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Silhouette Analysis Based Gait Recognition for Human Identification

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Abstract: *In this research, gait recognition as technique of recognizing a people based on how they walk has been studied. The fact that this technique does not need any interaction or cooperation from the object make it an attractive method for identifying people. Locomotion human model has been developed by extracting gait features or properties from a sequence of images. The developed model reduces the external noisy factors, for example, shoes, clothing, hand bags, and environmental context. Moreover, an advanced machine learning algorithm, from computer vision library OpenCV, has been utilized for gait recognition to give nearly real time recognition system. finally, the reliability of the proposed gait recognition system was 89.7% with ability to detect person 40 meters away from the camera.*

Keyword: *Gait recognition; morphological operator; biometric identification; back propagation; neural network; human detection and tracking; feature extraction.*

1. INTRODUCTION

Biometrics are technologies that analyze, detect, and measure human body properties for authentication purposes, such as finger prints, deoxyribonucleic acid (DNA), irises and eye retinas, speech patterns, facial patterns, and hand sizes. The verification or identification of a person become a very important process in public security systems, point of sale (POS) machines, automated teller machine (ATM), and ...etc. Biometric can be utilized as physical signature to uniquely identify or recognize a person. Fingerprint and face recognition are a well-known biometric system. Both fingerprint and face recognition have limitations, where first one needs contact with finger, while the second one needs controlled environment and distance. Human gait is a term used to describe a person's regular walking pattern, also known as a gait cycle.

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Gait recognition technology can be used for a wide range of medical applications, including clinical rehabilitation, automatic robotic rehabilitation of patients, the design of walking biped robots, and many others. Mainly, there are two approaches for gait recognition. The first approach is model-based approach, while the second one is model free approach. The model-based approach simulates or track body parts of human, for example, legs, arms, and limbs, this approach obtains a set of dynamics and static parameters. The basic idea behind this approach is that the model can be created by representing the human as Stick-Figure skeleton with joints or as a group of cylinders. After that, the model is using a number of parameters. The simple model can be described by, for example, calculating the distance between the pelvic and head, the feet and head, the feet and pelvis, and the step length of a subject [1-4].

In the other hand, model-free approaches depend on the geometry or shape of silhouettes of the object (dynamic/static) in order to identify and recognize object. The methods depend on extracting the properties and features directly. The Gait Energy Image (GEI) is without a doubt the most commonly used characteristic retrieved from silhouettes [5][6].

2. RELATED WORK

In 2005 han and bhanu [7], to address the problem of the lack of training templates proposed gei (gait energy image) for spatio-temporal gait representation based on to characterize human walking properties for individual recognition by gait.

In 2010 tafazzoli and safabakhsh [8], developed a model-based strategy for recognizing human gait that is based on evaluating leg and arm motions. Using active contour models and the Hough transform, an initial model is built based on anatomical proportions, and a posterior model is built based on the motions of the articulated sections of the body. The motion patterns of moving components are described using Fourier analysis. For classification, the k-nearest neighbor rule is used to the phase-weighted fourier magnitude of each segment's spectrum. In contrast to previous techniques, the major focus of this research is on improving the model's discriminating power by adding more characteristics generated by arm motion.

In 2018 kumar, et al. [9], human gait is a well-established biometric feature with security and authentication applications. However, due to a variety of circumstances, obtaining human gait data can be inaccurate, and multimodal integration of such erroneous gait data can be difficult. Shadow motion sensor and video sequences were used to suggest a multimodal gait identification technique. Where discovered that each person's walking pattern is influenced by the activity in which they are involved. As a result, were looked at four different walking patterns of people: normal walking, rapid walking, walking while listening to music and walking while watching a movie on a mobile device.

