Walking Pattern Biometric with Simple Pendulum Motion of Limbic Nodes

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Declaration

We, Palash, Nadia and Proshanta, declare that this thesis titled, **'Walking Pattern Bio-metric with Simple Pendulum Motion of Limbic Nodes'** and the work presented in it are our own. We confirm that:

- This work was done wholly or mainly while in candidature for research degree at this University.
- Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated.
- Where I have consulted the published work of others, this is always clearly attributed.
- Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work.
- I have acknowledged all main sources of help.
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Approval

The thesis titled **'Walking Pattern Bio-metric with Simple Pendulum Motion of Limbic Nodes'** has been submitted to the following respected members of the board of examiners of the department of computer science in the degree of Bachelor of Science in Computer Science and Engineering (C.S.E.) on January 2017 by Nath, Palash Kanti(13-23727-1); Zafrin, Nadia(13-23753-1); Ghosh, Proshanta Kumar(13-23543-1) and has been accepted.

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Abstract

Walking pattern is an emerging field of research for biometric human identification for which some techniques has been developed to recognize a person by his/her walking pattern. However currently used methods require multiple cameras a huge number of templates or an external device to retrieve data such as foot scanner, walking assistance apparatus, pressure plates, reflective markers etc. The methodology proposed in this paper utilizes pendulum motion to mimic human movement for the values to train or recognize. The analysis proves that the proposed method can be used to automatically recognize a person without the use of any external interaction with the system. Current experiment is currently conducted in controlled environment to prove the methodology. Future work will further improve the detection rate and use a specific machine learning algorithm to increase the recognition process.

Contents

List of Figures

Chapter 1

Introduction

Computer vision is a field which deals with extraction, analysis and understanding of information from a single image or a sequence of images[**cv**]. In a simple manner pattern recognition can be defined as branch of machine learning which works on recognition process in the data that are provided as input[8]. Walking pattern is a general way or manner which represents how a person normally walks. The walking of a person occurs in a sequence known as walking cycle.

There exists a huge variety of bio-metric identification systems that are commercially available in the market such as face detector, fingerprint and iris scanner, but all of these security systems require human interaction. In general such systems lack user acceptance, as they favours systems with least amount of interaction. Therefore a new bio-metric identification has been introduced based on human walking pattern recognition. In recent year Walking pattern recognition has became more renowned research topic in the field of computer vision and pattern recognition. Till date there are several researches conducted on identifying a person based on the person's general walking pattern, among these methods gait recognition system is most renowned system[29] which uses silhouette of a person to detect and recognize. The identification of a person using silhouette is easy, but at the same time it is vulnerable as the system can identify the person without any information such as basic personal details which can be shown in face, and fingerprint recognition systems. Which makes the system unreliable to be used outside the premises. Another problem with the GAIT recognition system is that the system works with height and movement of single walk cycle which can be changed due to sickness of the person or by an accident. The system learns the pattern when the camera gets the first visual contact on the person the the person is tracked throughout the premise. Which can be problematic if there remains multiple persons at the same height eventhough the walking strides are different but can be very close to each others

walk cycle which can make the system confuse.

The term human recognition by walking pattern comes up with many questions as well as several crucial points regarding bio-metric identification systems which has attracted interest on the research. While identifying a person it is necessary to obtain a highest accuracy to reduce the confusion and make the system as efficient as possible. Recognizing a person based on individuals walking pattern is a difficult task as it requires several segmentation of body parts as well as extracting angle values.

Several researches based on walking pattern recognition has overcome many of the issues, but required an external device to be attached to collect data and for proper segmentation. In the proposed methodology a single camera has been used without using other external devices to detect a person, and segmentation has been done through programming. Which makes the system easy to be implemented as well as efficient along with solving the problem of using external devices. Therefore making the learning process of the system more efficient and does not require to be trained.

