Research Article **RJMCS (2017) 1:1**

Research Journal of Mathematics and Computer Science (ISSN:2576-3989)

Human Gait identification System

Ali Mohammed mohaisun [1], Muayad Sadik Croock [2]

[1] Informatics Institute for Postgraduate Studies,
[2] University of Technology, Computer Engineering Department.

ABSTRACT

Few biometrics can be used to recognize a person from distance without need for direct sharing or cooperation of that person, gait (walking behavior) is one of them. Walking behavior (gait) recognition includes specifying person identity by analyzing his walking style (walking manner). In this paper, a human gait identification system depending on extracted features, which are vertical hip, horizontal hip angle and slop of thigh. The first step of the proposed system is detecting the binary silhouette of a walking individual from the uploaded videos. Then, the gait cycle is allocated using aspect ratio method. Finally, the required features from each frame in gait cycle are extracted. Different image processing operation have been performed to extract the required features. The outcome of the proposal system reflects flexibility in term of inserting, searching, updating, deleting and matching. The proposed system is tested in terms of offered functions, human recognition and noise effects. The obtained results show the efficient performance of the system and high ability of covering the error caused by surrounding conditions. The system is evaluated using the matching rate with the threshold of 70%. The adding noise can degrade the matching rate, particularly for high variance values. This is because of the increasing of noise values that might be the reason of moving the object irregularly while capturing or unexpected changing in the effected surrounding conditions.

Keywords: Human Gait, Gait Recognition, Biometric.

***Correspondence to Author:**
Ali Mohammed mohaisun
Informatics Institute for Postgraduate Studies.

How to cite this article:
Ali Mohammed mohaisun and Muayad Sadik Croock. Human Gait identification System. Research Journal of Mathematics and Computer Science, 2017; 1:1

eSciencePublisher
eSciPub LLC, Houston, TX USA.
Website: http://escipub.com/

1. Introduction

Biometric methods present primary role for all authentication and recognition operations as concerned with civilian and criminal investigations either for investigation aims or employing as a guide in a court of justice [1]. The problems related with specifying the identity of person depending on the witness's remembrance open the way for human identity specifying and identification methods build on biometric traits [1].

Biometric as a tool for automatic and dependable recognize identification represent a key role in monitoring, electronic passport, and observer list security. Latest years have showed important growth in the implementations of biometric identification, partially because of progress of technology, and partially because of security and person safety causes. In automated way biometric identification methods checking and specify the individual identity in the feeding image and video utilizing biometric features of person [2].In different important implementation Biometric systems for human identification at distance have ever been an increasing demand . Many biometric methods, for example iris, palmprint, fingerprint, hand geometry have been examined and used in a lot of systems. Despite their popular implementation, these methods experience from two major disadvantages: process of matching is failed with low resolution images; pictures captured from a distance, and require user collaboration for precise outcomes [3]. Gait recognition includes identifying an individual by examine his/her walking style [4].

Recently, the using of gait as a biometric in human identifications and recognitions has been widely considered by researchers [5], proved that the walking behavior angular measurements obtained from joint movement fundamental hip angle, knee angle, ankle angle, have most of recognition power for walking behavior identification with a completed valid classification rate of 95.7%. In [6], authors proposed technique for walking behavior identification, which was depended on estimated joint angle. The representation of walking behavior trait for movement angle of lower part and upper part of human body was explored (where silhouette is segmented into six regions and the joints are extracted) as well as joint angle was computed. Experiences were examined on CASIA (B) Database to prove that proposed approach can achieve an identification performance with high-quality. In [7], suggested algorithm that was used to chooses the comprehensive angles from top (head) to bottom (toe) of a person, in addition to calculate the height and width of that person. Experiential outcomes prove that the proposed method shows promising results.

Our method is focused on extract the features related of hip angle that are vertical hip angle (which constituted by thigh according to vertical axis), horizontal hip angle (which constituted by thigh according to horizontal axis) and slop of thigh. [8] tested the importance of 73 characteristic for identification. They discovered that, among the 73 characteristic ankles, knee, and hip rotations could be putted on a top 15 list. Where [9] state that the dataset of hip angle (upper leg) give higher average identification than the knee and ankle angle (lower leg) dataset.

2 The Proposed Algorithm

As mentioned earlier, the adopted features for human gait identification system are H_angle horizontal hip angle, vertical hip angle, and Slop. The user of the system can fill the personal information except its ID which added automatically by the system. The proposed algorithm consists of two main processes: Processing of image and Dealing with Database operations. The proposed algorithm steps can be shown in Figure (1).

A. A. Processing of image: This part includes the following:

❖ **Pre-processing:** Walking behavior recognition system begins with the first stage which is Pre-processing. This stage is divided into four steps:

1. *Read input video:* This is the first step of handling images where we have to read the video sequence. Every frame is chosen as color image to be used in the next operations.

2. *Background subtraction:* It is the process of extract an object (human) silhouette from the background, which enables us to make our calculation on it in easy way. It is an important step as it is considered as the base for the next steps of the proposed algorithm. The background is modeled using the average as follow:

$$B_t(x,y)=\frac{1}{n}\sum_{i=0}^{n-1} I_{t-i}(x,y) \quad \text{..... (1)}$$

Where, $B_t(x,y)$ is the background image at time ***t, N*** is the number of preceding images taken for averaging. This averaging refers to averaging corresponding pixels in the given images.

After the background model is calculated, the pixels of existing image are categorized as foreground pixels depending on the following:

$$|I_t(x, y)-B_t(x, y)|>T \quad \text{..... (2)}$$

Where $I_t(x, y)$ is the current image at the time ***t and T*** is a fixed threshold.

3. Morphological operations: The prior step lead to number of binary image these images could be suffered from holes, closing these holes by use morphological operation closing and structuring element with size ***(2*2)***. After that we using median filter with size mask ***(5, 5)*** to remove the noise

4. Individual silhouette detection: Until now we separate foreground objects from background, by using connected component operation for operation of detection, then remove all objects in image except one which is the largest object. The remaining object is the person silhouette and that is the goal of background subtraction process, then drawn bounding box to the blob that detects by connect component labeling. There are important notes have to be noticed about the captured picture: ***First***, there must be suitable environment where its lighting led to take picture for person with no shadow, which can help to get accuracy calculation and ***Second***, the video must capture by static camera; **Finally,** in this paper, we are dealing only with side view of person and normal gait.

❖ **Gait cycle detection:** After we get the individual silhouette from the background subtraction the aspect ratio of the bounding box of the individual silhouette as a function of time is employed to decide the interval of the gait as follow:

Step1: calculate aspect ratio of bounding box to all binary image that, outcome of last step: [10]

$$r = H/W \quad \text{..... (3)}$$

Where *H* represent height of bounding box, *W* represent width of bounding box, and *r* represent vector of Aspect ratio for all silhouette image.

Step 2: calculate mean of the result of step1(*r*)

$$\mu=\frac{1}{Nt}\sum_{i=1}^{Nt} r_i \quad \text{..... (4)}$$

Where *Nt* is the length of *r*

Step 3: subtract the step1 from step2.

$$V=\frac{1}{Nt}\sum_{1}^{Nt}(r_{i}-\mu) \quad \text{..... (5)}$$

Step 4: calculate the standard deviation of the result of step1.

$$\sigma=\sqrt{\frac{1}{Nt}\sum_{i=1}^{Nt}(r_{i}-\mu)^2} \quad \text{..... (6)}$$

Step 5: divide the result of step3 by output of Step4.

$$d=\frac{V}{\sigma} \quad \text{..... (7)}$$

Step 6: apply moving average on the result of step5

$$y_i=\frac{\sum_{j=0}^{M-1}(d_{i+j})}{M} \quad \text{if } i > 0 \wedge i < Nt - (M-1)$$

$$0 \quad \text{otherwise} \quad \text{..... (8)}$$

Step 7: apply autocorrelation on the result of step6

$$p_i=\frac{\sum_{t}^{Nt-i}(y_t-\mu)(y_{i+t}-\mu)}{\sum_{t=1}^{Nt}(y_t-\mu)^2} \quad \text{..... (9)}$$

Step 8: get the first three local minimum in curve of aspect ratio, which is represent the period of gait cycle.

The gait cycle detection step specifies number of image perform single gait cycle (from one heel strike to the following heel strike).These images are used in the next steps. Therefore, we deal with number of image that perform on one gait cycle instead of all images that is reading from video.

