IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

A monthly Peer-reviewed / refereed journal

Indexed by NAAS, Google Scholar, Crossref, Mendeley

DOI 10.17148/IARJSET

IARJSET

ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.066 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 11, Issue 7, July 2024

DOI: 10.17148/IARJSET.2024.11721

A STUDY ON A.I. BASED SECURITY SURVEILLANCE SYSTEM

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Abstract: Reliable and discrete authentication techniques are essential for security surveillance systems that protect public and private spaces. The inherent limits of conventional identity methods, such passwords and ID cards, are driving demand for more resilient solutions. The study of human walking patterns via the lens of gait analysis has become a popular biometric technique in security. It is especially desirable for a variety of surveillance applications due to its nonintrusive design and capacity for continuous authentication. Even with obstacles such fluctuating walking circumstances and privacy issues, research is still being done to improve gait analysis's accuracy and dependability. Gait analysis is a particularly useful tool for improving safety and protection in a variety of settings as security demands rise. The history of security authentication is examined in this review study, which also emphasises the potential of gait analysis as a biometric security frontier.

Keywords: Segmentation, Erosion, Dilation, Silhouette, Feature Extraction, Gait Analysis

I. INTRODUCTION

In today's dynamic security landscape, where challenges constantly evolve, there is a pressing need to integrate cutting-edge technologies into surveillance systems to enhance safety measures. Traditional methods of confirming identity, like passwords and ID cards, are proving inadequate, often requiring human intervention and revealing vulnerabilities unsuitable for modern security demands. Consequently, there is a growing momentum behind exploring advanced, inconspicuous biometric authentication techniques. One such innovation is gait analysis, a field dedicated to meticulously examining human motion patterns, particularly the unique way individuals walk. This emerging frontier within security shows promise due to its potential to provide nonintrusive yet highly effective means of authentication. By harnessing the capabilities of gait analysis, security systems stand to revolutionize identification and authentication processes, thereby bolstering overall security standards.

Our research embarks on an in-depth exploration of gait analysis within the context of security surveillance. We delve into its fundamental principles and methodologies, with a specific focus on its potential applications in enhancing security and access control. Additionally, we address the benefits, challenges, and ethical considerations that arise from integrating gait analysis into surveillance systems.

As we continue to explore the intersection of biometrics and security, gait analysis becomes clear as a revolutionary method that can completely change how we think about and use security technology. This analysis aims to clarify the revolutionary role that gait analysis may play in strengthening security monitoring in a variety of settings, including smart buildings and airports.

Our discussion's second section provides a review of earlier research and offers insights into the state of the field when it comes to gait analysis and its uses in security-related settings. In Section 3, we offer an in-depth study of our suggested technique with the goal of outlining a thorough process for integrating gait analysis into security monitoring systems. We hope that this analysis will help people grasp gait analysis on a deeper level.

II. PREVIOUS WORK

Automating surveillance systems has become essential to mitigate human errors, combat crimes effectively, and deter potential terrorist threats. Integrating biometric technologies into closed circuit television (CCTV) represents a significant advancement in automating the process of tracking criminals. Unlike other biometric methods, an individual's walking pattern can be reliably captured and recognized from a distance, even with low resolution video.

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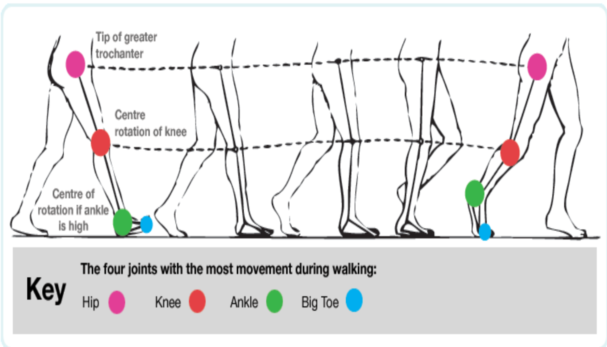
The primary concern revolves around the safety and security of a nation's citizens, especially with the alarming increase in crime rates and unexpected attacks. CCTV systems rely on remotely positioned cameras to transmit and store real-time video streams. Since the introduction of the gait energy image (GEI) by Han, various refined approaches have emerged, leveraging GEI for gait recognition and showcasing its effectiveness. In order to extract unique characteristics, this work presents a novel method that makes use of the Gabor magnitude of GEI and a dimension-reduction strategy. In order to attain a degree of security and precision that exceeds that of traditional techniques, multimodal biometrics must be implemented. This method establishes a person's identity by combining many biometric recognition methods

The two main categories of feature extraction strategies are characterising geometrical relationships and choosing individual features. By removing unnecessary data, holistic techniques like independent component analysis (ICA), principal component analysis (PCA), and linear discriminate analysis (LDA) extract appearance information from the entire image while reducing dimensionality. This greatly improves classification performance.