1.1 Overview

The contents of the thesis have been split-ed into various chapters. In this section an overview of the chapters will be discussed briefly:

Chapter 1 provides an introduction of the topic that has been chosen for this thesis.

Chapter 2 will discuss the previous works that have been conducted in this area of research. It will contain fundamental description of previous methodologies, benefits and drawbacks. As well as our proposed methodology.

Chapter 3 contains the overall procedure of the proposed method and its implementation. Which includes identifying and proving the concepts, implementation, execution and analysis of the proposed method.

Chapter 4 is all about future works.

Chapter 5 contains the conclusion.

1.2 Goal

Tasks that were performed to reach the goal are:

- Background subtraction from video feed.
- Detecting moving object from the scene by drawing contours and rectangle around it.
- subdivide the detected object into multiple segments known as ROI.
- Determine the persons walking pattern.
- Detecting and recognizing a person by the person's walking pattern.

1.3 Contribution

The contribution of this work can effect greatly in the field of computer vision and pattern recognition, some of them are outlined as follows:

- To detect a person efficiently and with maximum precision from distance.
- Recognize the person's identity without any physical interaction with the system.
- Study human behavior without use of any external equipment's.
- Can determine/predict a persons health condition, mood or intention from the persons walking pattern.

Chapter 2

Literature Review

2.1 Bio-metric Identification

A bio-metric identification system is a comparison mechanism which compares an individuals bio-metric signatures with a second set of parameters. Normally these parameters are consists of a unique pattern or features of a person, these patterns and feature points are used to distinguish between individuals. Currently there exists many bio-metric identification systems such as voice recognition, face recognition[28], iris recognition, hand and finger print recognition[34] as well as walking pattern and footprint recognition systems. Among these systems face recognition, hand and finger print recognition systems are used widely.

2.2 Existing Literature

In past few years human walking pattern recognition[14] has became one of the most popular topic of research in the field of computer vision and pattern recognition. It has been known as great approach in human computer interaction and for different security purposes. There remains several bio-metric identification systems to increase security and other purposes such as face detector[35], iris scanner[9], fingerprint recognition[1] etc. but all these techniques require human interaction to be identified. As the technology blooms in the field of computer vision and image processing peoples seemed to be uncomfortable with getting interacted with the devices. Therefore a new concept has taken place known as walking pattern recognition to detect and identify a person from a distance which will require the minimum amount of interaction with the system. It plays

a very important role to identify someone very easily. Human Gait accredit to motion achieved through the movements of human limbs. Different Gait pattern are individualized by differences in limb movement pattern. As walking pattern can be considered as part of human action, for recognition or detection process some methods are being used based on the requirement of the system. Where SVM(Support Vector Machine) stands tall when it comes to specific action or pattern recognition then the existing algorithms which are currently being used. There are several researches [23] [12] [20] [21]which are undertaken to recognize specific action or behaviour of a person or animal where SVM has been implemented widely. In the research [36] authors have introduced the walking pattern recognition method for smart rollator. Where SVM has been implemented for walking pattern detection and recognition; the data was extracted via reflective tags on the subject. To be more specific K-means clustering method and Gait has been used as primary phase to detect walking pattern of a person. The method is proven to be more promising then the existing three methods mentioned in [23].

2.2.1 Walking Pattern

Bio-metric Walking pattern recognition uses a variety of methods to detect, train and recognize a person from the persons general way of walking. Some of the methods are silhouette analysis-based gait recognition [31], model based approaches using coupled oscillators [33], reflective tags[26] and a signal processing technology used with template for gait recognition [2]. Among these techniques GAIT is known to be the most popular method as it does not require any external devices unlike other methods, but it has some problems such as change in walking pattern can take the person as a different individual who is not in the database or the silhouette can be tempered with by mimicking the stances as it works with templates.