In 2019 Gahramanova, [10] A rigid body's center of mass is a single point that reflects the average location of all matter that makes up the body. This notion, which allows complicated things to be represented as a single point, lies at the heart of all key mechanical computations and is hence a critical concern in engineering. To overcome This problem, proposed the way to determine determining the centroids of various planar objects, independent of their form This is done by developing a Python-based computer vision application that analyzes digital photographs of the things of interest. The first step is to use integral calculus to find the centroids of different geometrically representable forms. The next stage is to physically duplicate those forms, as well as a few additional oddly shaped things. After that, we write a script for a computer program that examines these items and locates their centroids in real time. The software scans the image with for-loop iterations, detecting the pixels that make up the item based on their color, and doing the appropriate computations.

In 2020 et al. [11], used millimeter wave (mmwave) gait data collection in this project. By using the data set, analyzing existing baseline gait recognition algorithms, and proposing mmgait, a novel mmwave gait recognition approach. Even in settings when numerous people are present.

In 2021 yaoa, et al. [12], human identification has always relied on gait characteristics. Model-free features and model-based features are the two types of gait recognition representations that are most widely utilized. Model-free features, on the other hand, are sensitive to appearance alterations owing to view variations and clothing modifications. Extracting the underlying models from gait sequences is extremely challenging for model-based characteristics. A new model-based representation, skeleton gait energy image (sgei), where proposed in this research based on the confidence maps and part affinity fields created by a two branch multi-stage neural network. Another addition is the creation of a hybrid representation that employs sgei to compensate for the lack of model-free characteristics, such as gait energy imae (gei).

3. THE PROPOSED APPROACH

The goal of this research is to create gait recognition system by combining machine learning algorithms that has an ability to recognize objects from previously given set of images, and an efficient human gait recognition system has been proposed depending on model-based approach. The proposed system classifies or characterizes gait basis on gait signature calculated of silhouettes. As seen in Figure 1, complex and difficult calculations needed for bad resolution images, therefore the complexity of the model-based method has grown. The one and the only benefit of this model is that it could be utilized to extract gait signatures from parameters without any influence of weight, step length, and step cycle features, while the artificial neural network (ANN) technique is utilized to train and test the goal. The preprocessing task can be considered as one of biometric recognition system tasks.

The database in this system collected in video form to create the frames of walking people. These frames will be transformed into silhouette. The feature extraction and silhouette extraction are the main preprocessing task in gait recognition system. The image processing method can be used to extract the silhouette frame. These processes are described in the following sections.

