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Walking Behavior Based Human Recognition System

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

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

ABSTRACT

In the recent period with the growing need for surveillance system, people looking for suitable method to identify person. Depending on the features of biometric that can specify human identity by using identification and verification functions. The verification process is done by compare the biometric features such as, fingerprint, iris, face recognition, etc., with a record stored previously. While the identification process is performed by find the best match between the biometric features and all records kept in a database. Walking behavior recognition is the only biometric that can specify an individual identity at distance that relying on walking behavior features such as step length, angle of hip and knee, etc. In this paper we propose a biometric based human identification system depending on walking behavior characteristic which is vertical hip angle, horizontal hip angle and slop of thigh that extract from captured picture of person. A database of numerous people has been used. A database has been constructed using SQL server software environment in which person identification performed with high efficiency. The outcome of the proposal system reflects flexibility in term of inserting, searching, updating, deleting and matching.

Keywords: Gait, Gait Recognition,walking behavior recognition.

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

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1. Introduction:

The use of biometric to distinguish person identity has developed quickly over the time [1]. Biometric specify the humans' identification depending on their characteristic and extracted features [2, 3]. Using the current recognition methods, such as fingerprint recognition, iris recognition or face recognition, have problems in recognizing people from far distances because they need cooperative user or physical contact. While walking behavior (gait) as an individual walk feature can deal with these kinds of constraints[3]. Walking behavior (gait) is the manner or way of human walking [4]. It is treat as human biometric and is unique feature of each individual person [4, 5]. Very 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[6].

Walking behavior (gait) recognition include specify person identity by analyzing his walking style (walking manner) [7]. Human walking behavior (gait) is a complex job involving the movement of different parts of the body. Walking behavior (gait) parameters like, hip angles, step length, walking cycle, knee and joint rotation can be unique features of the human walking behavior (gait) to recognize person identity [8].

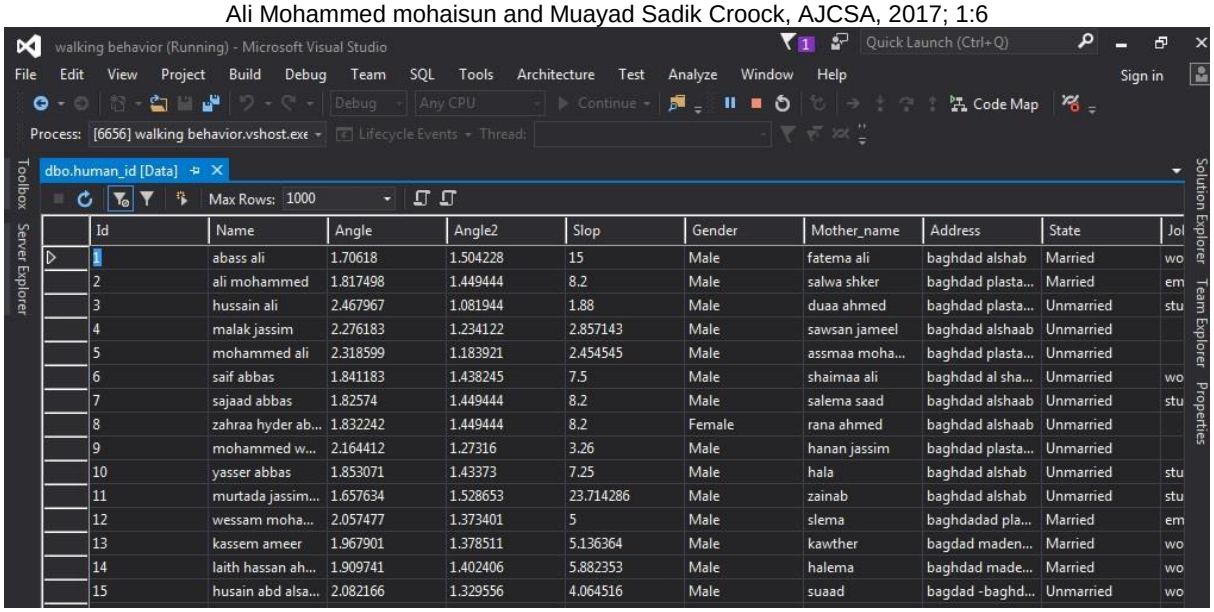
There are a number of research work tackled the walking behavior based recognition. In [6], author stated that walking behavior (gait) recognition was especially helpful in crime scenes where other biometric features might fail. In [9], authors explained that walking behavior (gait) compared with those classical biometric features has many individual vantages: walking behavior looks like to be unique, gait is non-contact and non-invasive: Most biometric features such as palm print, finger print and iris need physical contact. In spite of some biometric application have shown good dependability currently, they until now need to users' agreement to some extent, e.g., the users are disliking to make a physical contact with finger print device and they don't want to look at an iris capture scanner and gait is perceivable at a distance. In [10], authors calculated two spatiotemporal parameters of walking behavior, which is stride length and cadence as unique biometric features. In [11], the proposed method dealt with side view images of walking subject, the parameters that extracted to be used as features is hip angle (the angle between the thigh and vertical axis),the knee angle(the angle between the lower leg and vertical axis) and the ankle angle (the angle of bend of foot according to horizontal axis). The authors of [12], examined the features of people recognition in scenarios with multi camera surveillance. This method worked with broad range of human walking directions.

In this paper we propose an efficient biometric based human identification system depending on features extracted for walking behavior, These features are vertical hip angle (the angle between thigh and vertical axis), horizontal hip angle (the angle between thigh and horizontal axis) and slop of thigh. The obtained results show the superior performance of the proposed system over the conventional methods in terms of efficiency.

2. Profile of Database System

A relational database is a group of data items arranged as set of tables that allow dealing with stored data in providing fast response to a different queries. The relational database was created by E. F. Codd at IBM in 1970. Relational database are assisted by software called relational database management system (RDBMS) such as Microsoft Access Oracle and SQL server [13] and [14]. RDBMS are the heart of much infrastructures of applications in the world involve electronic commerce, health records, e-bill, etc [15] and [16]. In this paper we use SQL server management studio (SSMS) to build SQL database, where SSMS is a program that supply an integrated environment for managing all SQL server elements. SSMS act as tool of graphical management which is uncomplicated for practicing and dealing with it [17].

The underlying database, called ***walk,*** has been built in one main table structure for information about each individual inserted in database ,this table, called ***human_id***, which consist of 13 columns *Id*, *Name, Angle, Angle2, Slop, Gender Mother_name, address, state, job, Child_no, Phon_num* and *Age,* as shown in Figure (1).



