Walking Pattern Recognition using Generative Adversarial Network

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ABSTRACT
Walking pattern recognition is a fascinating biometric modality that seeks to identify people based on how theywalk. Its advantage over other biometrics is that it doesn't need subjects to cooperate. By recognizing people based on how they walk, it essentially seeks to alleviate this issue.

Keywords
Feature Representation, Pattern Recognition, Deep learning, GAN.

1. INTRODUCTION
For the first time, the authors provides a technique for gait recognition that only requires a single image, allowing for latency-free gait recognition. To reduce the dependence of an encoded feature of the phase of that single image, a phase estimation network is specifically introduced for the input single image, and the gait cycle reconstruction network uses the estimated phase. To achieve a suitable trade-off between reconstruction and recognition accuracies, the PA-GCR and recognition network are simultaneously tuned throughout the training phase. Computer vision researchers have recently paid a lot ofattention to gait recognition. This study uses statistical form analysis to suggest a straightforward and effective automatic gait detection technique. This approach captures the structural aspects of gait, particularly the shape cues of body biometrics,by implicitly using the action of walking rather than directly analysing the dynamics of gait. A library of 240 sequences from 20 distinct persons walking at 3 viewing angles in an outdoor setting is used to evaluate the system. To show the suggested algorithm's encouraging performance, experimentaldata are presented.

Every cycle of a person's gait, which includes both the left and right forward strides, occurs regularly. Shape describes how a person is positioned or shaped throughout various gait phases. The creation of effective gait identification algorithms does not seem to be an easy application of the techniques already discovered in either human motion research or shape research, independently of one another. The difficulty lies in overcoming gait motion variances brought on by a variety of factors, including walking surface, carrying goods, time passed, walking pace, indoors versus outside, footwear, clothing, and so forth. Another crucial element for accurate and efficient gait detection is gait feature representation. Publicly accessible gait datasets are necessary for comparing different methods, and these databases should have enough subjects and covariate variables to enable strong gait identification and statistically valid performance evaluation. Because of this, researchers who study gait recognition have created valuable gait databases that include a variety of topic matter and/or several covariates. For intelligent biped robot to be able to walk safely in a complicated human living environment, real-time surface identification has emerged as a crucial component. By reducing the required hardware to a cost-effective microcontroller and a single type of force sensor, this work intends to enable wide-scale, cost-effective deployment of sensing solutions for surface recognition via walking-pattern categorization. Using a system that combines a support vector machine with four time-domain feature descriptors for experimental analysis, they investigated the walking-pattern classification performance. The dynamical force-sensory data stream was retrieved utilizing a real-time overlapped-window-based technique during the online pattern categorization.

Due to their reasonable accuracy and minimal hardware implementation complexity, multiple binary SVM classifiers were used to solve the multi-class classification problem, allowing for the one versus-one simultaneous strength exploitation of up to four distinct feature descriptors. To identify human walking patterns, algorithms based on the pressure signal generated by the sensors in a pair of shoes as it reflects off the ground were studied. Support vector machines, SVM-PCA, and SVM-KPCA classifiers were created, and the classification abilities of each algorithm were tested using information gathered from a wearer of the sensing shoes. Two crucial problems in gait recognition are the accurate extraction of distinctive gait features from image sequences and their identification. In this research, a 5-link biped locomotion human model is used to present a unique 2-step model-based gait detection method. Secret Markov Recognition is then carried out using models that have been trained using the frequencies of these feature trajectories. The findings imply that the subject's proximity to the camera has a considerable impact on the recognition rate.

Additionally, GNSS does not offer detailed data regarding the manner of carrying the device or the gait pattern. This research proposes three innovations for how to classify the gait style and manner of carrying the device, learn human gaitparameters for better dead-reckoning indoors, and learn human gait parameters. This thesis's initial contribution is a fresh method for assisting pedestrian navigation when GNSS is not accessible. A multi-rate Kalman filter bank is used to learn human gait parameters when GNSS is available, using data from an inertial measurement unit. These parameters, which are often learned outdoors, can then be used to improve pedestrian navigation indoors using dead-reckoning techniques in typical indoor-outdoor navigation scenarios. The gait signatures—which constitute one complete cycle of a person walking—are collected for a variety of human motion types and device-carrying stances. The features are taken from the computed gait signature and the image gait measurement that was received. An interesting biometric method that identifies people by their walking style is called gait recognition. In this work, The authors provide a thorough overview of current advances and improvements in deep learning-based gait detection, covering a wide range of subjects such as datasets, test protocols, state-of-the-art solutions, difficulties, and future research objectives. They first go through the gait datasets that are frequently utilized as well as the standards for judging them. A thorough analysis of deep learning-based gait detection techniques is offered after our suggested taxonomy, together with comments on their capabilities, traits, benefits, and drawbacks. The most important phase of any human gait detection system is feature extraction. Even though gait is a dynamic process, static body characteristics are also crucial in defining human gait. In the past, a few research papers were conducted to evaluate the relative significance of static and dynamic gait parameters. However, there hasn't been much research done on comparing the performance of dynamic gait features from various portions of the silhouettes in an appearance-based configuration.

