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AN ACCESS CONTROL SYSTEM FOR E-LEARNING MANAGEMENT SYSTEMS

Knowledge is a key factor to the personal success. The certifications are the instant tools that are commonly available to assess the personal success. In an e-Learning environment, where the learning projects are delivered with the aim to provide a professional or an academic certification, it is integral that the Learning Management Systems provide security features that will ensure the credibility of the online real-time assessments and the certification. In a conventional examination environment, there will be invigilators to overlook the examinees, on the contrary, in an on-line examination environment; it is vital that an invigilation mechanism is implemented to ensure the integrity of the examination. In this article we present a face based access control system for online e-Learning systems.

1. INTRODUCTION

The e- Learning concept creates the freedom of choice for the learners, that is, the learners or candidates enjoy the freedom of choosing the location and time of study according to their convenience. However, when the e- Learning project is aimed at certification of candidates, at the end of the course, the candidates are expected to sit for the examination at a given predefined location.

In the past recent years the Learning Management Systems have gained momentum in terms of use and development, most of the learning management systems consist of almost the same functionalities and features with different architectures, the Learning Management Systems also seem to ignore the fact that the online testing should be automated as it is in the case of tutoring. The candidates should be given the freedom to attend the online tests from a place of their choice as it is in the learning process. The examinations could also be automated, if an integrated access control mechanism is present.

There are many readily available security measures, which can be utilized for access control mechanisms. Nevertheless, the conventional mechanisms are not robust enough for the purpose of invigilation; the username and password based access control is not appropriate for this purpose as these can be swapped with others. The high-level biometric access control mechanisms are neither a plausible choice as not everyone can afford a biometric hardware for a single occasion. Further, since the online examinations are conducted over a period of time of 1 hour or 2 hours, the access control system should be robust enough to guarantee the identity of the candidate throughout the examination session.

It is also vital to conceive that the access control and invigilation system should be robust enough to automatically fuse the identity of the candidate without any intrusive method or user response during the course of the examination. Taking all these above facts into consideration, we built a new face based access control and invigilation system for online examinations using a web camera.

The recent work carried out by Youji OCHI in [1] proposed an online system for monitoring a classroom in a remote lecture with face recognition techniques. We were conceivably inspired that a face based biometric access control system will open the gateway to a new era of e-Learning Management Systems.

2. ARCHITECTURE OF THE SYSTEM.

The architecture and the choice of the detection mechanics are decided based on the prior consideration of the application area and the other features such as detection accuracy and the required performance level. Our System is shown in Figure 1.

