



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

IJIRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 11, Issue 7, July 2022

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 8.118



9940 572 462



6381 907 438



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Identity Recognition of Humans in Video Surveillance System Using CFPI

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ABSTRACT: In the recent years, the security has become a major concern. Majority of the security systems consists of fingerprint and face recognition. But there is another form of security that is less discussed i.e. Gait recognition, which is identifying a person by his walking style and foot pressure images. In this project we focus on the ground reaction force which can be used to distinguish between human gaits. Cumulative foot pressure image (CFPI) may be a 2-D data that records the spatial and temporal parameters of ground reaction force during one gait cycle. The proposed system is a machine learning model that will be trained on the standard dataset i.e. CASIA-D. In this project we will demonstrate how these CFPI can be used to identify an individual in many cases such as homeland security, secret lockers in banks. It also helps us in medical field for injury prevention and diagnosing lower limb problems etc.

KEYWORDS: GAIT, CFPI, Floor Sensor

I. INTRODUCTION

Gait is one of many physical and behavioral traits of an individual that can be used for recognizing a person. Recognizing people using gait characteristics and their foot pressure images is an important area in biometrics with the applications in homeland security, secret lockers in banks, access control and human computer interactions. While majority of the researches for human identification using gait features has been focused on computer vision-based techniques, there has been researches addressing gait recognition using foot pressure information. Gait refers to a person's manner of walking. Gait recognition aims essentially to address this problem by identifying people at a distance based on the way they walk and their foot pressure images. Many number of studies have demonstrated the advantages of using gait information in biometrics to distinguish between individuals. Gait features are even used in criminal cases to identify culprit based on their walking behavior. The ground reaction force and the cumulative foot pressure images are not as popular as the limb movement obtained from video-based gait extraction systems does in pattern recognition and image process communities. Recognizing the individual using foot pressure data is intractable because it only contains the rough foot pressure distribution.

II. LITERATURE SURVEY

Early medical and psychological studies [1][2] showed that human gait had 24 different components, which could be used for identifying an individual. It was revealed that the light points attached to the joints of individual can be used for representing human motions, and point light displays can be used for differentiate human activities [3]. The above works indicates that every individual had unique muscular- skeletal structure which could be used for identifying him/her. Therefore, gait recognition is feasible. This survey is an attempt to bring an extensive, up to date research and analysis information about advances and the state of practice in gait-based authentication. Literature surveys of some papers-

- In 1994, the earliest gait recognition system was proposed by authors in Reference [7], which based on

a small gait database. Thereafter, the Defence Advanced Research Projects Agency (DARPA) implemented the famous Human ID program, which was considered as the first publicly accessible database for gait recognition. Since then, many researchers have done numerous works on human gait recognition. Recently, gait recognition has been done through sensor readings such as accelerometer, floor sensors etc.

