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Design and Implementation of Gait Recognition System

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ABSTRACT

Gait recognition is the process of identifying an individual by the way in which they walk.
This is a less unobtrusive biometric, which offers the possibility to identify people at a distance, without any interaction or co-operation from the subject; this is the property which makes it so attractive as a method of identification. This project aims to develop a system capable of automatic gait recognition. A person's gait signature is created using a model based approach. Temporal and spatial metrics extracted from the modal, such as length of torso, shin and variation in angles of the limb or the amplitude of a persons walking pattern can all be used to create a *"gait signature"* of the individual which are transformed into a self similarity matrix. The use of spacio-temporal correlation method to identify the subject in subsequent video sequences.

Keywords: *Biometrics, Gait, Video, Security*

1. INTRODUCTION

Biometrics is used in a wide array of applications, which makes a precise definition difficult to establish. The most general definition of a biometric is:

"A physiological or behavioural characteristic, which can be used to identify and verify the identity of an individual"

According to Mark (2002), there are numerous biometric measures which can be used to help derive an individual's identity. They can be classified into two distinct categories:

Physiological – these are biometrics which are derived from a direct measurement of a part of a human body. The most prominent and successful of these types of measures to date are fingerprints, face recognition, iris-scans and hand scans.

Behavioural – extract characteristics based on an action performed by an individual, they are an indirect measure of the characteristic of the human form. The main feature of a behavioural biometric is the use of time as a metric. Established measures include keystroke-scan and speech patterns. Biometric identification should be an automated process. Manual feature extraction would be both undesirable and time consuming, due to the large amount of data that must be acquired and processed in order to produce a biometric signature. Inability to automatically extract the desired characteristics which would render the process infeasible on realistic size data sets, in a real-world application. (Bedik, 2009; Aron and Amos, 2001 and Estrada et al., 2004)

With a biometric, a unique signature for an individual does not exist, each time the data from an individual is acquired it will generate a slightly different signature, there is simply no such thing as a 100% match. This does not mean that the systems are inherently insecure, as very high rates of recognition have been achieved (Gross and Shi, 2001, Carson et al. 2002)

2. GAIT BIOMETRICS

The definition of Gait is defined as:*"A particular way or manner of moving on foot"*

Using gait as a biometric is a relatively new area of study, within the realms of computer vision. It has been receiving growing interest within the computer vision community and a number of gait metrics have been developed. Early psychological studies into gait suggested that gait was a unique personal characteristic, with cadence and was cyclic in nature. Human recognition based on gait is relatively recent, compared to the traditional approaches such as fingerprint recognition (Aril et al., 2008, Braneli et al. 1998)

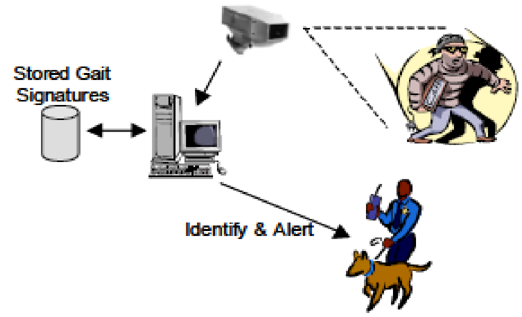

Figure 1: – Gait recognition in action (Mark , 2002)

Gait recognition can be used in a number of different scenarios. One example would be to analyse the video stream from surveillance cameras. If an individual walks by the camera whose gait has been previously recorded and the individual is a known threat, then the system will recognize such individual and the appropriate authorities can be automatically alerted and the person can be dealt with before such individual allowed becomes a threat. The threat has been successfully detected from a distance, creating a time buffer for authorities to take action.

Such systems have a large amount of potential application domains, such as airports, banks and general high security area (Foster et al., 2003, Kijetil 2008).

The objectives of this research are to design a model capable of performing recognition of individuals derived from a video sequence of a walking person and develop a software to implement the model designed. The method makes the following assumptions:

a. Only one person in the video footage at any given time.

b. The person is located sufficiently far from the camera.

c. The camera is stationary.