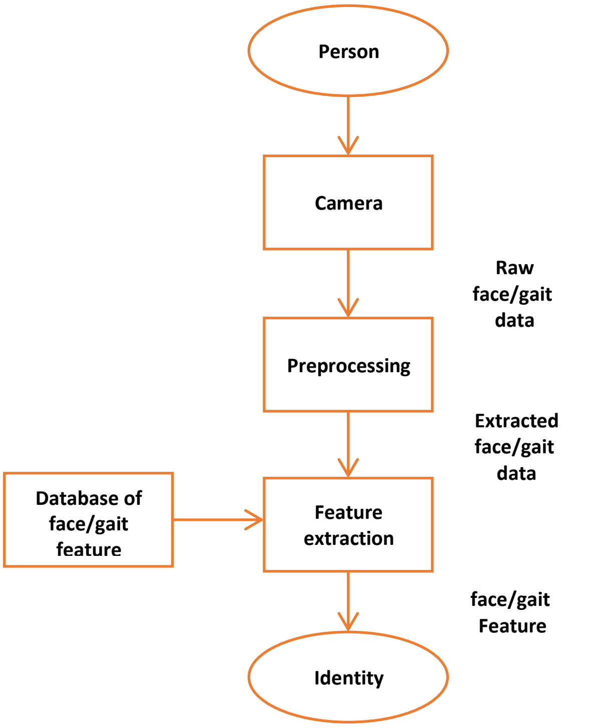

Figure 1 Calculation steps for low resolution pictures

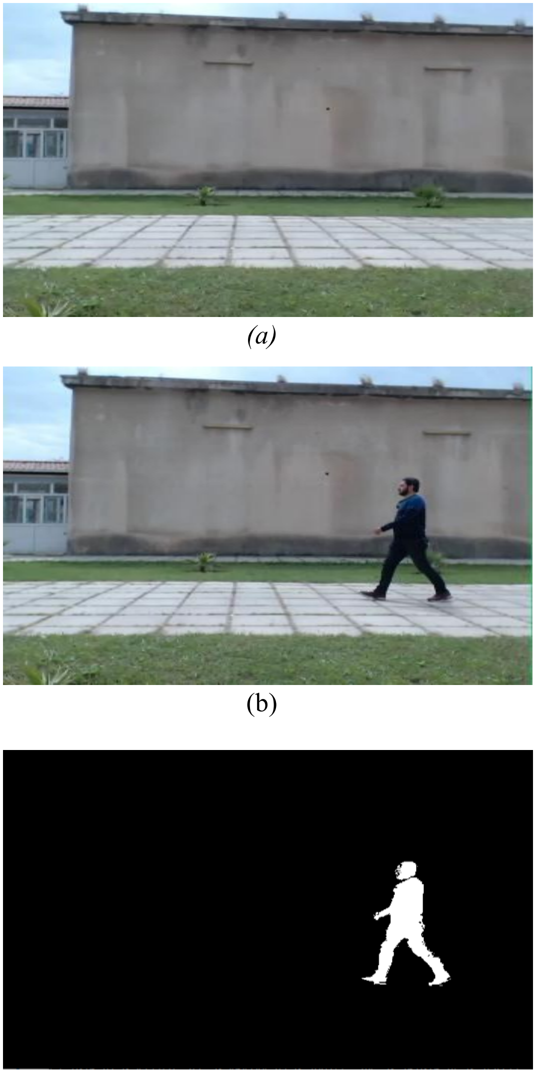

Figure 2 Example of gait recognition (a) background image; (b) original image; and (c) detected silhouette

4. BACKGROUND SUBTRACTION

The objects requested to pass in front of the camera in parallel way. Before the gait characteristic could be obtained, the motional individual silhouette had to be recognized. Background removal is a new and reasonably straightforward method of extracting a silhouette from a picture. Background subtraction is used to minimize noise during pre-processing. The Gaussian Mixture-based background/foreground segmentation model is utilized in the background subtraction method. Gait recognition includes the training portion and the testing portion is seen in Figure 2.

5. SILHOUETTE ISOLATION

A bounding rectangle is used to isolate the found silhouette, as seen in Figure 3. The top-left vertex of the bounding rectangle's x and y coordinates are indicated as (xmin, ymin), while the bottom-right vertex of the bounding rectangle's x and y coordinates indicated as (xmax, ymax). These coordinates utilized to compute the silhouette's width (Sw) and height (Sh) as explained in Equation (1) and (2).

$$Sw = xmax - xmin \tag{1}$$

$$Sh = ymax - ymin \tag{2}$$

Figure 3 Boundary box to measure width and height.

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6. FEATURE EXTRACTION

In order to distinguish one object from another, it is necessary to identify a feature. These are the parameters of moment features that are present in image regions that include a walking person. This is one of the most critical aspects of human gait recognition. That which can describe the quality of individuals must be reasonably resilient to changes in the environment. Intuitively, as a result, it appears that silhouette is a useful feature to employ most body parts are captured, as well as their motion. Both structural and transitional aspects information. It is particularly unaffected by clothes, lighting, and materials, among other things. The features can be extracted from this silhouette, since the database is stored in silhouette form as shown in Figure 4.

A feature vector is a method for representing an image feature, or a part of an image (an object), by measuring a set of features. These measurements are stored in a feature vector, which is an n-dimensional vector. This vector could be utilized to classify an object or to give the higher-level visual information. If a feature gives consistent outcomes across the whole application, it can be considered as robust feature. An array of two-dimensional data has been used to store each pixel (picture element) of the images studied. The notation B = (i,j) refers to an individual pixel in row i and column[4]. The brightness of the picture at the spot (i, j). The center of mass of the human body varies from instance to instance during walking, therefor; the center of mass has been utilized as a feature to exhibit the brighter weighted average of x and y coordinates pixels in the frame. For binary pictures, the center of mass of the white pixels region is the same as the center of mass if the intensity at a location is considered the mass of that point.

