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A Robust Part based Method for Human Gait Recognition

Manjunatha Guru V G, Kamalesh V N

Abstract**:** ***This paper explored a new part based gait recognition method to address the gait covariate factors. Firstly, three robust parts such as vertical-half, head, and lower leg are cropped from the Gait Energy Image (GEI). Since, these selected parts are not affected by the major gait covariates than other parts. Then, Radon transform is applied to each selected part. Next, standard deviations are computed for the specified radial lines (i.e. angles) such as 0^0, 30^0, 60^0, 90^0, 120^0 and 150^0, since these radial lines cover the horizontal, vertical and diagonal directions. Lastly, fuse the features of three parts at feature level. Finally, Support Vector Machine (SVM) classifier is used for the classification procedure. The considerable amount of experimental trails are conducted on standard gait datasets and also, the correct classification rates (CCR) have shown that our proposed part based representation is robust in the presence of gait covariates.***

Keywords**:** ***Covariate, Gait, Part based, Radon***

I. INTRODUCTION

The term gait denotes the manner of walking. The gait recognition is the way of identifying the people based on their walking styles. It is a behavioural biometric source. Since, it consists of both physiological and psychological characteristics of a person. Gait does not need physical cooperation and even alertness of an individual while recording the person's gait. Also, gait can be recorded from the longer distance (i.e. space). Gait is view independent biometric trait, since an individual can walk in any direction in front of the camera device or CCTV. Hence, gait can be recorded in all the viewing angles. [20-24]

The considerable amounts of gait literatures have already marked the significance of gait recognition in the field of human identification. However, the current gait literatures have been thoroughly studied and reviewed in this section. [1-28]

Jianyi Liu et al [1] have proposed an effective gait representation method called GHI (i.e. Gait History Image) and reported adequate results. Lili Liu et al [2] have proposed an outermost contour based gait representation and have used a combination of dimensionality reduction technique and discriminant analysis (i.e. Principal Component Analysis + Multiple Discriminant Analysis) to improve the better correct classification rate. Jing Luo et al [3] have proposed a combination of GEI & accumulated FDEI (i.e. frame difference energy image) for the effective gait classification. For each gait cycle, Jeevan et al [4] have explored a new representation using Pal and Pal Entropy. Khalid et al [5] have explored an innovative gait representation method (i.e. Gait Entropy Image). Dan Liu et al [7] have extracted 2D location information of human joints as the gait features. Fathima et al [6] have investigated the simple features such as height and width and also, the exhaustive angles form head to foot. Pomtep Theekhanont et al [8] have established a gait identification method using GEI and Pattern Trace Transform. Imad Rida et al [9] have explored a mask based method to address the influences of gait covariates. Further, they have used the CCA (i.e. Canonical Discriminant Analysis) followed by MDA. Lishani et al [10] have used Haralick features in their work. Nahid A Makhdoomi et al [11] have used the averaged silhouette representations in their work.

Md. Rokanujjaman et al [12] have used the frequency-domain gait entropy features in their work and also, explored the merits of part based gait identification. Parul Arora et al [13] have proposed the Gait Gaussian Image (GGI). Khalid et al [14] proposed a novel method called optical flow fields. Xiuhui Wang et al [15] have proposed the gait identification approach using Gabor wavelets and $(2D)^2$PCA. Further, they have used multiclass support vector machine (SVM) for recognition procedure.

Erhu et al [27] proposed a combination of AEI (Active Energy Image) and 2DLPP (Two dimensional locality preserving projections). Heesung et al [28] proposed an effective approach which removes the backpack from the gait energy image by using recursive PCA reconstructions.

Mohan Kumar et al [16-19] have investigated the interval features in the field of gait biometric research. They have also explored the merits of interval features in order to address the major gait covariates. Manjunatha Guru et al [24] have also discovered the facts of interval features in the field of gait biometric research and also, proposed a new dissimilarity matching for the intervals in their work.

II. PROPOSED APPROACH

A. Preprocessing

In this paper, we have used Chinese Academy of Sciences dataset i.e. CASIA (Version B & C) which is publicly freely available, considerably largest datasets in current gait literature.

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* Correspondence Author
Manjunatha Guru V G*, VTU RRC, Visvesvaraya Technological University, Belagavi, Karnataka, India. Email: vgmanjunathji@gmail.com
Kamalesh V N, Professor & Dean, T-John Institute of Technology (TJIT),Bangalore, Karnataka, India. Email: kamalesh.v.n@gmail.com

These datasets provides the raw silhouettes to the gait biometric research community. In these datasets, each subject's gait is represented as the sequence of silhouettes.

