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Design and Implementation of Gait Recognition System Based on Raspberry

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Abstract

The human gait is a biometric feature that may be used for identifying purposes. Johansson originally used the word "gait" in print in 1970. One aspect and usage perspective of gait is "individual ways or patterns of moving on lower body joints." When compared to other biometric features, such as extended range, non-intrusive, non-contact, ideal for concealment, and poor resolution, gait has certain unique advantages. Typically, there are 3 stages involved in gait recognition. Recognizing gait with 2D and 3D features, and transforming 3D radial and geodesic shape distribution, requires compact functional extraction and deep details. A person's gait is directly tied to their walking style. It includes the hands, shoulders, back, legs, feet, lower annexation, higher annexation, etc. Most of the new gait-based structures rely on analysis documents like data sets. In addition, technological advances in computer vision such as image or video preparation convenience, extract, and related innovations have raised the bar. In this research manuscript, the integration of open source hardware is done for the recognition of human gait and analytics. With the use of Raspberry Pi, the

effective IoT based applications can be developed on the implementation patterns of biometrics with assorted sensors including web cam for dynamic image frame capturing and gait recognition.

Keywords : Gait Recognition, Open Source Hardware for Gait Analytics, Raspberry Pi in Gait Recognition

Introduction

In biometrics, people's physiological and behavioural characteristics allow for their classification and recognition in the actual world. Biometric technologies make sense when used to see persons and provide them immediate access to locations, files, authorities, and privileges, including those at the international boundary. Software developed on computers now allows us to store and process biometric data without compromising our privacy or our marginal information [1].Even while biometric authentication can be quicker, encouraging, and safer than traditional methods, employers still need to be cautious with the personal information they collect. Biometrics are human traits or characteristics that may be used to verify an individual's identity in a digital setting, such as when gaining access to sensitive data or a computer system [2].

Biometric identifiers can be anything that can be used to reliably and consistently identify a person, such as fingerprints, facial traits, voice patterns, or typing speed. Any one of a person's unique identifiers can be used in tandem to strengthen the reliability of the identification process. An examination of human gait from a biometric and medical perspective is the major focus of this study. Human travel is captured by the reconnaissance system. It necessitates the disclosure of biometric data gleaned from people's gait, such as sex, gender, ethnicity, and age.

Research Problem

Physical abnormalities, like diseases, can sometimes be explained by research into the human body's inner behaviro. The gait or motion analytics and walking phase of human development is characterised by a broad periodic motion of the body, most notably the lower and upper limbs, which together create a type of developmental pattern. It's hard to keep the former and mask the latter if the gait acts differently in contrast to the different biometric techniques. This segment does a great job of recognising a wide variety of characteristics and analytics patterns related to gait analysis, all of which have their sights set on various components of the drivetrain and cutting-edge thrusters [3].

Application Domains of Gait in Real Time

After a crime or terrorist act has taken place, CCTV video may be utilised to piece together a complicated image of what happened and help identify individuals. For instance, the bombers' actions before the assault could be pieced together thanks to surveillance footage. The bombers made very little attempts to hide their identities, but even when identities are hidden, other distinctive biometric traits, such as gait, can be used to track them down. Biometrics experts are starting to focus more on gait analysis as a means of identifying individuals. Here, we suggest a fresh approach to gait biometrics that has the potential to aid in the fight against terrorism and the tracking down of criminals [4].

To take even one day to recognise the interconnectedness of our planet is today an act of enormous significance. Protection has a crucial role in the actual circumstance. A number of novel technologies were developed to provide the required level of safety.

Objectives

Biometrics is one example of such a tool. Together, the terms "bio" and "metrics" form the term "biometry," which refers to the quantitative study of living organisms. Biometrics is the field of study and technology that deals with the quantitative study of human biology. Through the use of a biometric recognition approach, a person may be identified by specific, identifying traits of their physiology or behaviour.

The biometric test has recently come into the spotlight because to a renewed interest in security. Slow but steady advances in biometric technology have brought profile, iris, and unique fingerprint identification out of the lab and into everyday use. Access control for workers, private systems, and even laptops was one of the first uses described for biometric identity frameworks [5].