The camera is perpendicular to the object being captured (Elgammal et al.,2002 and Nixon et al., 2006)

3. SYSTEM DESIGN

The continuous motion of a moving person in a video was converted into a series of still images before further process was carried out. “Media Listener Adapter” and “IMedia Reader” are third party (xuggle JAR file) classes written in Java capable of reading a video stream and process events generated. Specifying a path (from a directory in the operating system) to a video file as input parameter, “IMedia Reader” class is capable of reading video sequence as stream. The “Media Listener Adapter” response to events created when “IMedia Reader” reads the video file. On Video Picture is an event from “Media Listener Adapter” that is capable of creating an image frame from the video stream, given a specific time interval. For the purpose of this system, it was set to 200milliseconds. The maximum number of image frames created can be per-defined. Here it was set to 35frames. To ensure a uniform size (width and height) of image frame, each image frame created from the video was rescaled to a size of 450pixel by 450pixel (Carson et al, 2001).

Image segmentation was used to separate dynamic objects such as people or animal, which were parts of the foreground, from the background of the image sequence. It is a very important pre-processing step in many computer vision applications, accurate retrieval of the foreground objects are vital in order to minimise distortion or inaccuracies. A natural approach is then to model the observed feature vector distribution using a mixture of Gaussians (MoG) model.

Model fitting is to match the model of human to the image obtained from the series of segmented image frame. When this is done, gait signatures can be automatically derived from the fitted model to be used in the recognition process.

Medial Axis Transformation (MAT) (skeletonization) was used to extract a region-based (skeleton) shape feature representing the general form of an object. After the feature points have been extracted from the video sequence, the feature points were the position of the joints eight points namely: Front foot, Front Knee, Front Hip, Cox, Back Hip, Back Knee, Back Foot and Head these forms the skeletal model of the human frame. A gait signature had to be derived which would be able to uniquely identify, or at least provide a high rate of correct recognition for the gait subject. Self-similarity plots were the gait features that were created for each person based on the angles of various body parts over a number of frames to form a gait signature.

The total distance of all corresponding points was calculated as:

$$d_i = \sum_{t=1}^{N_i} |c_i(t) - q(t)|$$

Where $q(t)$ is the gait feature of the person to be determined and $c_i(t)$ is the stored gait feature and d_i is the distance from the comparison and N is the total number registered person in the system.

$$\mathrm{d_{value}} = \frac{\mathrm{d_{max}} - \mathrm{d_{min}}}{\mathrm{d_{max}}} \times 100\%$$

where $\mathrm{d_{min}}$ is minimum distance, $\mathrm{d_{max}}$ is the maximum distance and $\mathrm{d_{value}}$ is the mean distance. If $\mathrm{d_{value}}$ is less than 90% then the person not registered in the system.

The system was implemented on Intel Duo-core T4200, 32bit operating system, CPU 2.00GHz, 3.00GB RAM with inbuilt webcam with installed JDK (Java Development Kit) to provide the JVM (Java Virtual Machine) on which the gait recognition system can be executed and MySQL database server for storing and managing any information.
The evaluation of the system was carried out with CMU (Carnegie Mellon University) Motion of Body (MoBo) database, from the Robotics institute, Pittsburgh,

Pennsylvania (R.Gross et al, 2001). This database consists of 25 subjects performing four different walking activities on a treadmill.

4. SYSTEM IMPLEMENTATION

4.1 Registered Person Image View Page

Registered person image view page provides the means to view both the extracted(and edited) frame as shown in figure 4.8a and the corresponding generated segment as shown in figure 4.8b below. This page is opened by selecting the "View Image" submenu from "captured" menu. The drop-down menu at the bottom of the page contains the list of registered person with captured gait frame, the "Next" and "Prev" button is used to navigate through the selected person's frames or segments. To view frames or segments use the "Normal Image" and "Segmented Image" option button. The "Close" button closes the page.

