ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

REAL TIME VISUAL AUTHENTICATION USING FUZZY MOMENTS

[1]PRADIPTA K DAS, [2]S. C. MANDHATA, [3]S.N. PATRO
[1]Asst. Prof. Department of Computer Science & Engineering, DRIEMS
Cuttack-754022, India
[2]Asst. Prof. Department of Computer Science & Engineering, DRIEMS
Cuttack-754022, India
[3]Prof. Department of Computer Science & Engineering, DRIEMS
Cuttack-754022, India
Email: [1]daspradipta78@gmail.com, [2]smandhata@gmail.com, [3]snpatro@gmail.com

ABSTRACT

In this novel paper we propose real time visual authentication based on real time image matching using fuzzy moment descriptors, these descriptors are estimated for three common kinds of image attributes namely edge, shade and mixed range. Generally the methods for matching of digital images by the comparison of the positions of directed edges, shades and mixed-range in the captured image with the existing image present in the Data Base, are often prone to error, due to noise and/or variation in illumination. Since a Fuzzy moment descriptors being less sensitive to noise, so it makes the matching process invariant to the above said external disturbances. Further, the normalization and sorting of the moment vectors keep the matching process invariant to size and rotation of images. So in this paper we have considered the fuzzy moment descriptors for matching of digital images and the implementation of the propose work is done using openCv software package interface with the visual c++ to capture the real time image and convert into the gray image and after that, fuzzy moment descriptors for image matching and authentication.

Keywords: *Image Matching, Edges Shades, Mixed Range, Fuzzy Moment Descriptors, Euclidean Distance, Opencv.*

1. INTRODUCTION

With the advancement of information technology and development of World Wide Web (www) almost every netizens data or information is available to millions of unknown users every second. Everyday lots of money transactions are done in banking and other e-commerce related businesses. So the security of the information and verification of the authenticity of the user of the system is a vital issue. There exist mechanisms for verification of authenticity of user by the system such as biometric technology, password authentication, national ID cards, etc. Of late, biometric technology is not just limited to national security scenarios, but also being used for a wide range of application domains such as forensics, for criminal identification and prison security, and, a number of other civilian applications such as preventing unauthorized access to ATMs, cellular phones, smart cards, desktop PCs, workstations, and computer networks [1]. In addition, there is a recent surge in use of biometric technology for conducting transactions via telephone and Internet (electronic commerce and electronic banking), and in automobiles for key-less entry and key-less ignition. Visual authentication system is an automatic system that automatically verifies a person identity using visual information. Visual authentication system is easier to be socially accepted because of its user friendly procedures and low cost sensor [4]. However, the visual data are influenced by many unpredictable environment noises or variation in illumination. This necessitates developing a highly robust kind of image recognition or image matching procedure. Some of the well-known methods in solving illumination problems were proposed [5], [6]. In Ekenel and Sankur paper [7], they searched for the subbands that are insensitive to the variation in illumination by using wavelet transform to decompose the original image to three-level decomposition. They found that the mid-range frequency subband containing horizontal details is successful against variations in illumination. However, the high-frequency subbands that are less affected by illumination [8], [9] are

Journal of Theoretical and Applied Information Technology
30th September 2012. Vol. 43 No.2

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

abandoned. The author in [10] proposed audio-visual (AV) person authentication system. In the image recognition procedure they have considered image with variation in illumination and facial expression variation, the AV system is implemented over internet protocol (IP) to enable long distance access.

In this paper we propose a two stage person authentication system. First visual information is used in verification of an authentic person and after visual authentication stage is passed secondly the more conventional password verification process is again performed to make the system foolproof. The visual authentication is achieved using image matching procedure based on fuzzy moment descriptors. The fuzzy moment descriptor has been successfully applied in image matching [11-13] and robot motion planning [14].

2. PROBLEM STATEMENT

User authentication is performed by the system in two stages. A source digital color image is captured by a wireless camera fitted in the system and it converts into the gray image. Once the gray image has been generated, it starts the extraction of the feature of the image and matches the source image with the reference image database using fuzzy moment descriptors and fuzzy rule based phenomena. If one of the references image has matched with the input image with some threshold, then it provides the USER ID for the image which has matched with the reference image along with the field for entering its PASSWORD for second level authentication.