The usage of surveillance systems, such as closed-circuit television (CCTV), has spread beyond its original context in law enforcement to other areas, such as traffic management, manufacturing, transportation security, business and residential protection. Also, given their widespread use, surveillance cameras can aid in the fight against terrorism and crime by helping authorities see potential dangers and suspicious behaviour. Consider the United Kingdom (UK), where 100,000 are publicly operated out of an estimated 6 million total. While having that kind of coverage has its advantages, actually going through all of the footage can be quite a time-consuming process, and it often necessitates having security personnel on hand at all hours to monitor the CCTV stations. Therefore, it is quite difficult to keep tabs on everyone in the public square using human operators alone. Accordingly, a reliable automated person identification system for surveillance that can spot criminals in CCTV footage is an urgent necessity.

Open Source Hardware : Raspberry Pi for Biometrics

Here, a Raspberry Pi is utilised to construct a cheap biometric system. The Raspberry Pi (RPi) is a tiny computer about the size of a credit card that can perform many tasks a regular personal computer can. It serves as a distant enrollment hub in this research. Utilizing Raspberry Pi and cloud computing has opened up a fresh avenue of inquiry into the IoT [6]. A new Internet of Things (IoT) based biometrics system is presented, and it makes use of biometric technologies. Cryptographic methods like as RSA and improved AES-256 are used to protect gait biometric characteristics as they travel from the RPi client to the cloud via the Internet. Biometric service deployed on Azure cloud stores encrypted biometric data and performs authentication [7].