Lee et al[10] has described a delegation of gait introduction for the purpose of person identification and classification. Where they explored the recognition behaviors of two different methods to aggregate features over time under different recognition tasks. They made out the accuracy of recognition using gait video sequences collected over different days and times and under varying lighting environments.Gait has an advantage over other bio-metric systems that it can detect and measure at low resolution, and therefore it can be used in situations where face or iris information is not available in high enough resolution for recognition.Their gait appearance feature vector is comprised of parameters of moment features in image regions containing the walking person aggregated over time either by averaging or spectral analysis. They brought together gait data in indoor environments with different backgrounds on four separate days spanning two months.Twenty-four subjects, 10 women and 14 men, were asked to walk at their normal speed and stride, back and forth, twice, in front of a video

camera that was placed perpendicular to their walking path. The walking gait sequences going the opposite direction were ipped so that all sequences are of one walking direction. In all, 194 walking sequences were collected, between 4 to 22 sequences for each subject, averaging 8 sequences per subject. A minimum of 3 complete walking cycles were captured at 15 frames per second for each walking sequence. They have brought out gait appearance features from the CMU gait database by R. Gross and J. Shi. The CMU motion of body(MoBo)[4] database. A Technical Report, CMU-RI-TR-01-18, Carnegie Mellon University, 2001, has qualified and checked support vector machines on their gait appearance features under two conditions. Under the random-sequence test, Under the random-person test. Experiments had conducted by comparing gait appearance features from each individual against the rest of the population. Their representation is rich enough to show promising results in these tasks.

In [32] has proposed model based approach using systematic coupled oscillator and human locomotion as underlying concept along with temporal template[13][11] to develop a model to extract leg motion. Many researches has implemented force plates in different manner[27][15][37] to recognize a person with his/her walking pattern which has proven to be useful, but is not cost effective method. Beside being cost effective there are some other factors which can provide irrelevant result for example change of weight due to carrying extra wights shopping bags, school bags etc or malfunction of any of the tiles. Walking pattern has been categorized in many ways. For example, Finding and recognizing a person by walking and running can be detected by analyzing leg motion using gait.

2.2.2 Others

In the article [30] by Liang Wang et al. provides a huge survey of research on computer vision based on human motion analysis. Human motion analysis examines a huge number of large research projects worldwide. Such as DARPA(Defense advanced research projects agency) ,VSAM (Video surveillance and monitoring) etc. This paper [17] presents a survey of different methodologies which is used for human walking motion analysis. The proposal is used for human detection, segmentation, various tracking method, pose estimation and pose analysis by including the uses of unsupervised techniques for analyzing the human walking.

In paper [22] authors have developed the previous research on human gait to bring out a set of parameters to design a highly interpretable system capable of identifying different gait styles with linguistic fuzzy if then rules.

The method used in [16] have used multiplicative classification rule by using statistical distance for determining whether an unknown motion is consistent with normal walking pattern or not. They have represented the human motion

with low level categories to permit efficient recognition from partial visual input. They have used the W4 approach [5] to locate the head, waist and feet. For constructing a motion category they have recorded a video database of 17 male and female walkers each moving at slow, medium and fast paces.

Chapter 3

Development of Proposed Methodology

3.1 Introduction

Contour approach has been used in the experiment to detect the person from the video feed. To find the foreground image background difference algorithm has been deployed. By then detection of the person has been accomplished. Drawrectangle method is used to enclose the moving person to get the exact co-ordinate values which will be used later to collect data.

3.2 Framework

Framework is a basic structure of a system which gives an idea about how does a system runs or how the system will work. Every system has its own framework to have a logical understanding of the system or program. For the thesis project a framework of the system has been proposed.

