features are specific to each individual and remain, in most cases, unchanged throughout the life time. Consequently, the use and the methodologies behind operational biometric systems are constantly evolving; particularly those based on facial biometry [3].

Such research may also involve the recognition of virtual personages, since the convergence of social networks and the birth of multiple virtual worlds called metaverses.

These metaverses provide for their users interactive spaces and means of unprecedented entertainment for daily living activities (communication, exchange of ideas or information, virtual conference, education, leisure, e-business ...).

Currently, multi-user's virtual environments have more than 303 million subscribers spread over 21 different worlds such as "Second Life", "There", "Virtual MTV", "Active worlds", "LeVillage3d", etc. [4]

According to the Gartner's research firm on April 2007, it is expected that by the end of 2011, 80 percent of active Internet users, will have a virtual life [5].

Figure 1 shows some examples of images collected from various three-dimensional platforms showing some aspects of these virtual worlds.

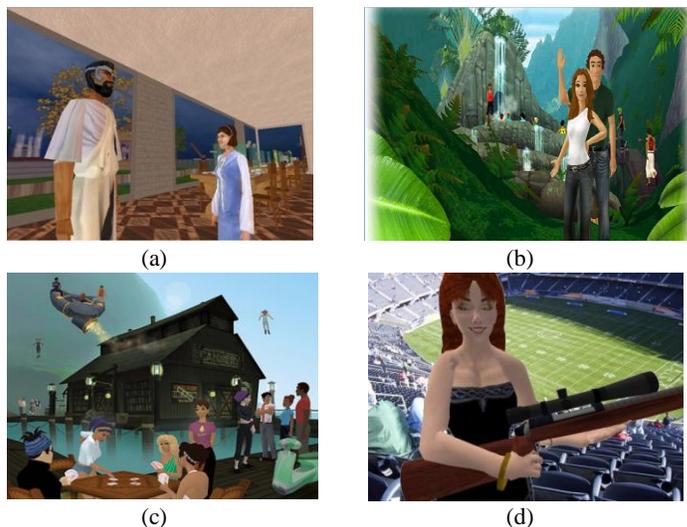


Fig.1. Images extracted from different virtual worlds,

((a) IMVU, (b) There, (c) Active worlds, (d) Second Life)

However, this social virtual sphere and these amazing magical worlds offer so many advantages (meetings, opportunities, enrichment) present also several risks and threats.

Indeed, virtual universes are sometimes more vulnerable than real-worlds owing to the spread of cybercriminals committing various offenses and crimes online such as the use of confidential access codes to banks, theft and sabotage of computer data, electronic piracy, fraud and money laundry and cyber-harassment, rendering the security of these digital areas necessary [6].

This research work is included in this context. It sheds light on biometric recognition of avatar faces, an axe of research which has not been addressed before in the international scale.

Thus, expanding on a number of published results in individual biometric authentication [7, 8, 9 and 10], we propose in this work a facial biometric approach for securing virtual communities. We have

approached avatar authentication via facial identification; a privileged biometric technology.

This work follows the work of M. Boukhris [11] which has developed, within our research team (SID: Signal, Image and Document), an identification approach for avatars faces stemmed from the virtual world “Second Life”. The approach is based on a textural analysis through the wavelet transform and SVM for faces classification.

The various experiments carried out on a dataset of 1000 images of avatars having a resolution of 72 PPI have allowed us to obtain an error rate of 4.07 percent. The recorded results are encouraging and were behind several tracks of research at various levels mainly on the level of database conception, the choice of primitives and the type of the classifier

In this paper, we propose an extension of the work developed by M. Boukhris [11]; we will concentrate on improvements to the database’s conception level.

In what follows, we describe at first the developed avatar face recognition system by detailing each stage of preprocessing, characterization and classification and exposing most techniques for the adopted system. In section 3, we present in details the main experiments conducted together as well as the recorded results and outline future work.

## II. PROPOSED APPROACH

As a first contribution to the avatar face biometric, we opted for the use of a human face identification system. This system follows classical model of a pattern recognition system.

Our Avatar Face Identification System-AFIS is inspired from Human Face Identification System HFIS that we have developed within our research team. The proposed approach follows the general block diagram of a pattern biometric authentication (Figure 2) which complete two principal stages: enrollment and recognition.