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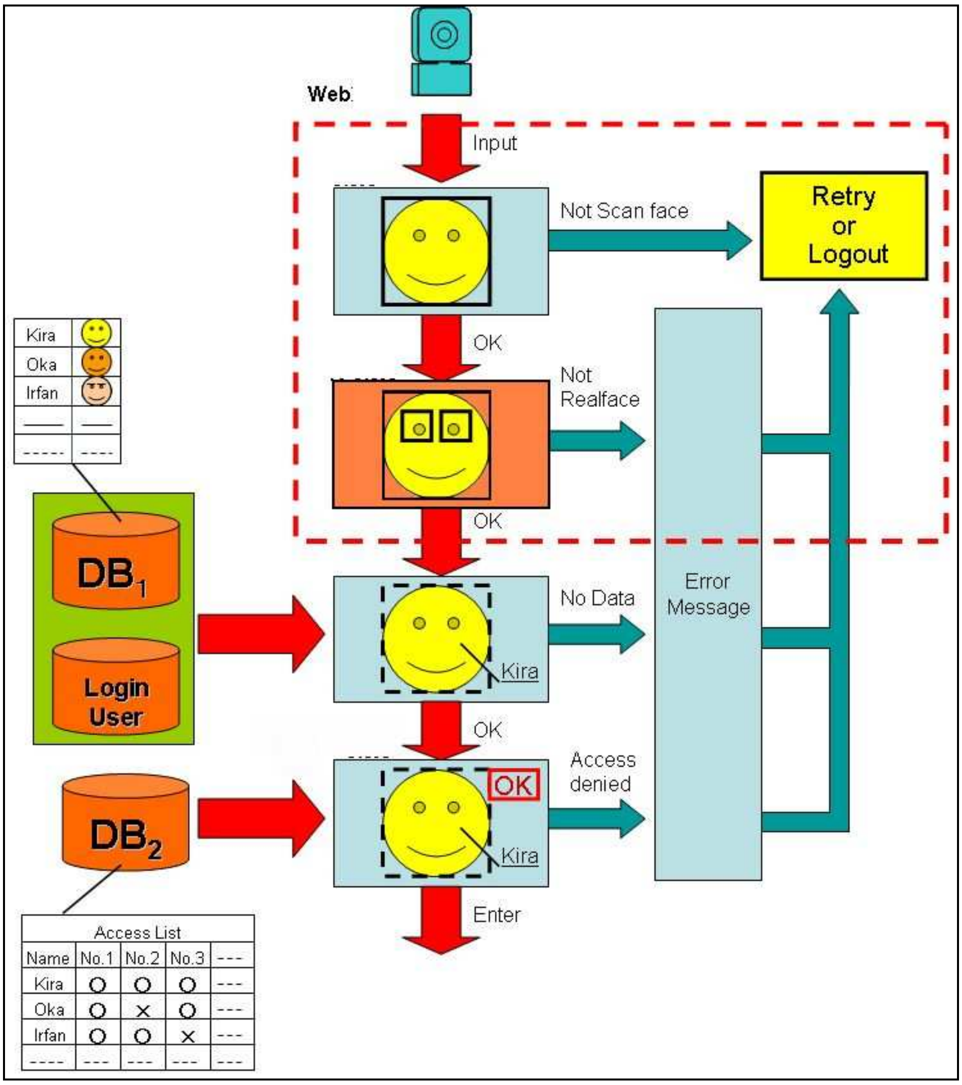

Fig. 1. A simplified Architecture of the System

3. FACE RECOGNITION

The process of face recognition and identification is impeded by the environmental factors such as illumination, scale, orientation, occlusion and other environmental factors [02]. Therefore, the face recognition and identification process is very complex. An enormous amount of work has been done on face recognition and identification in the recent years, the human face is of 3D shape, it is hard to circumvent the problems of occlusion, Illumination, arbitrary background, head orientation and Pose. It comes evident that in real time face detection and identification system, the detection accuracy and performance become very integral features. The conventional recognition algorithms are very expensive in terms of calculations and computer memory utilisation.

It will be wise to implement a light weight classifiers for the human face recognition. In the recent years there have been studies on the utilisation of Haar wavelets for humans face recognition. The study by [03][04][05][06] demonstrated that use of Haar-features can expedite the process of recognition. Unlike the other conventional algorithms, Haar-feature based object recognition is a matter of feature selection and pattern matching which makes it more suitable for real time object tracking.

The approach is so called because the chosen features resemble or are alike Haar wavelets. The Haar-feature based approach is based on the calculation of the intensity levels in different region of the digital images. Thus Haar-features operate on a window of a digital image rather than on individual pixels values.

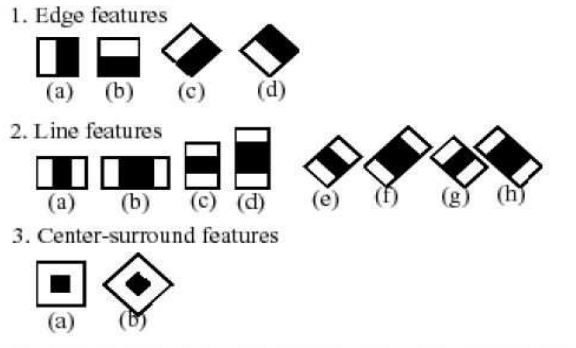

Fig. 2. A variety of Haar features

The feature's value is calculated as the difference between the sum of pixels within the white and black rectangle regions. The Integral image introduced in [06] made the calculation of the sum of pixels extremely light and low cost in terms of time and memory. The approach of Integral Image was inspired from the Summed Area Table which was introduced in [07]. Figure 3 and 4 respectively depicts the calculation mechanism of the Integral image.