Silhouette segmentation: After the silhouette is obtained , the segmentation for that silhouette can be obtained depending on [11]:

$$\breve{y}_{hip}=\min(y_{sil})+0.5*high \quad \text{..... (10)}$$

$$\breve{y}_{knee}=\min(y_{sil})+.75*high \quad \text{..... (11)}$$

$$\breve{y}_{ankle}=\min(y_{sil})+.90*high \quad \text{..... (12)}$$

Where, $\breve{y}_{hip}$, $\breve{y}_{knee}$, $\breve{y}_{ankle}$ and are subset of high which is represent silhouette's height. y_{sil} Represent the vertical coordinate belong to silhouette, $\breve{y}_{hip}$ Represent the start position of thigh part, $\breve{y}_{knee}$ Represent the end position of thigh part, and $\breve{y}_{ankle}$ represent the end position of the shin. By applying the (**(10)** and **(11)**) equations we can determine the considered thigh part.

Features extraction: By applying the following equations, the vertical hip angle (angle between the thigh and vertical axis), horizontal hip angle (angle between the thigh and horizontal axis) and slop of that thigh are calculated to be as features. The position of hip is performed with [11]

$$\breve{x}_{hipl}=1/p\sum_{j=1}^{p}\breve{x}_j+(2_l-3).high.\mu.10^{-3} \quad \text{..... (13)}$$

$$\breve{y}_{hipl}=\breve{y}_{hip}\,(2_l-3).\left(\frac{\breve{x}_{p-\breve{x}_1}}{2}\right).\sin(0.3.\mu) \quad \text{..... (14)}$$

$$l=\{1,2\}$$

Where $\breve{X}=[\breve{x}_1,\breve{x}_2,\ldots,\breve{x}_j\ldots.\breve{x}_p]$ is subset of p which is horizontal coordinates where $\bar{S}(\breve{X},y_{hip})=1$. Since μ represents walking direction and it is zero for side view image as [11] stated, therefore, the equation (13) and (14) is modified as follow:

$$\breve{x}_{hip}=1/p\sum_{j=1}^{p}\breve{x}_j \quad \text{..... (15)}$$

$$\breve{y}_{hip}=0 \quad \text{..... (16)}$$

An enhanced hip pose approximation is acquired with a linear estimation of the thigh by the first order polynomial with coefficients:

$$q_{l0}=\frac{y^m_{shinl}*.\breve{x}_{hipl}-\breve{y}_{hipl}*x^m_{shinl}}{\breve{x}_{hipl}+x^m_{shinl}} \quad \text{..... (17)}$$

$$q_{l1}=\frac{1}{2}.\left(\breve{\alpha}+\frac{\breve{y}_{hipl}-q_0}{\breve{x}_{hipl}}\right) \quad \text{..... (18)}$$

Where $\breve{\alpha}$ is the straight line slope that approximates the edge of the area of silhouette belonging to the thigh, the area of silhouette belong to the shin is between the $\breve{y}_{knee}$ **, and** $\breve{y}_{ankle}$, y^m_{shin}=min (y_{shin}) and x^m_{shin} is the mean value of the horizontal coordinates at y_{shin}. For side view image, the equation (17) and (18) is modified to be as follow:

$$q_0=\frac{y^m_{shin}*\breve{x}_{hip}}{\breve{x}_{hip}+x^m_{shin}} \quad \text{..... (19)}$$

$$q_1=\frac{1}{2}.\left(\breve{\alpha}-\frac{q_0}{\breve{x}_{hip}}\right) \quad \text{..... (20)}$$

Therefore, the vertical angle is calculated as follow:

$$Va=\pi-\arctan[q_1 \quad \text{..... (21)}$$

Horizontal angle is:

$$\hat{H}=\tan^{-1}\breve{\alpha} \quad \text{..... (22)}$$

B. **Dealing with Data Base:** This step includes five processes which explain below:

1. Adding: process of adding new record to the Human_id table where that record represents the personal information of certain person. We have to note that ID is added automatically, features table will be field automatically with features information after it extracted from the input video, and, fields marked with (*) must be filled as well as we have to choose upload video, after choosing video all other fields are enabled.

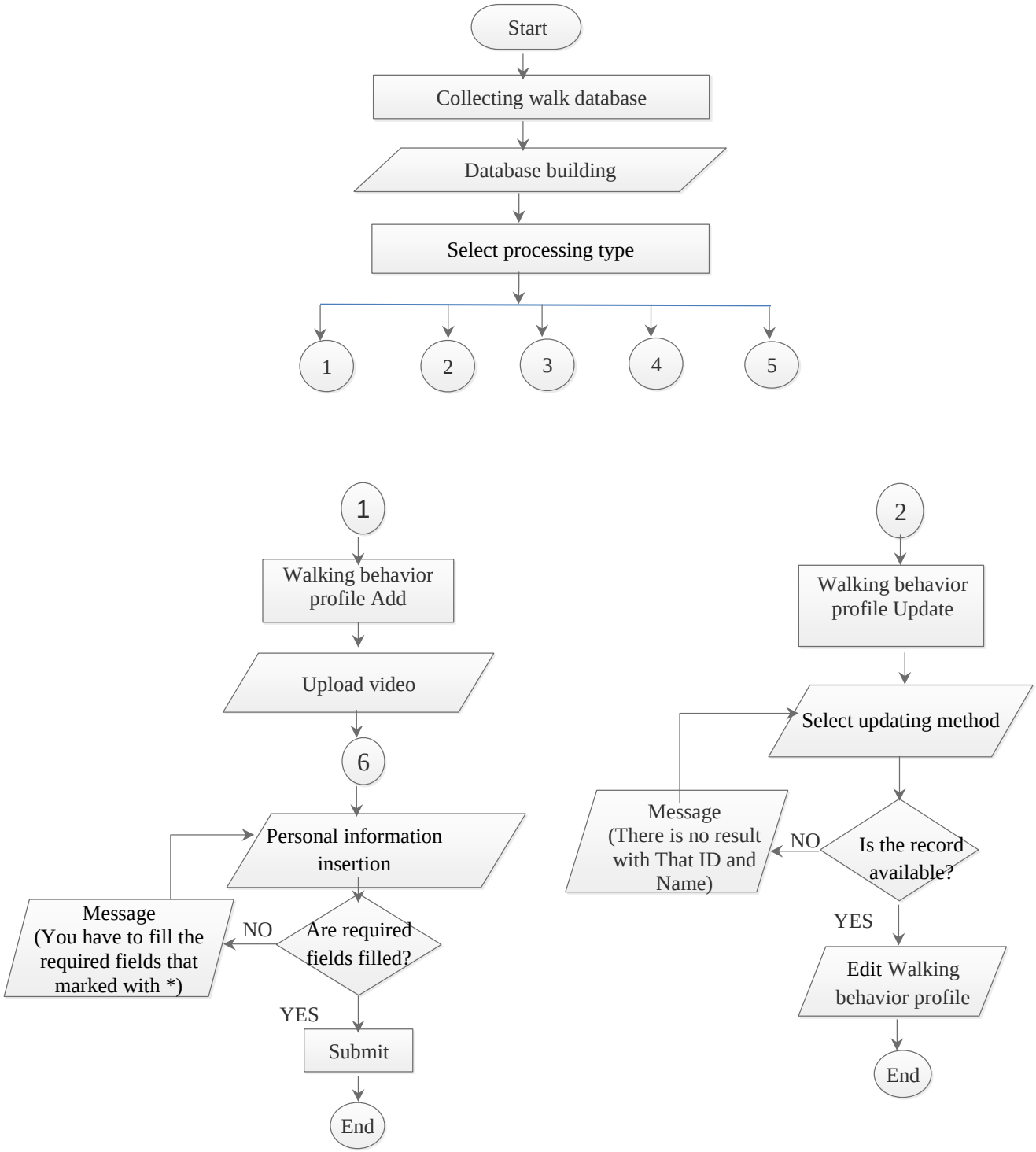
2. Updating: by using ID and Name we can specify the wanted record. Then it could be applied the updating process on the contents of that record.