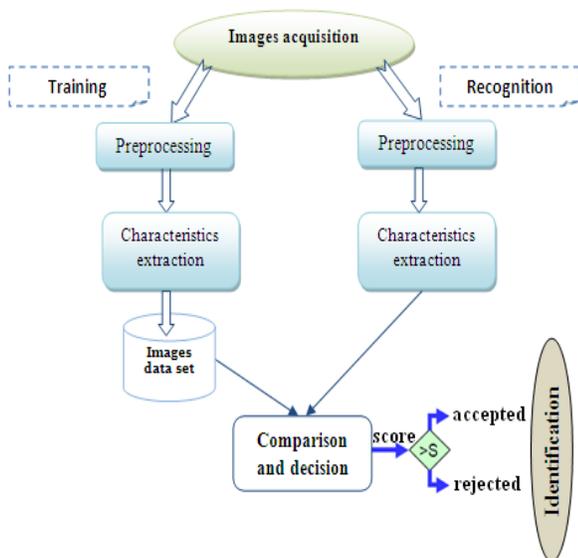


Fig.2. Schematic diagram of developed biometric recognition system

The enrollment stage is a training process step of pattern biometric recognition, the aim of which is to collect information about the person to identify. At the recognition stage, the system will compare the data gathered about the individual with the data obtained in the training stage.

Each stage includes the following modules: a module for detection and preprocessing of images, another for characterization and a final for classification and decision. What follows, is the detailed description of each of these stages.

### A. Acquisition and preprocessing

The phase of image acquisition is a crucial and a preliminary necessary step particularly in the case of our facial identification system AFIS, since there is not an existing image dataset of avatars faces except that of [11] and [12].

According to the traditional method, the acquisition of images is done via a wide variety of sources such as conventional or digital cameras and scanners [13]. But in virtual universes, the procedure of image acquisition is totally different from the process in the real world.

As a first experiment, M. Boukhris [11] fused the most popular three-dimensional platform, the virtual world “Second Life”. During her acquisition process, she has relied on the integrated camera in this metaverse and explored the possibility of changing the appearance and features of the avatar to build a rich database by reassembling new virtual objects (shape, skin color, hair type, etc.). Finally, she has taken different “snapshots” under a specific angle of vision, while changing facial expressions of the avatar (smiles, sadness, surprise, etc.).

To enhance our database, we have explored the website MyWebFace ☺ [14] designed for the construction of virtual characters. This site offers a complete and practical interface for users wishing to create their own character or virtual representation without any registration requirements, with a wide range of expressions (Figure3).

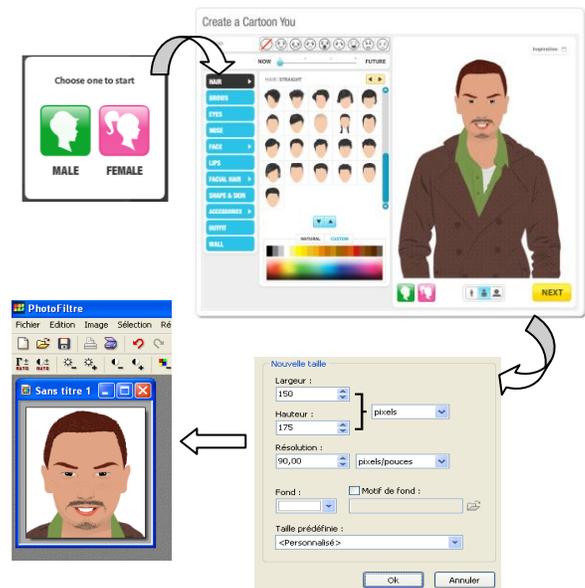


Fig.3. Acquisition Step

At first, we choose the sex of the avatar. Then, we made selections with regard to avatar's appearance (shape of the face, color of the different facial features, accessories, etc.). Finally, we register snapshots of the conceived avatar by means of special software called "captimag", with the possibility of changing facial expressions (smile, sadness, surprise, etc.).

Appropriate software called "PhotoFiltre" is then explored. It allows cropping and extraction of the acquired image manually by taking account of several factors (orientation, poses, dimensioning, scale variability, lighting conditions).

Finally, the preprocessing phase (filtering and normalization) allow us to reduce noninformative areas and prepare the facial thumbnails so they would be exploitable for the characterization stage.

