Human Gait Recognition Using Deep Learning and Improved Ant Colony Optimization

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Abstract:
Human gait recognition (HGR) has received a lot of attention in the last decade as an alternative biometric technique. The main challenges in gait recognition are the change in in-person view angle and covariant factors. The major covariant factors are walking while carrying a bag and walking while wearing a coat. Deep learning is a new machine learning technique that is gaining popularity. Many techniques for HGR based on deep learning are presented in the literature. The requirement of an efficient framework is always required for correct and quick gait recognition. We proposed a fully automated deep learning and improved ant colony optimization (IACO) framework for HGR using video sequences in this work. The proposed framework consists of four primary steps. In the first step, the database is normalized in a video frame. In the second step, two pre-trained models named ResNet101 and InceptionV3 are selected and modified according to the dataset's nature. After that, we trained both modified models using transfer learning and extracted the features. The IACO algorithm is used to improve the extracted features. IACO is used to select the best features, which are then passed to the Cubic SVM for final classification. The cubic SVM employs a multiclass method. The experiment was carried out on three angles (0, 18, and 180) of the CASIA B dataset, and the accuracy was 95.2, 93.9, and 98.2 percent, respectively. A comparison with existing techniques is also performed, and the proposed method outperforms in terms of accuracy and computational time.

Keywords: Gaitrecognition; deep learning; transferlearning; features optimization; classification
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1. INTRODUCTION

Human identification using biometric techniques has become a critical issue in recent years [1]. Techniques based on fingerprints and face detection are commonly used for identifying individuals based on their unique characteristics. Every person has distinct fingerprints and iris patterns, which are used for identification [2]. Recently, scientists have shown increased interest in human gait as a biometric approach [3,4]. Compared to fingerprint and face recognition technologies, gait recognition offers a more advantageous system. Gait recognition is particularly valuable in applications such as automatic human verification and video surveillance [5,6]. Human Gait Recognition (HGR) has emerged as a dynamic area of research in biometric applications, receiving significant attention in the field of Computer Vision (CV) [7]. Although gait is a common behavior observed in all humans, it is a complex process from an analytical standpoint, involving the coordination of various body parts.

The human gait recognition process is typically divided into two approaches: model-based and model-free [8]. The model-based approach directs human movement based on prior knowledge [9], whereas the model-free approach generates sketches of the human body, known as posture generation or skeletons [10]. The model-based approach analyzes human behaviors based on joint movement and upper/lower body parts. In contrast, the model-free approach is simpler to implement and requires less computational time. Numerous computational techniques have been utilized in the literature to automate this application [11]. Computer vision researchers have applied both classical and deep learning techniques. Traditional techniques involve a series of steps, including data preprocessing, segmenting the region of interest (ROI), feature extraction, and classification. For example, authors have employed contrast enhancement techniques during the preprocessing step [12]. In the following step, various segmentation techniques are used to extract the ROI, followed by the feature extraction step, where texture, shape, and point features are identified. These features are then further refined using feature reduction techniques such as PCA and entropy [13].In recent years, the introduction of deep learning has demonstrated significant success in various applications, including biometrics [14], surveillance [15,16], and medicine [17,18]. Unlike traditional models, deep learning models do not require preprocessing or the use of raw data, as they automatically extract features through multiple hidden layers. Convolutional layers, ReLU layers, max-pooling, and batch normalization are some of the hidden layers utilized in these models. The extracted features are then combined into a single dimension in fully connected layers, and the final classification is achieved using Softmax layers [19].

Mehmood et al. [20] presented a novel deep learning-based HGR framework consisting of four significant steps: preprocessing of video frames, modification of pre-trained deep learning models, feature optimization using a firefly algorithm, and classification. They also utilized feature fusion to improve feature representation. Experiments were conducted on three CASIA B dataset angles (18, 36, and 54 degrees), yielding accuracies of 94.3%, 93.8%, and 94.7%, respectively. Anusha et al. [21] implemented HGR using optimal binary patterns, addressing the issue of view-invariant clothing and conditions. Their method, named MLOOP, involved extracting histogram and horizontal width features, which were then refined using a reduction technique. Two datasets were used in their experimental process, showing strong performance. Arshad et al. [22] proposed a deep learning approach combined with feature selection for HGR, utilizing two pre-trained models modified for feature extraction. They further improved the features using fuzzy entropy and skewness-based formulations. Their experiments on four datasets achieved accuracy rates of 99.8%, 99.7%, 93.3%, and 92.2%, respectively. Sugandhi et al. [23] proposed a novel HGR method based on frame aggregation, introducing two key features: one based on dynamic variations in human body parts and the other on first-order statistics. The experimental process conducted on the CASIA B dataset resulted in improved accuracy.Given these studies, we identify several challenges in this work: (i) changes in human view angles; (ii) variations in human clothing conditions; (iii) changes in walking styles, such as slow or fast walking; and (iv) the deep learning model's requirement for large amounts of data to train effectively, which is not always feasible due to various factors. To address these issues, we propose a new deep learning and Improved Ant Colony Optimization (IACO) framework for accurate HGR.