- The work in Reference [8] is the first model-based feature representation approach. Ben Abdelkader et al. [8] modeled the human body using structural stride parameters of individuals. Reference [8], two parameters, namely the stride length (in meters) and cadence (steps per minute), are computed from the video based gait system for recognizing individuals.
- Tanawongsuwan and Bobick [11] modeled the human body using joint angles. They have done research by extracting joint angles from gait data and using the trajectories of joint angles for recognizing individuals.
- At the same time, since human legs play an important role in gait recognition, many works were focused on the model of legs. For example, Yam et al. patterned the human legs, and used them for analyzing the walking and running style. In this work, the recognition rate of running was higher compared to walking. Dockstader et al. patterned the human legs, too, where legs were represented as many thick lines meeting at one point. And Cunado et al. used Velocity Hough transform (VHT) for extracting features from legs and motions.
- Nakajima et al. utilized the floor sensors for collecting samples of gait data, such as pressure, for the first time. In 2005, Otero was the first one to introduce the continuous wave radar for collecting human gait data.
- As described within the paper that was presented at the Norsk Information security conference-2010, aside from the machine vision (MV) based and floor sensor (FS) based gait recognition, the wearable sensor based gait approach is the newest. It is based on wearing motion recording sensors on the person's body in different places such as, on the waist, pockets, shoes and so forth. The wearable sensors (WS) can have several uses as it retrieves numerous types of data. Sensors of different types like accelerometers, gyro sensors, force sensor etc, are currently in use, but most literature so far has put a great focus on accelerometer based gait recognition. After modeling the entire physical body, model-based feature representation methods typically use distances or joint angles of physical body for gait recognition. For example, Bobick and Johnson partitioned the human body using four main distances, namely head-pelvis, head-foot, and foot-pelvis, left-right foot distances. Wanget al. partitioned the entire human body into 14 parts and used joint angle trajectories in each parts for identifying the individuals.
- In 2008 Andreas Uhl and Peter Wild presented Footprint-based biometric verification system. It focusses on an approach considering the characteristics of biometric foot which is generated using the geometry, shape and texture of the foot. The image enhancement and the feature extraction stages mainly focusses on the definite characteristics of foot geometry, durability and their unique properties, are also explained by them. Collectability and generality are the main issues which were reflected. The Gait Recognition may be a remarkable signal processing tool for the biometric proof of identity [6].

III. PROBLEM STATEMENT

Most of the research is focused on camera-based gait recognition systems, and survey on other gait recognition systems was limited. As fingerprints, face and eyes are currently in use for the biometric method, many researchers also found that foot can also have the potential to be considered as a biometric factor in identifying individuals with the help of foot pressure images. Many approaches have done in this field but the small data size, low accuracy levels and other constraints made them not suitable for practical implementations.

IV. PROPOSED SOLUTION

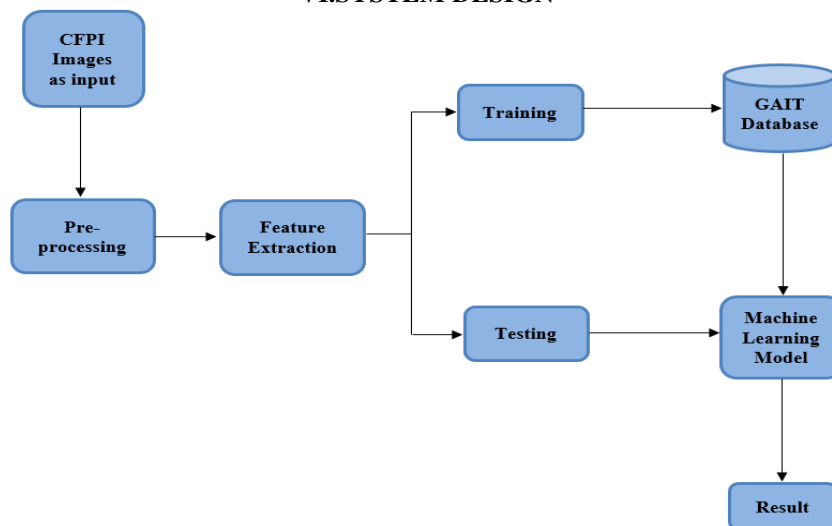
The proposed system aims to overcome all the problems identified by using a standard dataset i.e. CASIA – D obtained by floor-based sensor. It's a largest dataset consisting of 88 subjects which includes all the factors that affects the gait

recognition system, like walking speed, wearing conditions etc. It will be further preprocessed and the features will be extracted. The extracted features are then taken as input to the gait recognition algorithm for training and recognition. The main significance of this proposed system over the existing systems are the large dataset and can able to consider the inputs from both the barefoot and shod data.

V. PROPOSED OBJECTIVES

- To apply the pre-processing and segmentation techniques on the collected standard dataset.
- To identify and apply suitable techniques for extracting most prominent gait features.
- To apply the suitable machine learning algorithm to determine the results.