## B. Characterization

The characterization phase is a key step for the system. During this stage, a set of characteristic primitives is extracted which describes as well as possible the main variations of the images to be used. This step is concluded by the application of wavelet transforms in order to obtain information related to original image's texture.

Each avatar's facial image is decomposed into three thumbnails according to RGB color components. The wavelet transform of each of the three images (R, G, B) generates four images derived corresponding to the approximation, the horizontal, the vertical and the diagonal details (Figure 4).

Five characteristics for each color component are chosen: the mean and standard deviation of the approximation matrix, the deviations of the matrices associated with horizontal, vertical and diagonal details. From the color image, we have retained only the entropy. We judge that such a set of features is sufficient to describe the avatar face.

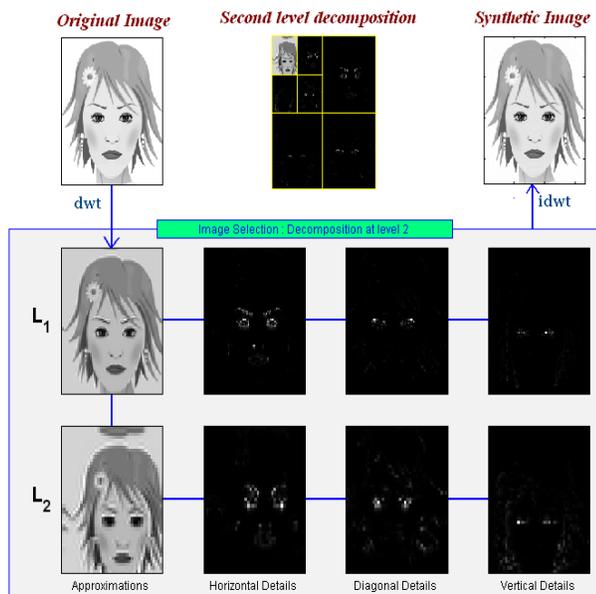


Fig.4. Characterization Step: the derived images

The result of this step is, then, a feature vector of 16 characteristics normalized afterwards by the mean and standard

deviation estimated for each subject. We assume that it is absolutely necessary that the family of wavelets and the suitable level of decomposition should be well-chosen in order to minimize the error of the system.

## C. Classification

During this stage, our algorithm makes a comparison of feature vectors issued from the previous step (identification process) with those associated with training base images. Therefore, it is a process of comparing a collected pattern to the data reference stored in the dataset in order to confirm the identity of the person who wants to access some resources in the virtual world.

The purpose of this task is to check that the identity of the avatar presented exists in the reference database by discerning the most obvious similarities for a better identification. The classification is provided through the use of SVM techniques to finally make the accurate decision. The results of authentication can be one of these forms:

- ✓ Right authentication.
- ✓ Wrong authentication (false acceptance or false rejection).

The last procedure allows the system to make the final authentication decision. Various tests carried out led to the choice of SVM architecture whose kernel is a radial basis function defined by the following equation [15]:

$$K(x_i, y_i) = e^{-\frac{\|x_i - y_i\|^2}{2\sigma^2}}$$

To determine the identity of a person at runtime, we compared the normalized outputs of the SVM classifiers, i.e. the distances to the hyperplanes in the feature space. The identity associated with the face classifier with the highest normalized output was taken to be the identity of the face. If the highest normalized output was below a preset threshold, the face in the input image was rejected by the classifier [16].

## III. EXPERIMENTATION AND OBTAINED RESULTS

In this section, we firstly describe the conceived database. Then, we give an overview on the main recorded results.

### A. Database

By considering the most famous facial databases utilized in human face recognition such as FERET [17], YalesFaces [18], AT&T [19] and AR [20]; we noticed the importance of size, resolution and format similarity of all images to guarantee the performance of face recognition system. We also discern the significant effect of variation pose, contrast and brightness on authentication results.

For the purpose of developing a reliable recognition system and deal with the problem of a possible avatar disguise in the virtual world, we were led to design a rich and large database of avatar images with various facial expressions and additions of makeup or accessories which would provide a consistent training database.

In addition we sought to take the best images from different viewpoints such as the image size, numerical resolution, brightness and contrast variation, the upgrade of gray and under different expressions and occlusions by adding accessories such as glasses, hats, pins, mustaches, etc.