The following Equations (3), and (4) [10] can be used to compute $\bar{x}$ and $\bar{y}$, which represents the center of mass coordinate in a binary image, while m and n are the dimension of the matrix that stores the picture in matrix form. A is the area of the region, which can be obtained using Equation (5)[10].

$$\bar{x} = \frac{\sum_{i=0}^{n}\sum_{j=0}^{m} j * B(i,j)}{A} \tag{3}$$

$$\bar{y} = \frac{\sum_{i=0}^{n}\sum_{j=0}^{m} i * B(i,j)}{A} \tag{4}$$

$$A = \sum_{i=0}^{n}\sum_{j=0}^{m} B(i,j) \tag{5}$$

The boundary box approach has been used to calculate the step size and the cycle duration. In silhouette, a boundary box is formed to bound the entire object from the outside, with the right edge boundary touching the rear foot back end and the left edge boundary touching the front foot front end. The width of the boundary box is recorded as the step size length. The silhouette's height Sh and width Sw are used to map the silhouette to a gait model. After that, divide the bounding rectangle into the anatomical parts provided in Figure 5 to estimate the head, torso, and leg segments in the silhouette. The head segment accounts for the upper 13 percent of the silhouette's height Sh, according to anatomical proportions. The width of the head segment is 10% of the overall width of the silhouette Sw. Sh makes up 53% of the torso segment [7].

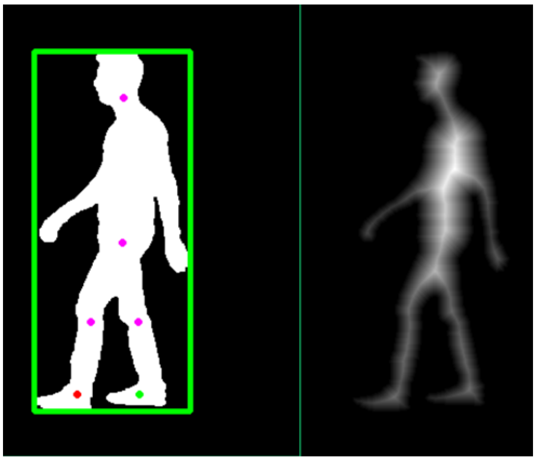

Figure 4 Silhouette for dataset and distance transform of the silhouette

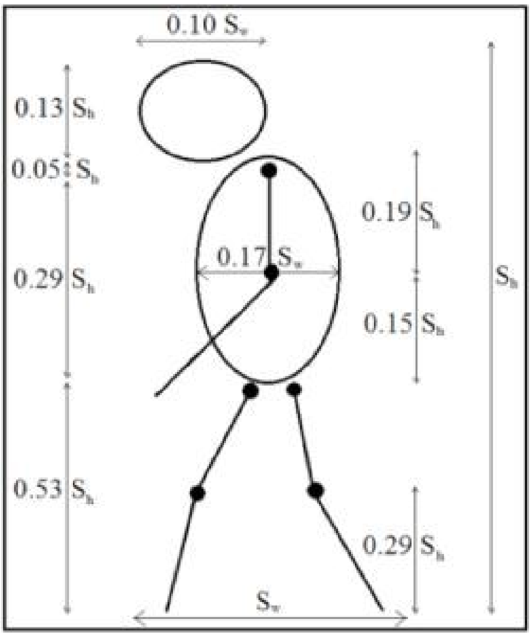

Figure 5 Human model proportions [13]

It noticed from the results that the shortest participant had the least angle, while the angle is greatest for

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the individual who is the tallest among all the participants. The first plan was to compute simply the greatest angle between each participant's legs. However, after seeing the results, every participant's resultant angles, as well as the range within which this angle varies are unique. For previous reason, the angles for each sample in each cycle have been computed. A triangle has been formed with the two legs and the distance from the bottom of the human torso to the two feet to compute the angle of the taken sample as shown in Figure 6 and Figure 7. To extract the other features, the height for each sample in each cycle has been computed using Equation (6), (7), (8), and (9) [13] for each participant, and then the distance between the neck and torso measured. Two joints A and B, and measure the distance between joint A and B with feet [8][13].

