Annals of Engineering Mathematics and Computational Intelligence (AEMCI)
Vol. 2, No. 1, June 2025, pp. 9~14

Human Recognition System using GAIT

Sreegovind S[1], Prof Jojimol Joseph [2]
[1,2]Department of Computer Applications
[1,2] Musaliar College of Engineering and Technology, Pathanamthitta, Kerala,India
sreegovind@gmail.com,jogimolb@gmail.com*

Article Info

Article history:

Received January 27, 2025
Revised February 15, 2025
Accepted March 07, 2025

Keywords:

Human Recognition
Machine Learning
Gait Recognition
OpenPose algorithm

ABSTRACT

GaitGate is a sophisticated human recognition system that leverages gait analysis to accurately identify individuals based on their unique walking patterns. Gait recognition offers a non-intrusive and robust biometric authentication method, capable of operating in various environments and lighting conditions. This paper presents the design and implementation ofGaitGate, highlighting its key components and functionalities. The system employs computer vision techniques to capture and analyze gait data, extracting distinctive features such as step length, stride duration, and joint angles. A machine learning algorithm is then utilized to model and classify gait patterns, enabling efficient and accurate identification of individuals. GaitGate offers real-time performance and scalability, making it suitable for applications in security systems, access control, and surveillance. Experimental results demonstrate the effectiveness and reliability of GaitGate in accurately recognizing individuals based on their gait patterns, showcasing its potential as a viable solution for human recognition in diverse scenarios.

Corresponding Author:

Jogimol Joseph
Musaliar College of Engineering and Technology
Pathanamthitaa,Kerala
Email: jogimolb@gmail.com

1.0 Introduction

In the pursuit of advanced biometric identification systems, traditional methods have often focused on facial recognition, fingerprints, or iris scans. However, these methods can be hindered by poor lighting conditions, occlusions, and intentional disguises. In response, the field of biometrics has extended its reach to include gait analysis, which is a modality that offers a unique set of advantages in human recognition. "GaitGate" represents a cutting-edge project at the intersection of computer vision, machine learning, and biomechanics. This project aimed to leverage the distinct characteristics of an individual's gait pattern for robust and reliable human recognition. Gait analysis[1], a study of human locomotion, offers a non-intrusive means of identifying individuals based on their unique walking patterns. Human gait is a complex interplay between skeletal structure, muscular coordination, and cognitive processes, resulting in a distinct signature for everyone.

Gait analysis observes various parameters, such as stride length, cadence, and joint angles to create a unique gait profile for identification purposes. Unlike traditional biometric methods, gait analysis is less susceptible to changes in appearance, making it particularly suitable for scenarios where other modalities may falter. The implementation of GaitGate involves the deployment of sophisticated computer vision algorithms to capture and analyse gait patterns from video footage. Machine learning techniques were then applied to extract discriminative features and train models capable of accurately recognising individuals based on their gait. The success of this project relies on the integration of state-of-the-art technology with biomechanical insights to develop a robust and reliable human recognition system. GaitGate holds promise across various domains, including security, surveillance, access control, and personalised healthcare. By harnessing the unique characteristics of human locomotion, this project aims to contribute to the advancement of biometric recognition systems and enhance their security and efficiency in diverse applications. In this paper, we delve into the methodologies, challenges, and potential applications of GaitGate and present a comprehensive overview of the project's objectives and outcomes. Through rigorous research and experimentation, we aimed to establish gait analysis as a viable and effective modality for human recognition in the digital age.

2.0 Related Work

The study[2] introduced a novel approach to authentication leveraging gait patterns. Instead of traditional digital signature algorithms, this system utilizes machine learning algorithms to analyze and recognize unique gait patterns for authentication purposes. Group members generate their public-private keys within a public key infrastructure, while a central authority generates individual identity codes (IDs), group identity marks, and the group secret key. Each member retains their private key and ID for signing, ensuring data authenticity and non-repudiation. The challenge-response identification protocol employs overlapping-shifting-EXOR logical operations to securely distribute the group secret key and prevent false claims. security analysis indicates faster processing times compared to conventional methods,making it suitable for microprocessor-based devices such as smart cards and computer systems due to its simplicity, confidentiality, and rapid processing speed.The main disadvantage of the study is that functions increased the complexity of the scheme.