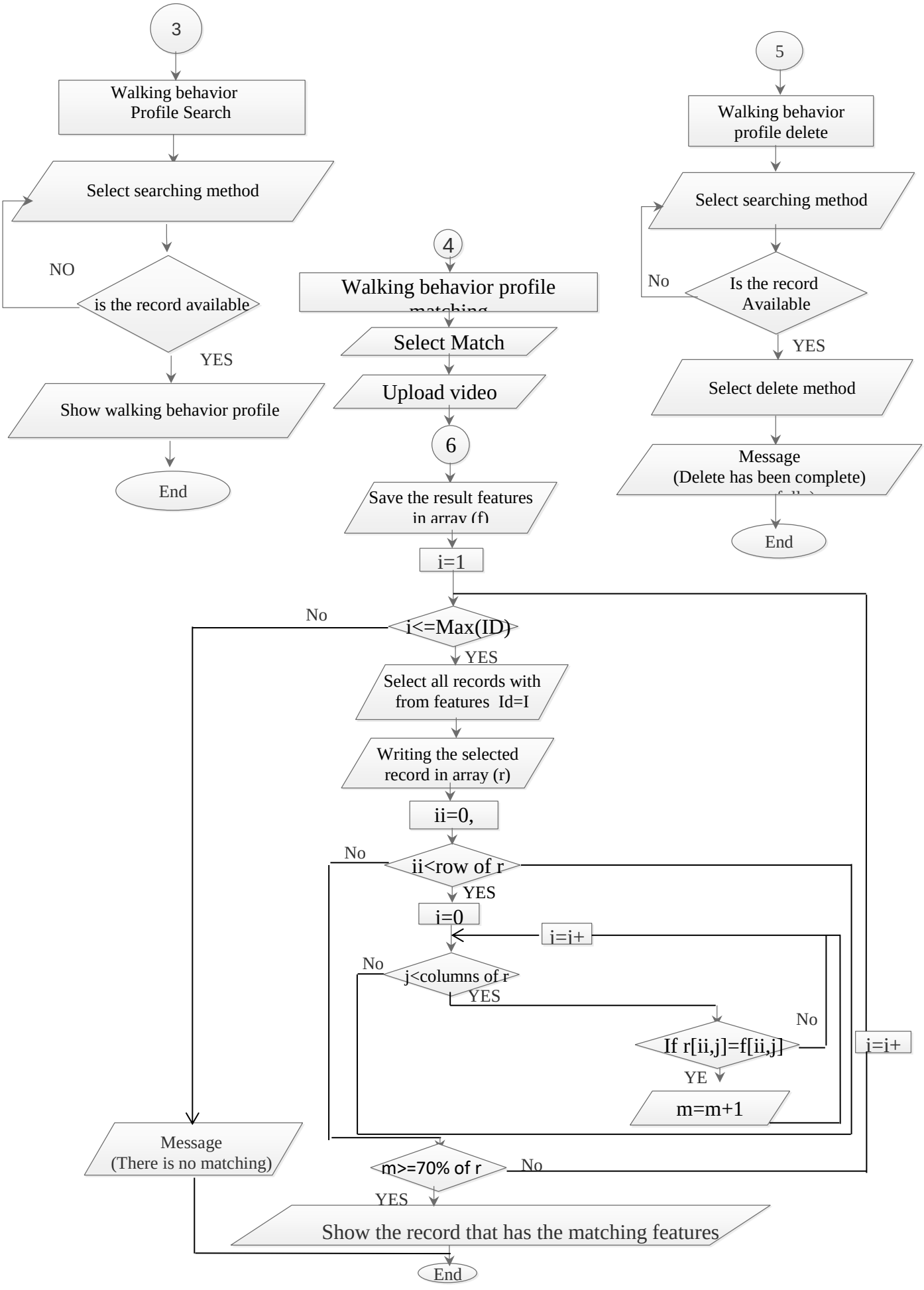
3. ***Searching:*** the process of locating a specific recorde depending on the ID and Name or just the Name.

4. ***Deleting:*** this process delete record from walking database using ***Name or ID***.

5. ***Matching:*** this process is performed by extracting the feature information from the input video then making comparison operation with

all records stored in database as explain below. For each primary key which reference to ***Human_id,*** there is features that stored in another table with foreign key. The process is shown in as shown in Figure (1).




3
Walking behavior Profile Search
Select searching method
NO
is the record available
YES
Show walking behavior profile
End
4
Walking behavior profile matching
Select Match
Upload video
6
Save the result features in array (f)
i=1
No
i<=Max(ID)
YES
Select all records with from features Id=I
Writing the selected record in array (r)
ii=0,
No
ii<row of r
YES
i=0
i=i+
No
j<columns of r
YES
No
If r[ii,j]=f[ii,j]
YE
m=m+1
i=i+
Message (There is no matching)
m>=70% of r
No
YES
Show the record that has the matching features
End
5
Walking behavior profile delete
Select searching method
No
Is the record Available
YES
Select delete method
Message (Delete has been complete)
End

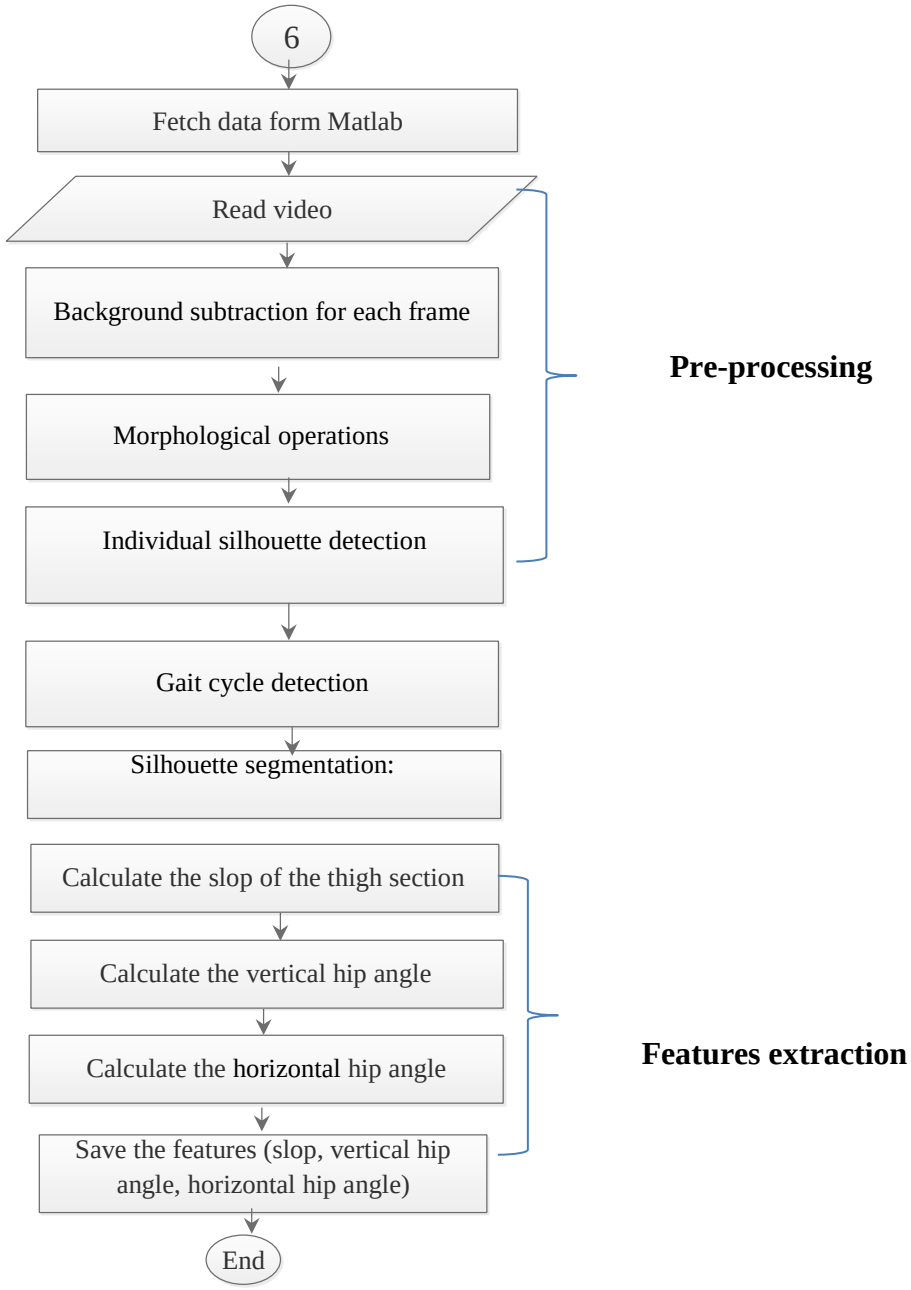
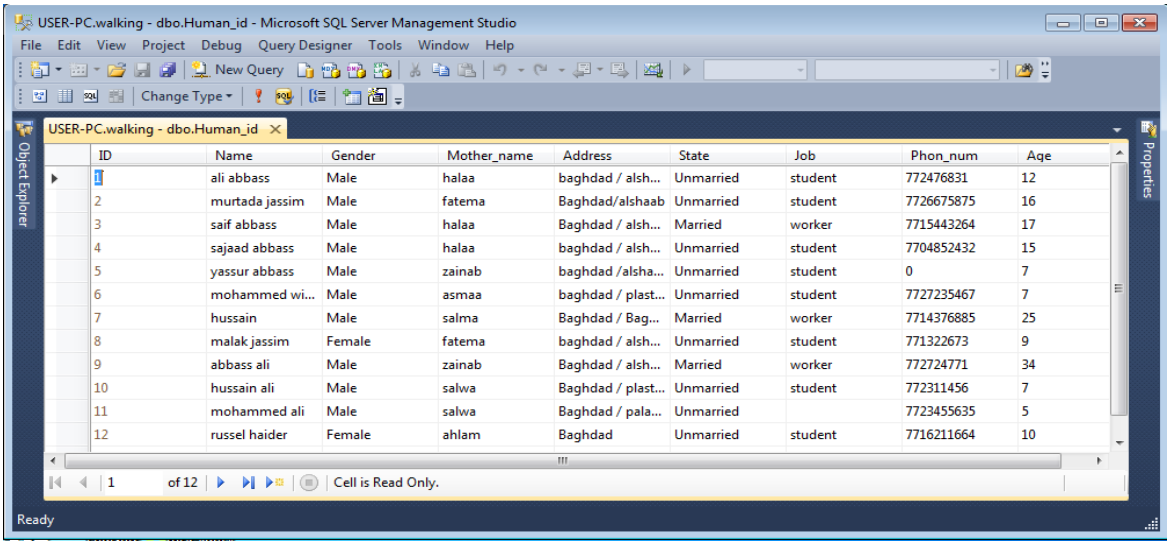