The image of the person is captured via ip camera and give it as an input where the image is being pre-processed and detects the moving object, here the person is being detected and then the segmentation takes place. In this stage ROI's are identified from the processed image. The detected ROI's can be marked using several method, but for feasibility a method from opencv boundingRect() has been used. the values are extracted for each of the detected segments and then system is being trained based on the data. The recognition process deals with the same set of data to recognize a persons walking pattern

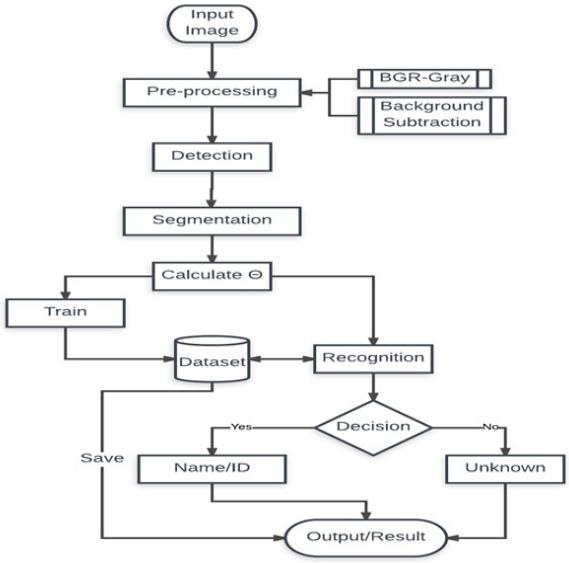

Figure 3.1: Proposed system framework

based on the trained values. The methods used for training and recognition are custom made without use of any methods such as SVM, which can be used in future to make the system more efficient then the current prototype as well as some templates can be trained to detect the ROI's more specifically to reduce the redundancy of the data further.

3.3 Preprocessing and Segmentation

An image provided through video feed can have several types of problem therefore it can not provide with a good result to be processed further. Although the image is in standard environment condition it still require to be preprocessed to get ROI from the image.

3.3.1 Background Subtraction

Background subtraction[19] is a method used to detect the changes in a sequence of images. In the beginning of the video sequence from a fixed camera an image frame is being provided and fixed it, as the background is static. Then rest of the frames are provided. If any of the frames includes an object which is

different from the first image then the background image was subtracted from the object image, and the foreground image was found out. Based on the applied threshold value a new binary image is then extracted. In the given sequence of images let I_n and I_b denoted as input and background image accordingly; then the foreground image I_f image can be found by

$$I_f = I_n - I_b$$

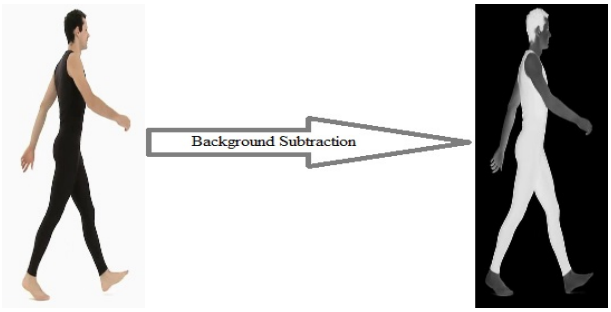

Figure 3.2: Background Subtraction

3.3.2 Image filtering and Edge Detection

Finding contours from an image is easy, but sometimes it may miss some important features which are required. The feature can be missed out by contour detection if the intensity level of the background and the pixels intensity values that contains ROI are almost near the threshold values that was provided to separate the interested region from the background region. Beside the raw image contains noise which is need to be removed before detecting the edges to get a better result. There remains several methods for image filtering and edge detection among them Gaussian blur technique and Canny Edge detector seemed to be more reliable. First the noise is reduced by using Gaussian bur then Canny edge detector applied for edge detection to detect[7] the objects properly which is then given as input for contour detection.

3.3.3 Person detection using Contour

To detect a person in front of the camera a big contour is required to be found out among all other objects in the scene. Applying the contour approach the biggest contour was found and the contour information has been extracted from

image. Next the contour has been smooth-en and reduce disturbance by applying threshold. Using the contour information as input the person on the scene has been detected. Then the detected person has been bounded by rectangle[3].