Figure 2: Registered image view page

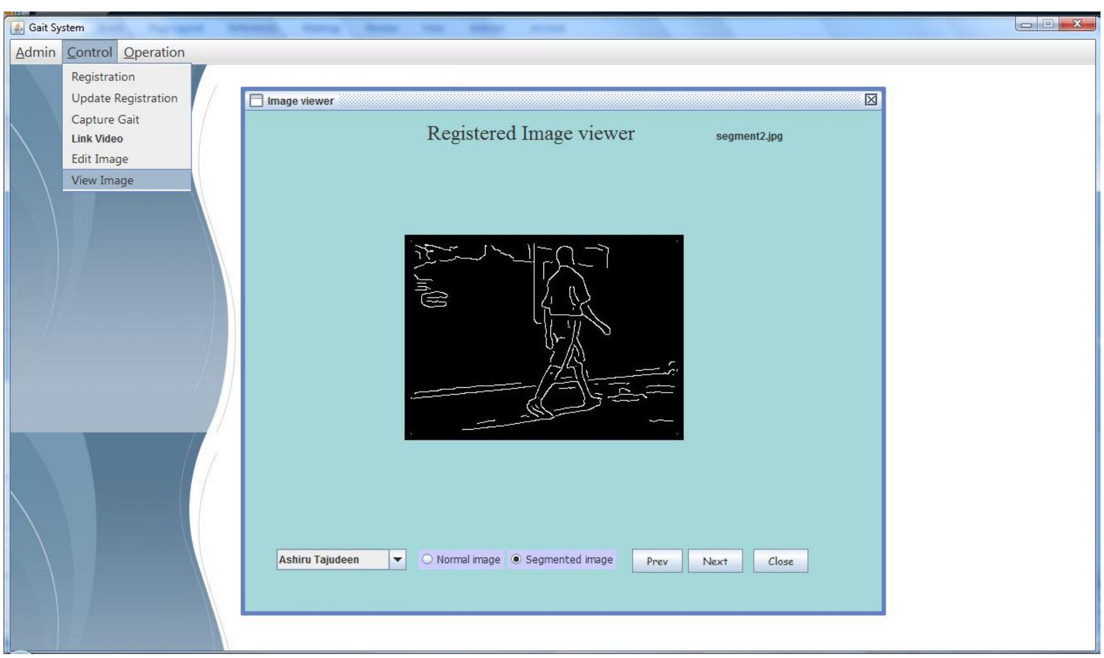

Figure 3: Registered person (segmentation) view page

Figure 4: Extracted skeletal image

4.2 Picture Identification Page

Picture identification page performs the verification and identification of a gait picture. This page opens when “Picture Identification” submenu is selected from “Operation” menu, this page is shown in figure 2 below. The “Open” button opens a dialog to navigate (or search) the system directories for picture, the selected picture is displayed on the page as shown in figure 4.. The “Identification” button performs the identification process and search for closest match and arranges the outcome in ascending order, based on the option selected: “Picture image” option will display the output with the image frame as shown in figure 5 while “Edge Image” will display the result with the segmented image as shown in figure 6. The “close” button closes the page.

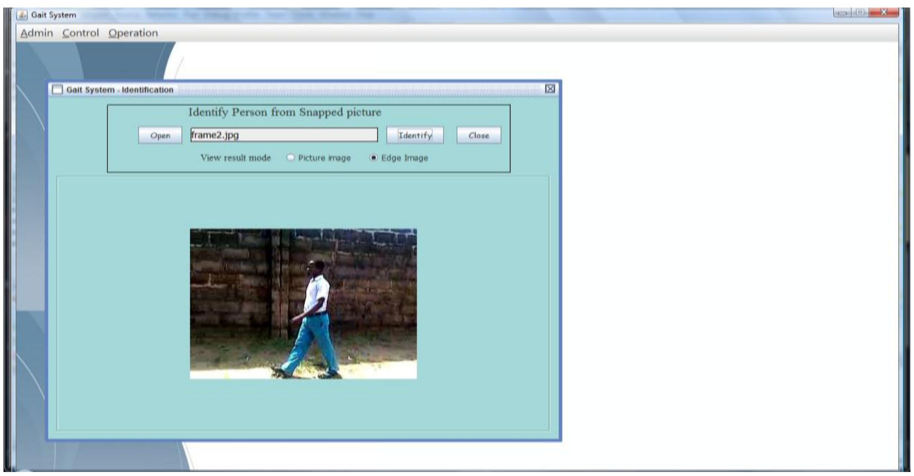

Figure 5: Picture identification page (selected picture)