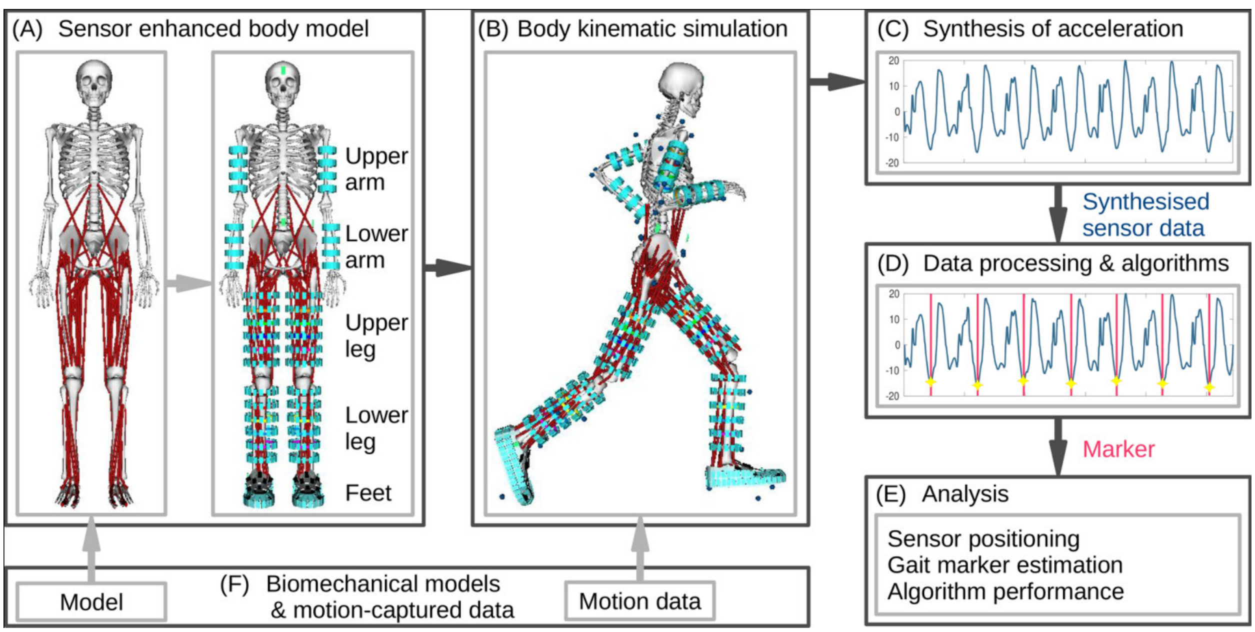

Figure 1 : Raspberry Pi and Gait Recording

In today's Internet of Things (IoT) society, user identification is becoming increasingly rigid. Human error and the increasing sophistication of malware assaults render current authentication methods like passwords bolstered by a second factor more ineffective. For this problem, we offered a solution that In fingerprint authentication, the focus is on the matching of minute details such as the bifurcation and ridge termination, which are treated as points and compared. When compared to pattern and singularity point matching, this technique is more robust. An optical sensor takes the fingerprint and sends it to the cloud using a Raspberry Pi. Webserver conducts 1:N verification after receiving data through POST request and then storing fingerprints in a file server for further use in authentication. It responds with a score and the fingerprint index ID if the two are a match. Because fingerprints are kept on a server rather than a local platform, our procedure is safe [8, 9].

The hardware modules are wired to a Raspberry Pi, which is utilised for data transmission. The system's Fingerprint Module and Facial Recognition Module both check pre-registered data to ensure attendance is recorded accurately and only once for each individual. After logging attendance, the system updates a Real-time database powered by Firebase, from which information may be accessible via the system's accompanying web interface. Customized attendance reports can also be generated by the system. As opposed to competing biometric attendance management systems, ours has a fully-functional backup mechanism to record attendance in case the primary technique fails or takes too long to do so.

Open Source Hardware in Global Market

These days, C, C++, Python, Java, and many others are used to programme bespoke hardware with a better degree of efficiency and precision thanks to the availability of open source hardware for a wide range of applications.

The following are examples of fields where open source hardware platforms can be used: computer; renewable energy; automation; bio-informatics; bio-technology; robotics; telephone; communication; photography; radio; and many others.

Audio electronic;include the Monome 40h, MIDIbox, Arduinome, and Neuros Digital Audio Computer.
Electronics for video: Milkymist One, Neuros OSD Telecommunications: Project Ara, PiPhone and ZeroPhone, Openmoko, OpenBTS, OsmoBTS, Telecom Infra Project, IP04 IP-PBX
Amateur radio: a D-STAR clone Radio
Wireless networking: PowWow Power Optimized Hardware and Software FrameWork for Wireless Motes, Sun SPOT, Openpicus, SatNOGS, Twibright RONJA,
Connectivity: NetFPGA
computers: Turris Omnia, Parallax Propeller, UDOO, Libre Computer Project, Netduino, NodeMCU, SparkFun Electronics, Chumby, Arduino, NodeMCU, Chumby, Libre Computer Project, Parallella, Turris Omnia.
Robotics: ArduCopter, Orb swarm, ICub, OpenRAVE, IOIO, multiplo, Tinkerforge, e-puck mobile robot, Spykee, OpenROV, RobotCub, Thymio,
Gaming: PocketSprite Cameras: AXIOM, Elphel
Renewable energy sources: windmills
Environmental: Air Quality, Open Source Ecology Egg
Chargers for electric vehicles: OpenEVSE
lighting and LED; LED throwies
3D printers; Opendesk, WikiHouse, and OpenStructures for architecture and designResults and Analytics.

Raspberry Pi and Integration Patterns

Technologies like biometrics are being used more often to automate verification. Identifying unique biometric traits to distinguish between two persons is essential to the operation of biometric-based individual identification systems. There are a number of benefits to using biometric characteristics for identification, including the fact that it is feasible to verify a person's identity without relying on physical evidence (such an ID card) or a person's memory [10, 11]. Biometric technologies collect and evaluate information about an individual, including their unique physical and behaviouralfeatures, for the purposes of identification, verification, and screening. DNA, irises, fingerprints, and facial patterns are just a few examples of regularly utilised physical traits. Face and fingerprint recognition are the most prevalent biometric technology, whereas voice and gait are the most frequent behavioural features. Face and fingerprint recognition are limited since they need people' permission and cooperation to be effective. When the individual is a suspect, when they are recorded from a distance, or when they are taken on CCTV, this information might be difficult to obtain [12].