3. IMAGE MATCHING

We use matching of digital gray images using fuzzy membership-distance products, called moment descriptors [6 -8]. These descriptors are estimated for three common kinds of image attributes namely edge, shade and mixed range. The existing methods for matching of digital images, which are concerned with the comparison of the positions of directed edges, shades and mixed-range in an image with the same form of another image, are often prone to error, due to noise and/or variation in illumination. Fuzzy moment descriptors being less sensitive to noise, makes the matching process invariant to the above stray external disturbances. Further, the normalization and sorting of the moment vectors keep the matching process invariant to size and rotation of images.

The authors have used two distinct approaches for image matching using fuzzy membership functions [2-3]. But none of these techniques consider both the membership value of the regions and their relative distances as image descriptors. These two descriptors of images are having considerable differences for two alike but distinct images. Further, the membership and relative distance between regions remain unchanged in spite of rotation and size variation of the images. As a consequence, the proposed technique is better than the existing techniques of inexact matching. A brief outline of the technique is presented below. In this technique, a gray image has been partitioned into n^2 non-overlapped blocks of equal dimensions. Blocks containing regions of three possible characteristics, namely, `edge', `shade' and `mixed range' are then identified and the sub-classes of edges based on their slopes in a given block are also estimated. The degree of membership of a given block to contain edges of typical sub-classes, shades and mixed range is measured subsequently with the help of a few pre-estimated image parameters like average gradient, variance and the difference of the maximum and the minimum of gradients. Fuzzy moment, which informally means the membership-distance product of a block b[i,w] with respect to a block b[j, k], is computed for all $1 \le i$, w, j, $k \le n$. A feature called `sum of fuzzy moments' that keeps track of the image characteristics and their relative distances is used as image descriptor. The descriptors of an image are compared subsequently with the same ones of other images. We used an Euclidean distance measure to determine the distance between the image descriptors of two images. For finding the `best-matched image among a set of images, we compute the Euclidean distance of the image descriptors of the reference image with all the available images. The image with the smallest Euclidean distance is considered to be the `best-matched image.

3.1 Image Features and Their Membership Distributions

A set of image features such as edge, shade and mixed-range and their membership distribution are formally defined in this sub-section[14].

Journal of Theoretical and Applied Information Technology
30th September 2012. Vol. 43 No.2

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

Definition 3.1. An edge is a contour of pixels of large gradient with respect to its neighbors in an image.

Definition3.2. A shade is a region over an image with a small or no variation of gray levels.

Definition 3.3. A mixed range is a region excluding edges and shades on a given image.

Definition 3.4. A linear edge segment that makes an angle a with respect to a well-defined line (generally the horizontal axis) on the image is said to be an edge with edge angle α. In this chapter we consider edges with edge angles - 45, 0, 45 and 90^0.

Definition 3.5. Fuzzy membership distribution $\mu_Y(x)$ denotes the degree of membership of a variable x to belong to Y, where Y is a subset of a universal set U.

Definition 3.6. The gradient at a pixel x; y in an image is estimated by taking the square root of the sum of difference of gray levels of the neighboring pixels with respect to pixel (x, y).

Definition 3.7. The gradient difference (G_{diff}) within a partitioned block is defined as the difference of maximum and minimum gradient values in that block.

Definition 3.8. The gradient average (G_{avg}) within a block is defined as the average of the gradient of all pixels within that block.

Definition 3.9. The variance (σ^2) of gradient is defined as the arithmetic mean of square of deviation from mean. It is expressed formally as $\sigma^2 = \Sigma (G - G_{avg})^2 P(G)$, where G denotes the gradient values at pixels, and P(G) represents the probability of the particular gradient G in that block.