For each frame, firstly morphological operations are used to reduce the isolated noise and, to fill the breaks in the contour of the human silhouette. Then, bounding rectangle was used to crop the human body. Next, it is center aligned and resized to constant dimension (i.e. 128 X 88). The same kind of process is applied to all frames of an individual. At the end, GEI (i.e. Gait Energy Image) is obtained by averaging all normalized silhouettes of an individual. In Figure 1, the sub figure (a) shows the GEI representation. [20-24]

B. Robust Part Based Gait Representation

People have different anatomical proportion of body parts with respect to height (H). Anatomical specialists have commented that the measurement from foot to neck is 0.870H, waist is 0.535H and knee is 0.285H. Based on these, GEI is divided into 3 parts in order to address the prominent gait covariate factors. Firstly, the GEI is vertically split into two equal size blocks. This kind of partition generates two blocks such as left vertical-half and right vertical-half. Suppose, if the subject walks from left to right, only right vertical part is selected. Likewise, only left part is selected when the subject walks from right to left. Further, lower leg and head parts are selected. However, totally 3 robust parts are selected for an individual as the gait representation. In Fig. 1, the sub figures (b) (c) and (d) shows the vertical half, head part and lower leg respectively. The reasons behind the selection of these 3 parts are as mentioned below

- When person walks from left to right, left vertical part is usually affected by the covariate factors such as backpack, clothing and carrying conditions. Likewise, right vertical part is affected by the covariate factors when the person walks from right to left.
- Head part is usually less affected part compared to other body parts.
- Lower half of the human body is more affected by the covariate factors such as the carrying and clothing conditions. Hence, lower leg part is selected.

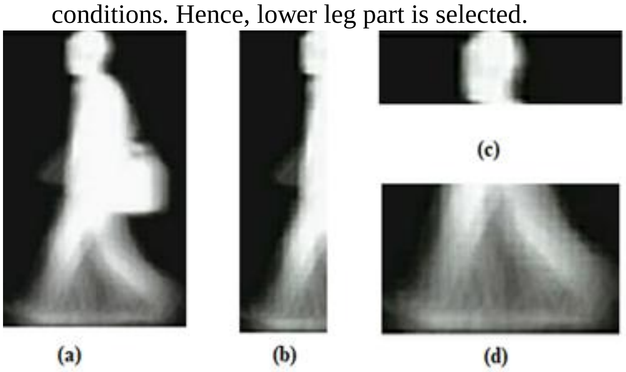

Fig. 1. Part Based Gait Representation (a) GEI (b) Vertical Half (c) Head (d) Lower Leg

C. Feature Extraction and Classification

In this paper, Radon Transform is applied separately on 3 parts and fuses the features for the classification procedure. The Radon transform projects the 2D input image from Cartesian coordinate system (x, y) to polar coordinate system (ρ, θ). The Radon transform on an image f(x, y) for a given set of angles can be considered as the projection of the image along the given angles. [22]

The Radon transform based features are invariant to geometric transformations such as translation, rotation, and scaling etc. After a Radon transform, standard deviations (i.e. σ) are computed from the Radon transform (R) for a given set of angles (i.e. radial lines). A set of angels usually from $\theta = [0^0; 180^0)$. The angle 180^0 is not included since the result would be identical to the 0^0. However, all radial lines oriented from 0^0 to 179^0 angles may miss lead the classifier and also it increases the dimension of the feature vector. Hence, the angles chosen here are 0^0, 30^0, 60^0, 90^0, 120^0 and 150^0, since these radial lines cover the horizontal, vertical and diagonal directions. As described in this paragraph, six features (i.e. 0^0, 30^0, 60^0, 90^0, 120^0 and 150^0) are selected for each part. Then, three part's features are fused at the feature level. At the end, total 18 features (i.e. 3 parts X 6 features) are used for the classification task. [22]

Furthermore, mean (μ) and standard deviation (σ) are computed from the feature vector. Then, each feature value is subtracted from the mean. Next, the subtracted result is dividing by the standard deviation. This procedure enhances the functioning of the support vector machine classifier to finds the support vectors with the minimal time duration.