$$f_i = \mathrm{Sum}(\mathrm{r}_{\mathrm{i,\ white}}) - \mathrm{Sum}(\mathrm{r}_{\mathrm{i,\ black}}) \quad (1)$$

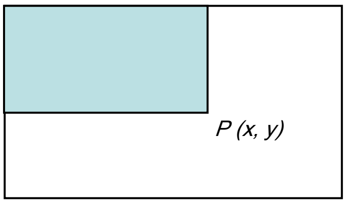

Fig. 3. Integral image at location of *x*, *y* contains the sum of the pixel values above and left of *x*, *y*, inclusive

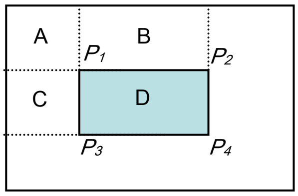

Fig. 4. The sum of pixel values within "D" can be computed by P1 +P4- P2 -P3

$$\begin{aligned} &P_1 = A, P_2 = A + B, P_3 = A + C, P_4 = A + B + C + D \\ &P_1 + P_4 - P_2 - P_3 = A + A + B + C + D - A - B - A - C = D \end{aligned} \quad (2)$$

$$h_i(x) = \begin{cases} 1 & if\ f_i > threshold \\ -1 & if\ f_i < threshold \end{cases} \quad (3)$$

Further to this, in order to make the process more faster the increasingly more complex classifiers are combined in a "cascade" which allows background regions of the image to be quickly discarded while spending more computation on promising object-like regions. The cascade can be viewed as an object specific focus-of-attention mechanism which unlike previous approaches provides statistical guarantees that discarded regions are unlikely to contain the object of interest [06].

Nevertheless, since the Haar-feature based systems only work on intensity levels of different windows of digital images and do not perceive what a face look like, they tend to classify non face object into the face classes. It is very critical to identify whether a recognised object is a face or some other object. in order to perform such a clarification it is vital that the system to have a prior knowledge of the human face. We have introduced a cascaded architecture into our system to nearly completely eradicate the false positives or face-like objects being classified into face class. This is an improvement that we have made compared to the other available Haar-feature based face detection systems. Our cascade is represented in Figure 5.

In our system, when an object is possibly classified into a face class we do another simple but a logical operation to ascertain it is indeed a face. When the Haar classifier detects a certain area as a possible face candidate, we retrieve the detected area and set a Region of Interest (ROI) at the top of the detected area and we search ROI for the presence of human eye. This idea stems from the thinking that all human faces contain a pair of eyes. The double checking mechanism has radically reduced the false positives that were present in the general Haar feature based face classifiers. We use a separate Haar classifier for the eye detection. Figure 5 shows the implementation of the system cascade.