Once the features of the partitioned blocks in an image are estimated following the above definitions, the same features may be used for the estimation of membership value of a block containing edge, shade and/or mixed range. Generally, the partitioned blocks in an image contain either edge or shades together or mixed range. Let us first consider the case, when a block contains edge and shades. The gradient in such blocks will have non-zero values only on the edges. So, there must be a small positive average gradient of the pixels in these blocks. Consequently, σ^2 should be a small positive number. We may thus generalize that when σ^2 is close to zero but positive, the membership of a block b_{ij} to contain edge is high, and low otherwise. Based on these intuitive assumptions, we presumed the membership curves $\mu(b_{jk}) = 1 - \exp(bx^2)$, b > 0. The exact value of b can be evaluated by employing genetic algorithms. It may be noted that $1 - \exp(-bx^2)$ has a zero value at x = σ^2 =0 and approaches unity as x=$\sigma^2 \to \infty$. The square of x, (x^2) represents the faster rate of growth of the membership curve $1 - \exp(-bx^2)$. Now, let us consider a block containing shades. Here, σ^2should ideally be zero. So, closer the value of x = σ^2= 0, the larger should be the membership function of the block bij to contain shade. This can be realized with a membership function of the form $\exp(-ax)$, a≥ 0. However, for a block containing mixed range, no denote value of σ^2 can be predicted. The value of σ^2 for such a block depends on the type and pattern of the mixed range. It can, however, be easily ascertained that σ^2 for such blocks will neither be too large nor be too small. Thus, the membership of a block b_{ij} to contain mixed range will be higher for moderate value of σ^2.

This can be represented by the function

$$cx^2/(d + ex^2 + fx^3), c, d, e, f > 0.$$

Analogously, the average gradient G_{avg} of a block b_{ij} containing only edge is large. Thus, the membership of a block b_{ij} to contain edge will be high, when G_{avg} is large, as x rises edge from zero. The selection of the membership curve for this phenomenon can be represented by the membership function $1 - \exp(-\alpha x), \alpha > 0$. Again, for shades, the average gradient is very close to zero. Consequently, the membership of the block to contain shade is high, when $G_{avg} \to 0$. This can be modeled by the membership function $\exp(-ax^2), x = G_{avg}$ for blocks containing shades. The G_{avg} of a block containing mixed range will be neither too low nor too high. Thus, a function like $\eta x^2/(\rho + \theta x^2 + \varphi x^3), \eta, \rho, \theta, \varphi > 0$ may be used to model the membership function of for block b_{ij} to contain mixed range. Further for a block containing shade, the maximum and minimum gradients are virtually identical. So, G_{diff} should be close to zero. Thus, a decaying membership curve with a unity value at $x = \sigma^2 = 0$ and a sharp falloff is required. This

Journal of Theoretical and Applied Information Technology
30th September 2012. Vol. 43 No.2

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

has been modeled in our work by $\exp(-ax^2), a > 0$. It is to be noted that the power 4 to x causes a sharp declination in the membership value and mixed range w.r.t. G_{diff} directly follows from the previous discussions. The list of membership functions used in this paper is presented in Table 1.

Table 1 : membership functions for features

Parameter x=	Mixed–range membership	Edge membership	Shade membership
G_{avg}	$\frac{\eta x^2}{(\rho+\theta x^2+\varphi x^3)}$ $\eta,\rho,\theta,\varphi \succ 0$	$1-e^{-8x}$	e^{-ax^2} $a \succ 0$
G_{diff}	$\frac{\alpha x^2}{(\beta+\lambda x^2+\delta x^3)}$ $\alpha,\beta,\lambda,\delta \succ 0$	$1-e^{-bx^2}$ $b \succ 0$	e^{-ax^4} $a \succ 0$
σ^2	$\frac{cx^2}{(d+ex^2+fx^3)}$ $c,d,e,f \succ 0$	$1-e^{-bx^2}$ $b \succ 0$	e^{-ax} $a \succ\succ 0$

The sample set of membership distribution of a block containing edge, shades or mixed range against σ^2 is presented in Fig. 1. and this figure shows that a block having a particular σ^2 may be said to contain edge, shade or mixed range but with different membership values.