In this work, we modified two pre-trained models, VGG16 and ResNet101, by adding a new layer connected to the preceding layers in the fully connected layers. We then proposed a feature selection technique named Improved Ant Colony Optimization (IACO). Initially, features are selected using ACO and then refined using an activation function based on mean, standard deviation, and variance. We applied the IACO technique to both modified deep learning models and compared their accuracy, selecting the best model for final classification based on performance.

PROPOSED METHODOLOGY

This section describes the proposed human gait recognition (HGR) method. Figure 1 depicts the main flow diagram of the proposed approach. The methodology consists of four main steps: dataset preprocessing, feature extraction using pre-trained models, feature optimization, and classification. Deep transfer learning is employed to modify two pre-trained models, ResNet101 and Inception V3. Features are extracted from both modified models, resulting in two feature vectors, which are then optimized using the Improved Ant Colony Optimization (IACO) algorithm. Finally, the optimized features are classified using multiclass classification methods.

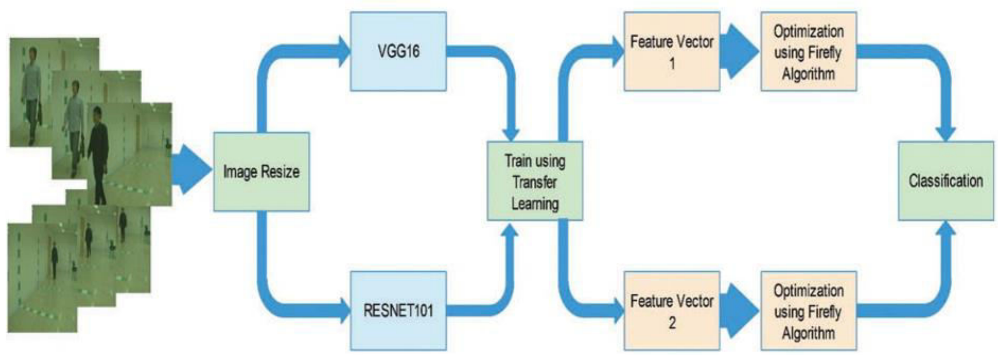

Figure 1:Proposed architecture diagram for HGR using deep learning and IACO algorithm

DATASET COLLECTION AND NORMALIZATION DETAILS

The CASIA B dataset [24], a large multiview gait dataset created in January 2005, is utilized in this study. It involves 124 subjects and captures gait data using 11 different view angles. This dataset includes three variations: changes in view angle, clothing, and object carrying. The dataset consists of three classes: walk with a bag, normal walk, and walk with a coat. For this study, we consider three angles: 0, 18, and 180 degrees, with three conditions included for each angle: bag carrying, normal walking, and wearing a coat. **Figure 2** shows sample frames from this dataset.

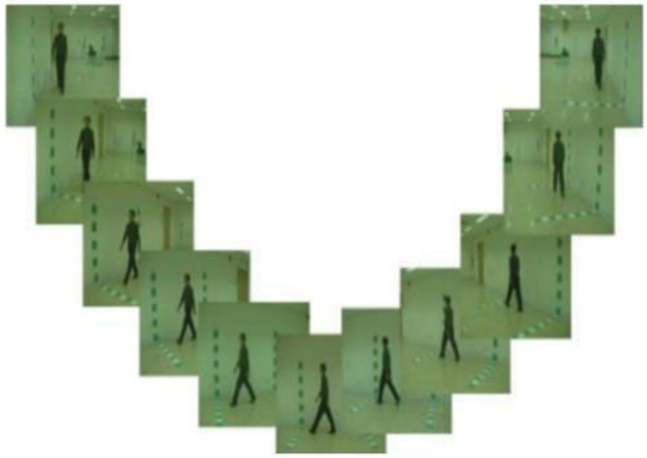

Figure 2: Sample frames of CASIA B dataset [24]

Convolutional Neural Network (CNN)

Deep learning has demonstrated massive success in the classification phase of machine learning [25,26]. The Convolutional Neural Network (CNN) is a deep learning technique where image pixels are convolved into features using a convolutional operator, aiding in image recognition, classification, and object detection. Compared to other classification algorithms, CNN requires minimal preprocessing. The CNN takes an image as input and processes it through several hidden layers to classify it. The training and testing process involves multiple layers, including a convolutional layer, a pooling layer, an activation layer, and a fully connected layer.

The introduction and sections you've provided are comprehensive and detailed, laying a solid foundation for the research work. Here's a refined and cohesive version of the sections with improved clarity and flow:

Conclusion and Future Work

The results demonstrate that the proposed framework performed well on the chosen dataset. The modified ResNet101 and IACO achieved better accuracy at 0° and 180°, while the modified Inception V3 and IACO performed better at 18°. Compared to Inception V3, the computational cost of ResNet101 and IACO was lower. Additionally, the computational cost of the original models was nearly three times that of the proposed framework when IACO was applied. Based on these results, we conclude that IACO aids in improving recognition accuracy while reducing computational time. However, the main limitation of this work is the choice of deep models, as both models were considered instead of optimizing a single deep model for HGR. Future studies will address this challenge by optimizing a single deep model for HGR.

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