



Indian Institute of Information Technology Design and
Manufacturing, Kancheepuram, Melakottaiyur,
Chennai 600127

Multimodal Biometrics using Gait and Ear as biometric features

K Sai Dinesh (CS20B1122), Lokesh Reddy (CS20B1128), Rudhra (CS20B1104)
Department of Computer Science and Engineering
Indian Institute of Information Technology, Design and Manufacturing,
Kancheepuram

ABSTRACT

Multimodal biometrics using gait and ear features combine two different biometric modalities to improve the accuracy and reliability of biometric identification systems. Gait recognition involves analyzing a person's walking pattern, while ear biometrics involves analyzing the unique shape and features of a person's ear. Recent research studies have shown that by combining these two modalities, a more robust and accurate identification system can be created rather than a standalone biometric system, as it is less likely that both gait and ear features will be affected by external factors such as clothing or lighting. This approach has potential applications in various domains, including security, healthcare, and sports. In this project, we shall attempt to design a multimodal biometric system using gait and ear features and also compare its performance to standalone gait recognition system & ear biometric system respectively and go on to increase the accuracy of the multimodal biometric system. The database for this project was done from our side by "taking the prior permission" of the subjects in the video.

I: INTRODUCTION

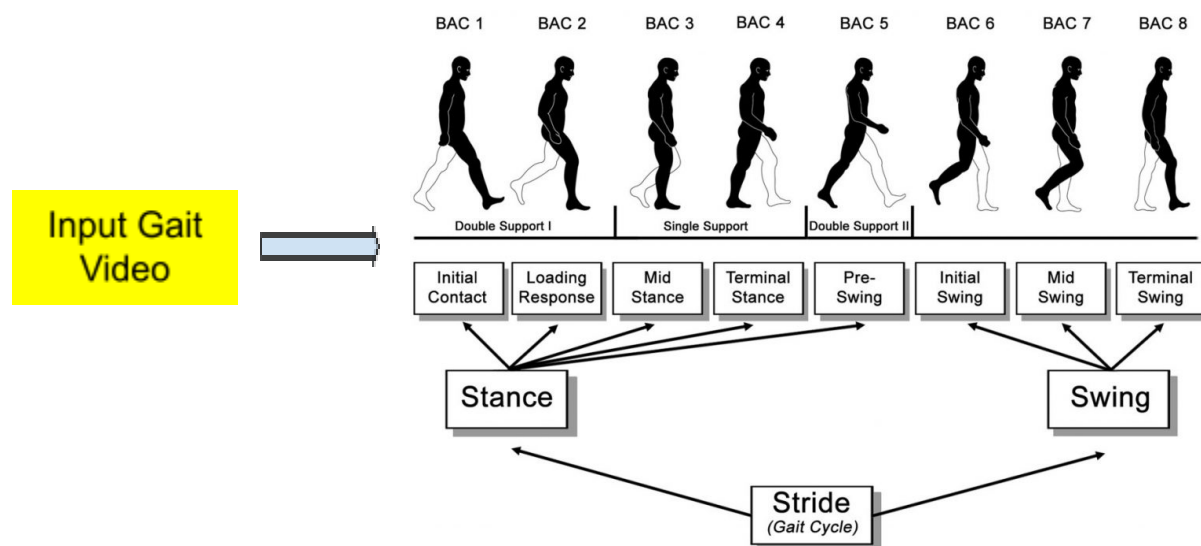
Let's look at gait and ear biometrics on an individual note and look at the techniques used in recent times to perform individual identification. We shall also look at the math behind the feature extraction and representation of the biometric.

Gait biometric involves using the person's walking style as the differentiating factor and recognising him/her based on certain factors associated with it. Medical

studies have shown that the Gait pattern is unique to a person and is sufficient to identify the person in normal circumstances. The factors associated with Gait can range from the positions of the various body parts, the paths traced by different joints of the hand and leg of the person in consideration to the swing and stance patterns of the person's hand and leg. These features can be extracted using specialized cameras and sensors to determine the body structure, muscle strength, gait line and neurological patterns. These features are then used to create a biometric template that can be used to identify the individual in future instances.