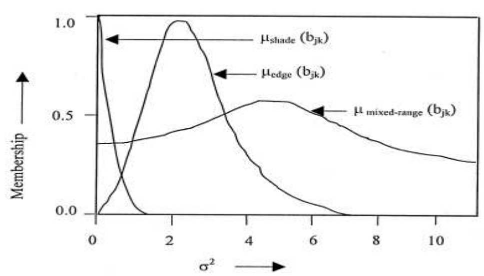

Figure 1: Membership Variations Of A Block $b[j,k]$ *Containing Edge, Shade Or Mixed Range With Respect To* σ^2.

The membership values of a block $b[j,k]$ containing edge, shade and mixed-range can be easily estimated if the parameters and the membership curves are known. A fuzzy production rule is an if-then relationship representing a knowledge in a given problem domain. For the estimation of fuzzy memberships of a block $b[j,k]$ to contain, say, edge, we need to obtain the composite membership value from their individual parametric values. The if-then rules represent logical mapping functions from the individual parametric memberships to the composite membership of a block containing edge. The production rule PR1 is a typical example of the above concept.

$$PR1: IF(G_{avg} > 0.143)\ AND$$
$$(G_{avg} > 0.703)\ AND\ (\sigma^2 \cong 1.0)$$
$$THEN(\text{the block contains edges})$$

Let us assume that the G_{avg}, G_{diff} and σ^2 for a given partitioned block have found to be 0.149, 0.8 and 0.9, respectively. The $\mu_{edge}(b_{jk})$ now can be estimated first by obtaining the membership values $\mu_{edge}(b_{jk})$ w.r.t. G_{avg}, G_{diff} and σ^2, respectively by consulting the membership curves and then by applying the fuzzy AND (minimum) operator over these membership values. The single valued membership, thus obtained, describes the degree of membership of the block $b[j,k]$ to contain edge. For edges with edge angle α, we use the membership curves through fig 2 and obtain the composite membership of a block containing edge with edge angle α by ANDing the membership of a block containing an edge with the membership of its having an edge angle α. The composite degree of membership of a block containing shade and mixed range has been computed similarly with the help of more production rules, the format of which are similar to that of PR1

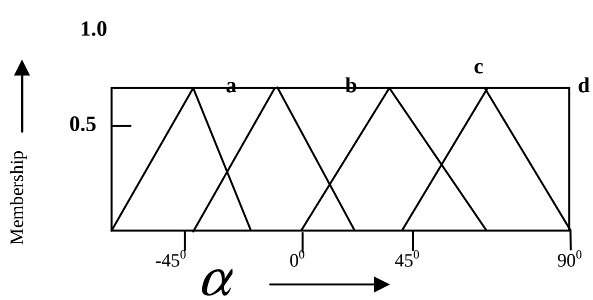

Figure 2: Membership Function Of A Block $b[j,k]$ contain edge with edge angle (a) $\alpha = -45^0$ (b) $\alpha = 0^0$, (c) $\alpha = -45^0$ and (d) $\alpha = 90^0$

Journal of Theoretical and Applied Information Technology
30th September 2012. Vol. 43 No.2

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

3.2 Fuzzy Moment Descriptors

In this section, we define fuzzy moments and evaluate image descriptors based on those moments. A few definitions, which will be required to understand the concept, are in order.

Definition 3.10 Fuzzy shade moment $\left[M_{iw}^{jk}\right]_{shade}$, is estimated by taking the product of the membership value $\mu_{shade}(b_{jk})$ (of containing shade in the block $b[j,k]$) and normalized Euclidean distance $d_{iw,jk}$ of the block $b[j,k]$ w.r.t. $b[i,w]$ Formally,

$$\left[M_{iw}^{jk}\right]_{shade} = d_{iw,jk} \times \mu_{shade}(b_{jk}) \quad (3.1)$$

Fuzzy mixed range and edge moments with edge angle α are also estimated using Definition 3.1 with only replacement of the term `shade' by appropriate features.

Definition 3.11 The fuzzy sum of moments (FSM), for shade s_{iw}, w.r.t. block $b[i,w]$ is defined as the sum of shade moments of the blocks where shade membership is the highest among all other membership values. Formally,

$$S_{iw} = \sum_{\exists jk} d_{iw,jk} \times \mu_{shade}(b_{jk}) \quad (3.2)$$

where $\mu_{shade}(b_{jk}) \geq Max[\mu_x(b_{jk})]$,

$x \in$ set of features.

