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A Novel Human Gait Recognition System

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***Abstract*—In this paper considering a new human gait recognition system based on Radon transform which gives a high precision recognition rate. Innovation of this paper allocate to feature extraction and usage of them during process by combined neural networks . feature extraction is based on the Radon transform of binary silhouettes .in this paper For each gait sequence, the transformed silhouettes are used after background estimation and human detection in the scene to make each related template's. then set of all templates is used to subspace projection by following PCA method and earning final decimated feature vector for each persons in database. consequently earned feature vector for each person's is applied to multilayer perceptron neural network and set of all neural networks feed to final neural network for final decision . Experimental results is performed over a suitable data base include 10 samples for ten person which each sample have 130 frames approximately. 97% recognition rate of the proposed system is obtained over 10 samples test patterns.**

***Index Terms*—Human Gait recognition,Background estimation, Radon Transform,Y-T plan,X-T plan , Feature extraction,PCA, Neural network classifier.**

I. Introduction

Gait is an attractive biometric feature for human recognition. In recent years, gait receives more and more attentions from computer vision and biometric researchers. Compared with fingerprint, face, iris, and other biometric features, gait has many advantages, such as non-invasive, non-perceivable and it can be capture at a distance. Gait can be detected and measured at low resolution, and therefore it can be used in situations where face or iris information is not available in high enough resolution for recognition. Recent gait recognition methods may be mainly classified into two types; model-based and motion-based methods. Model-based approaches purpose to explicitly model human body or motion, and they usually perform model matching in each frame of a walking sequence so that parameters such as trajectories are measured according to the model [3]. Most existing motion-based approaches can be further divided into two main classes [4]; state-space method and spatiotemporal methods. The state-space methods consider gait motion to be composed of a sequence of static body poses, and recognize it by considering temporal variations observations with respect to those static pose [1]. The spatiotemporal method characterizes the spatiotemporal distribution generated by gait motion in its continuum [5]. Based on body shape and gait, Collins *et al.* [3] established a method based on template matching of body silhouettes in key frames for human identification. Lee *et al.* [6] described a moment-based representation of gait appearance for the purpose of person identification. Phillips et al. [7] proposed a baseline algorithm for human identification using spatiotemporal correlation of silhouette images. Wang *et al.* [8] used outer contour and unwrapped it into a distance signal to recognize a person. In this paper, we focus on our proposal method as strongest way for gait recognition. we propose new approach without body parts tracking which fall into motion-based category. Main innovation of the proposed method includes gait recognition based on human body gesture classification by following Radon transform and multi stages classification by neural networks.

This paper is organized as follows. In Section 2,we present an overview of the proposed system. In Section 3, the Radon transform and usage of this transformation for making gait templates at this work is presented. In Section 4,the proposed method details described as background estimation, normalizing gait cycle. In section 5 subspace projection by PCA and training BP neural networks are presented and finally experimental results and conclusions are drawn in Section 6.

II. Overview of the Proposed System

The first step of our proposal system illustrated at Fig. 1.As depicted at Fig.1 this step of our proposal algorithm composed by several complementary stages .first ,input images stream feed to background estimation and background omission stage's to make silhouettes respect to each input images, then gait cycle will be identify and by following gait cycle radon transform should be calculating for images situated at gait cycle .consequently gait images that be transformed by radon will be used to make respect person gait template. These templates in fact preserve all of altering during gait in form of dynamic and static. Meantime will be notion to this point that radon transform calculate for each person's gait database independently hence for each person we will be make some template's as him gait video samples at database. in most practical cases, there will be a need for denoising [5] prior to the application of a gait recognition algorithm, but usage of radon transform at this work solve this problem as well by the essence of denoising which combined by Radon transform.