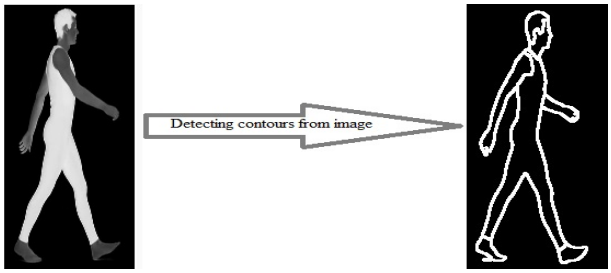

Figure 3.3: Contours of detected person

3.3.4 Segmentation

After pre-processing and detecting the person in the image it has been segmented into regions which contains ROI. In this paper the segmentation is based on only one side of the person to prove the theory followed by experiment.

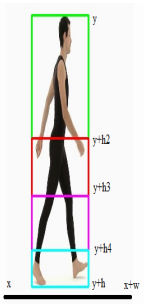

Figure 3.4: Single side Segmentation of Body based on Calculation

3.4 Experiment

3.4.1 Primary analysis of the implemented method

After pre-processing and segmentation it is important to perform a primary test on the proposed method. Therefore walking cycles of three different sample has

been recorded for all four segments by using the following equation.

$$\theta \;=\; \tan^{-1}\,(\frac{y_2 - y_1}{x_2 - x_1})$$

The collected data has been plotted here:

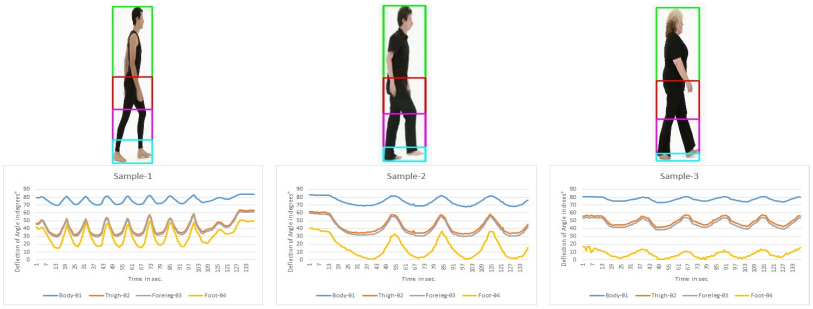

Figure 3.5: Graph of Body, Thigh, Foreleg and foot from three individual samples

Then the data dimensionality is decreased using the following formula.

$$\mu \;=\; \frac{\theta_1 + \theta_2 + \theta_3 + \theta_4}{n}$$

After stream lining the data a graph is plotted against each other for the samples where it is compared therefore proving the basic concept which is that every person has a different walking pattern regardless their age and height.

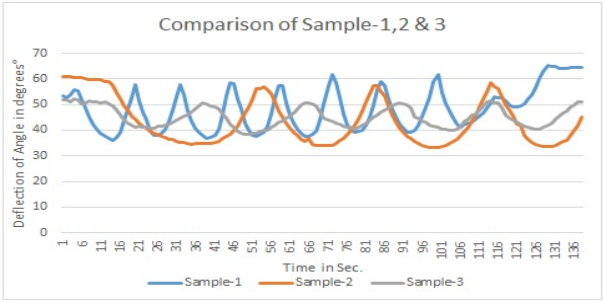

Figure 3.6: Comparison of walking pattern of three individual samples

3.4.2 Pendulum Motion

Pendulum is a system where a weight is hung from fixed point so that it can swing freely forward and backward. Human motion of limbs from lower body

segment also occurs in the same way as the pendulum. A similarity between the pendulum motion and human motion of thigh, foreleg and foot is shown here :