The FSM of the other features can be defined analogously following expression (3.2).After the estimation of fuzzy membership values for edges with edge angle a, shades and mixed range, the predominant membership value for each block and the predominant feature are saved. The FSMs with respect to the predominant features are evaluated for each block in the image. For each of six predominant features (shade, mixed range and edges with edge angles - 45, 0, 45 and 90^0) we thus have six sets of FSMs. Each set of FSM (for example the FSM for shade) is stored in a one-dimensional array and is sorted in a descending order. These sorted vectors are used as descriptors for the image. For matching a reference image with a set of known images, one has to estimate the image descriptors for the known images. Normally, the image descriptors for a known set of images are evaluated and saved prior to the matching process. The descriptors for the reference image, however, are evaluated in real time when the matching process is invoked. The time required for estimation of the descriptors, therefore, is to be reduced to an extent, whatever possible, to keep the matching process executable in real time. The matching of images requires estimation of Euclidean distance between the reference image with respect to all other known images. The measure of the distance between descriptors of two images is evident from definition 3.12.

Definition 3.12 The Euclidean distance $[E_{ij}]_k$, between the corresponding two k^{th} sorted FSM descriptor vectors V_i and V_j of two images i and j of respective dimensions $(n \times 1)$ and $(m \times 1)$ is estimated first by ignoring the last (n - m) elements of the first array, where n > m and then taking the sum of square of the elemental differences of the second array with respect to the modified first array having m elements. It may be added that the elements of the second and the modified first array are necessarily non-zero.

Definition 3.13 The measure of distance between two images, hereafter called image distance, is estimated by taking exhaustively the Euclidean distance between each of the two similar descriptor vectors of the two images and then by taking the weighted sum of these Euclidean distances.

Formally, the distance D_{ry} between a reference image r and an image y is defined as

$$D_{ry} = \sum_k \beta \times [E_{ij}]_k$$

Where the suffix i and j in $[E_{ij}]_k$ corresponds to the set of vectors V_i for image y, for $1 \leq i, j \leq 6$

For identifying the best-matched image (among the set of known images) with respect to the reference image, one has to estimate the image distance D_{ry} where $y \in$ the set of known images and r denotes the reference image. The image Q for which the image distance D_{rq} is the least among all such image distances is considered the best-matched image.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

4. ALGORITHM

In this section we present the image matching algorithm based on Fuzzy moments and visual authentication procedure respectively in separate sub sections.

4.1 Image Matching Algorithm

The major steps of the image matching are presented in procedure Image-matching, below.

Procedure: **image_matching (IM_1, $IM2$, ….IM_{m+1})**

||IM_1 =reference image||

Begin

for p:=1 to m+1 do begin

Partition IM_p into non-overlapping blocks of n x n pixels;

|| Estimation of parameters and membership values ||

for block:= 1 to n^2 **do** begin

Find parameters $\left(f(x, y), G_{avg}, G_{diff}, \sigma^2\right)$;

$\| f(x, y) = \text{gray level } (x.y) \|$

Find membership

$\left(G_{avg}, G_{diff}, \sigma^2, \mu_{edge}(\text{block}), \mu_{shade}(\text{block}), \mu_{MR}(\text{block})\right)$

end for;

|| Sum of moment computation ||

for $i := 1 \text{ to } n$ **do** begin

for $w := 1 \text{ to } n$ **do** begin

$k := n \times (i - 1) + w$;

|| mapping from 2-d with indices (i, w) to 1-d with index k ||

Find moment sum $\left(S_{iw}, MR_{iw}, E0_{iw}, EP45_{iw}, E45_{iw}, E90_{iw}\right)$;

$E45_p[k] := E45_{iw}$;

$E45[k] := EP45_{iw}$;

$E0_p[k] := E0_{iw}$;

$E90_p[k] := E90_{iw}$;