Id	Name	Angle	Angle2	Slop	Gender	Mother_name	Address	State	Jo
1	abass ali	1.70618	1.504228	15	Male	fatema ali	baghdad alshab	Married	wo
2	ali mohammed	1.817498	1.449444	8.2	Male	salwa shker	baghdad plasta...	Married	em
3	hussain ali	2.467967	1.081944	1.88	Male	duaa ahmed	baghdad plasta...	Unmarried	stu
4	malak jassim	2.276183	1.234122	2.857143	Male	sawsan jameel	baghdad alshaab	Unmarried	
5	mohammed ali	2.318599	1.183921	2.454545	Male	assmaa moha...	baghdad plasta...	Unmarried	
6	saif abbas	1.841183	1.438245	7.5	Male	shaimaa ali	baghdad al sha...	Unmarried	wo
7	sajaad abbas	1.82574	1.449444	8.2	Male	salema saad	baghdad alshaab	Unmarried	stu
8	zahraa hyder ab...	1.832242	1.449444	8.2	Female	rana ahmed	baghdad alshaab	Unmarried	
9	mohammed w...	2.164412	1.27316	3.26	Male	hanan jassim	baghdad plasta...	Unmarried	
10	yasser abbas	1.853071	1.43373	7.25	Male	hala	baghdad alshab	Unmarried	stu
11	murtada jassim...	1.657634	1.528653	23.714286	Male	zainab	baghdad alshab	Unmarried	stu
12	wessam moha...	2.057477	1.373401	5	Male	slema	baghdadad pla...	Married	em
13	kassem ameer	1.967901	1.378511	5.136364	Male	kawther	bagdad maden...	Married	wo
14	laith hassan ah...	1.909741	1.402406	5.882353	Male	halema	baghdad made...	Married	wo
15	husain abd alsa...	2.082166	1.329556	4.064516	Male	suaad	bagdad -baghd...	Unmarried	wo

Figure (1): human_id table

3. GUI Design:

The Visual Studio (VS) C# environment is used to design the GUI frames of the suggested system. It is possible to guarantee that GUI as designer software can introduce easy dealing design, so that user does not require skills to deal with it. Figure (2) show the system homepage which includes five main buttons related to walk database file processing: ***ADD, SEARCH, UPDATE, MATCHING and DELETE***.

When user click on Add button in the home page, the system shows adding form window as shown in Figure (3). It contains main button of (***SAVE***) that allows the system to fetch the extracted features from the given image as a Matlab file where the images has been processing in Matlab programming language. These features are added automatically to the new record of personal information table (***human_id***) in walk database while other information is inserted by user manually.

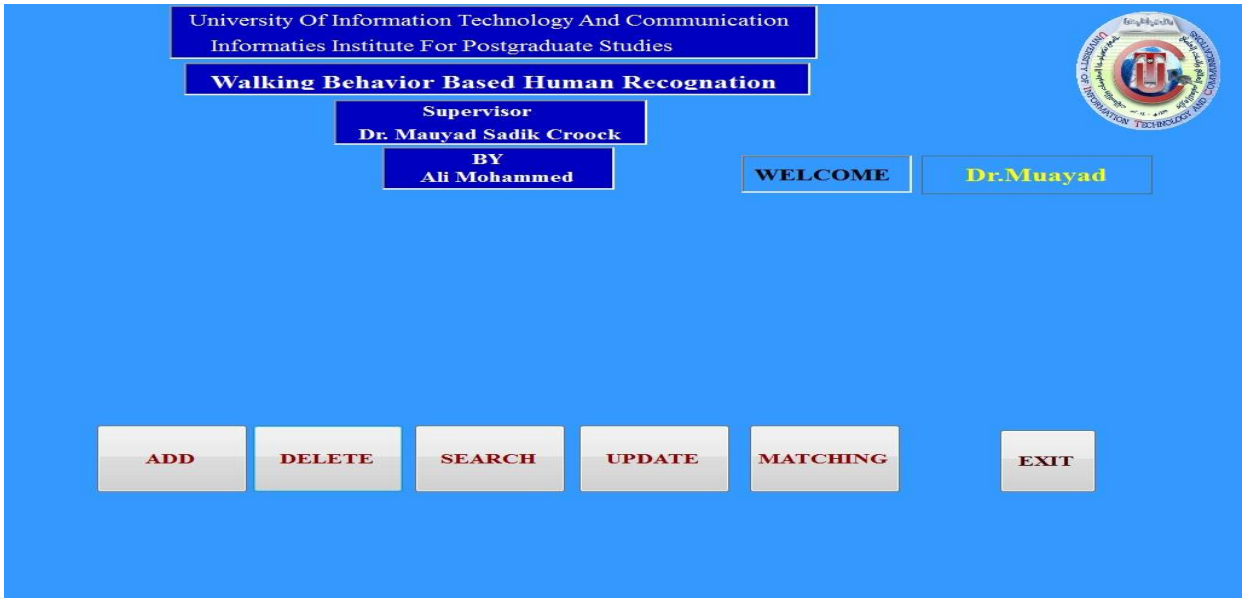


Figure (2): Homepage form

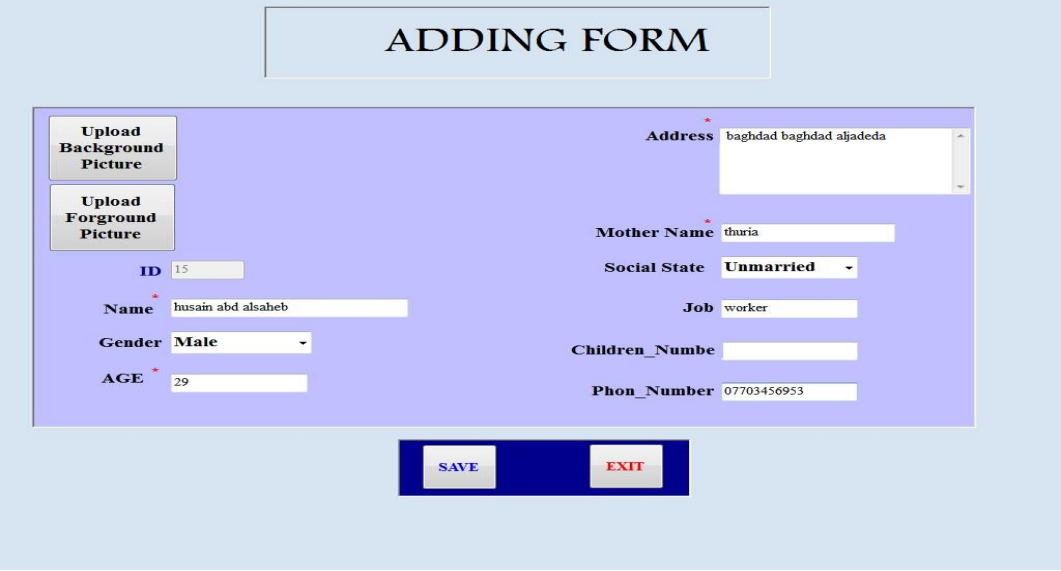


Figure (3). Adding new record form

The moving to window of updating form is done by selecting ***UPDATE*** button in homepage. This window contains two main buttons (***SAVE and SEARCH***) as shown in Figure (4). 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 change a record contents, ***UPDATE*** button is pressed.