To recognize gait, this research compares dynamic characteristics derived from the legs, arms, and shoulders. Their research largely confirms the widely held belief that leg motion is the primary determinant of gait identification. In other circumstances, these traits may contribute to the gait recognition process in a complimentary manner. They also suggest two brand-new feature extraction techniques for recognizing gaits.

2. RELATED WORK

On March, 2021 the CSE department of Soonchunhyang University, Asan, Korea proposed a method of human gait recognition. They have mentioned the main steps of this method, feature extraction is done using pre-trained models such as Resnet 101 and Inception V3, which are modified through deep transfer learning. The resulting vectors are optimized using IACO (Improved Ant Colony Optimization). The dataset used for this method consists of 124 subjects from the CASIA B multiview gait dataset, which includes 11 different view angles of each subject. This dataset includes variations in view angle, clothing, and carrying objects, and consists of three classes: walking with a bag, normal walking, and walking with a coat.

The dept. of Computer and Information Science Ohio State University, Columbus represented the model of recognizing walking movements using a small low level motion regularities and constraints[3]. For the experiment they have observed and made real video of 17 people walking at different speeds. To assemble the walking category they compute biomechanical motion features from the real video. As a result variant walking patterns and motions displayed the ability of the approach.

Academic Editor: Gelan Yang; proposed method for identifying walking patterns utilized KPCA and SVM with ground reflex pressure signals. In the experiment, participants wore shoes with pressure sensors installed in the soles, and their normal walking speeds were measured by 14 FSR402 sensors. This data was transmitted to a computer through a data processing board and analyzed using MATLAB 2010a on a PC with a 2G and 2 GHZ CPU.

Academic Editor:Wenkang Wang, Liancun Zhang, Juan Liu proposed a method of walking pattern recognition using soft knee power assist wear [10] was designed to collect data on the speed and angles of the thighs, shanks, and knee joint, and transmit it to a laptop through serial ports in real-time.

Electronics and Telecommunication Engineering Dept. of Jadavpur University, India has used a kinect sensor to recognize leg posture from Indian classical dance[6]. The kinect sensor has a IR laser with a diffraction grating. The IR camera recognizes different patterns produced by diffraction gratings. Optimum cost, ability to perform throughout 24 hours of the day are the advantages of the kinect. They also asserted a vehicle system which was driven by human foot[2]. The purpose of the author was to create a actual human computer interaction system which would sense position of the human body while under cover. To get the authenticated result they also used a humanoid robot HRP-2. A classification engine in Matlab validated the proposed algorithm here. The authors applied the method on laboratory data and got almost 84.6% accurate results.

Georgia Institute of Technology Atlanta, method for recognizing someone's gait, or walking style, has been proposed that involves analyzing the time-normalized movement of joints in the walking plane. The aim of this paper was to analyze the joint angle trajectories of human which was measured from normal walks. A motion capture system was used as a measurement tool to measure human gesture[4]. A method was presented for retrieving human joint positions in the walking level. The joint angle tracks can be recovered by using those joints. By standardizing these 2 indications so that they have the same formation, same number of steps and the same period.

Nishi-ku, Fukuoka, Japan's Wakamatsu University proposed a technique to distinguish between people who walk in straight or curved paths using a 4D gait database and adaptive virtual image synthesis. Multiple 3D models were put back together using the visual hull approach, which uses 16 cameras set up in the studio [7]. Additionally, they put up a voting-based approach to person identification that is resistant to high-frequency noise, which is produced as a result of a tiny flaw in virtual picture synthesis. The 4D database, which contained data on 42 persons, was used in studies to show that the new method outperformed existing techniques.\

Nanjing University of Science and Technology, 2 Osaka University, proposed a method of gait recognition via semi-supervised detangled representation learning to identity and covariate features. The name of the proposed method is ICDNet, in this approach, semi-supervised deep reinforcement learning is used to dissociate identity and covariate features using an auto encoder that encodes an input GEI into these features and then reassembles the input GEI.