Figure (1): Flowchart of Proposed Algorithm

3 Built Database

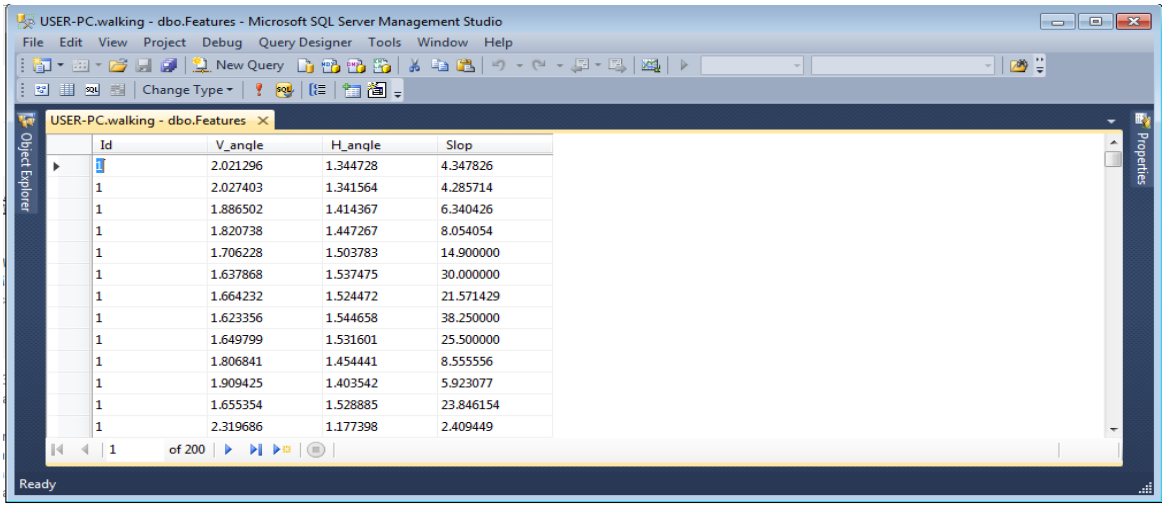
A walking database has been built to include two tables using SQL Server Management Studio (SSMS). The first one contains the personal information about individuals, called, "***Human_id***" that consist of 8 columns, which are *ID, Name ,Gender, Mother_name , Address, State(social state), Job, Phon_num, Age* as shown in Figure (2). This figure shows the involved columns and samples of data.

The other table called "***Features***" contains the extracted features information for individuals that consist of four columns: ID, V_angle, H_angle, and Slop, as shown in Figure (3). This figure shows the involved columns of the table with samples of information. For each person, the ID is generated to be primary and unique to hold the identity of each person. Another thing to be mention that the ID is shared column between the two table in which the person with specific ID in the "***Human_id"*** table have features in the "***Features"*** table belong to the same ID.



ID	Name	Gender	Mother_name	Address	State	Job	Phon_num	Age
1	ali abbass	Male	halaa	baghdad / alsh...	Unmarried	student	772476831	12
2	murtada jassim	Male	fatema	Baghdad/alshaab	Unmarried	student	7726675875	16
3	saif abbass	Male	halaa	Baghdad / alsh...	Married	worker	7715443264	17
4	sajaad abbass	Male	halaa	baghdad / alsh...	Unmarried	student	7704852432	15
5	yassur abbass	Male	zainab	baghdad /alsha...	Unmarried	student	0	7
6	mohammed wi...	Male	asmaa	baghdad / plast...	Unmarried	student	7727235467	7
7	hussain	Male	salma	Baghdad / Bag...	Married	worker	7714376885	25
8	malak jassim	Female	fatema	baghdad / alsh...	Unmarried	student	771322673	9
9	abbass ali	Male	zainab	Baghdad / alsh...	Married	worker	772724771	34
10	hussain ali	Male	salwa	Baghdad / plast...	Unmarried	student	772311456	7
11	mohammed ali	Male	salwa	Baghdad / pala...	Unmarried		7723455635	5
12	russel haider	Female	ahlam	Baghdad	Unmarried	student	7716211664	10

Figure (2): Human_id profile table



Id	V_angle	H_angle	Slop
1	2.021296	1.344728	4.347826
1	2.027403	1.341564	4.285714
1	1.886502	1.414367	6.340426
1	1.820738	1.447267	8.054054
1	1.706228	1.503783	14.900000
1	1.637868	1.537475	30.000000
1	1.664232	1.524472	21.571429
1	1.623356	1.544658	38.250000
1	1.649799	1.531601	25.500000
1	1.806841	1.454441	8.555556
1	1.909425	1.403542	5.923077
1	1.655354	1.528885	23.846154
1	2.319686	1.177398	2.409449

Figure (3): Features profile table

4 Designed GUI

The GUI of the proposed system has been designed and implemented using Visual Studio (VS) C# environment. Figure (4) shows the home page of the proposed system which consist of five main buttons that are relating to the walking data processing: *ADD, SEARCH, UPDATE, MATCHING and DELETE*.

Figure (4): Shows the home page of the proposed system

When user click on ADD button , adding form window is displayed, as shown in Figure (5). It contains two main buttons which is Upload video, and SAVES. The sequence of operations in that window is as follow:

- Selecting ***Upload video*** button that responsible for select the video to be processed.
- Filling the personal information fields manually (the user at least have to fill all the fields with *).
- Finally clicking ***SAVE*** button that allows the system to fetch the extracted features

from the given video. After the images of video are processing by Matlab programming language, these features are added automatically to the new records of ***"Features"*** table (which keep the information of features) in walking database. While other information (personal information) is inserted to "***Human_id"*** table. It is important to note that the ***ID*** for individual is generated by clicking ***SAVE*** button.