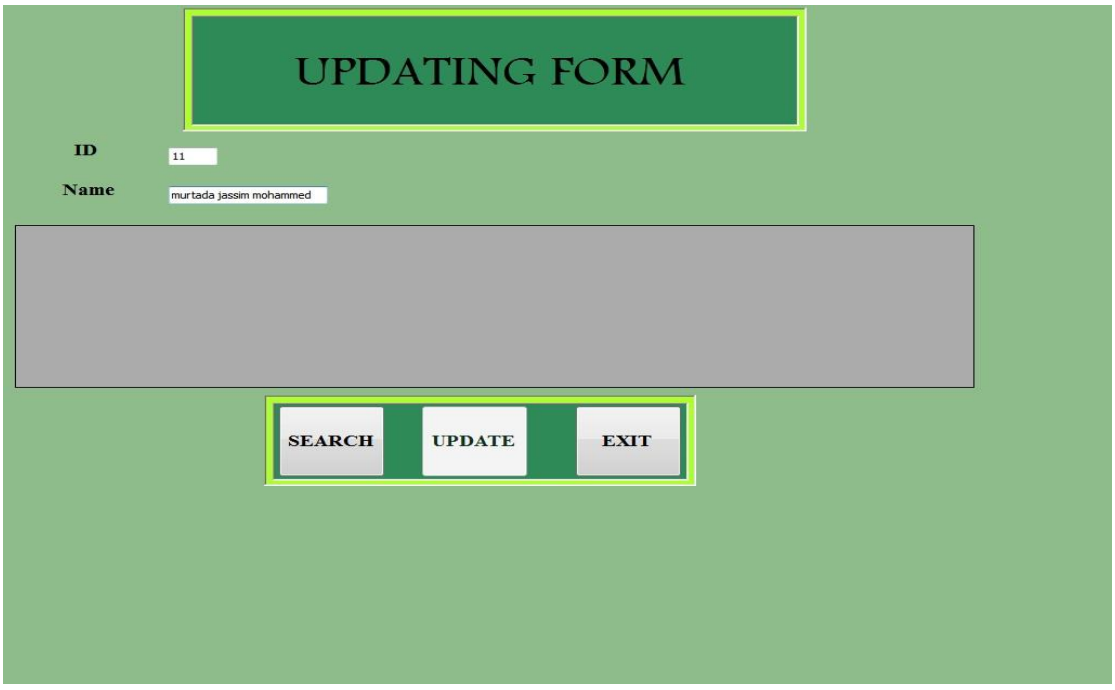


Figure (4). Updating form

When the user clicks on ***SEARCH*** button in the home page then the system displays Searching form window as shown in Figure (5), which contents ***SEARCH*** button and button of ***SEARCH FOR NAME***. The search operation is performed in two ways: ***Name and ID.*** The most common used is the ***Name*** way, but for more accuracy the ***ID*** method is adopted.

Figure (5). Searching form

For example, the searching by ***Name*** method and entering the required name, the system shows the potential required records as shown in Figure (6).

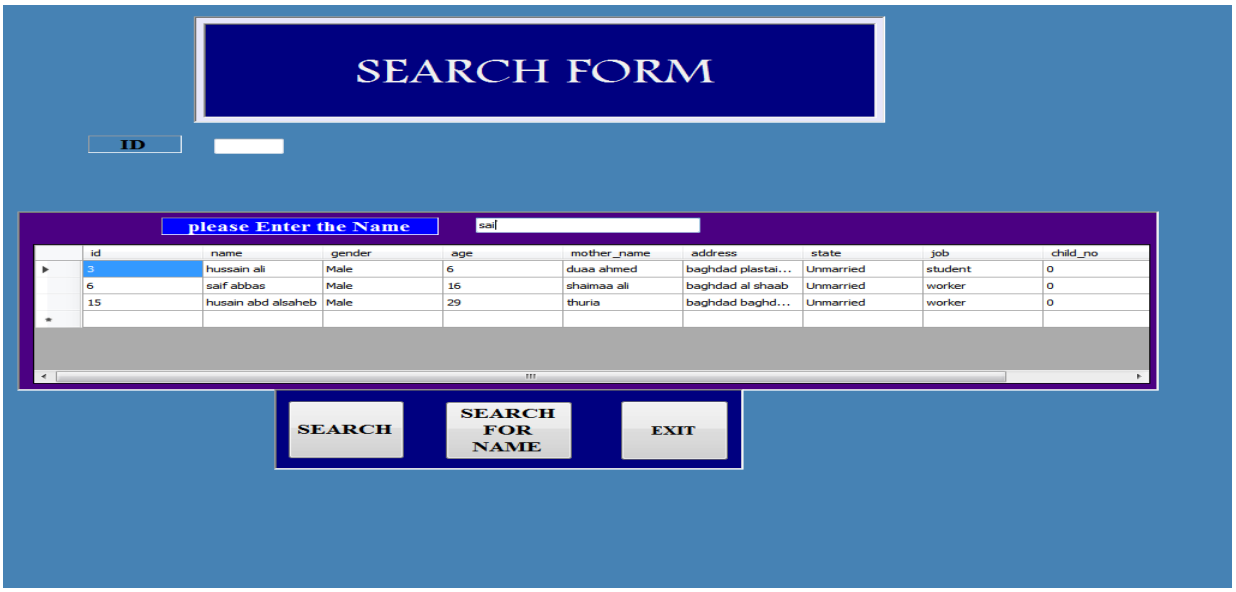


Figure (6). Searching by name form

At the same manner, the deleting operation is performed by clicking ***Delete*** button in homepage. At this window two main buttons (***DELETE, SEARCH***) are founded as shown in Figure (7). At the beginning the user should fill the ***ID and Name*** fields then click ***SEARCH*** button this leads to show the desired record. After the user ensure that is the required, he/she can now press ***DELETE*** button to remove it from walk database.

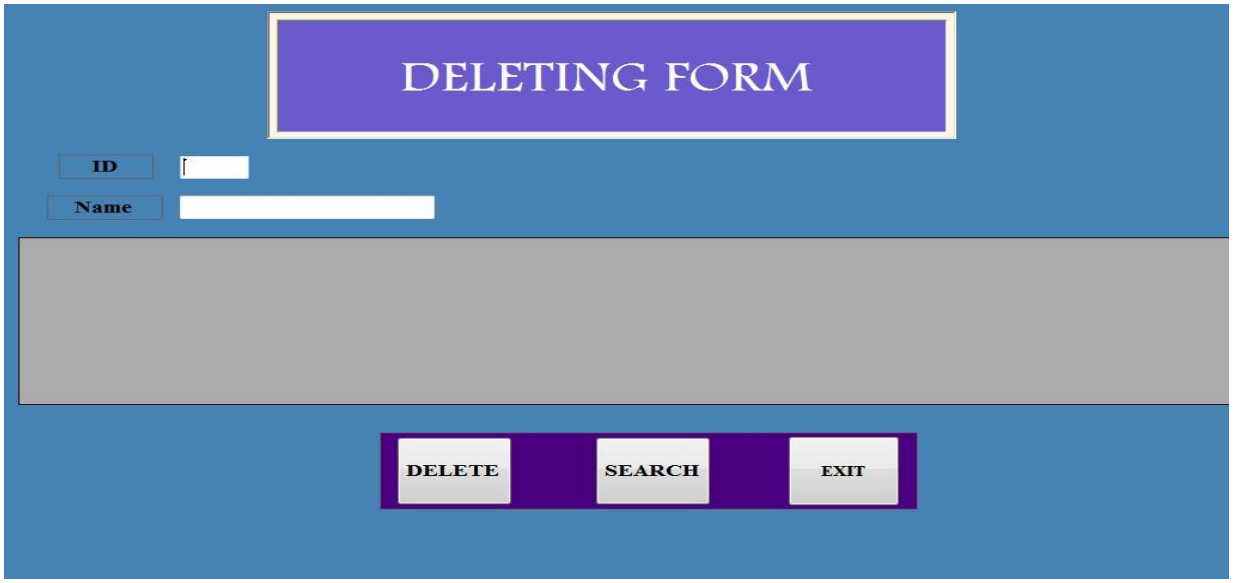


Figure (7). Deleting form

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 (8). This window contains ***Upload Background Picture***, ***Upload Foreground Picture*** and ***MATCH*** buttons.