Figure 6: Picture identification page (Result, using segments)

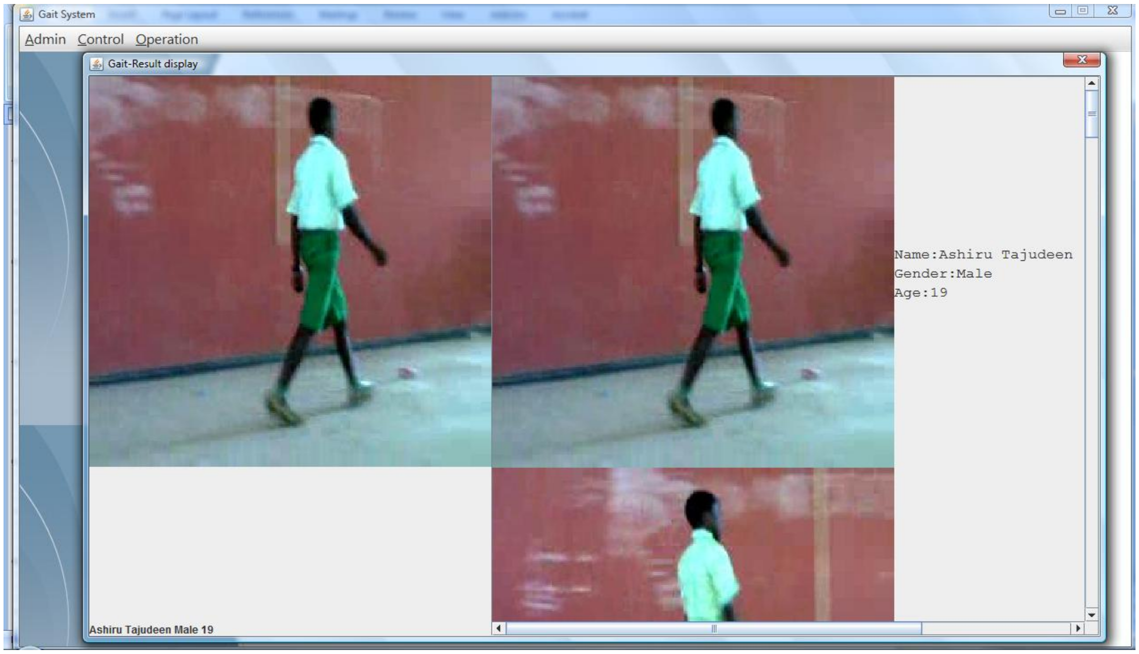

Figure 7: Picture identification page (Result, using frames)

5. EXPERIMENTAL SETUP AND RESULTS

The gait recognition system performs a repetitive and lengthy task on video, the image frame (picture) and extraction of gait signature. The format settings used for the webcam include: avi (audio video interleave) video file format. To enhance the process of capturing or attaching video for a registered persons with webcam (inbuilt laptop camera). gait videos of different persons were captured with an external device(digital video camera) before registration. These videos are converted from mpeg (moving picture expert group) into avi file format with leawo AVI converter. During registration, each of these videos are linked to the registered person then, further processes such as image frame creation, segmentation and gait extraction.

5.1 RESULTS

The following table is the result obtained from identification of five different persons using a single picture for identification. The frames generated from registered individual gait video are varied to observe the outcome of the identification. The table 4.1 below shows the outcome. The columns rightly marked were identified correctly but the wrongly marked gave a wrong identification.