$$neck = top + Sh * 0.13 \quad (6)$$

$$torso = top + Sh * 0.53 \quad (7)$$

$$joint = top + Sh * 0.71 \quad (8)$$

$$foot = bottom - Sh * 0.05 \quad (9)$$

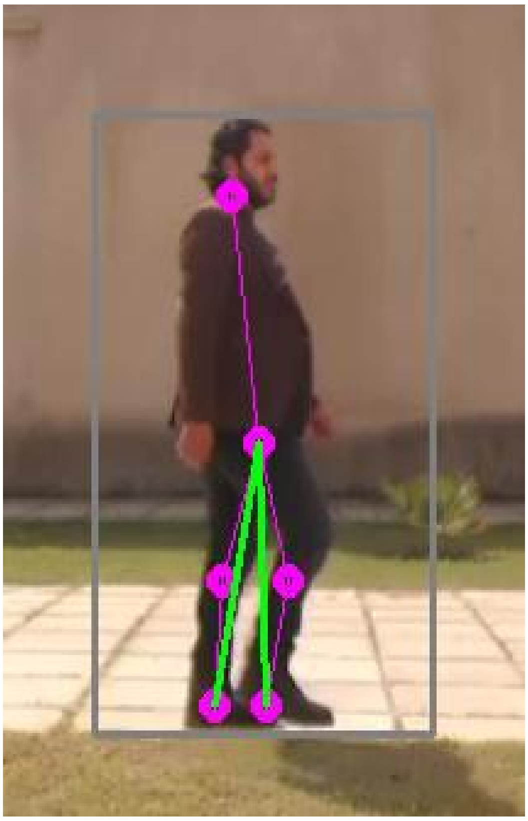

Figure 6 Measure angle between legs

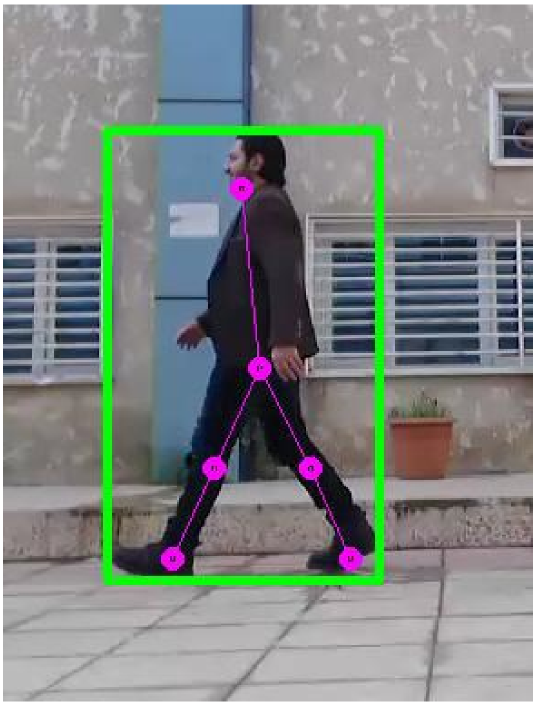

Figure 7: Contours and joint fitting

7.ARTIFICIAL NEURAL NETWORK TRAINING AND TESTING

ANN is used to achieve aims in different fields, including education, computer science, business, medicine, and engineering. It's a well-known synthetic model [9, 10, 13]. Biometrics is based on patterns, and human gait refers to a certain walking pattern. Gait analytics is the result of all of this research into algorithms and approaches. Every human has a unique walking style, which means that each walking pattern is identifiable and may be stored in a dataset. These various gait types may be utilized as patterns, and these patterns can be used to identify someone without having to tell them by comparing the shapes that are created after applying the algorithm and removing the backgrounds.