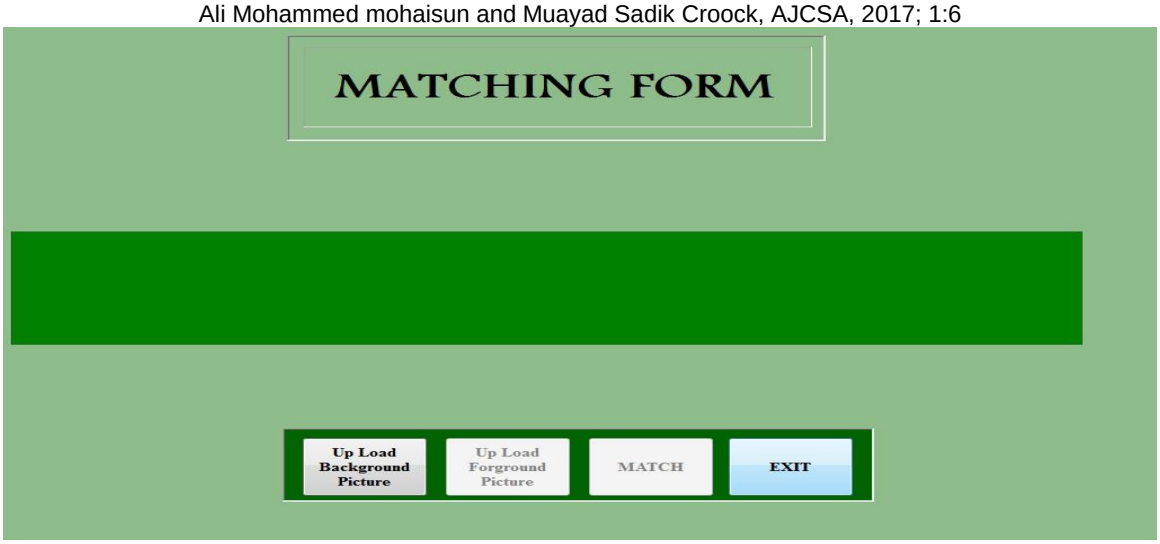


Figure (8). Matching form

At first access, the background picture button is active, while other button are passive. After the background picture is selected and uploaded, ***Upload Foreground Picture*** button is activated, and by selecting and uploading the foreground picture, ***MATCH*** button is activated. When match button is pressed, the features of an individual picture are extracted in Matlab file using Matlab environment. The extracted features are used for matching with the already saved records of the same features of different people. The matched record(s) is appeared in the screen, a message box is appeared (***There is no matching***) as shown in Figure (9).

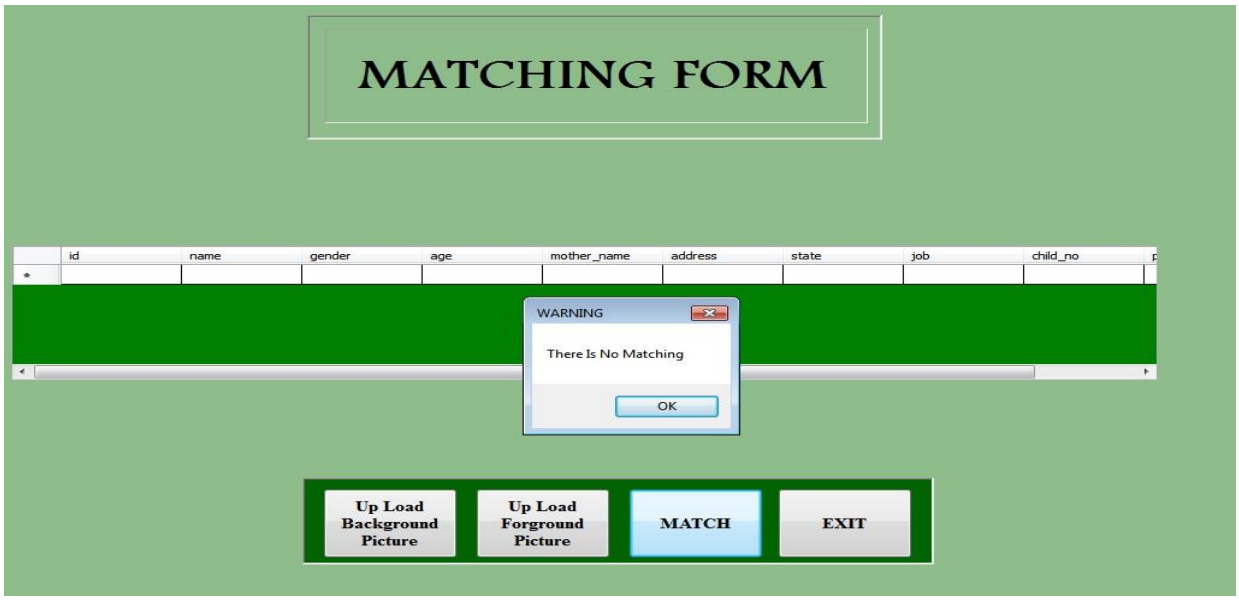


Figure 9. Show message when there is no matching result

3. Proposed Algorithm

As mentioned above, the adopted features for human walking behavior recognition are angle (horizontal), angle2 (vertical), and slop. The system adds to the saved features an ***ID*** and the user can complete the rest of information about the individuals. Dealing with database is flexible and easy in term of adding, updating, deleting, searching for existing record and matching with all records to satisfy the identity. The proposed algorithm consists of two main processes: Processing of image and Dealing with Data Base operations (add, delete, search, update, and matching). The proposed algorithm steps can be shown in Figure (10)

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

A.1 Pre-processing:

Walking behavior recognition system begin 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. As explained in Figure (10), the background subtraction process composed of seven steps:

- **Convert RGB pictures to HSV:** HSV((Hue, Saturation, Value) color system where Hue is the type of color such as red, blue, yellow and so on. Saturation represents the intensity of certain Hue, and Value that give measurement of color brightness. The primary reason to convert to the HSV color space of an image is the employing of Hue component that makes the algorithm less reactive to lighting difference.
- **Background picture XOR Foreground picture:** In this step XOR operation is applied between the background and foreground pictures, so the different objects that are in one picture but not on the other are appear in the result image.
- **Convert result image to gray:** To apply processing operations on plan of image data, it is better than applying it on three plans of image data that is required to make processing operations on each plan then combine the results of these three plans. For this reason, the colored image which contains three plans is converted to gray scale image which containing only one plan is helpful step in terms of make processing operations less complicate.
- **Read rows and columns of the result Image:** This step is to determine the size of image in terms of number of columns and rows.
- **Convert result Image to binary Image:** Create array with two dimensions with same size of gray scale image.
- **Apply median filter to remove noise:** Median filter has been adopted as it is the most regular method of removing noise of image [18]. 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.