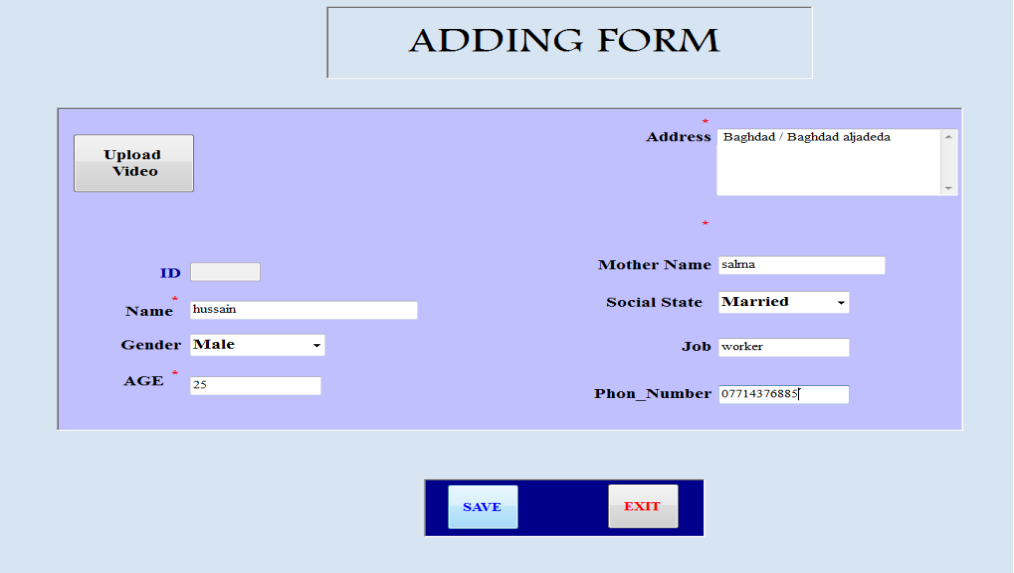


Figure (5): Shows the ADD Form window of the proposed system

clicking UPDATE button from homepage lead to display updating window. This window involves two main buttons (***SAVE*** and ***SEARCH***) as shown in Figure (6). At beginning, the user fills the fields of ***ID*** and Name and then he clicks ***SEARCH*** button to show the desired record. In order to modify record contents, the ***UPDATE*** button is pressed. This process gives the user the ability to change any field of the selected record in easy way.

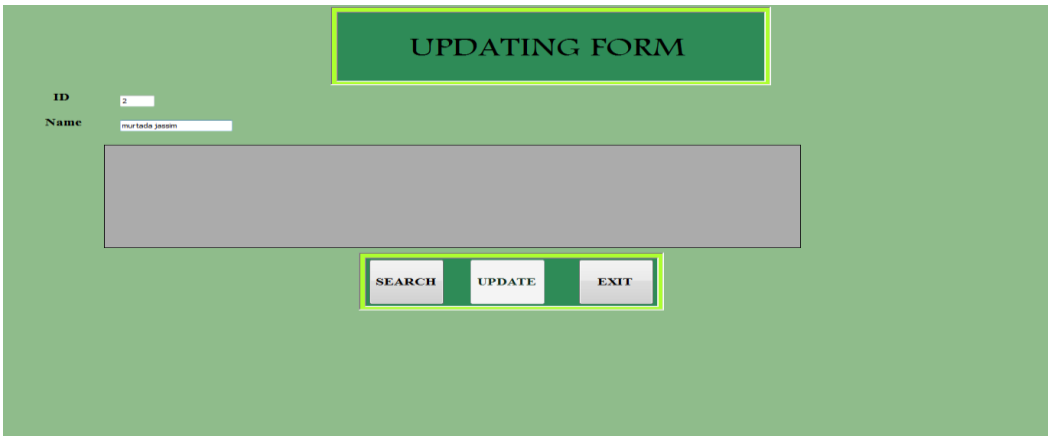


Figure (6): Shows the Updating Form window

Search process is using to help the user of finding information about specific person. When the user select on ***SEARCH*** button from the home page Searching form window is displyed as shown in Figure (7), which contents ***SEARCH*** button and ***SEARCH FOR NAME*** button. The search process is done in two ways: Name and ID. The first one is the Name, where the user click ***SEARCH FOR NAME*** button which views text box to write the name of a user looking for then the system displays all records that near the name as explained in Figure (8). For more accuracy the ***ID*** method is adopted (just enter the ID) that show up only the record that has this ***ID***.

The deleting operation is performed by clicking ***Delete*** button in homepage then move to DELET Window. This window has two main buttons (***DELETE and SEARCH***) as shown in Figure (9). First the user should fill the ***ID*** and Name fields then click ***SEARCH*** button this leads to display the desired record. After the user ensures that the appeared record is the required, he/she can now click ***DELETE*** button to remove it from walking database.

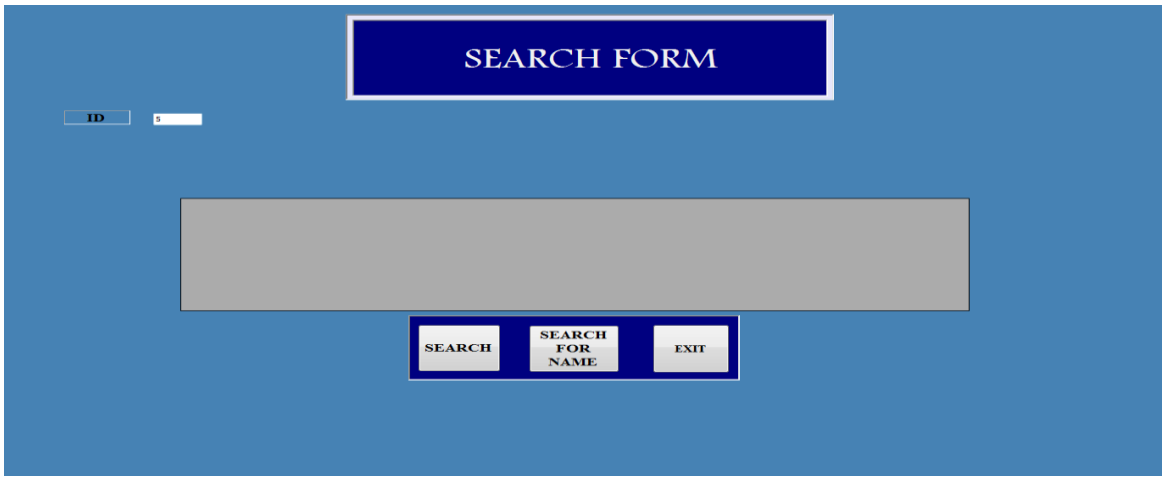


Figure (7): Shows the Searching Form window by typing ID

It is important to focus on the process of matching that can be accessed from homepage by clicking the ***MATCHING*** button to show matching form as shown in Figure (10) . This window contains ***Upload video***, and ***MATCH***.

This form contains the ***Upload Video*** button which is active, while match button is passive. After the upload video is selected, ***MATCH*** button is activated. When ***MATCH*** button is clicked, the features of person video are extracted in Matlab file .The extracted features are used for matching with the already saved records of the same features of different. The matched record is appeared in the screen,or a message box is appeared (There is no matching).