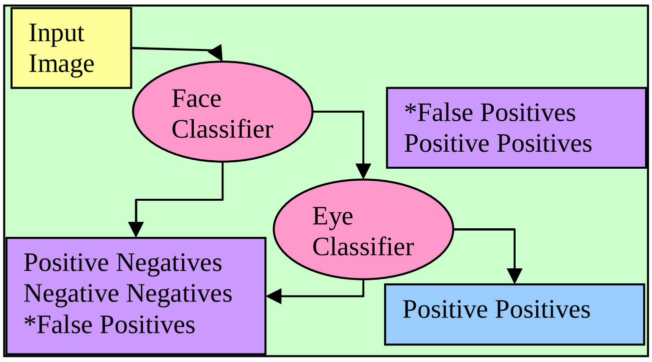

Fig. 5. Cascaded classifiers for object confirmation

Fig. 6. Represents an output of a general classifier

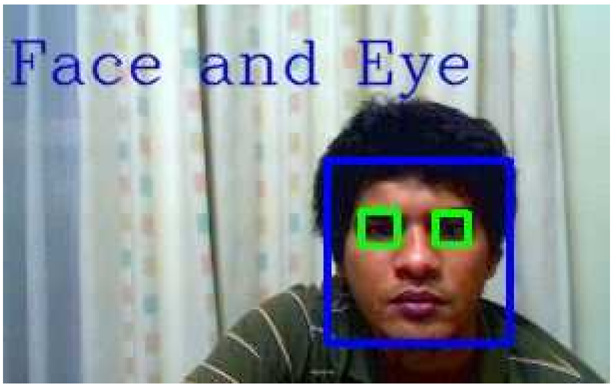

Fig. 7. Represents an output of cascaded classifiers

4. FACE IDENTIFICATION OR VERIFICATION.

We employ DCT-mod2 algorithm proposed in [08] for individual salient feature extraction. This approach is utilised for its simplicity and performance in terms of computational speed and robustness.

Face Images are divided into overlapping N×N blocks. Each block is decomposed in terms of orthogonal 2D DCT basis functions and is represented by an ordered vector of DCT coefficients.

$$\left[c_0^{(b,a)} c_1^{(b,a)} .. c_{M-1}^{(b,a)}\right]^T \tag{4}$$

where (b,a) represent the location of the block, and M is the number of the most significant retained coefficients. To minimize the effects of illumination changes, horizontal and vertical delta coefficients for blocks at (b,a) are defined as first-order orthogonal polynomial coefficients, as reported in [08].

The first three coefficients c0, c1, and c2 are replaced in (6) by their corresponding deltas to form a feature vector of size M+3 for a block at (b,a):

$$\left[\Delta^h c_0 \Delta^v c_0 \Delta^h c_1 \Delta^v c_1 \Delta^h c_2 \Delta^v c_2 c_3 c_4 \cdots c_{M-1}\right]^T \qquad (5)$$

Face identification or verification can be perceived as a two-class classification problem. The first class corresponds to the claimed identity, and the second is of an impostor, in our system we also utilise a simple clustering algorithm followed by FLD to classify the sparse subclasses into more tighter ones. In our system we classify the classes based on their Euclidean distance. Further the FDL will reduce the within-class scatter.

5. CLASSIFICATION ALGORITHM

We initially select a couple of random samples namely $x^c(p)$, $x^c(q)$ with the highest Euclidean distance $d^c(p,q)$ from a random class c. where c = 1,2,3…m, these two samples are called Classification Source Samples(CSS).

When a new sample from another class or the same class is projected, the Euclidean distance from CSS to the new sample $x^k(i)$ as such $d^{ck}(p,i)$ and $d^{ck}(q,i)$. k =1,2,3 m, and i = 1,2..n^c and these are the number of samples from other classes not c.

$$d^{ck}(p,i) = || x^k(i) - x^c(p)||, c \neq k \qquad (6)$$
$$d^{ck}(q,i) = || x^k(i) - x^c(q)||, c \neq k \qquad (7)$$

where ||.|| denotes the Euclidean norm then we calculate the mean value and standard deviation of $d^{ck}(p,i)$ and $d^{ck}(q,i)$, the scope range $r^c(p)$ and $r^c(q)$ as below.

$$d^{\bar{c}}(p) = \frac{1}{n^{\bar{c}}}\sum_{i=1}^{n^{\bar{c}}} d^{ck}(p,i) \qquad (8)$$

$$v^c(p) = \left[\frac{1}{n^{\bar{c}}}\sum_{i=1}^{n^{\bar{c}}}\left(d^{ck}(p,i) - d^{\bar{c}}(p)\right)^2\right] \qquad (9)$$

$$d^{\bar{c}}(q) = \frac{1}{n^{\bar{c}}}\sum_{i=1}^{n^{\bar{c}}} d^{ck}(q,i) \qquad (10)$$

$$v^c(q) = \left[\frac{1}{n^{\bar{c}}}\sum_{i=1}^{n^{\bar{c}}}\left(d^{ck}(q,i) - d^{\bar{c}}(q)\right)^2\right] \qquad (11)$$

$$r^c(p) = d^{\bar{c}}(p) - \alpha v^c(p) \qquad (12)$$

$$r^c(q) = d^{\bar{c}}(q) - \alpha v^c(q) \qquad (13)$$

Here the α is a constant clustering factor, if the Euclidean distance of p,q is greater than maximum scope range of p and q a new cluster within the class is created. The classification is dealt with as described below