There are important notes have to be noticed about the captured picture: **First**, we must have background picture where its content are firm, and if there is any change in the background picture then it must be updated with the last change; **Second**, 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 **Third**, the picture must capture by static camera; **Finally,** in this paper we are dealing only with side view of person and normal gait.

2. *Silhouette segmentation:*

After the silhouette is obtained, the segmentation for that silhouette can be done depending on [12]:

$$\breve{y}_{hip}=\min(y_{sil}) + 0.5*high \quad \ldots\ldots (1)$$

$$\breve{y}_{knee}=\min(y_{sil}) + .75*high \quad \ldots.. (2)$$

Where, $\breve{y}_{hip}$ and $\breve{y}_{knee}$ are subset of high which is represent vertical coordinate belong to silhouette, $\breve{y}_{hip}$ Represent the start position of thigh part, and $\breve{y}_{knee}$ Represent the end position of thigh part. By applying the above equations we can determine the considered thigh part.

3. *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, which are the needed features. From [12], the position of hip is performed with

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

$$\breve{y}_{hipl}=\breve{y}_{hip}\,(2_l - 3).\left(\frac{\breve{x}_{p-\breve{x}_1}}{2}\right).\sin(0.3.\mu) \quad \ldots.. (4)$$

$l= \{1,2\}$

Where $\check{X}$= $[\check{x}_1, \check{x}_2, \ldots, \check{x}_j \ldots . \check{x}_p]$ is subset of p which is horizontal coordinates where $\bar{S}(\check{X}, y_{hip})$ =1. Since μ represents walking direction and it is zero for side view image as [12] stated, therefore, the equation (3) is modified as follow:

$$\check{x}_{hip}=1/p\sum_{j=1}^{p}\check{x}_j \text{ ..... (5)}$$

$$\check{y}_{hip}= 0$$

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

$$q_{l0}=\frac{y^m_{shinl}\cdot\check{x}_{hipl}-\check{y}_{hipl}\cdot x^m_{shinl}}{\check{x}_{hipl}+x^m_{shinl}} \text{ ..... (6)}$$

$$q_{l1}=\frac{1}{2}.(\check{\alpha}+\frac{\check{y}_{hipl}-q_0}{x_{hipl}}) \text{ ..... (7)}$$

Where $\check{\alpha}$ is the straight line slope that approximates the edge of the area of silhouette belonging to the thigh, 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 (6) is modified and it became as follow:

$$q_0=\frac{y^m_{shin}\cdot\check{x}_{hip}}{\check{x}_{hip}+x^m_{shin}} \text{ ..... (8)}$$

$$q_1=\frac{1}{2}.(\check{\alpha}-\frac{q_0}{\check{x}_{hip}}) \text{ ..... (9)}$$

Therefore, the angle between the thigh and the vertical axis calculated as follow:

$$\check{V}=\pi-\arctan[q_1] \text{ ..... (10)}$$

Angle between the thigh and horizontal axis is: $\hat{H}=\tan^{-1}\check{\alpha}$.

B. Dealing with Data Base: This step includes five operations as we explain below:

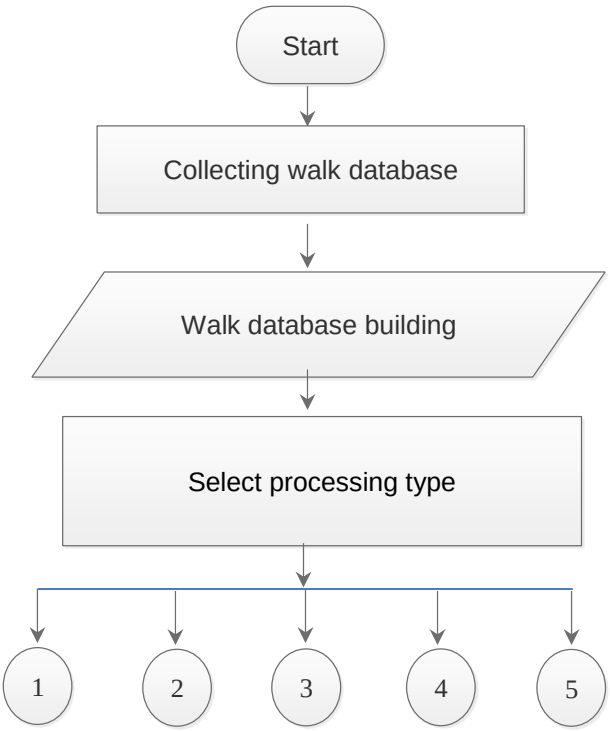
1. Adding: this process is employed to insert a new record to the ***human_id*** table which contains all personal information about an individual. We have to take in consider some points: ***ID*** is added automatically, fields marked with (*) must be filled as well as we have to choose upload background picture first then foreground picture is enabled, after choosing foreground picture all other fields are enabled.

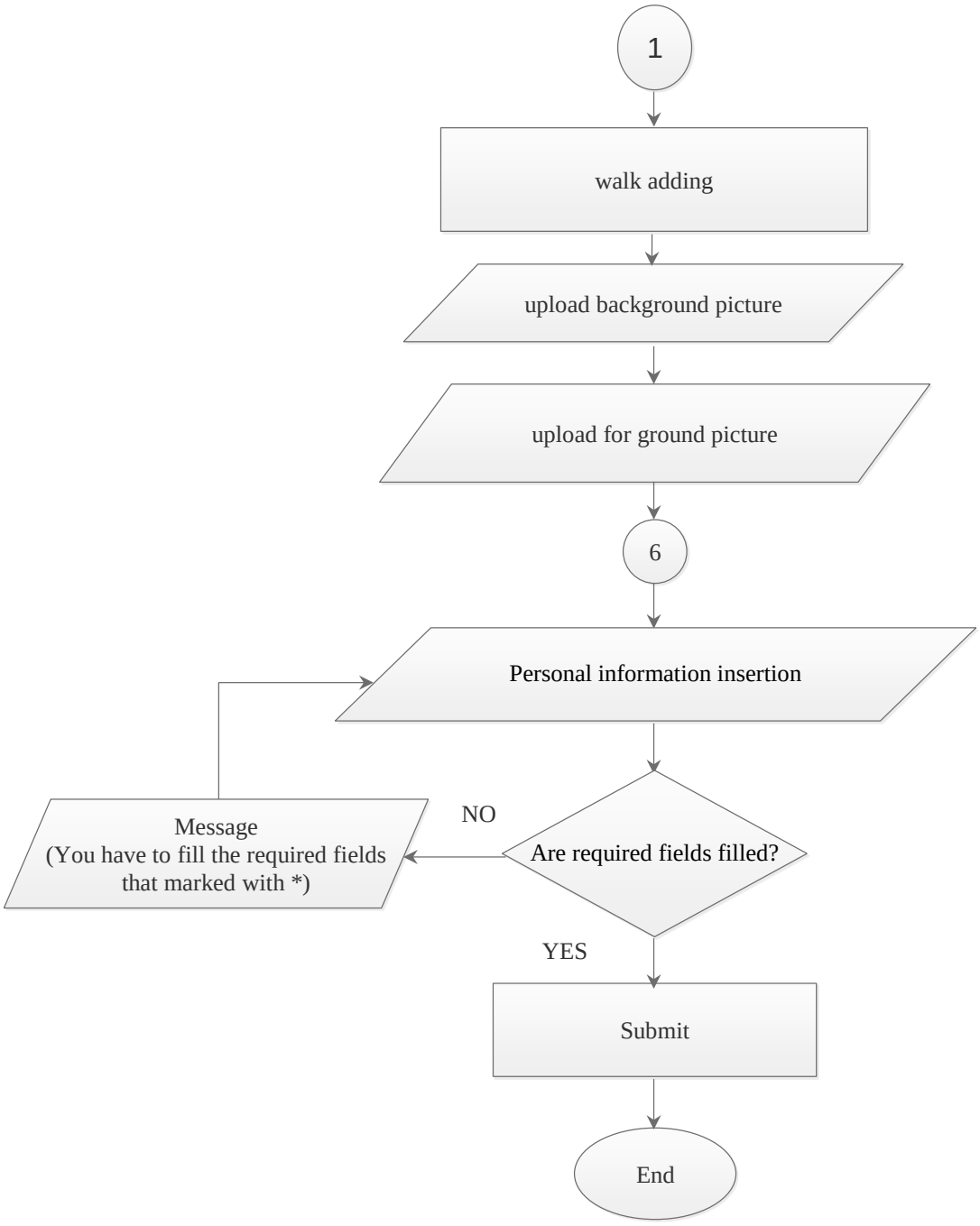
2. Updating: this process is applied on records that are existed previously in database. The wanted record can be found using either ***ID or Name***.