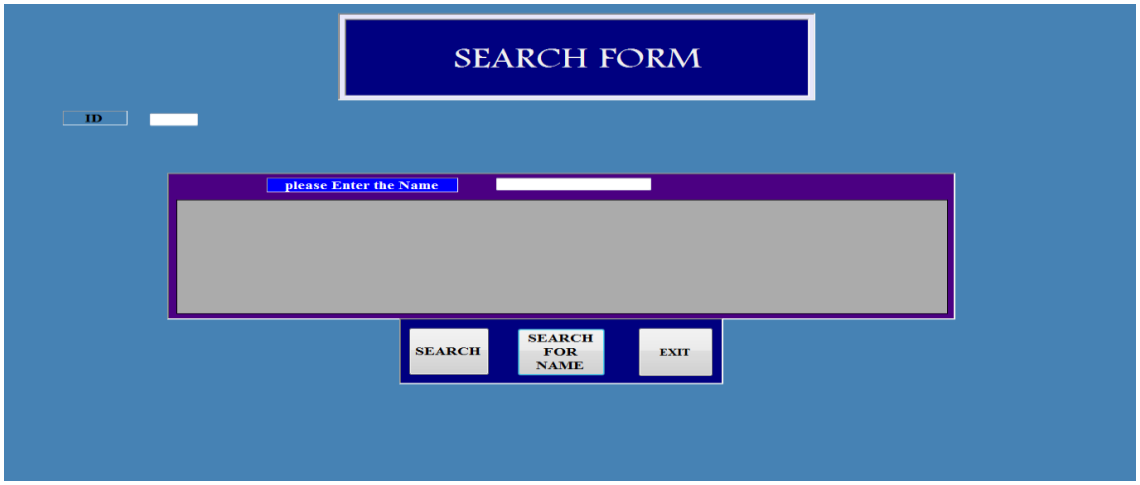


Figure (8): Shows the Searching Form window by typing Name

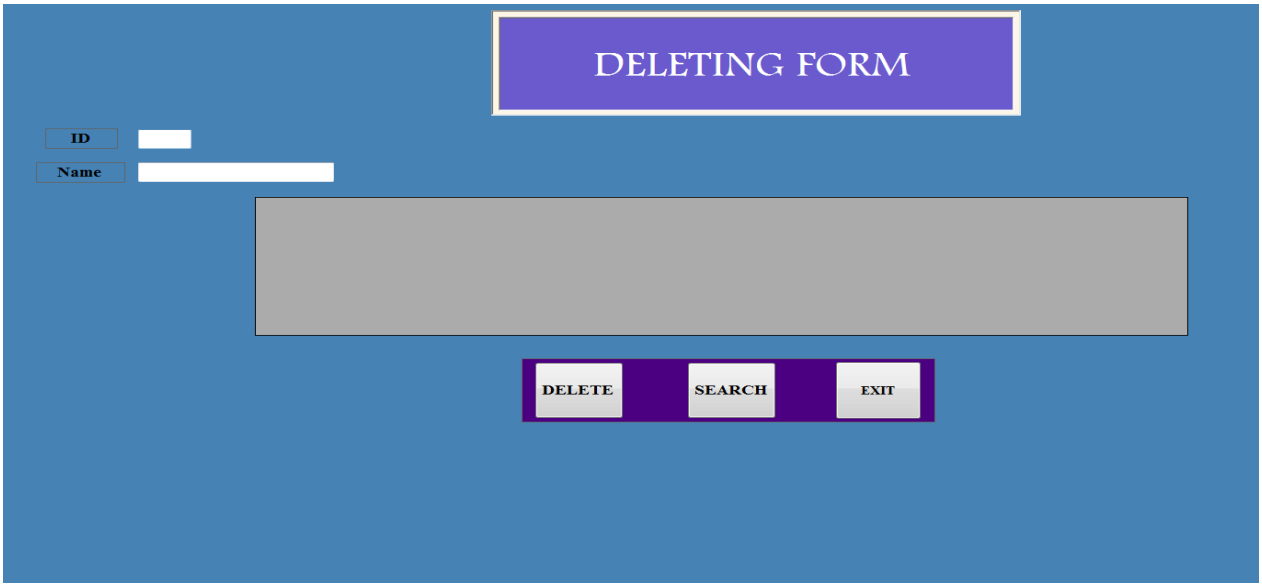


Figure (9): Shows the Deleting Form

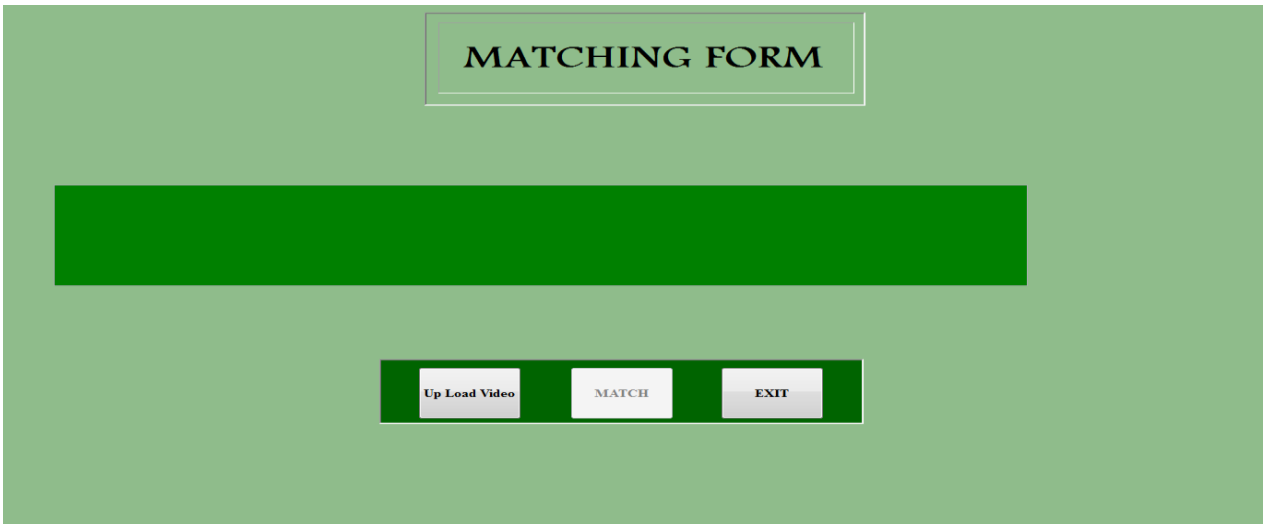


Figure (10): Shows the Matching Form window

Finally, the proposed system gives an authentication level with limited access to the database. There are three login levels: first level where the user (administrator) has a full permission. She/he can perform all the process that was mentioned above (*Add, Search, Update, Matching and Delete*). The second level allows the user to have a permission to perform all the processes except the matching process. The third level gives the user ability to perform the matching process only.

5 Testing Results of the System Functions

The proposed system introduces the ability of adding, searching, updating, and matching on the designed database, built using SQL server 2014. This is performed with employing two processes. The first process starts with uploading the videos to the Matlab2016b software for extracting the required. These features play as the main factors for performing the matching. The second process is controlling the database using designed GUI frames, designed using visual studio (C#). These frames deal with database by applying (Add, Search, Update, Matching and Delete) functions.

The adding function is tested by inserting information of 20 persons as explained in Figure (5). In order to examine the updating task, illustrated in Figure (6), Figure (1) shows the output of updating task where each field is prepared to update.

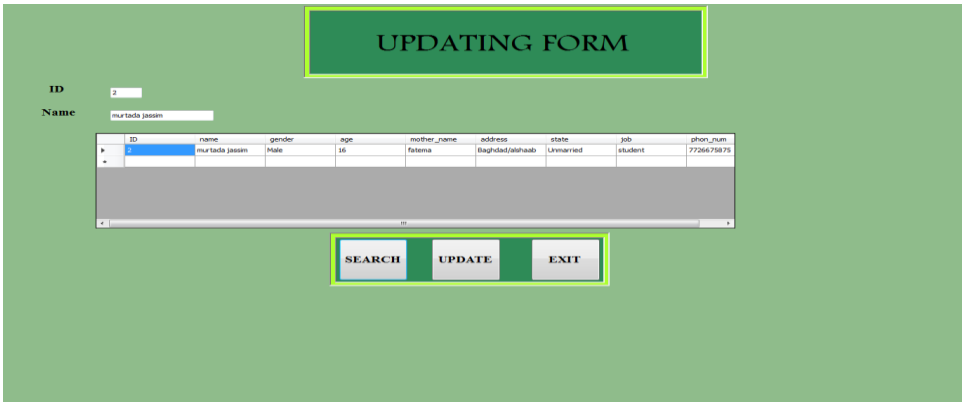


Figure (11): Updating window where each field is prepared to update

In case of searching task, we either select ID or name for searching. Figure (12) shows the output of searching function depending on ID, if it is known or name then the button of SEARCH FOR NAME button is pressed.

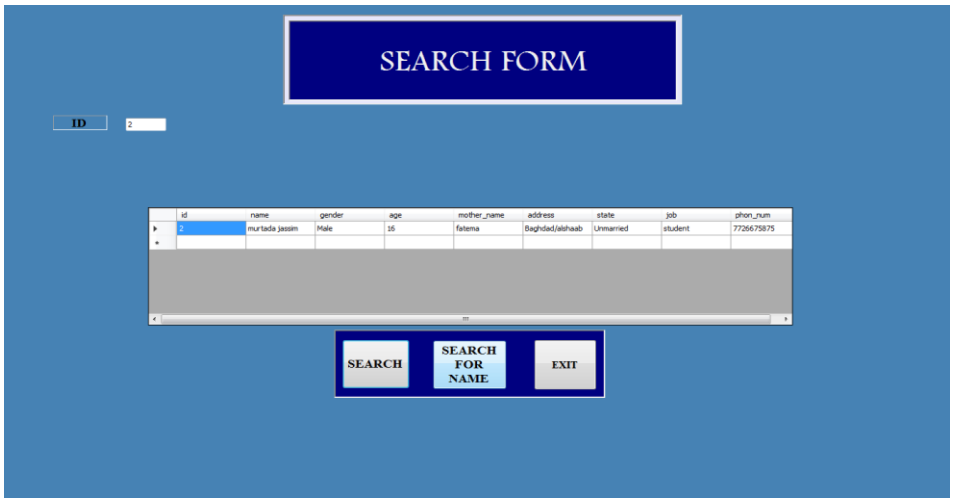


Figure (12): Output of Search window based on ID

The deleting function is started by specifying the wanted person using ID or Name, as shown in Figure (9). In term of matching process, Figure (13) shows the result of matching for person's features with those stored in database. Additionally, Figure (14) shows the appeared message box of (There is no matching) as there is no record in the stored database can match the person.