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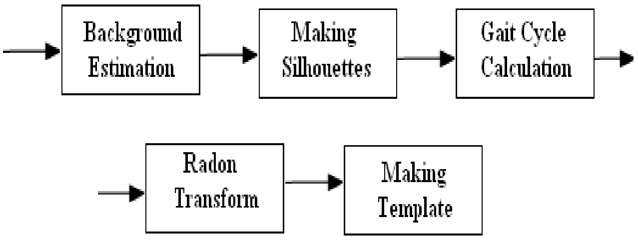

Fig1: First step of proposed algorithm

Hence by following first step of our work all of each person gait video sample converts to respect template's .this earned templates can describe each person's gait as well as dynamic and static features.

Then at the second stage's, PCA algorithm as described by [9] is used to subspace projection and templates data reduction .PCA algorithm calculate transformation for each set of person's templates .the final reduced data will be earned by multiplication of this transformation vectors by each person's template vector. At third section of this work each person's templates reduced by respect transformation, hence all of templates reduced in view point of data volume .consequently each set of earned templates for each person's is used to train respect BP neural network's. Hence at this stage's each person's features trained by respect neural network .at fourth section another BP neural network will be use to compensate the errors that may be maked at last section. Hence first BP neural networks outputs feed to this final BP neural network. Final neural network will be train by using first trained neural networks and each person's templates respectively.

III. Radon Transform and Usage of this Transformation for Making Gait Templates

In recent years the Radon transform have received much attention. These transform's are able to transform two dimensional images with lines into a domain of possible line parameters, where each line in the image will give a peak positioned at the corresponding line parameters. This have lead to many line detection applications within image processing, computer vision, and seismic.

Several definitions of the Radon transform exists, but the related, and a very popular form expresses lines in the form $RHO = x \times cos(\theta) + y \times sin(\theta)$,where theta is the angle and rho the smallest distance to the origin of the coordinate system. As shown in the two following definitions (which are identical), the Radon transform for a set of parameters (rho,theta) is the line integral through the image g(x,y), where the line is positioned corresponding to the value of (rho,theta) Eq.1. The delta() is the Dirac delta function which is infinite for argument 0 and zero for all other arguments (it integrates to one), and in digital versions the Kronecker delta is used.

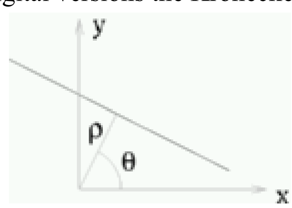

Fig2: Radon integral around the determined line by ρ, θ

$$gt(\rho,\theta) = \iint_{-\infty}^{+\infty} g(x,y)\delta(\rho - xcos\theta - ysin\theta)dxdy \qquad \text{Eq.1}$$

or the identical expression,

$$gt(\rho,\theta) = \int_{-\infty}^{+\infty} g(\rho cos\theta - ssin\theta, \rho sin\theta + scos\theta)ds \qquad \text{Eq.2}$$

Where in above equations $gt(\rho,\theta)$ is the line integral of a 2-D function $g(x,y)$ along a line. The position of the line is determined by two parameters ρ and θ.Using this definition an image containing two lines are transformed into the Radon transform shown to the right.

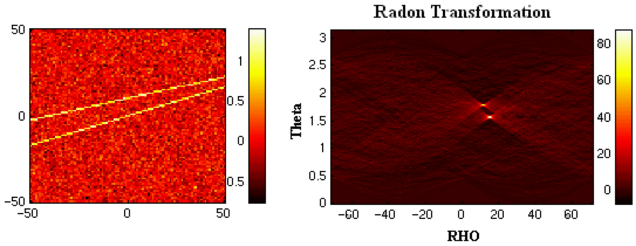

Fig3: Radon transform

It can be seen that two very bright spots are found in the Radon transform, and the positions shown the parameters of the lines in the original image. A simple thresholding algorithm could then be used to pick out the line parameters, and given that the transform is linear many lines will just give rise to a a set of distinct point in the Radon domain. Meantime the very strong property of the Radon transform is the ability to extract lines (curves in general) from very noise images as shown below.