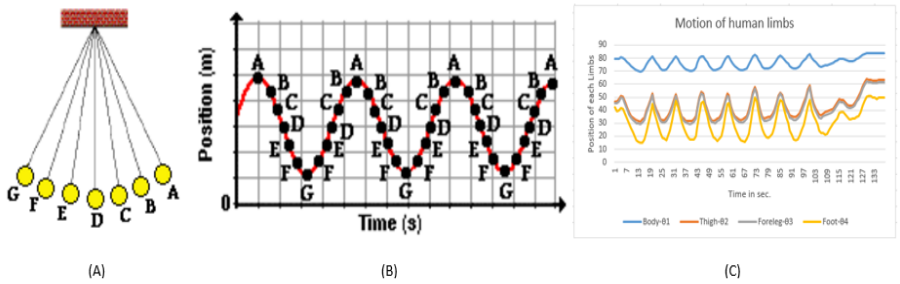

Figure 3.7: Similarities between human motion and pendulum motion. Where (A) is the Pendulum[6], (B) is the motion of pendulum[6], and (C) is the Limbic motion of a person.

In this project single segment of a human body is represented as a pendulum. So that a relation can be established in future for efficiency and greater accuracy.

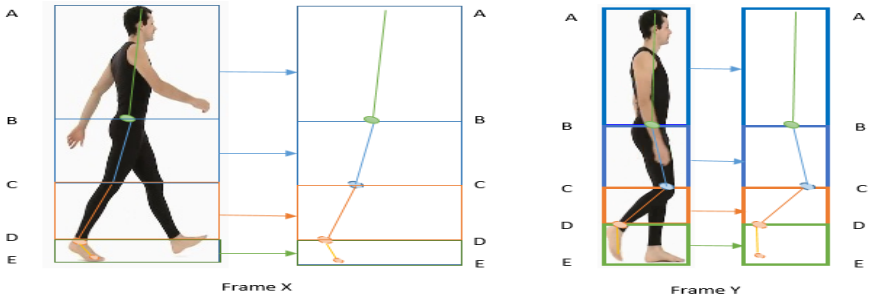

Figure 3.8: Representation of human motion as a pendulum by each segment.

From the above image (Fig 3.7) if A(beginning of head) is taken as the base and at B is (Hip) can be considered as bob for the single segment among three segmented part of lower body, and values can be extracted from these. Later for the second part of the Three segment B can be considered as the base and C (end of thigh or can be considered as knee)can be considered as blob; Same goes for foreleg and foot segment.

3.4.3 Secondary Experiment

As the method is proven in section 3.3.1 the experiment is ready for next step which is to recognize a person's by his or her walking pattern. The process is

explained step by step. Although the walking pattern is proven to be unique for each person the person is required to be recognized by the system. Therefore firstly the values are taken for each segment upper body, thigh, foreleg, and foot. A snapshot of the primary training data for two samples is given below:

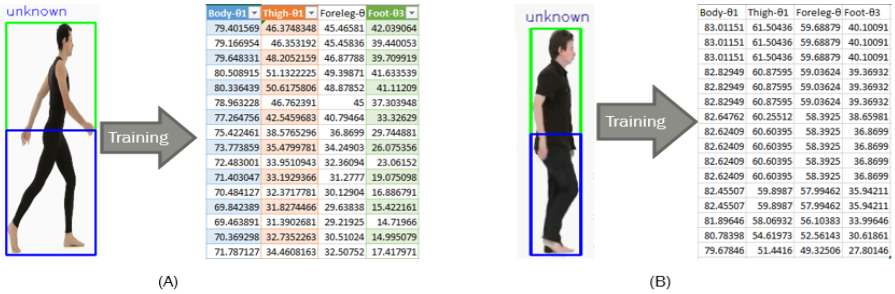

Figure 3.9: Sample of extracted data from sample 1(A) and 2(B)

Next the data dimensionality of training data is reduced by taking mean of the values for each frame and save into a file to use later for recognition.