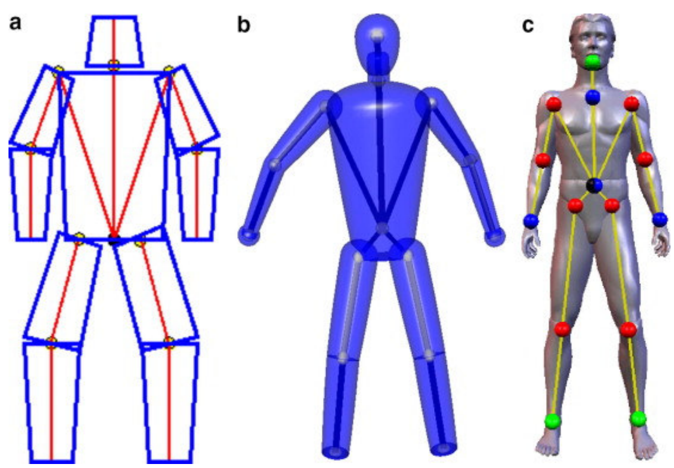

Figure 2 : Fetching and Analytics of Gait Features

In recent years, biometric technologies have shifted to emphasise real-time, remote, distance-based, non-cooperative, and non-invasive monitoring. Unobtrusive solutions for identifying people who pose a security risk or act suspiciously can be built on the foundation of gait analysis and identification. To filter people entering high-security civilian or military institutions and keep an eye on possible theft or terrorist targets, a biometric surveillance solution would be helpful[13].

Each individual has a particular walk. In contrast to other biometrics, such as fingerprints or iris scans, gait may be recorded remotely from low-resolution recordings without the subject's knowledge or permission. It allows for covert, non-intrusive threat identification from a distance when iris and/or facial information are unavailable. It also enables ample subject analysis time during gait recognition. Gait recognition at an airport, for instance, might be used to verify passengers against a database of surveillance footage before they ever reach the terminal or go through the first round of security checks. This information could be used to locate and apprehend criminals and terrorists who are using disguises, such as switching up their clothing or carrying strange objects or documents.

The gait biometrics system, a relatively recent biometrics system that examines the form and gesture of the an individual's walking style, is classified using behavioral biometric features. An isolated human body silhouette from a video clip is used to create a set of gait metrics that describe the subject's shape and motion. The gaitsignature of a person, which is used for gait identification, is made up of physical characteristics (cadence, stride length, plus height parameters) as well as the movement trajectories of different body components. Forensic gait analysis using widely accessible CCTV film has indeed been accepted as proof in British as Danish courts, resulting in successful prosecutions.

An advanced CCTV option, a gait-based surveillance system may effectively automate the identification procedure. Heuristic search capabilities are essential for a centralised or decentralised gait-based surveillance system to sift through massive volumes of data and compute gait similarity metrics[14].

An example use of gait-based recognition capabilities is shown below. CCTV footage may be studied for gait information if a crime has occurred at the location and cameras are present. The algorithm looks through a database of CCTV photographs for matching gaits of people who have been in past incidents. Once an unknown person is identified, they are added to the database and compared to the known persons there. When a match is found in many occurrences, the unknown individual is not named but is confirmed to be a part of the incidents. If the unknown person is spotted in live CCTV footage, the system can pinpoint his or her location and issue an immediate alarm.

Tracking one's gait

In typical situations, people tend to stick to their signature stride characteristics. Therefore, it is feasible to develop an individual's distinctgait profile. Simply put, a gait identification system is a pattern recognition system that uses training movies to identify unique people' gait characteristics and then saves those characteristics as "reference templates." When presented with a fresh video, the system will extract gait features and judge the degree of resemblance between those features and the probe template it has on file. The basic layout of a gait-based recognition system is seen. As illustrated in the final image, a human silhouette is extracted by analysis of CCTV camera video of a person walking[15].

There are two types of gait analysis approaches: model-based as well as appearance-based recognition. In model-based techniques, the full human shape is modeled while the person is in motion. Appearance-based techniques extract both static (head and torso) as dynamic (arm and movement) information from a sequence of walking human silhouettes. The computational cost of developing model-based procedures is significant, but the benefits are well worth it. Therefore, methods focused on appearance are increasingly frequently employed. Furthermore, we discuss visual methods for recognizing gait.