$MR_p[k] := MR_{iw}$;

end for ;

end for ;

sort $\left(S_p, MR_p, E45_p, EP45_p, E0_p, E90_p\right)$;

||| This procedure sorts array S_p, MR_p etc. into descending order and laces the resulting vectors into corresponding arrays||

|| Image identification from Euclidean distance ||

for $p := 2 \text{ to } (m+1)$ **do** begin

|| *p*= an index to represent image||

$Euclid_p = 0$; $Euclid_1 := 0$;

for $X_p \in \left(S_p, MR_p, E45_p, EP45_p, E0_p, E90_p\right)$ and $X_1 \in \left\{S_1, MR_1, E0_1, E45_1, EP45_1, E90_1\right\}$ **do** begin

find distance (X_p, X_1, d_{x_p}) ;

$Euclid_p = [Euclid_p + d^2 x_p]^{1/2}$;

end for

if $Euclid_p > Euclid_{p-1}$ then

image: =p-1;

else image: =p;

end for ;

end for ;

end

Journal of Theoretical and Applied Information Technology
30th September 2012. Vol. 43 No.2

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

4.2 Visual Authentication Algorithm

Procedure: **visual_authenication**

Initialization: set of images store in the database

Begin

1. Repeat
2. Grab the digital image from wireless camera using OpenCV.
3. Convert the digital image into the gray image.
4. Call procedure **image_matching**.
5. If (match >=THERSHOLD)
6. Display the corresponding user_ID and field for password.
   a. If enter password is valid then user is authenticated.
   b. Else re-enter the password
7. else invalid user and goto step 2.
8. Until input image is matched with the references image.

End

4.3 Rotation and size invariant matching and Noise-insensitive matching

In order to keep the matching process free from size and rotational variance of the reference image, the following strategies have been used.

1. The Euclidean distances used for estimation of fuzzy moments are normalized with respect to the diagonal of the image, which is assumed to have a unit distance. Thus, the Euclidean distance between each two blocks of an image is normalized with respect to the image itself. This normalization of distances keeps the matching process insensitive to the size variation of the images.
2. The descriptor vectors are sorted so as to keep the blocks with most predominant features at the beginning of the array, which only participate subsequently in the matching process. Thus, the matching process is free from rotational variance of the reference image. The insensitivity of matching process to size and rotational variance of the reference image has also been proved through computer simulation.

The matching process used in the paper does not directly depend on the elementary image attributes like G_{avg}, G_{diff} and σ^2 but includes a fuzzy mapping from these features to fuzzy memberships. The fuzzy moments in turn depend on fuzzy memberships and Euclidean distance between blocks. The Euclidean distance between partitioned blocks, for obvious reasons is insensitive to noise. The fuzzy membership distributions, on the other hand, because of their non-linearity, blocks the passage of small Gaussian noise in the elementary image attribute to the computation process of fuzzy moments

For instance, a small Gaussian noise of ± 0.05 over a $\sigma^2 = 0.2$ will have as small as 10^{-6} variations when $1-\exp(-bx^2)$ with $x = \sigma^2$ and b= 0.005 is used as the edge membership distribution.The effect of noise on elementary image attributes is further reduced because of the non-linear mapping of the memberships by the fuzzy production rules.

5. IMPLEMENTATION DETAILS

The implementation of the real time visual authentication is carried out with the opencv in the visual c++ software. The OpenCv software provides the real time digital image grapping and in the first step the OpenCV software is used to grab the digital image in the BMP format. The visual c++ code is used to convert the digital image into the digital gray image. After the convertion into the digital gray image, it call the function "match( )" to match the input gray image with the reference image present in the Data base . In the matching process, we have used the 90% as threshold; if the input gray image is matched with any of the reference images, then it displays the id of the user as one field and another field for user to provide the password for the corresponding user. Now after providing the password, if it matches then the system is authenticated and treats the user as a valid user of the system. The image database used in this work is shown in Table 2.The image database is stored in the system. A test image is captured by the webcam is shown in Figure 3 and Figure 6. Since the captured image i.e figure 3 is matched with the image present in the Data Base, so it displayed the user id and asked for password which is shown in figure 4. Now the user is required to provide the password and if the password is valid then it authenticates the user, which is shown in the figure 5. In the other case for figure 6, since the captured image is not matching with Data Base image so it rejects the user and result is shown in figure 7. Hence figure 6 captured image is not a valid user for system authentication..