Yasushi Yagi Osaka University, proposed a method of adaption to walking direction changes for gait identification [8]. The first step in this method involves correcting for body tilt by estimating the centrifugal force and creating a gait silhouette volume. The second step involves introducing a view transformation model (VTM) in the frequency domain to align gallery features in the same walking direction.

3. TECHNICAL APPROACH

3.1. Proposed Model

In their study, the CASIA gait database B was used. It is one of the largest datasets available with a variety of view, clothing, and carrying conditions. It also achieves a great correct classification rate. For their recognition technique, Generative Adversarial Networks, or GANs model, was used.

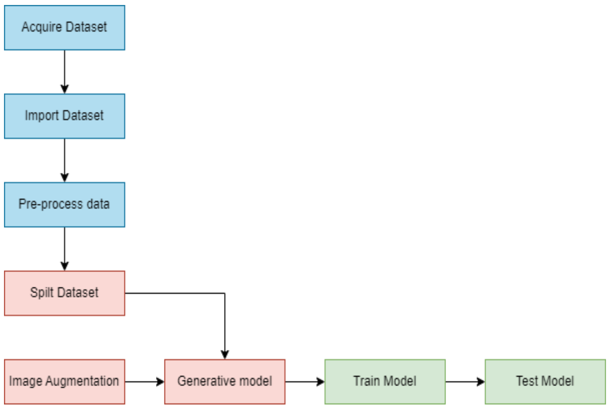

Fig 1: Workflow of the proposed system

3.2. Dataset Introduction

The CASIA Database is made available by the Institute of Automation, Chinese Academy of Sciences (CASIA). The extensive multiview database was established in January 2005. 124 participants were recorded for this dataset across 11 perspectives. The study considers three types of variations separately: changes in view angle, changes in clothing, and changes in carrying conditions. The CASIA-B dataset was used for the research.

3.3. Data visualization

The aim of this study is to evaluate an algorithm and to recognize the walking pattern. In order to determine whether they will be able to match subjects, the algorithm's sensitivity, accuracy, temporal complexity, and precision are all assessed. The authors are excited to learn more about it because it is such an important subject today in order to get better and more trustworthy results.

3.4. Data Preprocessing

The significant impact of data preprocessing in the machine learning domain is very high. The data must be preprocessed before it is applied to the model while constructing a machine learning application, training a model. With any form of unstructured input, the machine learning algorithm and deep learning architecture are unable to draw any conclusions. Preprocessed data must be used when applying these methods. The automatic data pretreatment capabilities of recent deep learning discoveries are far below to those of manual DP. Data preprocessing involves a few steps. Such as data minimization, data cleansing, and data transformation. In machine learning, the raw data obtained for training must be appropriately purified. The next step is to preprocess our data by transforming it. In DT, there are a number of processes that must be taken to convert data correctly. The outcomes of the data normalization must be perfect. After meeting our basic demands, if the raw data still contains too much information, a data reduction approach can be used to minimize it. The data chosen for their study was secondary information. This indicates that the data underwent minor preprocessing. Raw data typically contains less extraneous information. To normalize our images and produce the image representation, some image transformations are used, such as resizing, thresholding, and cropping.

The dataset must be divided into a few sections in order to properly train a deep learning model in every aspect. Theterms "training section," "testing section," and "validation section" are generally used to describe these portions. The datamust be organized in order to train our algorithm. For the first 62 subjects, the data would therefore be set at all views with clothing and carrying variation as the source and typical walking at 90° as the target. The data was split into 90% for train and 10% for testing. An algorithm is a particular approach to resolving a well specified computing problem. It also provided guidelines for addressing mathematical and logical problems. Numerous algorithms are widely employed in all aspects of real life. Because of their computing efficiency and conceptual simplicity, classification trees have increased in popularity. In a machine learning (ML) model called a generative adversarial network (GAN), two neural networks compete with one another to make predictions that are more correct.

Typically, GANs operate unsupervised. The dataset must be divided into a few sections in order to properly train a deep learning model in every aspect. The terms "training section," "testing section," and "validation section" are generally usedto describe these portions. Any main datasets obtained come in a single directory. When using those datasets, they are altered to suit their purposes, such as splitting the dataset into portions for training and testing. Most of the time, it stands to reason to split the dataset into training and testing. The data must be organized in order to train our algorithm. For the first 62subjects, he data would therefore be set at all views with clothing and carrying variation as the source and typical walking at 90° as the target. The data was split into 90% for train and 10% for testing.