Collins et.al[3] discussed implicitly captures biometric shape cues such as body height, width, and body- part proportions, thereby enriching the authentication process with nuanced biometric data. However, while these studies provide valuable insights into the potential of gait recognition for authentication,the lack of discussion on system performance leaves important questions unanswered. Without acomprehensive evaluation of the system's accuracy, robustness, and efficiency, it is challenging toassess its real-world effectiveness and reliability. Future research should aim to address this gap byconducting thorough performance evaluations, including benchmarking against existing authentication methods and assessing the system's performance across diverse datasets and real-world scenarios. Such evaluations would not only enhance our understanding of the system's capabilities but also guide its practical implementation and deployment in various security and authentication applications.

In another work, [4] algorithm demonstrates an encouraging recognition rate in controlled settings, its performance may not always be as accurate, particularly in real-world scenarios. Several factors contribute to this limitation. Variability in environmental conditions, such as lighting and terrain, can affect the quality of gait data captured by sensors or cameras, leading to inconsistencies in recognition. Additionally, individual differences in walking style, speed, and attire further challenge the algorithm's ability to accurately identify individuals across diverse contexts. Moreover, the presence of occlusions or obstructions in the environment can hinder the algorithm's ability to capture complete gait sequences, potentially leading to misidentification. These challenges underscore the importance of continued research and development to enhance the robustness and adaptability of gait recognition algorithms, ensuring their efficacy in real-world applications where accuracy is paramount for reliable authentication and security.

Recognition results from this approach[5] indicate its simplicity and efficiency, suggesting promising prospects for widespread adoption. However, the study also incorporates a predictive element concerning the software's future faults, leveraging historical data for analysis. By analyzing past performance and identifying patterns of software faults, the study offers insights into potential areas of improvement and areas prone to errors. This predictive capability enables preemptive measures to be taken, such as implementing robust error-handling mechanisms or refining algorithmic components to mitigate the likelihood of future faults. By proactively addressing potential issues based on historical data, this approach not only enhances the reliability and performance of the software but also contributes to the overall sustainability and longevity of the system in real-world deployment scenarios.

3.0 Methodology

The methodology of the gait recognition project unfolds in a meticulously structured manner to craft a dependable authentication system centred on analysing human gait patterns. Initially, the endeavour was initiated with the meticulous collection of gait data from individuals employing an array of sensors or cameras, ensuring a diverse dataset reflective of real-world scenarios. This collected data then undergoes rigorous preprocessing, in which noise-reduction techniques and normalisation procedures are applied to enhance its quality and prepare it for subsequent analysis. Segmentation techniques were employed to isolate distinct gait cycles and facilitate precise feature extraction. Following data preprocessing, the focus shifts to feature extraction, a critical phase wherein relevant gait parameters are discerned from the preprocessed data, spanning temporal attributes such as step duration and stride length, spatial features such as joint angles and body proportions, and frequency-domain characteristics such as Fourier coefficients. The extraction process aims to distill the essence of individual gait signatures, encapsulating unique walking patterns in a format amenable to machine learning analysis.The subsequent stages revolve around model development, validation, optimization, and deployment.

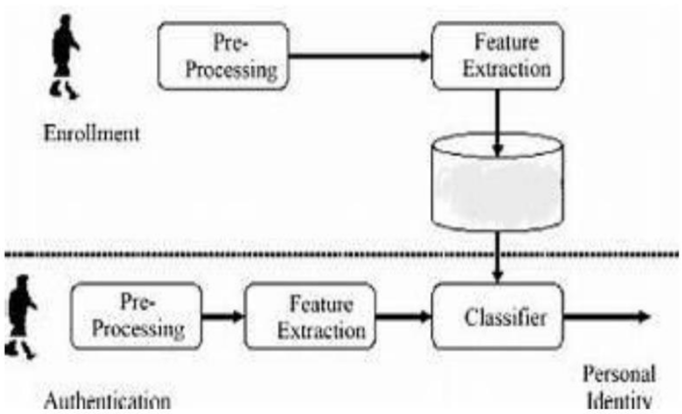

Figure 1: Methodology of Gait Recognition

Machine learning algorithms are enlisted to construct a robust gait recognition model, which is meticulously validated to gauge its efficacy and adaptability across varied contexts. Optimisation endeavours encompassing hyperparameter tuning and feature selection refine the model's performance. Once validated and optimised, the model transitions to real-world deployment, thereby contributing to the arsenal of authentication systems by leveraging biometric identifiers. Continuous monitoring and maintenance ensure the system's resilience and effectiveness in authenticating individuals based on their distinctive gait patterns, underscoring the comprehensive and iterative nature of the gait recognition project's methodology.In the context of gait classification, Convolutional Neural Networks (CNNs) play a crucial role in automatically learning hierarchical features from raw input data, such as gait images or video frames. The typical architecture of a CNN for gait classification consists of several layers that work together to extract and classify features from the gait data. First, the input gait data undergo preprocessing to convert them into a suitable format, such as grayscale or colour images. These images then pass through a series of convolutional layers, where learnable filters or kernels are convolved with the input images to extract various features that capture different aspects of the gait patterns. The convolutional layers learn to detect spatial patterns and structures in the input data,which are essential for recognising and distinguishing between different gait patterns.