VI. SYSTEM DESIGN



Data Acquisition

- Sensors, which convert physical properties to electrical impulses, are among the components of data acquisition systems.
- Circuitry for signal conditioning, which converts sensor signals into a format that can be converted to digital values.
- Analog-to-digital converters, which transform conditioned sensor signals into digital values.

We are working on the standard dataset i.e. CASIA-D dataset that consists of 88 subjects.

We are performing on the quality data set i.e. CASIA-D dataset that contains 88 subjects. When a topic walked within the scene, he/she was asked to steer naturally along a line through the pressure sensor 5 times first and 5x88 normal walking cumulative foot pressure images were captured for each subject.

There are 20 female subjects, 66 male subjects. All subjects are Asian aged between 20 and 60. The data are representative and ensure the future experiments to be not limited in any specific group of people. After normal walking, the themes were asked to steer fast through the pressure sensor 5 times. In that case, there are totally $10 \times 88 = 880$ cumulative foot pressure records, three cumulative foot pressure images for every record, so there are totally 2640 images for considering the effect of walking speed.

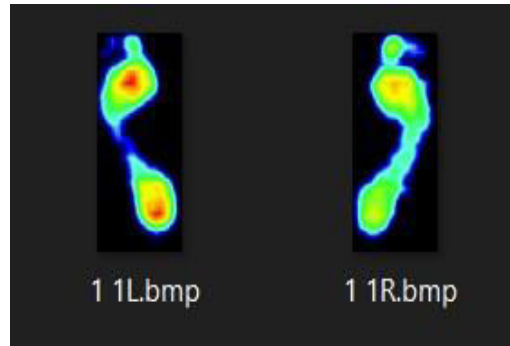


Fig 1: cumulative foot pressure image

DataPre-processing

Resizing:

Resize images is a critical pre-processing step in the computer vision technology. Principally, In our machine learning model train faster on smaller images. An input image that's twice as large requires our network to find out from fourfold as many pixels — which time adds up.

PIL is that the Python Imaging Library which provides the python interpreter with image editing capabilities. The Image module provides a category with an equivalent name which is employed to represent a PIL image.

ConversionfromRGBtoGrayscaleImage:

TheAverageMethod:

TheAveragemethodtakestheaveragevalueofR,G,andBasthegrayscalevalue

$$\text{Grayscale} = (R + G + B) / 3.$$

Theoretically, the formula is 100% correct. But when writing code, you may encounter uint8overflow error — the sum of R, G, and B is greater than 255. To avoid the exception, R, G,andBshould becalculated respectively.

$$\text{Grayscale} = R / 3 + G / 3 + B / 3.$$

The average method is simple but doesn't work as well as expected. The reason being thathuman eyeballs react differently to RGB.

The WeightedMethod:

Theweightedmethod,alsocalledluminositymethod,weighsred,greenandblueaccordingto theirwavelengths. The improvedformulais as follows:

$$\text{Grayscale} = 0.299R + 0.587G + 0.114B$$

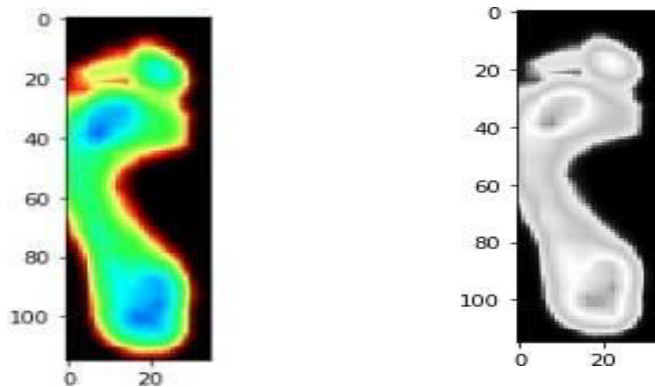


Fig2: RGBGRAYSCALE

Feature Extraction

Grayscale pixel values as features

The simplest way to create features from an image is to use the raw pixel values of an image. Machines see any images within the sort of a matrix of numbers. The size of this matrix all depends on the amount of pixels of the input image. The Pixel Values for each of the pixels stands for or describe how bright that pixel is, and what colour it should be. So within the simplest case of the binary images, the pixel value may be a 1-bit number indicating either foreground or background. So pixels are the numbers, or the pixel values which denote the intensity or brightness of the pixel. Smaller numbers which is closer to zero helps to represent black, and therefore the larger numbers which is closer to 255 denote white. So this is often the concept of pixels and the way machine sees the pictures without eyes through the numbers. A color image consists of three channels, red, green and blue, each of the matrix has values between 0-255 which represents the intensity of the colour of that pixel.

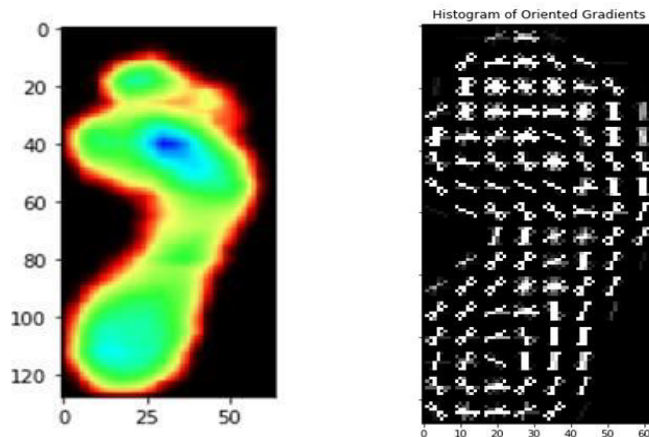
$$\text{sizegroup1} + \text{sizegroup2} + \text{sizegroup3} = m \times n + m \times n + m \times n = 3 \times m \times n$$

So our generic formula would be:

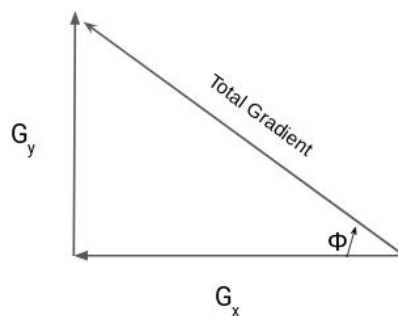
$$m \times n + m \times n + C(m \times n, 2) = 2m \times n + C(m \times n, 2)$$

Histogram of Oriented gradients

The other technique that can be used is HOG. Histogram of Oriented Gradients, may be a feature descriptor that's often went to extract features from image data. It is widely used in computer vision tasks for object detection. The HOG feature descriptor counts the occurrences of gradient orientation in localized portions of a picture. The HOG descriptor focuses on the structure or the form of an object. HOG can provide the edge direction as well. This is done by extracting the gradient and orientation (or you'll say magnitude and direction) of the sides. Additionally, these orientations are calculated in 'localized' portions. This means that the entire image is weakened into smaller regions and for every region, the gradients and orientation are calculated. We will discuss this in far more detail within the upcoming sections. Finally the HOG would generate a Histogram for each of these regions separately. The histograms are created using the gradients and orientations of the pixel values, hence the name 'Histogram of Oriented Gradients'.



Process of Calculating the Histogram of Oriented Gradients (HOG)



The gradients are basically the base and perpendicular here.
Let's apply the Pythagoras theorem to calculate the total gradient magnitude:

$$\text{Total Gradient Magnitude} = \sqrt{[(G_x)^2 + (G_y)^2]}$$

Next, calculate the orientation (or direction) for the same pixel. We know that we can write the tan for the angles:

$$\tan(\Phi) = G_y / G_x$$

Hence, the value of the angle would be:

$$\Phi = \text{atan}(G_y / G_x)$$

Model Design

SVC (support vector classifier)

SVC may be a nonparametric clustering algorithm that doesn't make any assumption on the amount or shape of the clusters within the data. In our experience it works best for low-dimensional data, so if your data is high-dimensional, a preprocessing step, e.g. using principal component analysis, is typically required.