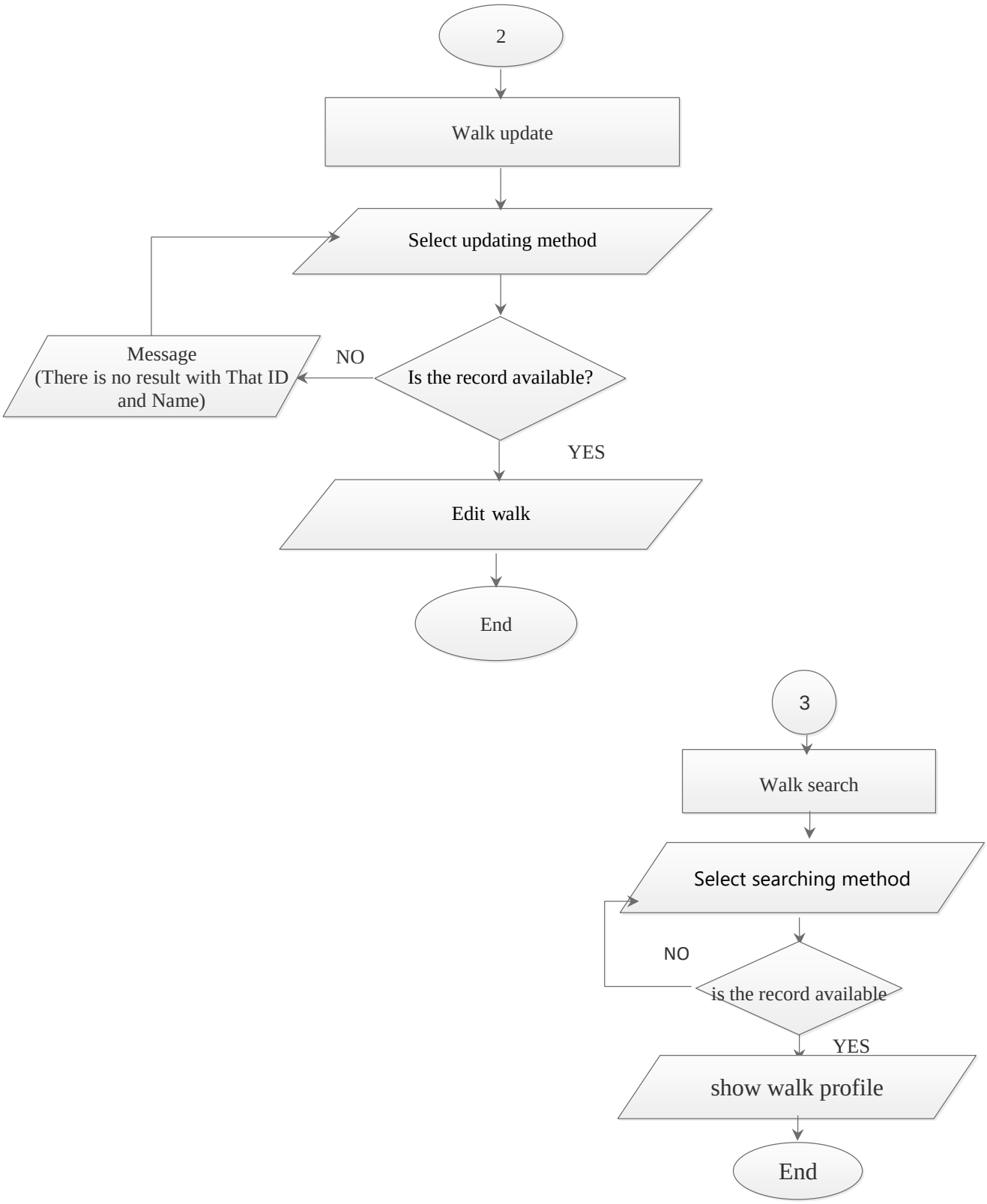
3. ***Searching:*** this process is used to find a specific record using ***ID and Name*** or just using name.