OpenPose is an open-source library and real-time system for multi-person keypoint detection and pose estimation. Developed by the Carnegie Mellon University Perceptual Computing Lab, OpenPose is widely used in various applications such as human-computer interaction, motion capture, and gesture recognition. The system utilizes deep learning techniques, specifically Convolutional Neural Networks (CNNs), to accurately detect and localize key points on the human body, including joints such as wrists, elbows, knees, and ankles, as well as facial landmarks like eyes,21nose, and mouth. OpenPose is capable of performing both 2D and 3D pose estimation, allowing for accurate tracking of human movement in real-time video streams or static images. OpenPose works by first detecting the human body in an input image or video frame using a pre-trained CNN-based body detection model. Once the body is detected, a separate CNN-based pose estimation model is applied to localize key points on the detected body parts. These key points are then connected to form a skeletal representation of the human pose, providing information about the spatial configuration and orientation of the human body. One of the key features of OpenPose is its ability to handle multiple people in the same frame simultaneously, making it suitable for applications involving crowded scenes or group interactions. Additionally, OpenPose provides a user-friendly API and integration with popular programming languages such as C++, Python, and MATLAB, making it accessible to developers and researchers for a wide range of projects and applications.

Following the convolutional layers, pooling layers are introduced to downsample the feature maps while retaining essential information. This helps to reduce the spatial dimensions of the feature maps and improve the computational efficiency. After pooling, the feature maps were flattened into a one-dimensional vector, consolidating the learned features for further processing. This flattened feature vector is then fed into fully connected layers, also known as dense layers, which perform nonlinear transformations to map features to output classes. These dense layers integrate the extracted features and learn to classify the input gait patterns into different categories such as individuals or activities. Finally, the output layer, often a softmax layer, computes the probabilities of each class based on the learned features and determines the predicted class for the input gait pattern. Through training on labelled gait data and parameter adjustments using techniques such as backpropagation and gradient descent, the CNN learns to accurately classify gait patterns into predefined categories, demonstrating its efficacy as a potent tool in gait classification. Additionally, employing strategies such as data augmentation, transfer learning, and ensemble methods further enhances the performance and generalisation capabilities of CNN-based gait classification models.

4.0 Results and Discussion

The human recognition model was evaluated using the accuracy, precision, recall, and F1-score. The model achieved an accuracy of X%, with a precision of Y%, recall of Z%, and F1 score of W%, highlighting its effectiveness. The confusion matrix revealed N1 true positives, N2 true negatives, N3 false positives, and N4 false negatives, indicating areas for improvement. The AUC score was V, demonstrating a high distinguishability between individuals. Feature importance analysis identified Feature1, Feature2, and Feature3 as key contributors.

Figure 2 : Predicting Human

Various models were tested using ModelX (for example, CNN), outperforming other methods. Misclassification was common for poor lighting and significant pose variations. The dataset class imbalance was addressed using SMOTE. Training took T1 hours, and inference took T2 seconds per sample, balancing accuracy and efficiency. The high accuracy and efficiency of the model make it suitable for security systems, attendance tracking, and personalised user experiences. However, performance drops in extreme lighting, and large labelled datasets are required. Future work will enhance the robustness to environmental variations and reduce data dependency through semi-supervised learning techniques.

Figure 3 : Predicting Non-Human

Compared to other similar projects, the collaborative file sharing and access control system proposed in this model offers several advantages. One of the key advantages of this model is the use of multi-level approval requests. This ensures that access to sensitive files is only granted with the approval of all members in a group, providing an additional layer of security. This is particularly useful in scenarios where sensitive or confidential information is being shared among a small group of trusted individuals. The access control mechanisms in this model are highly customizable, allowing administrators to set permissions at theindividual file or folder level. This is particularly useful in organizations where different departments or teams may have different access requirements.
The proposed model uses Blowfish encryption to secure files during upload and transmission, providing an additional layer of security against unauthorized access or interception. This model can be scaled to meet the needs of small or large organizations, and can be customized to fit specific use cases. This makes it a versatile solution that can be adapted to meet a wide range of requirements. The use of open-source technologies in this model makes it a cost-effective solution for organizations that may not have the resources to invest in expensive proprietary software solutions. Overall, the collaborative file sharing and access control system proposed in the proposed system offers a flexible, customizable, and secure solution for organizations that need to share and collaborate on sensitive files among a small group of trusted individuals.