Discrete symmetric operators, continuous hidden Markov models (HMMs), trajectory and velocity analysis, and other methods have all been suggested by earlier research as methods for gait analysis. In order to improve recognition, Han and Bhanu's work made considerable use of the gait energy image (GEI) and combined fusion methodologies with a statistical feature extraction method. In a different method, the dimensionality of the feature space was reduced by Eigen space transformation using Principal Component Analysis (PCA), and the recognition was achieved through supervised pattern classification algorithms inside the lower dimensional Eigen space. Fuzzy principal component analysis was used by Su and Zanga for identification.

In conclusion, this paper aims to contribute significantly to the field of gait analysis and biometric recognition by introducing a pioneering method. It underscores the critical importance of automating surveillance systems to bolster security and ensure public safety.



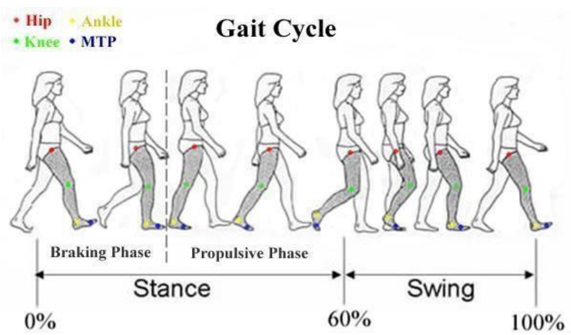


Fig II(a): Dynamic Gait Analysis

Fig II(b): Gait Cycle

III. PROPOSED METHODOLOGY

We are going to deliberate about the different methodology that can be used in the gait analysis of security surveillance system.

A. SEGMENTATION

• Edge Based Segmentation Method

Edge detection techniques are a well established field within image processing, playing a pivotal role in image analysis by identifying abrupt changes in intensity. These changes often correspond to object boundaries or significant features in an image, which are challenging to discern using traditional intensity values alone. Edge detection methods primarily identify edges where either the first derivative of intensity surpasses a predefined threshold or where the second derivative exhibits zero crossings. In edge-based segmentation approaches, the primary objective is to first detect these edges and then connect them to outline object boundaries, enabling the segmentation of specific regions within an image. Two fundamental categories of edge-based segmentation methods include Gray histograms and Gradient-based methods. These techniques aim to detect edges through the application of well-known edge detection operators such as the Sobel operator, Canny operator, Robert's operator, among others. Typically, the outcome of these methods is a binary image, where pixels are assigned values to indicate the presence of edges.

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• Region-Based Segmentation Method

Region-based segmentation methods are strategies that divide an image into multiple regions with similar characteristics. This approach relies on two fundamental techniques to achieve segmentation.

• Region growing methods

Segmentation techniques that divide an image into different areas based on the expansion of starting pixels, or seeds, are known as region growing-based techniques. Depending on the particular need, these seeds can be selected automatically or manually based on past experience. Then, based on the connectivity between pixels—which is frequently influenced by past knowledge of the topic—seed growth can be stopped as necessary.

B. EROSION

Erosion is one of the two fundamental operators in mathematical morphology, with the other being dilation. While erosion is typically applied to binary images, certain variations can also operate on grayscale images. In its basic form, this operator acts on a binary image, and its primary effect is to gradually erode or diminish the boundaries of regions containing foreground pixels (usually represented as white pixels). Consequently, the areas occupied by foreground pixels become smaller, and any internal holes within those regions tend to expand or become larger.

C. DILATION

Erosion and dilation are the two basic morphological processes. In dilation, pixels in an image are expanded towards the edges of objects, whereas in erosion, pixels along object boundaries are removed. The size and form of the structuring element used during the operation determines how many pixels are added to or subtracted from objects in the image During morphological dilation and erosion processes, the state of a particular pixel in the output image is determined by applying a rule to the correspondingpixel and its neighbouring pixels in the input image. The specific rule employed to process these pixels defines whether the operation is a dilation or an erosion.

D. SILHOUETTE

Features for gait analysis are typically extracted from the GAIT ENERGY IMAGE (GEI). This process involves generating a silhouette through the following sequence of steps:

i. Conversion of video frames into individual images, followed by the transformation of colour images (in RGB) into grayscale images.

ii. Estimation of an approximate background from a sequence of images depicting people walking. The primary mean image is computed by averaging the gray-level values at each pixel over the entire image sequence (illustrated in Fig.II (b)). Let $I_k(x, y)$, where $k=1, 2, ..., N$, represent the sequence of N images. Background images, denoted as $b(x, y)$, can be calculated as follows: $b(x, y) = \text{median}(I_k(x, y))$, where $k=1, 2, ..., N$.

iii. Extraction of the moving object is achieved by performing background subtraction.

iv. Application of image processing techniques such as erosion and dilation to enhance and refine the obtained silhouette.