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

Table 2. Image Database With Password Field

Image file (BMP format)	Password
 2..bmp	A12
 3..bmp	A@A
 4..bmp	!@#
 5..bmp	A1B

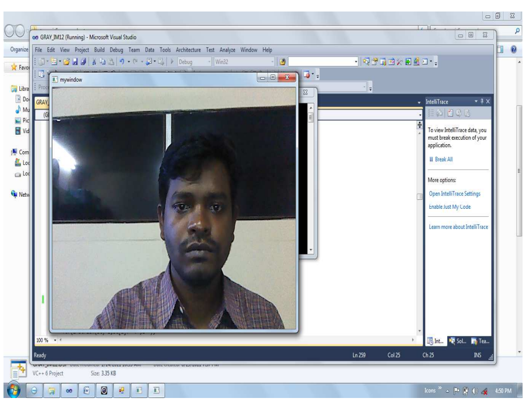

Figure 3: Image Captured By System Camera Through C++ Using Opencv

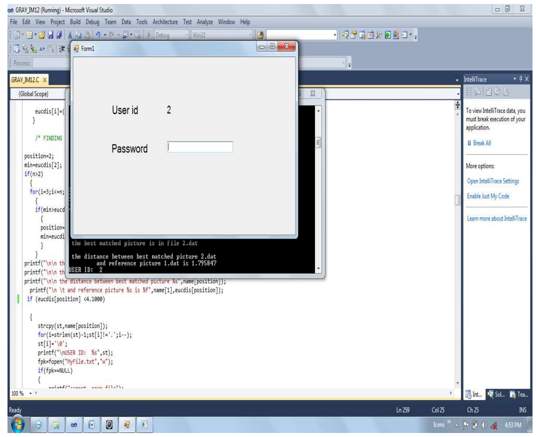

Figure 4: Captured Image Matched In Data Base And Displays Respective User Id And Asked For Password

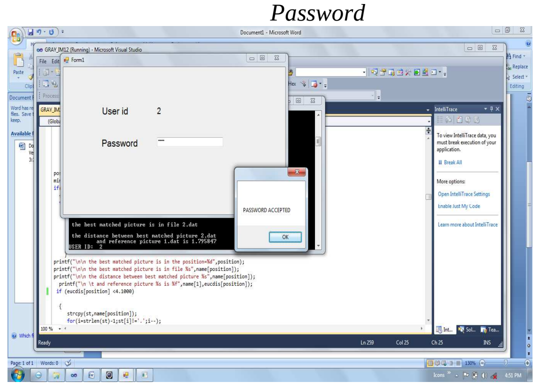

Figure 5: System Authenticate By Valid Password

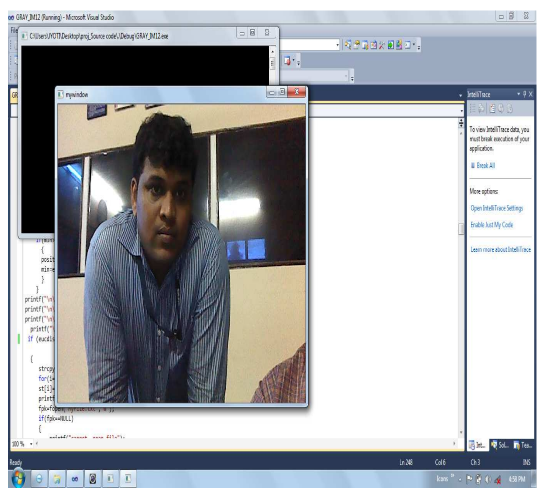

Figure 6: Captured Image By System Camera

Journal of Theoretical and Applied Information Technology
30th September 2012. Vol. 43 No.2