Human gait recognition based on outward appearances

The structure as well as dynamics of such a person's gait can be ascertained using methods based on visual recognition. Gait dynamics refers to the rate of change, whereas gait shape refers to the overall shape of a person's walking. According to Wang et al., a promising recognition rate may be reached by using static gait characteristics. However, Cutting with Profit contend that dynamic gait features are more crucial for identification. Recent research has demonstrated that combining dynamic and static gait data canresults can be improved above those obtained using either approach separately.For appearance-based gait detection, the first step is to pre-process a video in order to extract a series of frames[16].

Pre-processing

Pre-processing involves identifying and removing the background from each frame of a video clip. In this study, we apply the approach given by Stauffer and Grimson to extract human silhouettes from each frame of a walking sequence. Scaling issues brought on by shifts in camera depth are resolved by performing a resize. This means the width and height of each video sequences shot at various times will be variable. After the silhouettes have been scaled, their horizontal alignment is adjusted such that their centroid lies in the centreof the new, smaller silhouette[17].

Video length and frame rate determine how many individual images make up the final product. Therefore, a gait cycle is defined as a set of frames that occurs inside a single gait cycle. A person's whole sequence of steps when walking is thought of as a gait cycle. A person's walking sequence consists of alternating between a mid-stance position (both legs together) and a double-stance position (both legs widely apart), and then returning to a mid-stance position.

By measuring the amount of pixels with in bottom third of the a binary silhouette picture that are in the forefront, we can determine how long a gait cycle is (white). In silhouette images taken in the mid-stance and double-stance positions, the quantity of foreground pixels was lowest with in bottom third and largest in the upper third.Distance between three successive peaks and valleys are used to determine a gait cycle[18].

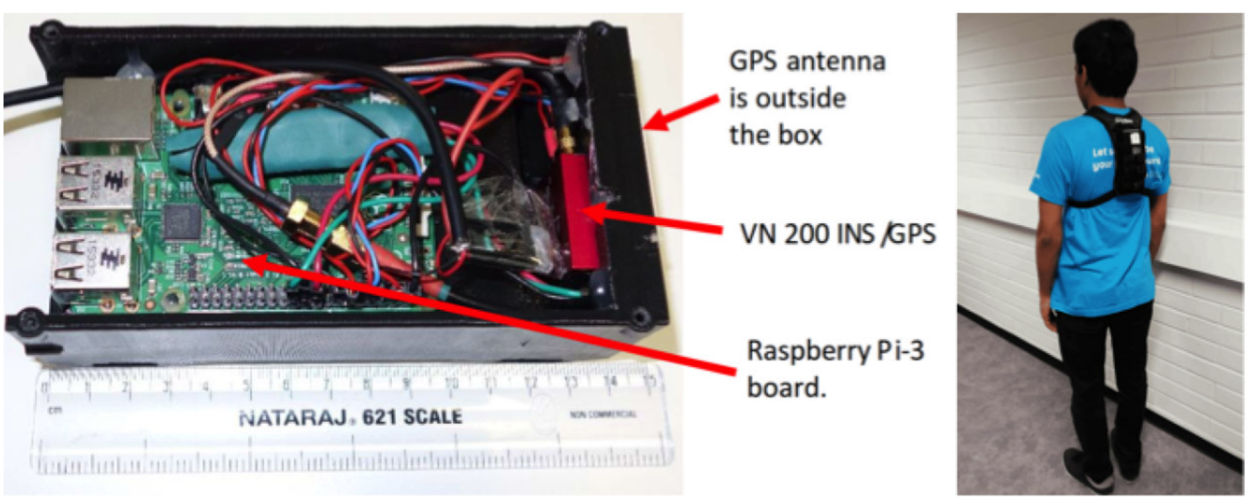

Figure 3 : Raspberry Pi for Human Gait.

Energy Snapshot of Gait

The data is preprocessed, and then the aspects of the person's gait that are most useful in identifying them are extracted. One typical method employed by appearance-based methods to describe human motion sequence as a single gait feature image is to average all frames from a full gait cycle into a single symbol. The Gait Energy Image (GEI) is a popular gait representation approach in which many frames from a single gait cycle are averaged to produce a single grayscale image. Computational details of the GEI gait feature include:

$$\mathrm{GEI}(i, j) = \frac{1}{N}\sum_{t=1}^{N} I(i, j, t) \qquad (1)$$

N - Number of Frames
i and j : Image Coordinates
I is the silhouette image
t frame number in the gait cycle

Variables relating to the body as a whole

A characteristic that may be used on its own for matching is the GEI. Although GEIs are generally unique, a change inside a subject's appearance may lead to a GEI containing worthless information. The system cannot recognize the individual so when individual presents additional covariate variables, even though the system has familiar with both the individual in regular contexts (i.e., the system knows that individual's usual GEI reference templates).