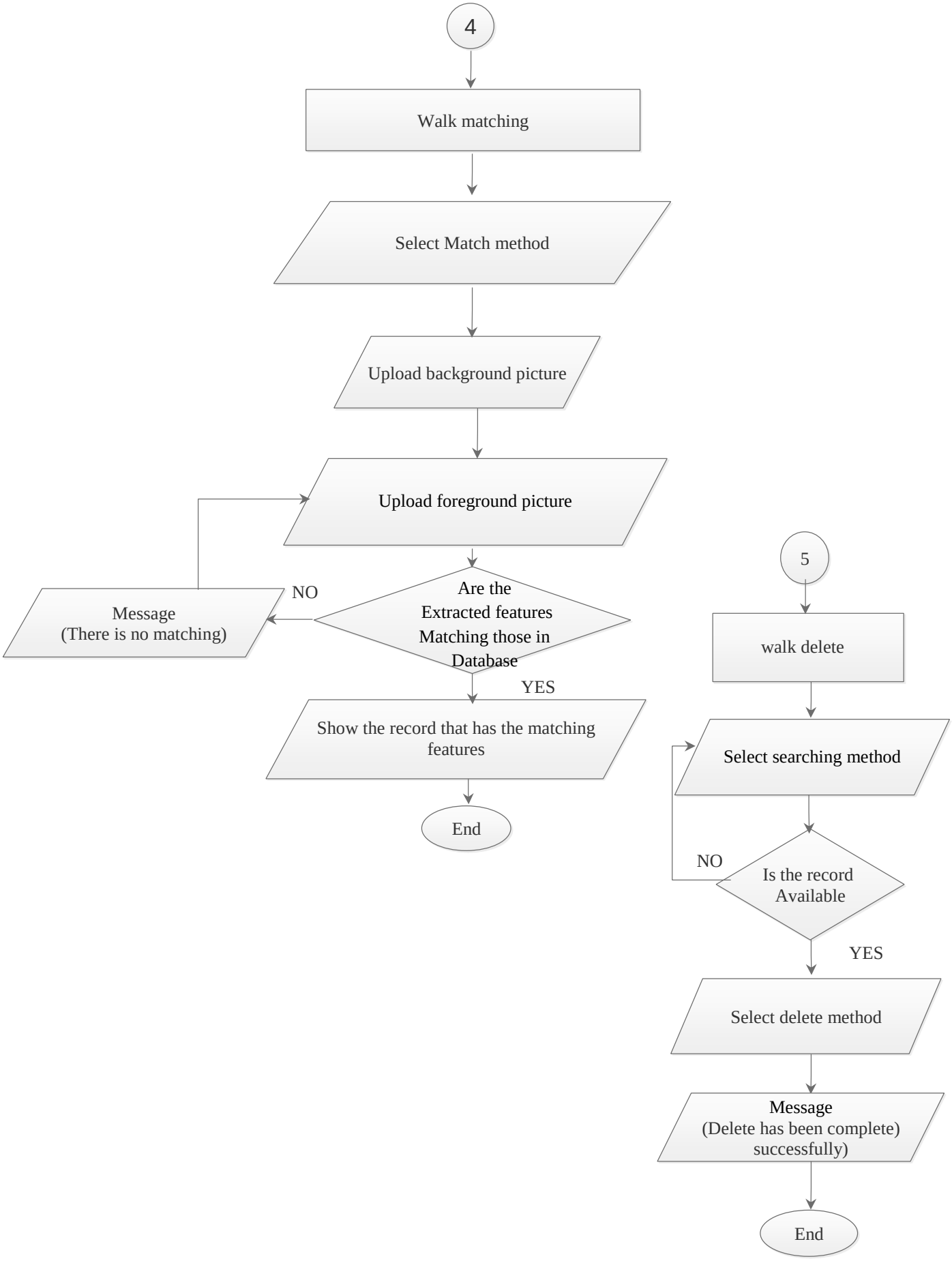
4. ***Deleting:*** It provides the ability to delete record from walk database using ***Name or ID***.

5. ***Matching:*** It is done by insert background picture and foreground picture, to get the record that has features matching with features extracted from input pictures.




1
walk adding
upload background picture
upload for ground picture
6
Personal information insertion
Are required fields filled?
NO
Message
(You have to fill the required fields
that marked with *)
YES
Submit
End


2
Walk update
Select updating method
Is the record available?
NO
Message
(There is no result with That ID and Name)
YES
Edit walk
End
3
Walk search
Select searching method
NO
is the record available
YES
show walk profile
End


4
Walk matching
Select Match method
Upload background picture
Upload foreground picture
Are the Extracted features Matching those in Database
NO
Message (There is no matching)
YES
Show the record that has the matching features
End
5
walk delete
Select searching method
Is the record Available
NO
YES
Select delete method
Message (Delete has been complete) successfully)
End

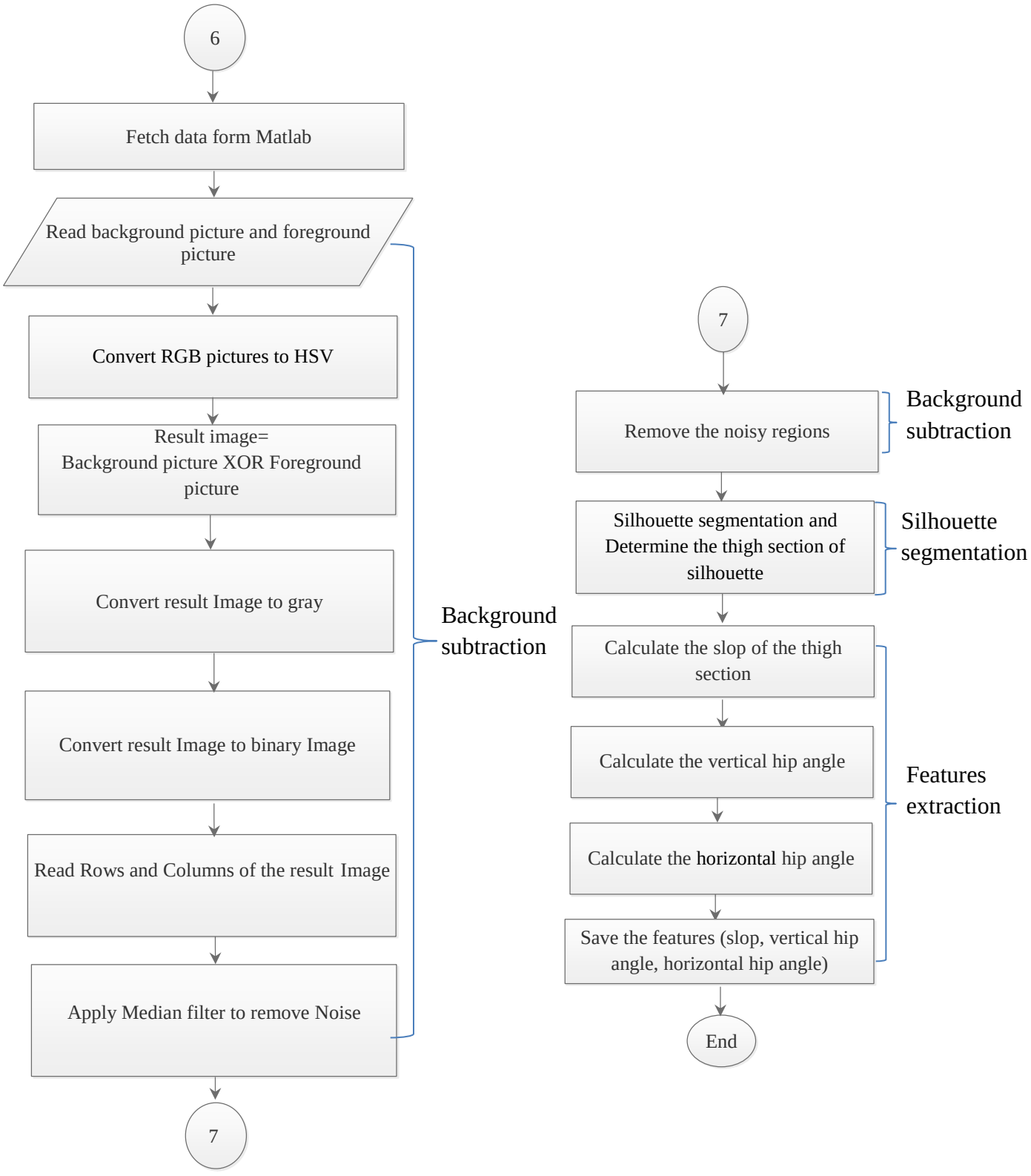


Figure (10) Flowchart of Proposed Algorithm

4-Results

As mentioned above, the proposed system gives the ability of adding, searching, updating, and matching of walking behavior database using SQL server 2014. This is done with employing both processing of the input images provided from Matlab2016b and graphical user interface (GUI) provided from the visual studio(C#). The proposed system was examined in term of adding function by inserting information of 30 persons as explained in Figure (3). In order to examine the updating task, illustrated in Figure (4), Figure

(11) shows the output of updating task where each field is prepared to update. In case of searching task explained in Figure (6), we select ***ID*** for searching, Figure (12) shows the output of search. About deleting task, the required record is specified by ***ID and Name***, as shown in Figure (8).