E. FEATURE EXTRACTION

A feature is defined as a characteristic or attribute of an object that can distinguish it from other objects. In the context of gait analysis, our feature vector is composed of moment features extracted from image regions that cover a walking person. Gait feature extraction is a crucial step in recognizing human gait, and it must be robust enough to handle varying conditions while describing individual characteristics effectively. The silhouette of a walking person is a promising feature to exploit since it captures the movement of most body parts and encodes both structural and transitional information. Importantly, it is independent of factors like clothing, illumination, and textures. Given that we have a database in silhouette form, which displays most of the body parts, we can extract features from these silhouettes. There are two fundamental approaches to feature extraction: feature-based and holistic methods.

we can extract features from these silhouettes. There are two fundamental approaches to feature extraction: feature-based and holistic methods.

1. Feature-based methods focus on selecting individual features and characterizing geometrical relationships.
2. Holistic methods, such as principal component analysis, linear discriminant analysis, and independent component analysis, extract information from the entire image. Holistic feature extraction aims to find features with reduced dimensionality by projecting the original data onto basis vectors. These extracted features can enhance classification performance by eliminating irrelevant information from the dataset.

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A feature vector is a representation of an image portion by measuring a set of features. In a 2D matrix representing an image, each individual pixel is denoted as B(i, j), which represents the brightness at the point (i, j). During walking, the centre of mass of the human body changes from one instance to another. Therefore, the centre of mass is used as a feature, reflecting the weighted average of x and y coordinates of pixels within the frame. The centre of mass for binary images remains the same as the centre of mass if we consider intensity as a mass point. In a binary image, the centre of mass coordinates can be computed using the following formula:

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

IV. ADDITIONAL STUDIES

Deep Learning for Gait Recognition:

- Convolutional Neural Networks (CNNs): Utilize CNNs for feature extraction from gait sequences.
- Recurrent Neural Networks (RNNs) and Long Short-Term Memory Networks (LSTMs): These can be used for temporal feature extraction and sequence modelling.

3D Gait Analysis:
- 3D Pose Estimation: Study the use of 3D pose estimation to capture detailed gait dynamics.
- Kinect-based Gait Analysis: Explore the use of Microsoft Kinect or similar depth sensors for 3D gait analysis.

Gait Analysis under Different Conditions:
- Cross-view Gait Recognition: Study how to handle gait recognition from different camera angles.
- Gait Recognition in Occluded Environments: Develop methods to deal with partial occlusion of the subject.

V. COMPARATIVE STUDY OF GAIT ANALYSIS TECHNIQUES AND METHODOLOGIES IN RELATED RESEARCH AND OUR WORK

Reference	Methodology/Technology	Features/Techniques	Our Work
GAIT ENERGY IMAGE (GEI)	Image Processing, Feature Extraction	Conversion of video frames to grayscale, background subtraction, erosion, dilation	Our work also involves GEI, but we might have different approaches in background subtraction and silhouette refinement
Feature Extraction Methods	Principal Component Analysis, Linear Discriminant Analysis, Independent Component Analysis	Reducing dimensionality, enhancing classification performance	Similar to our holistic approach, but our feature extraction might use additional or different techniques
Edge-Based Segmentation	Sobel, Canny, Robert's operators	Edge detection to outline object boundaries	We may use similar edge detection methods, with potential differences in implementation and optimization
Region-Based Segmentation	Region Growing	Dividing image into regions with similar characteristics	We might have used different seed selection techniques or connectivity rules
Morphological Processes	Erosion and Dilation	Modifying pixel boundaries to enhance images	Similar to our use, but our structuring elements and rules might vary

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Key Differences in Our Work:

1. Technologies and Tools: We use Python, PyQt5, numpy, PIL, and OpenCV for our gait recognition demo.
2. Project Focus: Our project, emphasizes real-time video processing, GEI generation, and person recognition in security systems.
3. Future Projects: Future projects are planned for enhanced features and performance.

VI. CONCLUSION

In conclusion, the utilization of gait analysis and logistic regression machine learning algorithms for human motion analysis represents a significant advancement in various fields of computer science, particularly in biometrics and security monitoring. The ability to extract features from human motion has far reaching implications, from enhancing authentication processes to detecting suspicious behaviours in security settings. Despite the inherent advantages of gait biometrics, including its unobtrusive nature and resistance to imitation, challenges such as terrain, fatigue, injury, and viewpoint variability must be addressed to ensure the precision and reliability of gait recognition systems. Recent advancements, such as the integration of Convolutional Neural Networks (CNNs), hold promise for overcoming these challenges and improving the accuracy of gait identification. Furthermore, the exploration of multimodal biometrics, combining multiple biometric modalities like gait, facial recognition, and foot pressure, offers exciting possibilities for further enhancing security measures. By integrating diverse biometric data sources, we can create more robust and comprehensive authentication systems that are less susceptible to spoofing or manipulation. Looking forward, continued research and development efforts in gait analysis and multimodal biometrics are essential for advancing security technologies and ensuring the safety of individuals in various environments. By leveraging emerging technologies and interdisciplinary approaches, we can further refine human motion analysis methods and contribute to the continuous evolution of security surveillance systems.

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