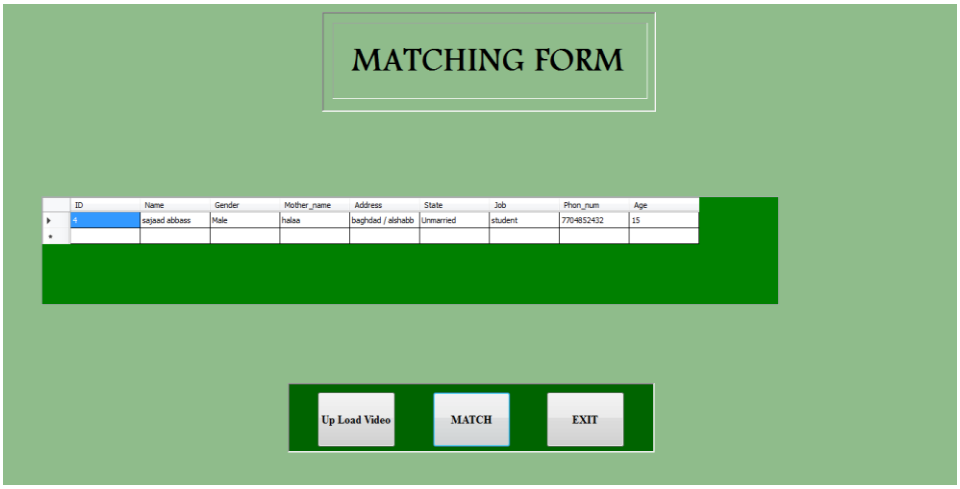


Figure (13): Matching result window

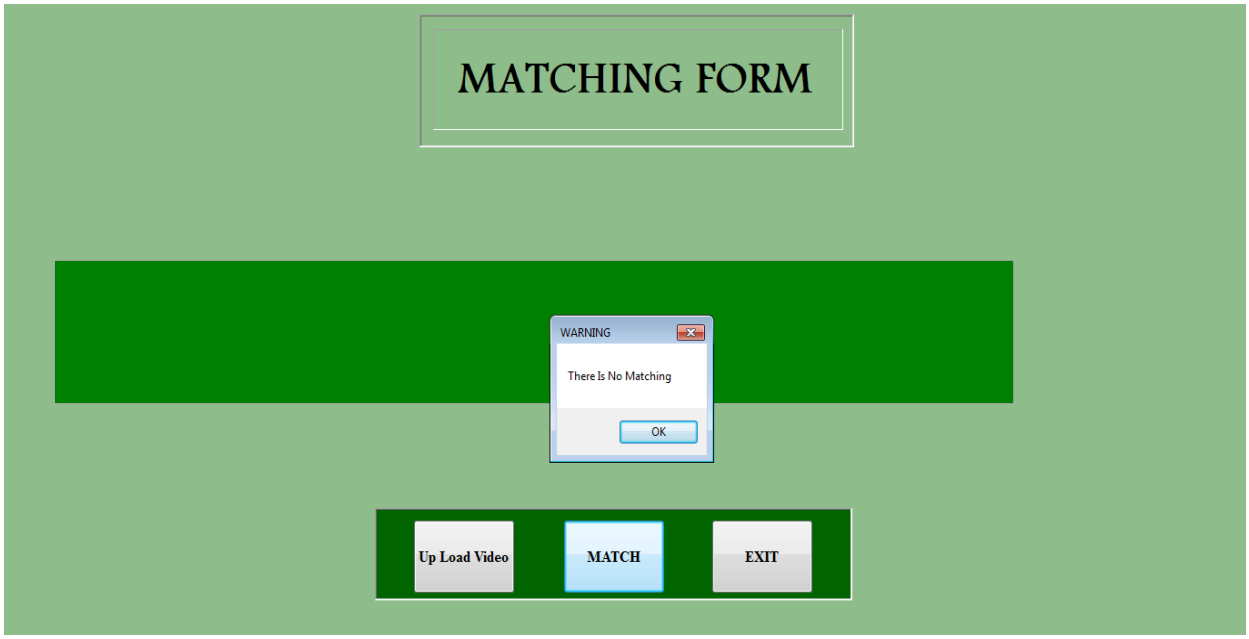


Figure (14): Match window with empty result

5.1 Evaluation of the System

In order to evaluate the proposed system in terms of accuracy of matching and allocating the limitations. This can be done by adding an additional noise to the uploaded videos, in which affecting the resolution of the included images. As it is well known that the extracted features used for matching and recognition are obtained from a stream of images of a particular video. The normal distribution of the added noise is considered in this work with the noise type of Additive White Gaussian noise (AWGN). The AWGN can be calculated following the equation [12]:

$$N_{AWGN}(x,y) = \sigma\, \eta(x,y) \ldots\ldots\ldots\ldots (23)$$

where, $\eta(x,y)$ is a two-dimensions random variable has a Gaussian probability distribution of an additive noise that is characterized by its variance σ^2.

The generated noise is added to the original images of the uploaded video as follows:

$$f_{AWGN} = f(x, y) + N_{AWGN}(x,y) \ldots\ldots (24)$$

In equation (24), $f(x, y)$ represents the original image (uncorrupted image), f_{AWGN} represent the noised image after adding the noise of $N_{AWGN}(x,y)$.

To show the effects of the added noise to the underlying videos (group of images), Figure (15) explains the noise effects on a group of original images with different values of variance as a histogram. It is well seen that the noise effects are increased with the increasing of noise variance (values of adding noise) and the normal distribution is clearly appeared.

The matching rate of the involved images is considered for evaluating the accuracy of the proposed system in terms of achieving the aim of this work. The meaning of matching rate is the number of identical features of the uploaded video and the saved ones in database divide on the total number of features. The matching rate can be mathematically represented as:

$$\mathbf{R_M} = \frac{\mathbf{M_{ch}}}{\mathbf{T_F}} \times \mathbf{100} \ldots\ldots\ldots \mathbf{(25)}$$

Where $\mathbf{T_F}$ is the total number of features of distinct videos, stored in the database. $\mathbf{M_{ch}}$ is the number of identical features of the uploaded video with the stored features in the database. $\mathbf{R_M}$ is the matching rat

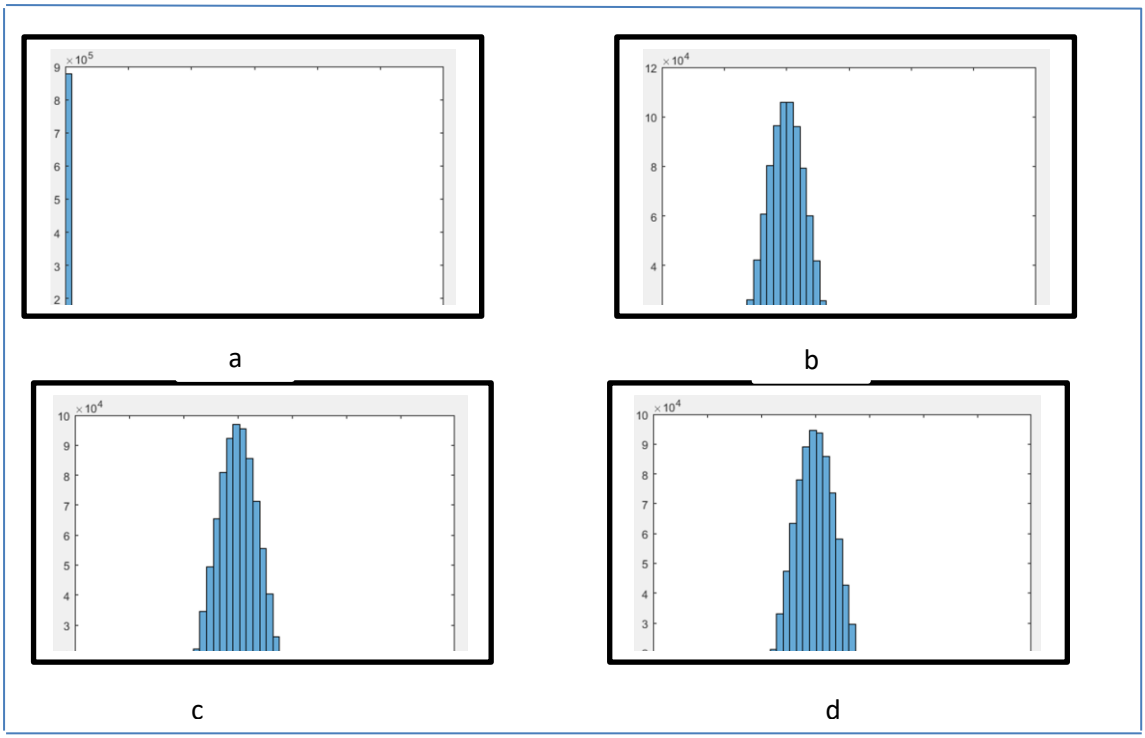


Figure (15): Histogram of noise effects: (a) represents the histogram of one video frame without noise, (b) represents the histogram of a video frame affected by noise with variance of 0.03, (c) represents the histogram of a video frame affected by noise with variance of 0.048, (d) represents the histogram of a video frame affected by noise with variance of 0.05

Five case studies have been considered in this work to satisfy the expected probability of recording a video for specific person to be recognized. Result of one case study will be showed in this paper.