Table 1 identification using picture

No. of frame	Person 1	Person 2	Person 3	Person 4	Person 5	Total
5	✓	✗	✓	✓	✓	4
10	✓	✗	✓	✓	✓	4
15	✓	✓	✓	✓	✓	5
20	✓	✓	✓	✓	✓	5
25	✓	✓	✗	✓	✓	4

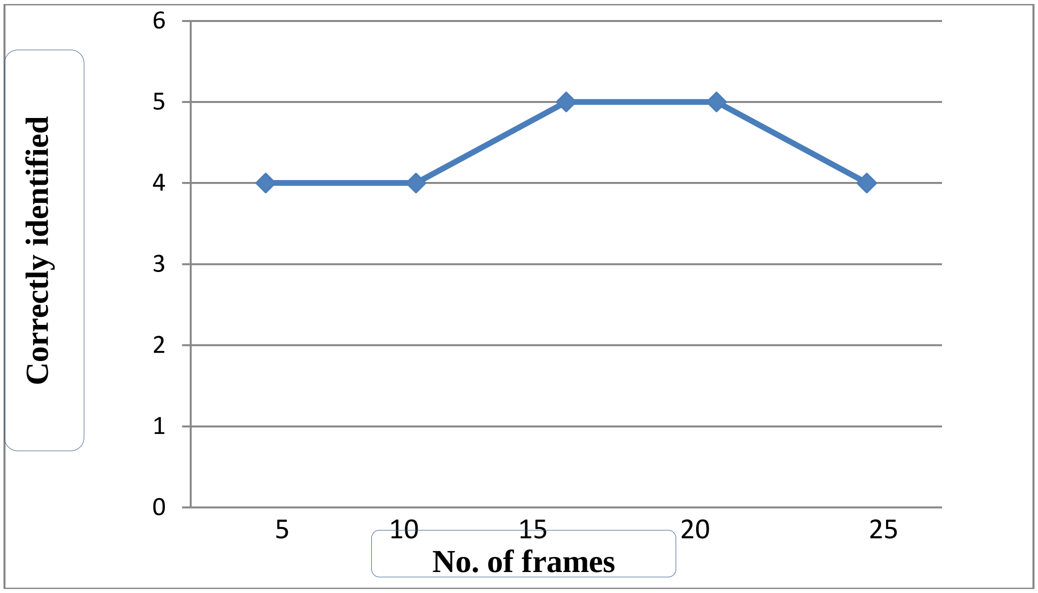

Figure 8: Line graph from table 1

The table below show the result for the gait identification carried out using video identification. The number of frames used for identifying the registered persons were varied (4, 8, 12, 16) against a video to be identified. Identification using video requires more processing and takes a longer time, nevertheless, both image and video performs huge graphics processing.

Table 2: identification using video

No. of frame	Person 1	Person 2	Person 3	Person 4	Person 5	Total
5	✓	✓	✓	✓	✓	**5**
10	✓	✗	✓	✓	✓	**4**
15	✓	✓	✓	✓	✓	**5**
20	✓	✓	✓	✓	✓	**5**
25	✓	✓	✓	✓	✓	**5**