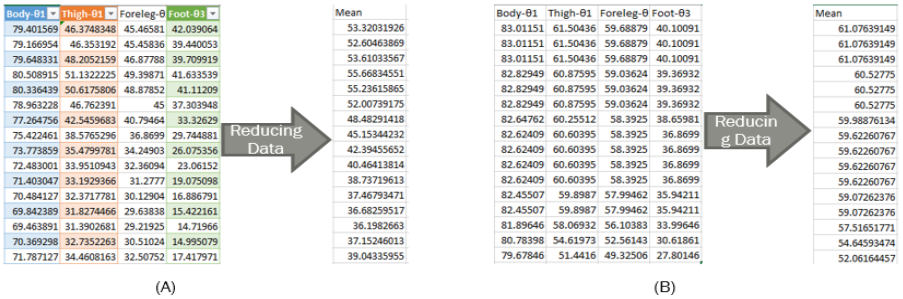

Figure 3.10: Sample of reduced data for sample 1(A) and 2(B)

3.4.4 Comparison

Although the proposed method is a prototype which is proven to be working as expected and requires comparison with the existing systems to prove its efficiency. The comparison of the system is shown in the below figure:

The comparison of the systems are based on most closely related researches. Where it can be observed that currently developed does not require any templates, whereas further developing the system may require some templates to detect the ROI's more specifically instead of having multiple pattern templates

SL.#	Related Researches	External Devices			Template	Implementation/ Algorithm Complexity	System Requirement	System Implementation Cost
		Multi. camera	Pressure Sensor	Reflective Tags				
1	**Gait analysis for human identification**	-	-	-	Yes	Medium	High	High
2	**Human Recognition Based on Gait Poses**	-	-	-	Yes	Yes	Medium	Medium
3	**Gait Recognition Using Joint Moments, Joint Angles,and Segment Angles**	√	√	√	No	High	V.High	V.High
4	**Gait Recognition: A challening signal Processing technology for biometric Identification**	-	-	-	Yes	V.High	V.High	V.High
5	**Our Method**	-	-	-	No	Low	Low	Low

Figure 3.11: Comparison between existing methods and proposed method where SL. 1, 2, 3 and 4 are from [25], [24], [18], and [2] respectively.

for same subject. In terms which makes the proposed system's working process much faster and less power consuming along with less system implementation cost.

Chapter 4

Future Work

Currently developed system is able to detect and recognize a individual person, but it still requires some updates to make the detection and recognition process more precise and efficient.

4.1 Current Status

As of current progress the system was developed to detect and identify a person from single side either from right or from left side of the person. current system is tested in an ideal condition.

4.2 Problems in current developed system

In the current developed system the segmentation was based on by taking the ground as base reference point for the person. And currently used algorithm for machine learning is not robust for training and detection. For which the system is limited to a specific range. Also the whole experiment was carried out in a controlled environment.

4.3 Proposal for Future Work

The above mention problem can be solved by processing the image further to detect hip, thigh, ankle and toe so that a proper relation can be established

which can also aid in machine learning algorithm. Support Vector Machine (SVM) learning algorithm can be implemented for the learning and recognition process instead of the custom learning process. The system can be tested for real time environment with the above mentioned tweaks.

Chapter 5

Conclusion

Currently developed system brings a revolution in security and tracking system which is capable of detecting and recognizing a person from a specific distance without any human interaction with the system or any templates of a subject walking or running to match with. The system does not require multiple cameras, force plate sensor, foot scanner or any kind of external devices to recognize or detect a person. Although there remains a slight chance of getting same value for both persons at any given time period are being neglected in the current developed system, but can make the process more efficient by using any machine learning algorithms such as SVM. beside this the detection rate of segments or limbs can be improved by further processing the image. With some tweaks and improvement mentioned in future work the system can be tested and further implemented in real time environment. Which will be very helpful in tracking and detecting perpetrator and any subject in any given time as the streets already contains cctv or security cameras.

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