In SVC data points are mapped from data space to a high dimensional feature space employing a kernel function. In the kernel's feature space, the algorithm searches for the smallest sphere that encloses the image of the info using the Support Vector Domain Description algorithm. This sphere, when mapped back to data space, forms a group of contours which enclose the info points. Those contours are then interpreted as cluster boundaries, and points enclosed by each contour are associated by SVC to an equivalent cluster.

SVC uses the Support Vector Domain Description (SVDD) to delineate the region in data space where the input examples are concentrated. SVDD belongs to the general category of kernel-based learning. In its "linear" version SVDD looks for the smallest sphere that encloses the info. When used in conjunction with a kernel function, it looks for the smallest enclosing sphere in the feature space defined by the kernel function. While in feature space the info is described by a sphere, when mapped back to data-space the sphere is transformed into a group of non-linear contours that enclose the info. SVDD provides a choice function that tells whether a given input is inside the feature-space sphere or not, indicating whether a given point belongs to the support of the distribution. More specifically, it's the radius-squared of the feature-space sphere minus the distance-squared of the image of a knowledge point x from the middle of the feature-space sphere. This function, denoted by $f(x)$ returns a value greater than 0 if x is inside the feature space sphere and negative otherwise. For more details on SVDD the reader is mentioned the SVDD article.

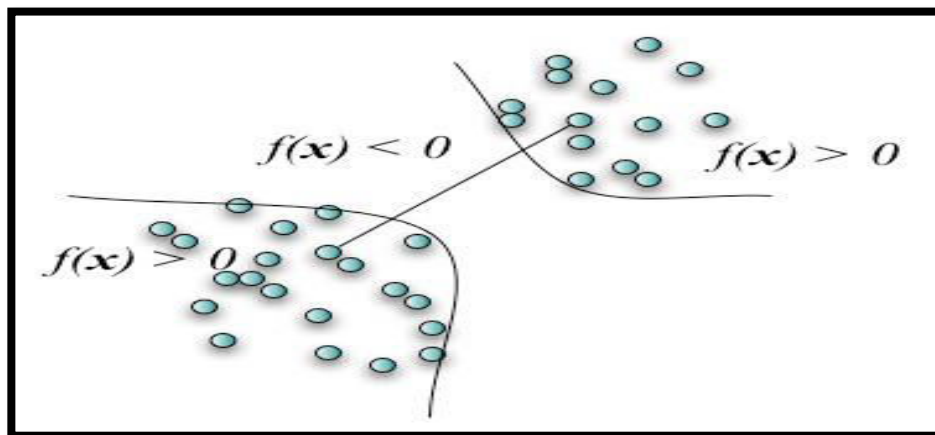
The contours where $f(x)=0$ is then interpreted as cluster boundaries. An example of such contours is shown in Figure 2. However, these boundaries define the clusters implicitly, and a further step is required to "tease" the cluster membership out of the SVDD.

$$A_{ij} = \begin{cases} 1, & \text{if } f(x) > 0 \text{ for all } x \text{ on the line segment connecting } x_i \text{ and } x_j \\ 0, & \text{otherwise.} \end{cases}$$