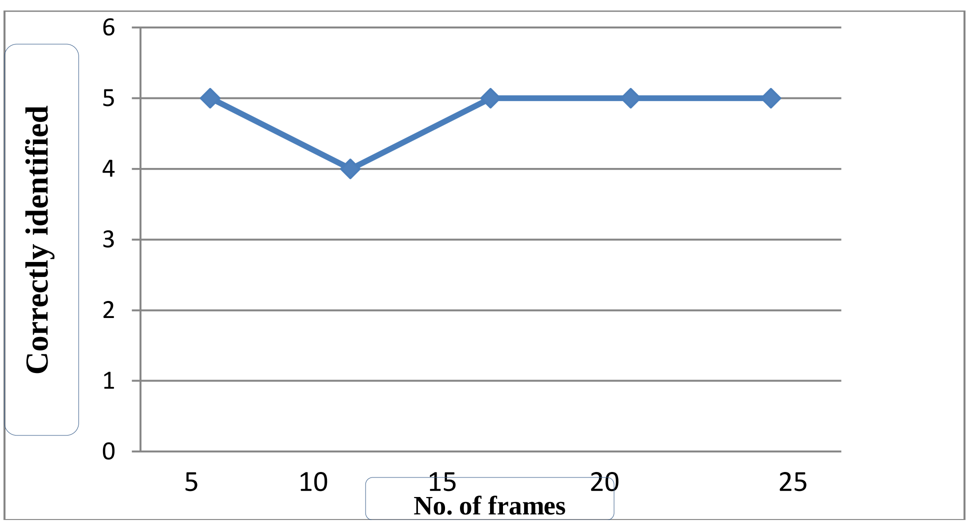

Figure 9: Line graph from table 2

6. SYSTEM EVALUATION

The evaluation of the system is carried out with CMU(Carnegie Mellon University) Motion of Body (MoBo) database, from the Robotics institute, Pittsburgh, Pennsylvania (R.Gross et al, 2001). This database consists of 25 subjects performing four different walking activities on a treadmill. All subjects are captured using six high resolution color cameras distributed evenly around the treadmill and were evenly distributed around the treadmill capturing more than 8000 images per subject. The sequences are each 11 seconds long, recorded at full frame rate (30 frames/second). The subjects perform four different walk patterns: slow walk, fast walk, incline walk and walking with a ball. For evaluation performance of this system, only the camera parallel to the walking person was used (i.e left, right, front and rare camera). The following results were obtained.

Table 3: identification of MOBO from right-side camera

Person	Slow walk	Fast walk	Walking with a ball
Person1	✓	✓	✓
Person2	✓	✓	✗
Person3	✓	✓	✓
Person4	✓	✓	✗
Person5	✗	✗	✗

Slow walk: $\frac{4}{5} \times 100\% = 80\%$

Fast walk: $\frac{4}{5} \times 100\% = 80\%$

Walking with a ball: Slow walk: $\frac{2}{5} \times 100\% = 40\%$

Table.4 identification of MOBO from left-side camera

Person	Slow walk	Fast walk	Walking with a ball
Person1	✓	✓	✓
Person2	✓	✓	✗
Person3	✓	✓	✓
Person4	✓	✓	✓
Person5	✓	✗	✗

Slow walk: $\frac{5}{5} \times 100\% = 100\%$

Fast walk: $\frac{4}{5} \times 100\% = 80\%$

Walking with a ball: Slow walk: $\frac{3}{5} \times 100\% = 60\%$

Table 5 identification of MOBO from rare camera

Person	Slow walk	Fast walk	Walking with a ball
Person1	✗	✓	✓
Person2	✓	✗	✗
Person3	✓	✗	✓
Person4	✓	✓	✗
Person5	✓	✗	✗

Slow walk: $\frac{3}{5} \times 100\% = 60\%$

Fast walk: $\frac{2}{5} \times 100\% = 40\%$

Walking with a ball: Slow walk: $\frac{2}{5} \times 100\% = 40\%$

Table 6 identification of MOBO from front camera

Person	Slow walk	Fast walk	Walking with a ball
Person1	✗	✓	✓
Person2	✓	✓	✓
Person3	✓	✓	✓
Person4	✓	✗	✗
Person5	✓	✗	✗

Slow walk: $\frac{4}{5} \times 100\% = 80\%$

Fast walk: $\frac{3}{5} \times 100\% = 60\%$

Walking with a ball: Slow walk: $\frac{3}{5} \times 100\% = 60\%$

Table 7 Summary of identification of five persons from MOBO dataset

	Slow walk	Fast walk	Walking with a ball
Right camera	4	4	2
Left camera	5	4	3
Rear camera	4	2	2
Front camera	4	3	3