Neurons make up an ANN. This ANN can be utilized to solve a range of artificial intelligence problems without the need for any real-world models. Even the most complex biological models can be represented using artificial neural networks. The ANN model takes away the complication and directs attention to the actual problem and point of view. As shown in Figure 8, hidden layer calculation are performed with the help of an intermediate layer before transforming the input to the output.

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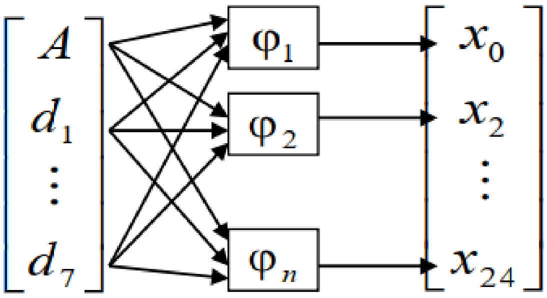

Figure 8 Neural network layers

All features in the database will be compared with the features stored in neural and nodes of ANN model. It can be feasible only with artificial neural network. The dataset of all people that wanted to be verified or identified will be saved. Whenever there is a match between the data set and the output, an alert or tag will be given indicating that the person has been identified or obtained. The feed forward back propagation learning technique is used to generate training and testing process for gait detection recognition in this ANN architecture [12].

In this paper, the proposed approach is trained and tested on collected and recorded dataset. the collected dataset is CASIA gait (Dataset A) [7]. The CASIA A dataset includes 20 objects in an outdoor environment. Each object walks along a straight-line path at free cadences in three different views with respect to the image plane, and the camera view perpendicular to the line path. For each object have four gait video sequences. And the recorded datasets by using Logitech c920 webcam consists of the data from nine objects in an outdoor environment, including eight males and one female among all objects. The data are captured under different lighting condition with view angle 90°. The total dataset for 29 people participants, we produce 116 videos (29×4). The length of each gait sequence video is about 90 frames in average, and each gait sequence video contains two to four gait cycle. The length of each sequence is not identical for the variation of the walker's speed. For each object three videos for

Training and one for testing. The total 29 objects divided into 20 classes, with object for each class (p1 to p19) and the last class named other with 10 objects (none). The total videos for training and testing are 87 and 29 videos respectively.

8. PERFORMANCE EVALUATION

The goal of the performance evaluation is to provide some quantitative measurements of the efficiency of biometric systems. The traditional statistical measurement used to quantify the performance of a biometric system includes computation time. For evaluating results to a classification problem, a confusion matrix can be used. A confusion matrix is a matrix where each row and each column are labeled with one of the possible output classes. One axis represents the true answer, and the other axis represents the predicted answer. The sum of the diagonal is the number of times the system predicted correctly. For each class, true positive (tp), false positive (fp), false negative (fn) and true negative (tn) can be calculated. True Positive is a result under which the model forecasts the positive class accurately.

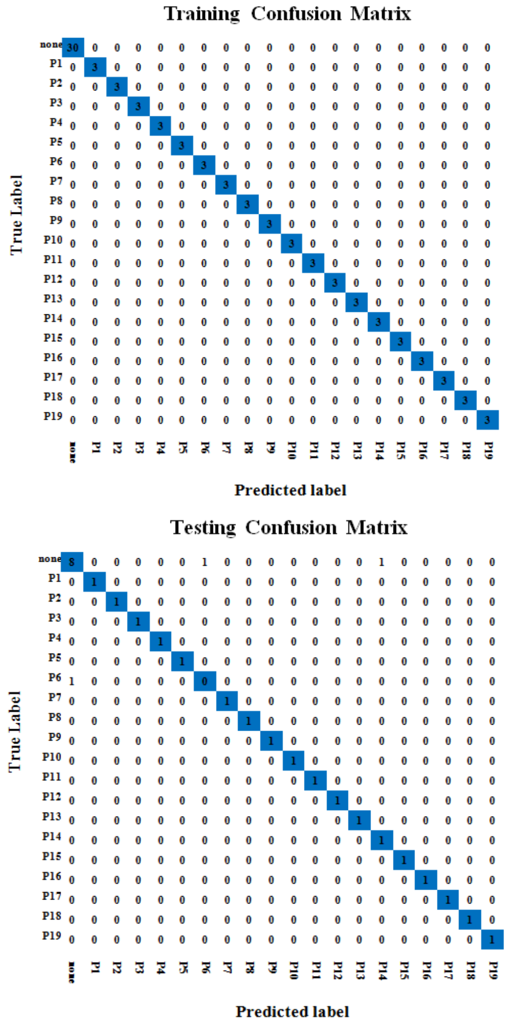

Figure 9: The Training and Testing Confusion Matrix of the System.