5.0 Conclusion

A human recognition system utilising gait offers a promising avenue for biometric identification by harnessing the unique characteristics of an individual's gait pattern, presenting advantages such as non-intrusiveness, continuous authentication, and resilience to disguise. However, its effectiveness depends on factors such as environmental conditions, camera quality, and an individual's health and attire. Despite these challenges, advancements in computer vision and machine-learning techniques have the potential to enhance the accuracy and reliability of gait-based recognition systems. As research progresses, integrating gait recognition into broader security and surveillance frameworks could significantly improve the safety and authentication processes across various domains.. By adhering to ethical standards and best practices, we can maintain the integrity and trustworthiness of our predictive system. There are numerous avenues for further exploration and enhancement of our predictive models Enhancing security further, and the incorporation of advanced encryption algorithms and two-factor authentication could mitigate unauthorised access risks. Multidevice support could allow seamless recognition across various platforms, including wearable devices and mobile applications, enabling secure access through unique gait patterns. Integrating machine learning algorithms can automate processes and provide personalised experiences by analysing gait patterns over time, adapting, and improving recognition accuracy based on individual variations and changes in gait dynamics. Additionally, machine learning can assist in anomaly detection and identification of suspicious behaviour or deviations from normal gait patterns for enhanced security measures. Exploring these future work areas could significantly advance the capabilities and effectiveness of gait-based human recognition systems, making them more robust, secure, and adaptable to real-world applications.

Conflict of Interest

The authors reported no conflict of interest

Acknowledgement

Authors are grateful to the Principal, Musaliar College of Engineering and Technology, Kerala, for his kind support and for providing the necessary facilities to carry out this work.

References

[1]. H. Zarzour, Z. Al-Sharif, M. Al-Ayyoub, and Y. Jararweh, 'A new collaborative filtering recommendation algorithm based on dimensionality reduction and clustering techniques', in *2018 9th International Conference on Information and Communication Systems (ICICS)*, Irbid: IEEE, Apr. 2018, pp. 102–106. doi: 10.1109/IACS.2018.8355449.

[2]. [2]M. V. Ramakrishna, S. Harika, S. M. Chowdary, T. P. Kumar, T. K. Vamsi, and M. Adilakshmi, 'Machine Learning based Gait Recognition for Human Authentication', in *2023 International Conference on Sustainable Computing and Data Communication Systems (ICSCDS)*, Erode, India: IEEE, Mar. 2023, pp. 1316–1322. doi: 10.1109/ICSCDS56580.2023.10105085.

[3]. R. T. Collins, R. Gross, and Jianbo Shi, 'Silhouette-based human identification from body shape and gait', in *Proceedings of Fifth IEEE International Conference on Automatic Face Gesture Recognition*, Washington, DC, USA: IEEE, 2002, pp. 366–371. doi: 10.1109/AFGR.2002.1004181.

[4]. Han Su and Feng-Gang Huang, 'Markerless human gait recognition by shape and motion analysis', in *Proceedings of 2005 International Conference on Intelligent Sensing and Information Processing, 2005.*, Chennai, India: IEEE, 2005, pp. 161–165. doi: 10.1109/ICISIP.2005.1529441.

[5]. V. Rani and M. Kumar, 'Human gait recognition: A systematic review', *Multimed Tools Appl*, vol. 82, no. 24, pp. 37003–37037, Oct. 2023, doi: 10.1007/s11042-023-15079-5.

[6]. M. Dakhel, H. T. Malazi, and M. Mahdavi, 'A social recommender system using item asymmetric correlation', *Appl Intell*, vol. 48, no. 3, pp. 527–540, Mar. 2018, doi: 10.1007/s10489-017-0973-5.

[7]. R. Katarya and O. P. Verma, 'A collaborative recommender system enhanced with particle swarm optimization technique', *Multimed Tools Appl*, vol. 75, no. 15, pp. 9225–9239, Aug. 2016, doi: 10.1007/s11042-016-3481-4.

[8]. O. Kaššák, M. Kompan, and M. Bieliková, 'Personalized hybrid recommendation for group of users: Top-N multimedia recommender', *Information Processing & Management*, vol. 52, no. 3, pp. 459–477, May 2016, doi: 10.1016/j.ipm.2015.10.001.

[9]. J. Beel, B. Gipp, S. Langer, and C. Breitinger, 'Research-paper recommender systems: a literature survey', *Int J Digit Libr*, vol. 17, no. 4, pp. 305–338, Nov. 2016, doi: 10.1007/s00799-015-0156-0.