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

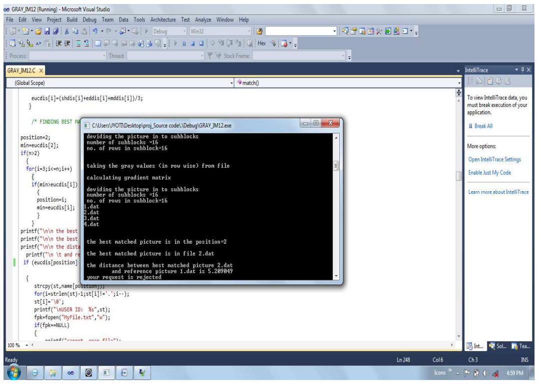

Figure 7: Captured Image Not Found In The Data Base And Rejected By System

6. CONCLUSION

Since the authenticity of user, who uses the system is an important issue. So in this paper we have considered the problem of person authentication using a two stage verification system. Hence whenever a person wants to use the system, the system first verifies the authenticity of the user by visual authentication process developed in this paper. The main contribution of the work is the use of more robust and accurate fuzzy moment descriptor based image matching procedure for visual authentication**.** In this work we have implemented the automatic control of the user authentication and real time visual authentication to control unauthorized access of the system.

7. REFERENCES

[1] A. K. Jain, A. Ross and S. Prabhakar, "An Introduction to Biometric Recognition", *IEEE Transactions on Circuits and Systems for Video Technology, Special Issue on Image- and Video-Based Biometrics*, Vol. 14, No. 1, pp. 4-20, 2004

[2] H. Wu, Q.Chen, M.Yachida," Face detection from color images using a fuzzy pattern matching method", IEEE Transaction on Pattern Matching and Machine Intelligence 21 (6), 557-563 1999.

[3] Dellepiane, S., Vernazza, G., 1992. Model generation and model matching of real images by a fuzzy approach. Pattern Recognition 25 (2), 115-137.

[4] P.S. Aleksic and A.K. Katsaggelos, "*Audio-visual Biometrics*", in Proc. Of the IEEE, vol. 94, no. 11, pp. 2025- 2044, 2006.

[5] P.N. Belhumeur, J.P. Hespanha, D.J. Kriegman, " *Eigenfaces vs.fisherfaces: recognition using class specific linear projection*", IEEE Trans. Patt. Anal. Mach. Intell., Vol.19, no.7, pp. 711–720, 1997.

[6] M. J. Er, W. Chen, S.Wu, J. L, "*High-speed face recognition based on discrete cosine transform and RBF neural network*", IEEE Trans. Neural Netw., vol. 16, no. 3, pp. 679–691, 2005.

[7] H. K. Ekenel and B. Sankur, "*Multiresolution face recognition*", Image and Vision Computing, vol. 23, pp. 469-477, 2005.

[8] C.Naster, B. Moghaddam, A. Pentland, "*Flexible images: matching and recognition using learned deformations*", Comput. Vision Image Understanding 65(2) pp. 179-191,1997

[9] C. Naster, N. Ayache, "*Frequency-based non-rigid motion analysis*", IEEE Trans. Pattern Anal. Mach. Intell. 18 (11) pp. 1067-1079, 1996.

[10] Yee Wan Wong, Kah Phooi Seng, and Li-Minn Ang, "*Audio-Visual Authentication System over the Internet Protocol*", Proceedings of the International MultiConference of Engineers and Computer Scientists 2009 Vol I,IMECS 2009, March 18 - 20, 2009, Hong Kong.

[11] Biswas, B., Mukherjee, A.K., Konar, A., "*Matching of digital images using fuzzy logic*", AMSE Publication 35 (2), 7-11, 1995.

[12] B.Biswas, A.Konar,A.K.Mukherjee,1996. "*Fuzzy moments for digital image matching*", Proceedings of the International Conference on Control, Automation, Robotics and Computer Vision (ICARCV '96), Singapore.

[13] Bijita Biswas, Amit Konar, Achintya K. Mukherjee "*Image matching with fuzzy moment descriptors*", Engineering Applications of Artificial Intelligence 14 43-49,2001.

[14] P.K. Das, A.Konar, R.Laishram, "*Visual-perceptron based motion planning using road map*", International Journal of Computational vision and robotics, pp. 330-440, vol.1,no.4,2010