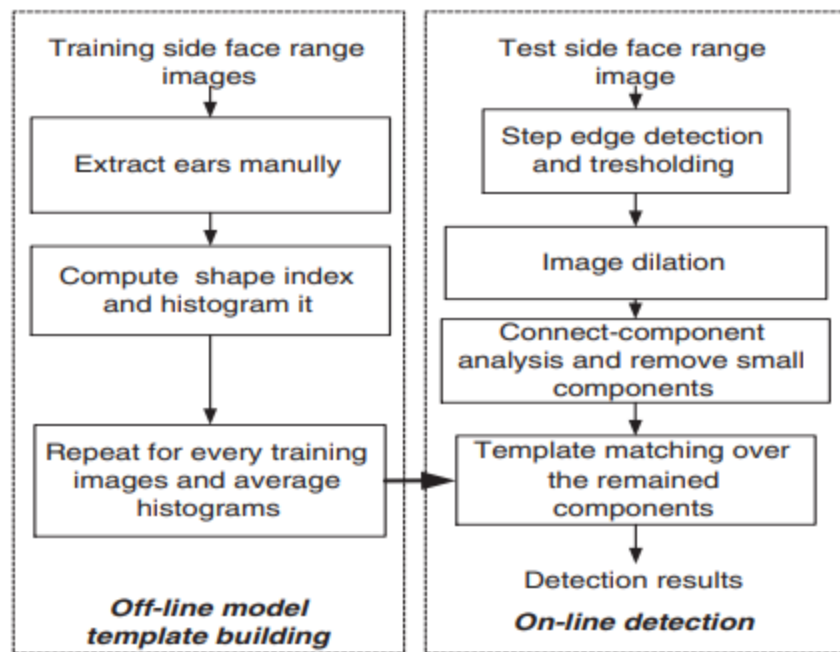
However, there are also some challenges associated with gait biometric, such as variations due to clothing and footwear, different walking speeds, and environmental factors. Despite these challenges, gait biometric has shown promising results in research studies and has the potential to become an important tool for biometric identification in various domains.

Here, we would be using a video of the person walking as the input and extract the phases of the gait cycle which are shown below:



There are a couple of methods to get the features from the gait cycle phases from the video which are discussed in the next section.

Ear biometrics involves detecting the side face of the person and then his/her ear ,later we will extract features like ear contours. For the face we can start with the Haar cascade algorithm but for the ear detection we can't get an ear by just using the Haar cascade So, we have used edge detection and template matching method like mentioned below. This gave us a very good accuracy in finding the ear.



Later after getting the ear segmented from the face we have extracted its ear contours and used them for identifying the person.

II: METHODS FOR FEATURE EXTRACTION

For extracting gait features, there are 2 methods to do so. They are:

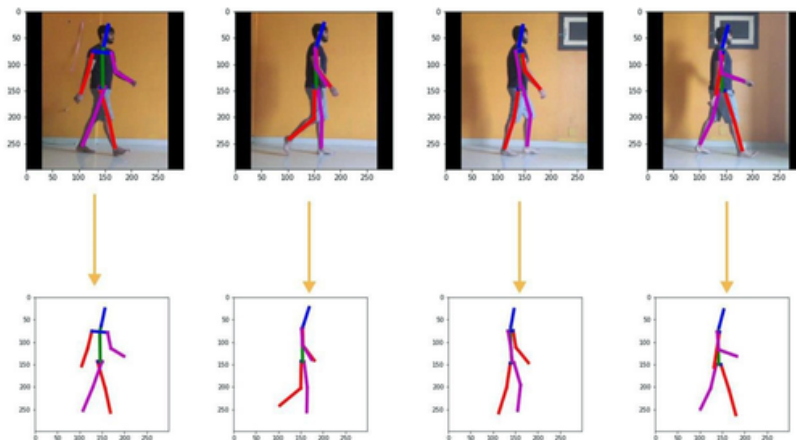
1. Using Pose Estimation:

This approach to get gait features involves the extraction of keypoints from the image of a single phase of the gait cycle of the person. Keypoint extraction involves identifying specific points on a person's body that are critical to their gait. These key points can include the position of the head, shoulders, hips, knees, and ankles. By analyzing the movement and position of these key points over time, it is possible to create a unique "gait signature" for each individual. Example is shown below:



Once the key points have been extracted, they can be used as input to a machine learning algorithm to classify the gait pattern and identify the person. This can be done using techniques such as deep neural networks, support vector machines, or decision trees.

Gait recognition using pose estimation has several advantages over other biometric identification techniques. For example, it can be done at a distance, without the need for physical contact or the subject's cooperation. It is also less intrusive than techniques such as fingerprinting or iris scanning.



Disadvantages: Computationally intensive & takes a lot of time to get the features on a local system. Susceptible to external objects like bags , coats, etc.