Even though the system is aware of the individual's GEI under normal settings, it will not recognise a matching GEI if the new GEIs contain extra irrelevant information (shown as a red circle in both images). Bags, clothing, and other elements can interfere with the accuracy of body-related parameters (head and torso), leading to an identification system failure. Recognizability is reduced since the aGEI's upper body section includes data that isn't related to the subject's gait[19].

This study provides a solution to this issue by outlining a method that may be used to create a gait characteristic for a person even if their outward look varies owing to factors like clothes and accessories. In the following paragraphs, I will explain how to fix the problem.

Silhouette Sample with Moving and Still Elements

The human silhouette, or abinary, may be broken down into two distinct categories: the static component, which predominantly depicts the upper body (head and torso), and the dynamic part, which describes the human locomotive process and includes angular movement of the legs and hands. In our method, we use Static Silhouette Templates (SSTs) to represent the inert portions of the GEI, while Dynamic Silhouette Templates (DSTs) are used to represent the active portions (DST). We present a unique approach that quickly eliminates the covariate variables from the SST and provides a covariate free SST since the SST includes upper body portions that may be impacted by body related covariate factors. The final gait feature template, called the Dynamic Static Silhouette Template (DST), is derived by merging the covariate-free SST with the DST (DSST). The steps required to determine a GEI's SST and DST are outlined below[20].

Immovable Silhouette Pattern

As we've established, the static portion of GEI has greater pixel intensity values than the lower body portion, signifying the upper body attributes like the head and torso in the SST. Therefore, a threshold value is employed to segregate the lower and higher pixel intensity values in order to extract the SST and DST from the provided GEI. GEI's standard stoichiometric formula is as follows:

$$\mathrm{SST}(i,j)=\begin{cases}\mathrm{GEI}(i,j) & \text{if} \quad \mathrm{GEI}(i,j)=\xi \\ 0 & \text{otherwise}\end{cases} \qquad (2)$$

ξ : represents the maximum intensity value in the GEI. Figure 8illustrates the obtained SST for an individual's GEI with a carrying bag covariate condition.

$$\mathrm{DST}(i,j)=\begin{cases}0 & \text{if} \quad (M(i,j)>\mu) \ \text{and} \ (i<\frac{2}{3}*H) \\ M(i,j) & \text{otherwise}\end{cases} \qquad (3)$$

H: Height of GEI image.

Taking out the covariates from standard sea-surface temperatures

Figure 9 illustrates how body-related covariate variables might influence the obtained SST of GEI. Figure 9(b) shows that an SST with a bag accessory covariate component contains irrelevant information (green circles) that must be eliminated before proper recognition may occur. Using the human body's innate bilateral symmetry as a tool, we are able to eliminate the covariate components. When a human body is cut down the middle, we can see that we have bilateral symmetry (referred to as symmetric axis). As you go towards the centre of your body, you will notice that the left side of your body will begin to mimic the right. Similarly, a walking human being under typical conditions may be split down the middle along the symmetric axis, creating two equal halves. In cases where the person has covariate conditions, however, finding the axis of symmetry becomes more challenging[21].

When dealing with covariate components, a Distance Transform (DT) technique is first used to pinpoint the axis of symmetry[22]. The DT plays a vital role in the fields of image analysis, computer vision, and pattern recognition. When used on a binary image, the DT method returns the distance of each pixel from the backdrop pixel. An example of a binary image's DT matrix is shown herein[22][23].