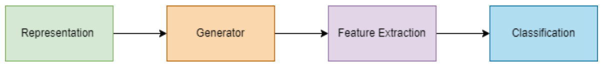

Fig 2: Framework

An algorithm is a particular approach to resolving a well specified computing problem. It also provided guidelines for addressing mathematical and logical problems. Numerous algorithms are widely employed in all aspects of real life. Because of their computing efficiency and conceptual simplicity, classification trees have increased in popularity. The machine learning technique employed in this method is a generative adversarial network (GAN), two neural networks compete with one another to make predictions that are more correct. Typically, GANs operate unsupervised.

3.4.1. Train-Test Split

The dataset must be divided into a few sections in order to properly train a deep learning model in every aspect. Theterms "training section," "testing section," and "validation section" are generally used to describe these portions. Any main datasets obtained come in a single directory. When using those datasets, they are altered to suit their purposes, such as splitting the dataset into portions for training and testing. Most of the time, it stands to reason to split the dataset into training and testing. The data must be organized in order to train our algorithm. For the first 62 subjects, The data would therefore be set at all views with clothing and carrying variation as the source and typical walking at 90° as the target. The data was split into 90% for train and 10% for testing.

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3.5. Generative adversarial network

The generator and the discriminator are the two neural networks that make up a GAN. A deconvolutional neural network serves as the discriminator, and a convolutional neural network serves as the generator. The generator is then fed this randomized data until it develops a basic level of output accuracy. To start, the fundamental building components for their model are established. After defining the down sample and up sample blocks, the Generator is constructed. The discriminator aids in their ability to retrain as much as possible. The model is run for 10 epochs. To train the GAN, the first 62 subjects' six normal walking sequences are employed, two coat-wearing sequences, and two sequences that involved walking with a bag. The test set will consist of the remaining 62 participants.

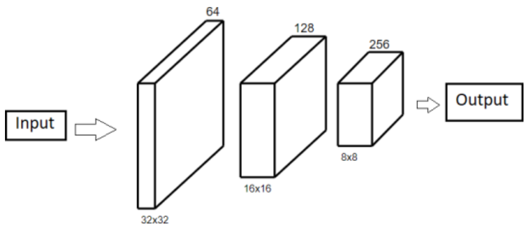

Fig 3: GAN Model

3.6. Tools and Libraries Used

By leveraging tools and libraries, this implementation was made easier. In various tasks, there are several libraries utilized. Particularly in the area of computer vision, these libraries and tools facilitate research on convolutional neural networks and deep learning.

3.6.1. OpenCV

OpenCV is a library that offers real-time optimization for tasks such as computer vision, machine learning, and image processing. It plays a key role in the real-time operation that is crucial in modern systems.. For picture processing and other computer vision-related tasks, OpenCV is an excellent tool. Using it, you may manipulate images from movies and pictures to see people's faces, objects, or even their handwriting. It is a free library that may be used for tasks like face recognition, object tracking, landmark recognition, and many more. It supports other languages in addition to Python, Java, and C++.

3.6.2. NumPy

The NumPy package, which is written in Python, provides functions for manipulating arrays, performing Fourier transform, and working with matrices and linear algebra. It includes a set of integrating tools for Python implementation and multidimensional objects in arrays. Data in the form of numbers are represented as arrays for multidimensional functions and rearrangement operations in this programming language, which is essentially a blend of C and Python.

4. RESULT

Accuracy is a common technique for evaluating an algorithm's performance in various issue conditions. However, precision isn't always the preferred choice for metrics measurement.

Fig 4: Normalization of Dataset

Their dataset has a number of classes. The statistic that will be employed is the correct classification rate (CCR), which is calculated as the proportion of properly identified samples to all samples.

Based on our different angles of view and variation on average the NM have the highest recognition.