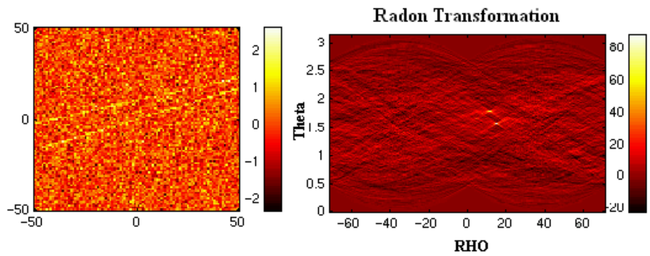

Fig4: Radon transform at noisy condition

It is possible to generalize the Radon transform in order to detect parameterized curves with non-linear behavior.

Gait templates at gait recognition works be so valuable because of it's gait information essence ,hence making strongest template be competitive works. G.huang and Y.hong wang in [10] try to make gait templates by using gait timing profile in direct of silhouette Y axis (Fig5).this profile only able to describe gait information in one angle and meantime maybe useful to extract the gait cycle . As described lastly, radon transform detect all of images information in each angle and position by line integral calculation without noise effect, hence usage of this transform as feature extractor around our work (gait feature extraction) superior than each other existing work as X-T plan or Y-T plan [10].indeed radon transform select to making gait templates at this work.

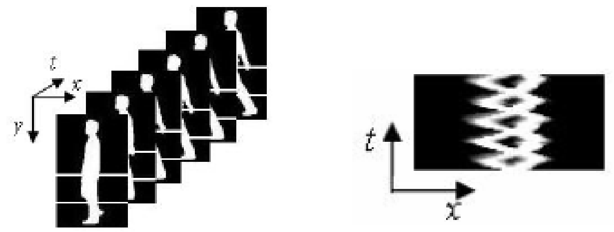

Fig5: X-T plan algorithm for making gait template

By following what mentioned in above at this work radon transform selected to extract the gait feature strongly ,hence for each gait sense (each gait images that attributed to gait cycle in the next of background omission) this transformation can be calculating by Eq.1 as depicted in the bellow.

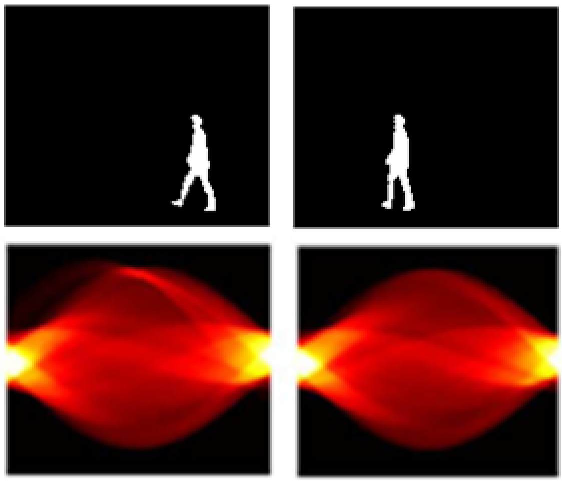

Fig6: Silhouettes radons transform

As described lastly, above figure depicted base on ρ and θ.hence line integral in all direction calculeted and emerge as a graphical point in above picture. In above images, Region closest to yellow color represent big part of altering and information at respect ρ and θ.

To make gait template base on radon transform we use continuous transform as bellow,

$$Ct = \begin{cases} g(\rho,\theta) & t = n \\ (n+1-t)g(\rho,\theta) + (t-n)g'(\rho,\theta) & n < t < n+1 \end{cases} \qquad \text{Eq.3}$$

Where the g and g' denote each frame radon transform and next frame radon transform respectively. n denote frame number as gait cycle (n=1...N). in fact above equation convert sampled and transformed images into continuous transform images.