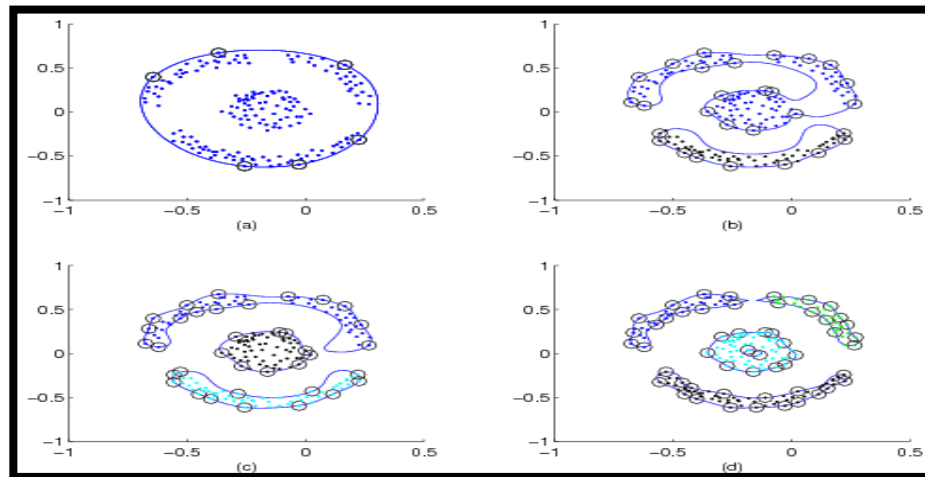
SVC uses SVDD to generate non-linear cluster boundaries in conjunction with the Gaussian kernel:

$$k(x, x') = \exp(-\gamma \|x - x'\|^2).$$

Fig 3: The line segment that connects points in different clusters has to go through a low-density region in data space where the SVDD returns a negative value.



The boundaries generated by SVDD become increasingly non-linear as the parameter γ which governs the width of the Gaussian, is increased as shown in (Figure 2). As the value of γ is increased the SVDD boundary fits the data more tightly, and at several values of γ the enclosing boundary splits, forming an increasing number of components (clusters). The so-called support vectors are the data points that are on the boundary. As γ is increased their number increases, increasing the complexity of the boundary. The choice of the Gaussian kernel is motivated by Roberts (1997) where a related method produces a sequence of cluster splitting when used in conjunction with the Gaussian kernel.

Fig 4: Contours generated by SVDD as γ is increased.

VII. RESULT

Algorithmused	Accuracy
SVC(supportvectorclassifier)	80.48192771

Accuracy is one metric for evaluating classification models. Informally, accuracy is the fraction of predictions our model got right. Formally, accuracy has the following definition:

$$\text{Accuracy} = \frac{\text{Number of correct predictions}}{\text{Total number of predictions}}$$

For binary classification, accuracy can also be calculated in terms of positives and negatives as follows:

$$\text{Accuracy} = \frac{\text{TP} + \text{TN}}{\text{TP} + \text{TN} + \text{FP} + \text{FN}}$$

where TP = True Positives, TN = True Negatives, FP = False Positives, and FN = False Negatives.

After building model by applying foot pressure images and trained the algorithm SVC (support vector classifier) it produces the accuracy of unknown data is 80.4819277 and also save this result in pickle file named as "classifier.pickle" as follows

```

18
19 # Loading the Trained Classifier
20 classifier = joblib.load('FootPrintClassifier.pkl')
21
22

```

VIII. CONCLUSION

The literature review helped us understand the scope of gait recognition in biometric system. It was identified that a lack of accurate and reliable solutions for CFPI based biometric systems and thus the problem was formulated. We proposed a system on Cumulative Foot Pressure Images (CFPI), with the aim of achieving good results and objectives, by developing appropriate model using various tools and technologies. The proposed approach makes use of linear version of support vector classifier (SVC) for computational efficiency. This indicates that the features used in our approach from different people are mostly linearly separable.

IX. FUTURE SCOPE

- Improving accuracy by using some variations or modifications for the existing model .
- Using ANN and Deep learning to obtain more accurate predictions with considerably large dataset.
- Implementation of human identification using CFPI techniques on real time data.
- Ground reaction force of real time data can be used to calculate pressure applied on the foot of a person.
- Provide security measures to avoid misuse of technology.
- Further work for constructing large amount datasets is required.

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