1. if $x^c(h)$ is within the scope of CSS, then it is added to the cluster of the CSS
2. if $x^c(h)$ fits into the scope of more than one CSS, then it is added to the cluster which has the shortest distance to the CSS.
3. if $x^c(h)$ does not fall within the range of any CSS, the $x^c(h)$ is considered as a new CSS of a new cluster t = t + 1 and calculate the radius $r^c(h)$ and we perform the above operations until t does not change.

and we perform the FLD to obtain the most salient features, we apply the FLD after clustering so that most discriminating facial features can be extracted for verification.

Since the system is custom made for e-Learning environment we also do an additional check for access privilege based on an access control list.

6. RESULTS AND DISCUSSION

In our working system a simple but a logical operation to ascertain face was introduced. It certainly helped in routing out the false positives. The double checking mechanism has radically reduced the false positives that were present in the general Haar feature based face classifiers. Figures 6 and 7 are more precise evidence of the performance of the system. For the performance check, we collected statistics from the system for a specified time of 30 seconds; we tested 3 different individuals on the system posing approximately from about 90 cm (a general distance between a user and a computer display) from the mounted camera. In 30 Seconds our system processed 179 images; which is, nearly 6 images per second. Our system was entirely developed for the sole purpose of e-Learning systems and to work in the closed environments. We did not carry out a performance check in the out door environment. Most of the vision based face recognition systems are susceptible to the out door environments.

BIBLIOGRAPHY

[1] YOUGI OCHI, HIROKI OHNISHI, NOBUKAZU IGUCHI, YOSHIAKI SHIRAISHI and SONOYO MUKARI, Proposal and Prototype of Student-Video Shooting Support System Using Face Recognition Technology, Japanese Society for Information and System Engineering, vol.24 No.4, pp.301-309, 2007.

[2] W. ZHAO, R. CHELLAPPA, A. ROSENFELD, P. J.PHILLIPS, Face recognition: A literature survey, UMD CfAR Technical Report CAR-TR-948, 2000.

[3] CONSTANTINE P. PAPAGEOURGIOU, MICHAEL OREN, TOMASO POGGIO, A general Framework for Object Detection, Computer Vision, Sixth International Conference on Volume, Issue, 4-7 pp:555 – 562, 1998.

[4] MICHAEL OREN, CONSTANTINE PAPAGEORGIOU, PAWAN SINHA, EDGAR OSUNA, TOMASO POGGIO, Pedestrian Detection Using Wavelet Templates, Computer Vision and Pattern Recognition, Proceedings., 1997 IEEE Computer Society Conference on Volume, Issue, 17-19 Jun 1997 pp:193 – 199, 1997.

[5] CONSTANTINE PAPAGEORGIOU, THEODOROS EVGENIOU, TOMASO POGGIO, Object and Pattern Detection in Video Sequence, Thesis (M.S.)--Massachusetts Institute of Technology, Dept. of Electrical Engineering and Computer Science, 1997.

[6] PAUL VIOLA, MICHAEL JONES, Rapid Object Detection Using Boosted Cascade of Simple Features, Computer Vision and Pattern Recognition, 2001. CVPR 2001. Proceedings of the IEEE Computer Society Conference on Volume: 1, pp: I-511-I-18, 2001

[7] FRANKLIN C. CROW, Summed-area tables for texture mapping, Proceedings of the 11th annual conference on Computer graphics and interactive techniques, pp: 207 – 212, 1984.

[8] C. SANDERSON AND K. K. PALIWAL, “Fast feature extraction method for robust face verification,” Electronics Letters, vol. 38, no. 25, pp. 1648–1650, 2002.