Hence, we fixed images size and increased the digital resolution of the images in the dataset at a certain minimal level so that it would not affect the runtime of the algorithm and from which the performance of the system remains unchanged. The best results are obtained with a resolution of 90 PPI and a fixed size of 150x175 pixels. We also chose to diversify the total number of facial screenshots for each avatar by adding more expressions and accessories to obtain a robust system and fill the gap of impersonation, disguise and cheat attempts.



Fig.5. Few Examples of different face images

Our new gallery dataset contains a plethora of 1800 facial images belonging to 100 different avatars (classes). From each virtual character, a series of 18 images have been derived: the first 14 show different facial expressions (joy, sadness, surprise, fear, etc.). As for the remaining four images, they show some variation in appearance (glasses, accessories, hair, etc). All these color images (Figure 5, Figure 6) were taken in the frontal position with a homogeneous background (white map) and under the same lighting conditions. Among the 18 images of each subject, we chose 12 images for training and 6 for testing.



Fig.6. Examples of different facial expressions with accessories

### B. Recorded Results

In the characterization phase, we multiplied the tests for the choice of the best wavelet family (Haar wavelet, Daubechies's family, Symlets family, Coiflets and bi-orthogonal wavelets) as well as the best decomposition level associated with the family chosen.

Similarly, we carried out several tests to choose the adequate SVM kernel among the following ones: linear, polynomial and Gaussian.

The elaborated experiments and tests of controls have led to the choice of the Daubechie's 9 wavelet family's with second decomposition level. As for SVM kernel, an RBF kernel type was selected.

The performance of our identification employed system AFIS was evaluated by the measure of the two classical error rates: the false rejected rate (FRR) and the false acceptance rate (FAR). The representation of FRR in terms of FAR allows us to obtain the DET curve "Detection Error Trade-off" by varying the system's parameters like the threshold classification.

As shown in Figure 7, we recorded an Equal Error Rate (EER) of 2.2%. It is a specific point of the curve where FAR = FRR. This curve is asymptotic to large values of its axes and near to the origin [21].

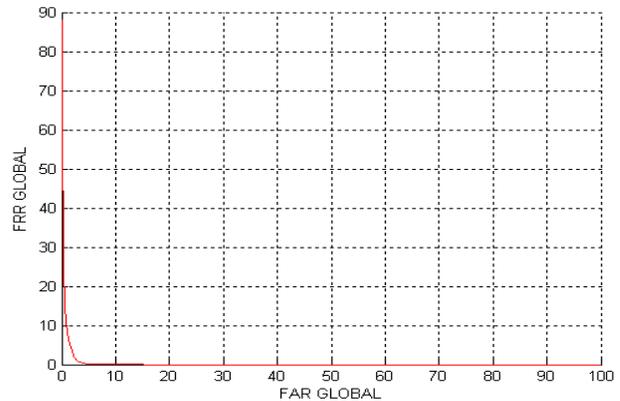


Fig. 7. Obtained DET curve

This obtained rate is more optimized than that reported in the work of M. Boukhris [11] which EER was about 4%. This signifies that the rate of total recognition is appreciably improved despite the extension of training images over a larger range of images and the adding of accessories and makeup to deal with virtual disguise problems of avatars.

### IV. CONCLUSION AND FUTUR WORK

In this paper we have proposed a biometric recognition approach applied on virtual faces, a newly explored area by our research team SID. The proposed system is based on global features resulting from wavelets transform used in the characterization of different face images and on support vector machines classifier in the classification phase.

The various tests led us to the choice of Daubechie's 9 wavelets family with a level of decomposition 2 and RBF kernel SVM.

Furthermore, we have performed several tests for the conception of the data set of avatar images, which led us to increase the total number of images for each virtual faces (from 10 to 18 images per avatar) while adding various accessories and choosing a resolution of 90 PPI and a fixed size of 150x175 pixels for all images in the database.

We are currently pursuing these experiments and tests carried in order to improve the obtained results by attempting to exploit the developed techniques and addressing other virtual worlds such as "Active worlds", "LeVillage3d" and "There". In addition, we project to integrate a specialized platform such as "Luxand FaceSDK" [22] to automate the described face extraction procedure.

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