5. RESULT ANALYSIS

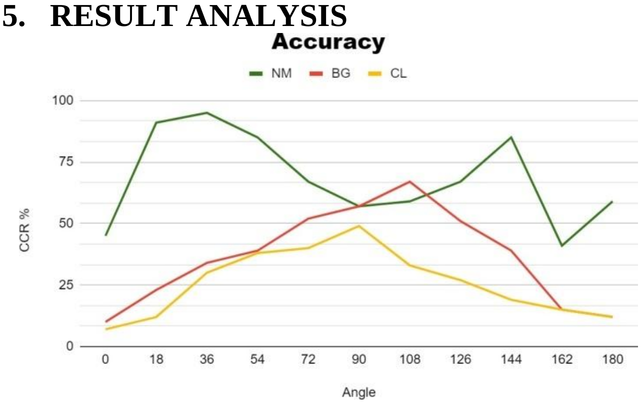

Fig 5: Accuracy

One of the most challenging issues in the big data era is turning the enormous amounts of data produced by quickly evolving technology into knowledge. The sheer amount of data being generated is often too large to be processed using traditional methods, requiring new technologies and approaches to handle and analyze it. In the work presented here, methods for recognizing the pattern of a person's walking are concluded implementing. To sum up, the development and testing of various end-to-end multimodal deep learning models for pattern recognition can serve as a security safeguard for future systems. The table shows that the diagonal view outperforms the cross view in terms of average accuracy. The diagonal view had an average accuracy of 67.66%, while the cross view had an average accuracy of 37.33%. This trend was consistent across all of the test subjects, with the diagonal view consistently achieving higher average accuracy scores.

Table 1: Accuracy

Class	Angle	Accuracy
Diagonal View	NM	0.90
	BG	0.72
	CL	0.41
Cross View	NM	0.57
	BG	0.35
	CL	0.20

Here, the SPAE method is compared with the author's method. As shown here in the charts in diagonal view, both results are mostly the same, and sometimes their method does better than the SPAE. On the other hand, for Cross View the SPAE method does slightly better than author's method. The authors hope to improve their method in the future to match the SPAE method or do better than it.

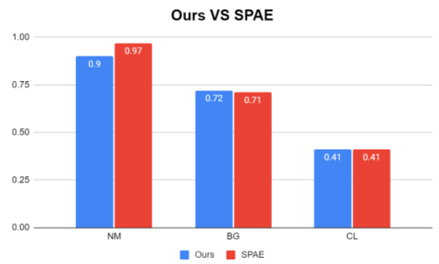

Fig 6: Diagonal View Comparison

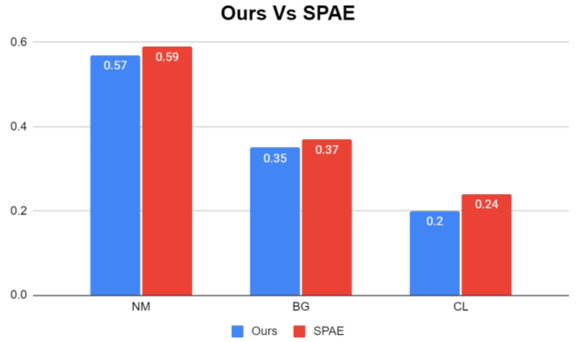

Fig 7: Cross View Comparison

6. LIMITATION

6.1. Data Set

The dataset is from 2005 and it was captured with old technology. As with the advancement of science and technology a dataset can have better information with higher quality. Finding a high quality dataset is tough. It was not feasible with our existing hardware and, in some cases, it made the classification process more difficult. That's why high-performance computers are needed to work with it. With their current gear, it was not possible, and in some situations, it made the categorization process more challenging. Because of this, powerful computers are required in order to use it.

6.2. Pre-Processing

Images can be preprocessed using a variety of techniques. According to their own points of view, each strategy is effective. However, most of them are constrained by technological restrictions. How thoroughly the training picture data is preprocessed often determines the success of any research that uses it. Every component of the new generations has drawbacks of its own. Even new technology, which improves our everyday lives in many ways. The preprocessing technique now utilized has several drawbacks. The similarities between each individual file and the previous one were enormous.

7. CONCLUSION AND FUTUREWORK

It is demonstrated in this research that their approach for recognizing the walking pattern had roughly 62 percent accuracy. To the best of their knowledge, several studies have used convolutional neural networks to recognize gait. The decision is made on GANS. In order to assess the validity and reliability of the system, a large data set training method is essential. Every effort is made to identify the best classifier that will correctly identify the pattern. By overseeing high-performance computers and including more features to increase the system's correctness, their field of work will be advanced.

Unsupervised algorithms, which may be utilized to determine greater accuracy, were the main emphasis of this research. Our future aim is to improve our work by overseeing high-performance computing equipment and to increase the precision of their system, a few additional features might be added. Additionally, an alarm system may be employed to quickly find irregularity in their daily life.

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