For classification, we have incorporated multi class SVM (Support Vector Machine) classifier by adopting the one versus rest technique. Since, it is more generalized and powerful classifier in the biometric research. In this work, we investigated the polynomial kernel (order 3) with sequential minimal optimization (SMO) procedure. Since, it finds the hyper plane which bisects the data effectively. [22]

III. EXPERIMENTS & COMPARATIVE ANALYSIS

A. CASIA Dataset (B)

CASIA (Version B) which is one of the leading multi view gait dataset in the field of gait biometric research. This dataset comprises of 124 subjects which are recorded from eleven view directions (i.e. from 0^0 to 180^0 with an interval of 18^0). Totally, this dataset consist of 13,640 gait sequences. [26]

In our trials, we used only 90^0 view sequences with the presence of most important gait covariates. Each subject comprises of ten sequences (i.e. six normal walking sequences + two wearing cloth sequences + two carrying condition sequences). For each subject, we have considered first four normal walking sequences as training set. The remaining two sequences with normal walking condition, two sequences with different cloth condition and two sequences with carrying condition are used as the testing set.

The above same experimental arrangement is investigated in most of the existed literatures. The below Table I show the proposed results for the above mentioned experimental arrangement and also, the detailed comparison results on current gait literatures.

B. CASIA Dataset (C)

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CASIA (Version C) which is one of the leading speed transition gait dataset in the field of gait biometric research.

This database comprises of 153 subject's which are captured in 90^0 view condition. Totally, this dataset comprise of 1,530 gait sequences. [25] In our trials, we used the gait sequences with the presence of different walking speed condition. Each subject comprises of ten sequences (i.e. four normal walking sequences + two slow walk sequences + two fast walk sequences + two backpack sequences). For each subject, we considered three normal walking sequences as training set. The remaining 1 normal walking sequence, two sequences with slow walk condition, two sequences with backpack and two fast walk sequences are used as the testing set.

The above same experimental arrangement is investigated in most of the existed literatures. The below Table II show the proposed results for the above mentioned experimental arrangement and also, the detailed comparison results on current gait literatures.

Table I: Comparative results on CASIA (B) Dataset

Methods	Training Set	Testing Set & CCR		
		Normal Walk	*Clothing*	*Carrying*
GEnI [5]	Normal Walk Sequences	98.3%	33.5%	80.1%
AFDEI [3]		88.7%	91.9%	89.9%
GGI [13]		98.0%	-	-
Proposed Results		98.38%	96.77%	97.17%

Table II: Comparative results on CASIA (C) Dataset

Methods	Training Set	Testing Set Correct Classification Rate			
		Normal walk	*slow*	*fast*	*backpack*
AEI[27]	Normal Walk Sequences	88.89 %	89.22 %	90.20 %	79.94%
Backpack Removal [28]		-	-	-	78.10%
Proposed Results		98.69 %	89.86 %	90.84 %	98.03%

IV. CONCLUSION

This paper has demonstrated the effectiveness of the proposed part based representation in the field gait biometric research. The selected three parts are insensitive to the major gait covariates such as clothing, carrying, backpack etc. The considerable amount of experimental trails are conducted on standard gait datasets and also, the correct classification rates (CCR) have shown that our proposed part based representation is robust in the presence of gait covariates. The detailed comparative analysis on current gait literatures shown that our proposed part based representation is effective in the real time scenarios.

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AUTHORS PROFILE

Manjunatha Guru V G received his MCA degree from Visvesvaraya Technological University (VTU) in 2011. He is pursuing Ph.d (Part Time) from Visvesvaraya Technological University (VTU), Belagavi District, Karnataka state, India. Also, he is currently working as Assistant Professor & Head, Department of Computer Science, Government First Grade College, Honnali – 577217, Davanagere District, Karnataka, India. He is having 7 years of teaching experience & research. He has published research papers in the international journals and in the reputed book chapters. His research interests include computer vision, digital image processing, video processing, pattern recognition, algorithms and biometrics. Email: vgmanjunathji@gmail.com

Kamalesh V N is Professor and Dean in the Department of Computer Science & Engineering, T-John Institute of Technology (TJIT), Bangalore, Karnataka, India. Previously, he worked as Special Officer for e-Learning Department, Visvesvaraya Technological University, Mysore Region. He obtained doctorate in Computer Science and Engineering from Satyabhama University. He is having 25 years of experience in academics, research and administration. He has published a quite number of research papers in the international and national journals and in the conference proceedings. He received national and international awards for academics and research. His area of research is algorithms, biometrics, graph algorithms, image Processing, pattern recognition and technology for education. Email: kamalesh.v.n@gmail.com

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