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.

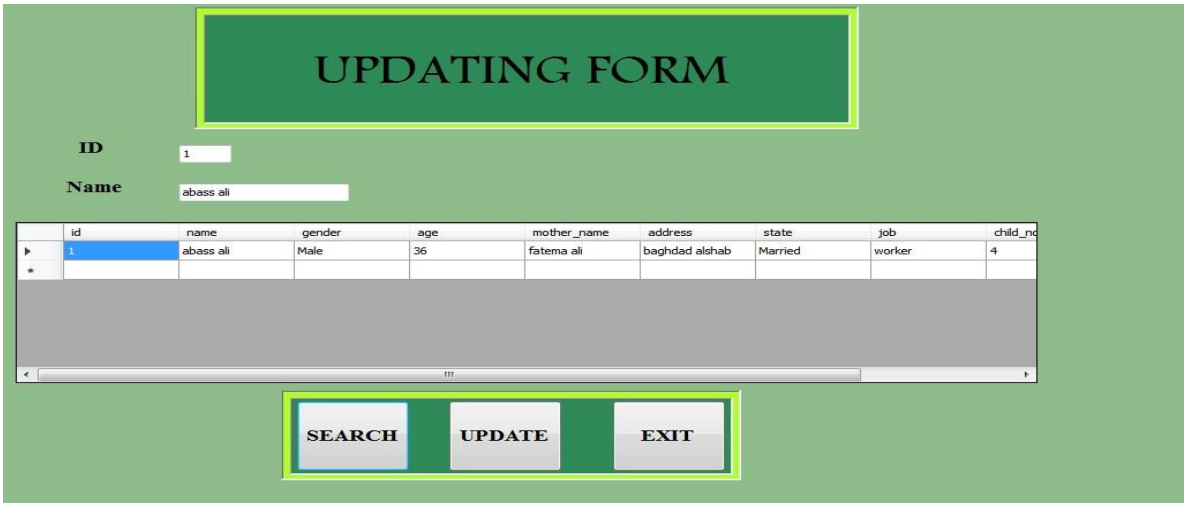


Figure (11). Output of updating form

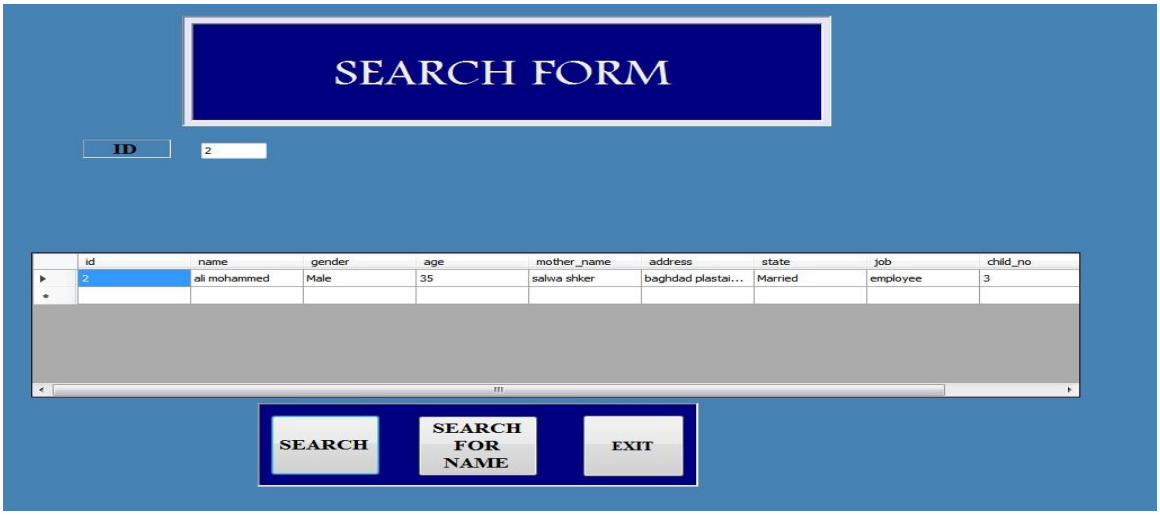


Figure (12). Output of searching form

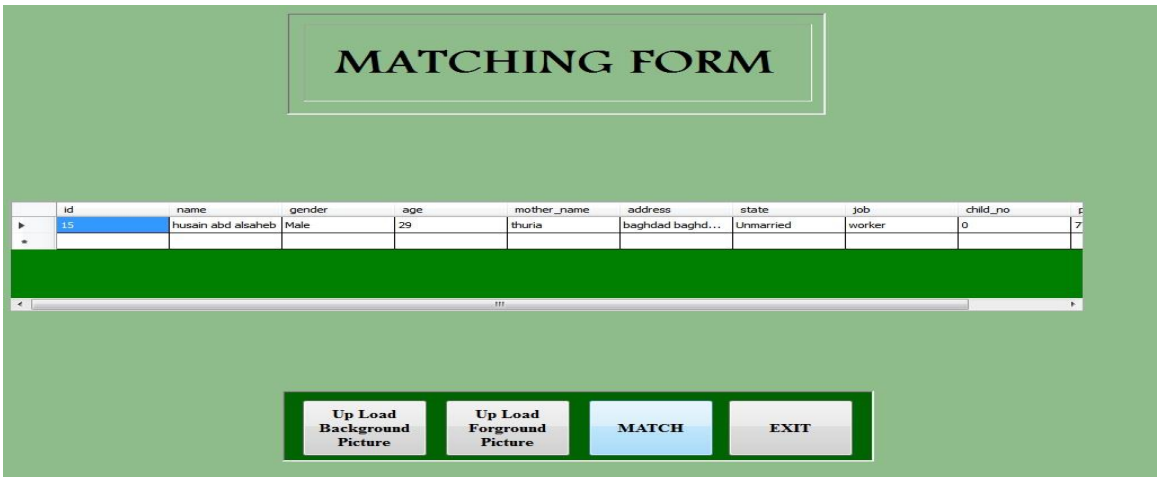


Figure (13). Output of matching form

5. Conclusions

A human recondition system based on the walking behavior was proposed. The database was built with pictures of 30 people by extract features for each person. These features are vertical hip angle (the angle between thigh and vertical axis), horizontal hip angle (the angle between thigh and horizontal axis) and slop of thigh. SQL server 2014 software was used to build that database. It is important to know that the features above were considered in specifying person identity. After testing all application function including add, search, update, matching and delete, we concluded that these processes were performed efficiently in terms of many aspects of capacity, efficiency, and accuracy. Moreover Matlab was used for image processing and feature extraction operations that dealing with taken image and visual studio environment. The proposed system was tested throughout different case studies to cover the offered facilities. The obtained results showed the superior performance of the proposed system in terms of efficiency accuracy and time saving.

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