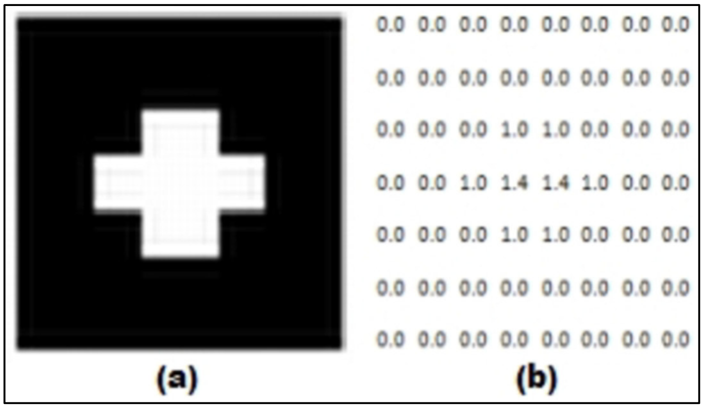

Figure 4: Binary Image Format

After applying the DT technique on GEI's SST, we can pinpoint its symmetry axis. The SST of a regular GEI and a GEI in a carrying bag after being processed by the DT method are depicted.

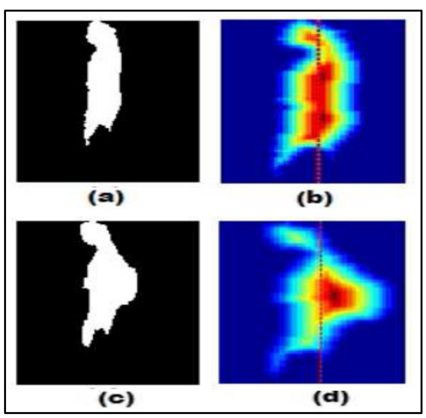

Figure 5 : Symmetry axis.

Evaluation of DSST approach

Figure 2(b) shows the output of the feature extraction phase: a DSST gait feature template. After data collection, gait recognition moves on to the next stage of matching and generating decisions based on that data [24][25]. The gait recognition system compares the probing DSST template of an unidentified person to a database of reference DSST templates of known people's gaits. Through an assessment procedure, we check the proposed DSST gait feature for its accuracy in recognising persons. We utilised a gait database that includes people's walking patterns while wearing various types of apparel and accessories. The CASIA dataset and the Southampton Human ID gait database are the two most popular publicly accessible gait datasets with covariate components[26][27].

The University of Southampton established the Southampton Human ID gait database (SOTON dataset). Ten healthy individuals are included in the dataset, and they walk normally under a variety of covariate situations. For training, we utilise 90 films in which our subject is not wearing a backpack or wearing any special equipment, and for testing, we use another set of videos with covariate circumstances (90 test videos). Example SOTON dataset training and test sequences are displayed.

Figure 6 :SOTON Data Analytics for Gait

Since we propose the DSST method for dealing with body-related covariate conditions, we employ the CASIA Dataset-B covariate dataset, which includes information on 124 participants in a variety of outfits and bag configurations. Sequences used for training and testing from the CASIA Dataset-B[28][29][30].

Conclusion

This manuscript has taken into account a novel behavioural biometric based on gait. While the unique qualities of gait features make them useful in surveillance systems and applications, the covariate variables problem means that effective identification may be hindered by factors like the subject's clothes and any goods they might be carrying. When these obstacles are cleared out, surveillance systems will be able to employ gait as a biometric trait for person identification. This study offered a method for identifying individuals from surveillance footage based on their stride, even if their appearance has changed. The covariate free SST and the DST are combined to create a unique hybrid appearance-based covariate free gait feature template, DSST. SST includes both mobile and immobile components of the upper body, including the head and torso. DST includes motion characteristics from a gait, such as leg motion collected while walking. The primary aim of this work was to enhance gait recognition rates by utilising various garment and bag covariate gait sequences. We have devised a method to exclude the covariate components from the SST. The benefit of the DSST gait feature is illustrated on two publicly available gait datasets. The suggested DSST gait characteristic yielded useful results in recognising persons despite their appearance changing due to factors like clothes and bag contents. If implemented, the suggested approach might give the counter-terrorism effort a real-time, distant, distance-based, non-cooperative, and non-invasive surveillance tool.

Future Recommendations and Scope

The integration of multiple open source hardware with dynamic and parallel connectivity can be done using Arduino. The performance evaluations on Arduino as well as Raspberry Pi can be analyzed with the webcam interfacing.

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