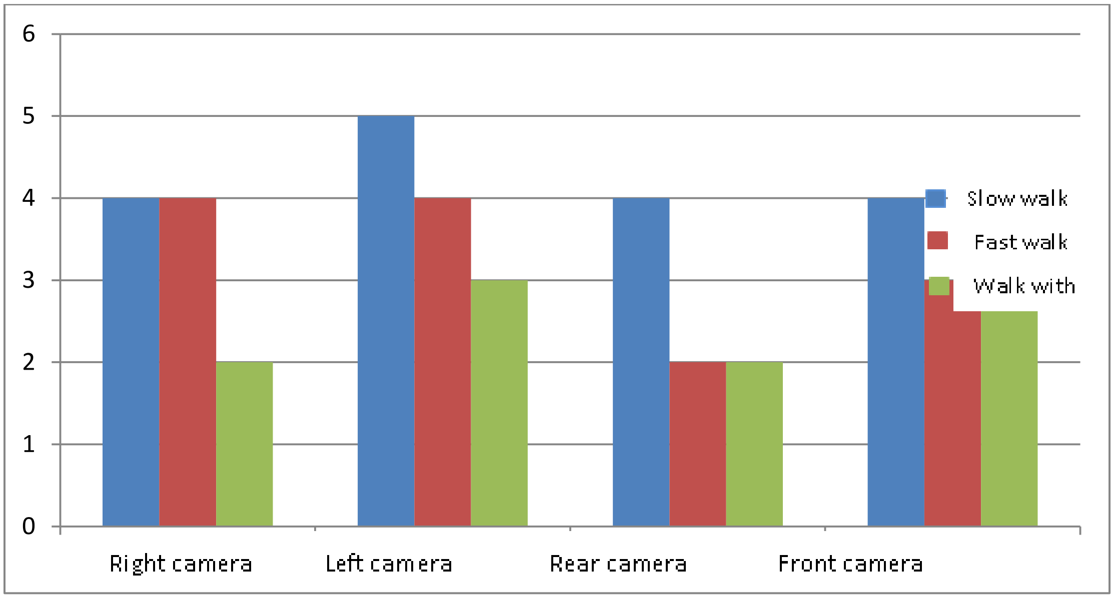

Figure 10: Compound graph from table 4.6

7. CONCLUSION

The aim of this system is to identify the presence of human in video streams for the extraction of important features. However, this task becomes more complicated in the presence of different variations in brightness, lightings, contrast levels, poses, and backgrounds. This system is designed to identify the presence of human in a video sequence and differentiating them from non-human objects. The purpose of human identification is to extract gait patterns and give a method by which people can be recognized using these patterns. This system is capable of recognizing people based upon their gait, from already extracted gait patterns. Extracting high level features is an important field in video indexing and extraction. Identifying the presence of human in video is one of these high level features, which facilitate the understanding of other aspects concerning people or the interactions between people. The motion detection technique and model fitting method is used for identifying the presence of human in videos. Variations in different part of the limbs, hands and body posture are extracted as the gait signature.

The main two techniques used in building the system are mixture of gaussian model (MoG) and medial axis transformation techniques. A series of images were created from a captured video of a walking person whose gait signature is to be extracted. The proposed system detects the walking pattern of different person under different lightning conditions. The need for effective and efficient gait recognition system cannot be over-emphasized. This is because gait recognition can be used in a number of different scenarios. One example would be to analyse the video stream from surveillance cameras. If an individual walks by the camera who's gait has been previously recorded and they are a known threat, then the system will recognise them and the appropriate authorities can be automatically alerted and the person can be apprehended before they are allowed to become a threat. The threat can be detected from a distance, creating a time buffer for authorities to take action. This system has a large amount of potential application domains, such as airports, banks and general high security area. A gait recognition system was developed to provide a means for identifying humans based on their gait pattern. This system was described and implemented on Intel Pentium Dual core, CPU 2.0GHz, 3GB RAM using Java programming language, The results of the developed system are satisfactory though, it can be improved upon. This system will go a long way in assisting both security agents and different organizations like banks cub threats, aid identification and investigation.

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