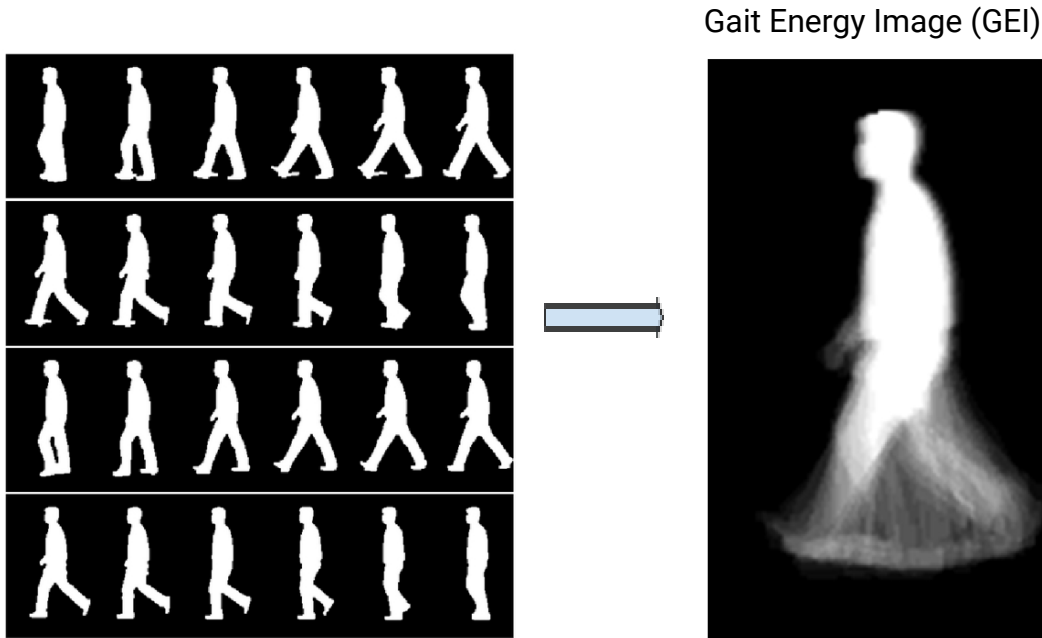
2. Using Gait Energy Image (GEI):

In this method of feature extraction, we use the phases of the gait cycle from the video to get the “silhouettes” of the phase image. We then take the average/weighted average of these silhouettes and thus obtain the Gait Energy Image (GEI) of the person in consideration. The purpose of silhouettes is that it’s invariant of background noise and other environmental factors and removes all such noise. Also, it is unaffected by the external

objects like bags, coats, etc. and also its space efficient in terms of database template storage.

$$G(x, y) = \frac{1}{N} \sum_{t=1}^N B(x, y, t)$$

Formula for Gait Energy Image Extraction.



For extracting ear features, we find the ear contours using the following method:

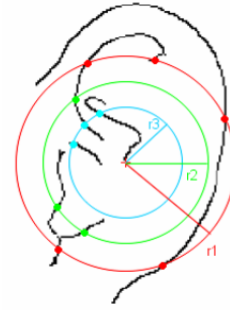
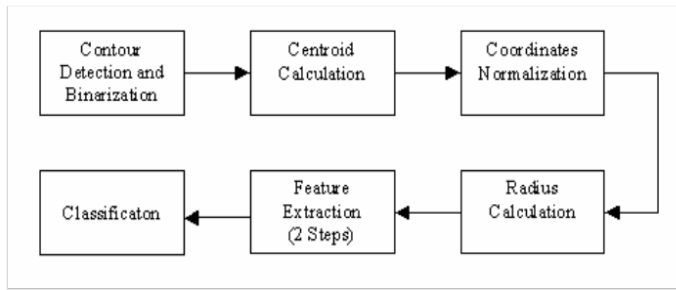
Using Ear Contours:

In this method we start with edge detection and thresholding for contour Detection and will do the Binarization.

Then will calculate the centroid and do the normalization of coordinates. Later for the feature vector we will follow below steps:

1. we create a set of circles with the center in the centroid
2. number of circles N_r is fixed and unchangeable
3. we create circles in such a manner that the corresponding radiuses are α pixels longer from the previous radius
4. since each circle is crossed by the contour image pixels we count the number of intersection pixels I_r
5. next we calculate all the distances d between neighboring pixels, we proceed in the counterclockwise direction
6. we build the feature vector that consists of all the radiuses with the

corresponding number of pixels belonging to each radius and with the sum of all the distances between those pixels $\sum d$

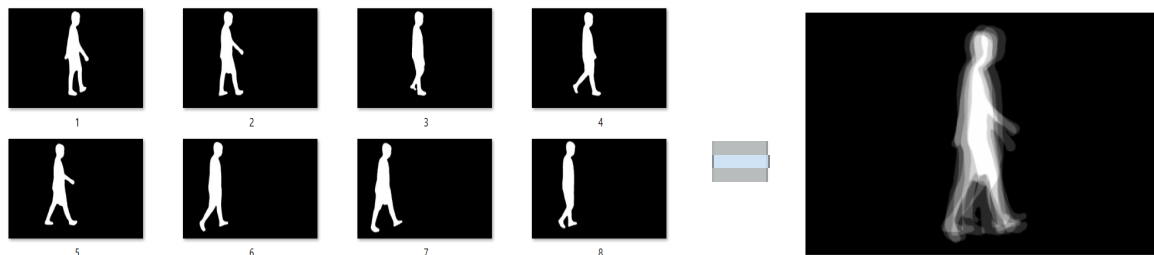


III: PROPOSED METHODOLOGY:

In this project, we shall be using the concept of Gait Energy Image (GEI) for gait feature extraction and contour boundaries for ear feature extraction. We then use the “SIFT detector” to get feature matches and identify the person using the “Minimum Distance” classification technique. The detailed procedure is given below:

(i) Gait Classification using GEI:

- First, we shall take the video of the person’s walking style as input.
- From this video, we shall extract the 8 phases of the gait cycle (as shown in the images of the feature extraction section of this doc).
- We then obtain the silhouettes of these 8 individual phases using “deeplabv3_resnet101” which is a deep learning and semantic segmentation algorithm used to extract the contours of the person’s body.
- Using the output of the above model, we shall binarize the image, which in turn gives the silhouette of the image.
- We then center the silhouette images (8 images) before performing the averaging operation.
- Finally, we take the mean of the 8 silhouettes to obtain the final gait energy image (GEI) and store this template in the database for further use.



(Example Template for a test subject we considered)

For Classification, we shall get the feature matches using the SIFT detector and calculate the distance from database templates using these matches as the criteria. Finally, we assign the class as the template class with the minimum distance from the test subject's GEI. We store the distances of the test subject's GEI from the Database templates in an array for further use in the multimodal system.

(ii) Ear Detection using Ear Contours:

- First, we shall start with detecting the side face of the person using Haar cascade algorithm
- Then we shall do the ear segmentation by edge detection and template matching.
- After Segmenting the ear from the face, We shall get the feature vector by finding the contours and using centroid for feature representation as mentioned in above Ear contours method.

For Classification, we shall get the feature matches using the SIFT detector and calculate the distance from database templates using these matches as the criteria. Finally, we assign the class as the template class with the minimum distance from the test subject's feature vector. We store the distances of the test subject's feature vector from the Database templates in an array for further use in the multimodal system.

(iii) Combining the two biometrics:

Now, after we acquire the gait and ear distance arrays, we shall normalize the distance values in these arrays as the gait array has values in the 200-300 range whereas the ear distances are in the range 20,000-30,000. Thus we see that the ear feature is dominating over the gait feature and thus must be normalized to nullify this effect on the biometric system.

Now, we combine the two distances by assigning a specific weight value to these distance values. The formula we used is:

$$\text{Combined_distance} = \alpha * (\text{Gait Distance}) + \beta * (\text{Ear Distance})$$

Based on this distance metric, we shall classify the subject depending on its minimum distance from the stored database templates. This process is carried out for every test subject and the corresponding class labels are obtained to calculate the accuracy score.

IV: RESULTS:

Biometric Considered	Accuracy Score
Gait Classification System (GEI)	45.45%
Gait Classification System (Hamming Distance)	41.67%
Ear Classification System (Ear Contours)	41.67%
Multimodal (Gait + Ear)	58.33%

V: CONCLUSION:

Thus, we conclude that the multimodal biometric system performs better than the individual biometric systems of gait or ear. This system can find its applications in person identification through CCTV cameras, pedestrian detection through dash cams, etc. This is a non-invasive system and works for the subjects at a distance from the camera. Also, it is robust to artifacts on the body like bags, coats, etc.

In the future, we can make an advanced implementation of this system by fusing it with other biometric traits like face, hand geometry, etc. in order to improve its reliability and security. Also, there is a huge scope in improving the accuracy score of this system by using higher resolution cameras as in our case, even in lower resolution conditions, we could achieve a decent accuracy of more than 50%. Also, we can work on making the system robust to external occlusions like tables, walls, etc. which affect the capturing of gait patterns of the persons.

Thus, this project can serve as an example for many other multimodal systems to come up in the future and develop more robust and secure identification systems.

REFERENCES:

1. [Gait Recognition Using GEI and AFDEI \(hindawi.com\)](http://hindawi.com)
2. <https://ietresearch.onlinelibrary.wiley.com/doi/10.1049/bme2.12103>
3. <https://www.vislab.ucr.edu/PUBLICATIONS/pubs/Journal%20and%20Conference%20Papers/after10-1-1997/Conference/2004/Human%20Ear%20Detection%20from%20Side%20Face04.pdf>
4. <https://elcvia.cvc.uab.cat/article/view/v5-n3-choras/104>