For person named as Abbess Ali, Table (1) shows the results after adding different values of noise variance.

The matching rate is 100% with variance of random noise of (0-0.03), since the values of noise is small and they do not affect the original images. This can happen in ideal case with offering the same conditions of background, camera type and the used software. The matching rates are about 94% and 88% for variance of random noise =0.036, and 0.04 respectively. This is the results of changing some of features due to the noise effects. Matching rates are about 76% and 65% for variance of random noise =0.05, and 0.055 respectively. When the variance of random noise becomes greater, there is possibility to get high difference between the original images and noisy images and as a result of noise effects. Therefore, the matching rate become less.

As mentioned earlier, the matching rate of 70% and above is considered for verifying the matching process. Figure (16) displays the system window of matching form with matching rate of 100%.

Table 1

Noise with variance	Rate of matching
0.03	100%
0.036	94%
0.04	88%
0.05	76%
0.055	65%

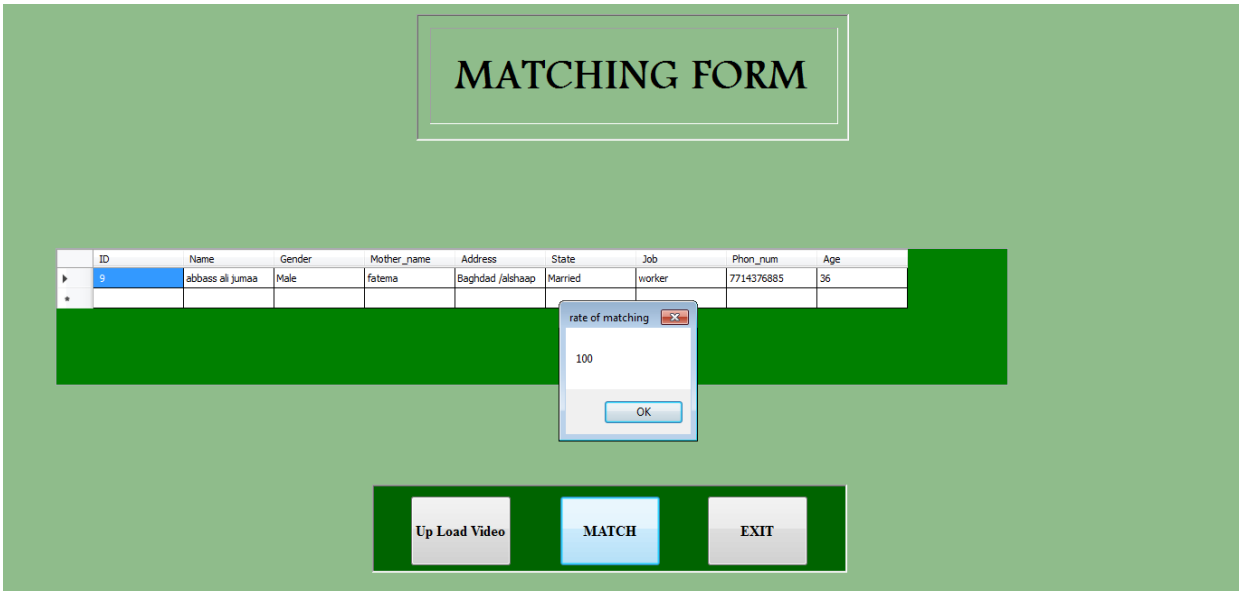


Figure (16): show the matching rate with variance 0.03

6 Conclusions

Different types of image processing functions have been used, such as background subtraction, noise removing and object detection. The proposed system included two main parts: GUI design with algorithms and database of the stored data used for recognition. The GUI design (using Visual Studio C#) involved numerous forms that perform the included functions used for extracting the features using Matlab software. The database was built using SQL server 2014 to store videos of different real people that were used for extracting features for each person. These features are vertical hip angle ((which constituted by thigh according to vertical axis), horizontal hip angle (which constituted by thigh according to horizontal axis) and slop of thigh. It is important to know that the above features were considered in specifying person identity. Based on the work of this thesis, the following points can be concluded as:

1. At first from each frame in the input video a binary silhouette of a walking human was detected. Then, gait cycle was specified using aspect ratio method. Finally, the required features from each frame in gait cycle were extracted.
2. After testing all application function including add, search, update, matching and delete, these processes were performed efficiently in terms of many aspects of capacity, efficiency, and accuracy.
3. Matlab R2016b was used for image processing and feature extraction operations that dealing with taken video and visual studio 2015 environment (C#) was employed to design the GUI. These softwares were selected for suitability reasons.
4. The proposed system was tested throughout applying the offered functions that covered the introduced facilities. The obtained results showed the superior performance of the proposed system in terms of efficiency and accuracy.
5. An examination in terms of matching rate to the proposed system to evaluate the efficiency and specifying the limitations. Five case studies were adopted to test the proposed system against the effect of normal distribution random noise with different variance values, AWGN to simulate the expected changing in the recorded videos overall the process of the system.
6. The obtained results of matching rate

showed that the system can compensate the error happened from different circumstances. The limitation was occurred with increasing of noise values and the adopted matching rate threshold was 70%.

References

[1] S. Kang, "Advances in Computer Vision and Pattern Recognition."

[2] M. Tistarelli, S. Z. Li, and R. Chellappa, *Handbook of remote biometrics* vol. 1: Springer, 2009.

[3] M. P. Rani and G. Arumugam, "An efficient gait recognition system for human identification using modified ICA," *International Journal of Computer Science and Information Technology,* vol. 2, pp. 55-67, 2010.

[4] F. Ahmed, P. Polash Paul, and M. L. Gavrilova, "Kinect-based gait recognition using sequences of the most relevant joint relative angles," 2015.

[5] I. Bouchrika and M. S. Nixon, "Gait recognition by dynamic cues," in *Pattern Recognition, 2008. ICPR 2008. 19th International Conference on*, 2008, pp. 1-4.

[6] A. Saadoon and M. J. Nordin, "An automatic human gait recognition system based on joint angle estimation on silhouette images," *Journal of Theoretical and Applied Information Technology,* vol. 81, p. 277, 2015.

[7] S. S. S. Fathima, R. W. Banu, and S. M. M. Roomi, "Gait Based Human Recognition with Various Classifiers Using Exhaustive Angle Calculations in Model Free Approach," *Circuits and Systems,* vol. 7, p. 1465, 2016.

[8] P. K. Larsen, N. Lynnerup, M. Henriksen, T. Alkjær, and E. B. Simonsen, "Gait recognition using joint moments, joint angles, and segment angles," *Journal of forensic biomechanics,* vol. 1, pp. 2090-2697.1000102, 2010.

[9] W. N. M. Isa, R. Sudirman, and S. H. Sh-Salleh, "Angular features analysis for gait recognition," in *Computers, Communications, & Signal Processing with Special Track on Biomedical Engineering, 2005. CCSP 2005. 1st International Conference on*, 2005, pp. 236-238.

[10] C. Coronel and S. Morris, *Database systems: design, implementation, & management*: Cengage Learning, 2016.

[11] M. Goffredo, I. Bouchrika, J. N. Carter, and M. S. Nixon, "Performance analysis for automated gait extraction and recognition in multi-camera surveillance," *Multimedia Tools and Applications,* vol. 50, pp. 75-94, 2010.

[12] M. Hari Krishnan and R. Viswanathan," A New Concept of Reduction of Gaussian Noise in Images Based on Fuzzy Logic," Applied Mathematical Sciences, Vol. 7, 2013, no. 12, 595 - 602