True Negative is a result under which the model forecasts the negative class accurately. False Negative is a result under which the model forecasts the negative class wrongly. False Positive is a result under which the model forecasts the positive class wrongly. Figure 9 shows the training and testing Confusion Matrix of the system. The training and testing accuracies were obtained of the system 100% and 89.7% respectively. The system has an ability to identify a person who is near or far away from the camera, and Figure 10 shows the overall system of human gait recognition. The bio-

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metric system recognition reliability (R) is statistically examined for each extracted feature as well as for the system as a whole, by analyzing the result obtained by Equation (10).

$$R=100\% - FRR - FAR \qquad (10)$$

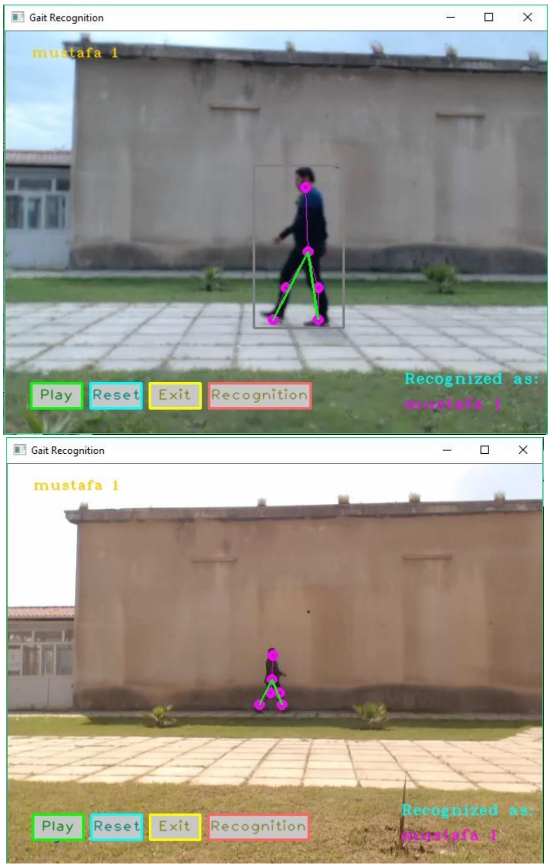

Figure 10: overall system of human gait recognition

The false reject rate (FRR) indicates the probability that an imposter is identified as an enrolled person, while the false accept rate (FAR) indicates the statistical probability that the system fails to detect an enrolled person. When, FRR and FAR approach to zero, the gait recognition system is completely reliable. Table 1 shows the performance evaluation in terms of FRR, FAR, and recognition reliability. The recognition reliability is 74.7%.

TABLE 1: Performance evaluation in terms of FRR, FAR, and recognition reliability.

Data (degrees & view)	False Acceptance Rate (%)	False Rejection Rate (%)
90 Left View & 90 Right View	20%	5.3%
Reliability= 74.7%		

9. CONCLUSION

This research describes a gait recognition system that utilizes of some parameters such as center of mass, step size length, and cycle length. A neural network is employed to recognize individuals. The results show that these characteristics or features are effective at identifying persons from a distance where, the proposed approach has training and testing accuracies of 100% and 89.7% respectively. The system has an ability to identify a person 40 meters away from the camera with processing speed 30 frame per second, even with face covered or back turned. The proposed approach can only identify one person in camera frame, the future work is to propose an approach to identify two or three persons in one frame, therefore; the new approaches need more image processing, bigger data set, and new neural network.

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