This earned continuous transform have a two type of information as static and dynamic information hence to take this features use bellow filter,

$$filter = a \times (1 + j) + b \times (Coswt + j \times Sinwt) \qquad \text{Eq.4}$$

Where the a and b in above equation be constant value for time invariant and time variant part of our feature selection filter .and valued this parameters during this work respect to noise ratio for extract more effective features. a and b in fact determine, which part (static or dynamic) be more reliable to take it as feature. Static part identify by some fix feature as width and dynamic part identify by features maked by gait method. in above equation earned from the gait cycle hence time variant part of this filter use to filter another information(in this work w determined $\frac{2\pi}{4T}$ by follow [11]). if define T as gait cycle ,out proposal gait template will be make as bellow ,

$$template = \frac{1}{T}\int_0^T g(\rho,\theta) \times filter\, dt \qquad \text{Eq.5}$$

Template's that will be make by using above details have two controllable static and dynamic part .static part will be extract by calculating average of transformed image and dynamic part will be extract by filtering around gait frequency .

Although radon transform isolated templates from noise but algorithm that will be use to make silhouettes as background estimation and morphology tools maybe cause to create a few part of noise in the silhouettes, hence making template's by notion this subject could increase efficiency of our work. Indeed a and b in Eq.4 will be controlling the effect of silhouette noise as bellow,

- a and b take value between zero and ones.
- a will be increasing when respect silhouette noise ratio grow up (to argue gait features by static features)
- a *and* b will be equal when respect silhouette noise ratio be low (to argue gait features by static and dynamic features)

Experimentally we find a and b will be adjust by following silhouette's vertical profile standard deviation as bellow,

$$a = Std\left\{\frac{1}{Max(\text{silhouette vertical profile})} \times \text{silhouette vertical profile}\right\} \qquad \text{Eq.6}$$

And

$$b = 1 - a \qquad \text{Eq.7}$$

By following above equations, it is inevitable that by increasing noise in silhouette ,templates depend on static part and vice versa.

IV. Peripheral Details

In this section some of peripheral methods that be used during this work's will be describe.

- ***BACKGROUND ESTIMATION***

As described in last sections, silhouettes will be making by implementation of some algorithm as background estimation. In this work we use Gaussian PDF method [12] to estimate and remove each human background. To estimate each frame's background ,in each person's gait database we assume several background frames ,which at this several frames only fix background exist.

Gaussian PDF, equation (8), (9) is used which can accept scene variations.

$$\mu_t\ (x,y) = (1-\alpha)\mu_{t-1}(x,y) + \alpha I_t(x,y) \qquad \text{Eq.8}$$

$$\sigma_t^2(x,y) = (1-\alpha)\sigma_{t-1}^2(x,y) + \alpha(I_t(x,y) - \mu_t\ (x,y))^T(I_t(x,y) - \mu_t\ (x,y)) \qquad \text{Eq.9}$$

Where I(x,y) is the pixel's current value in location x,y and μ_{t-1} the previous average, σ_{t-1}^2 the previous variance, is transpose, α is an empirical weight often chosen as a tradeoff between stability and quick update.at each t frame time, the I pixel's value can then be classified as a foreground pixel if the inequality :

$$|I_t - \mu_t| > k\sigma_t \qquad \text{Eq.10}$$

Where k is a threshold value.

- ***HUMAN GAIT CYCLE ESTIMATION***

To estimate each person's gait cycle in each database ,in the next of making binary silhouette stage we can calculate horizontal profile from each silhouette's and save this earned vector as col of a matrix.

Then by calculating the vertical profile at maked matrix ,gait altering curve will be earned, hence in this curve distance between to peak will be select as a gait cycle . meantime horizontal axis at this curve determine the silhouettes frame number, hence by following silhouette frame number and distance between to peak we can take all of silhouettes that situated at gait cycle. Such human curve depicted in the bellow figure.

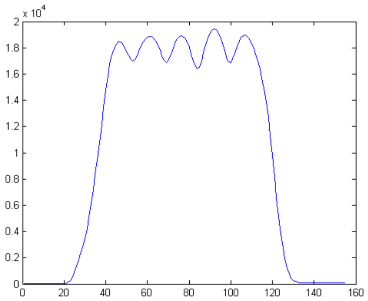

Fig7: Human gait altering curve

V. SUBSPACE PROJECTION AND FINAL HUMAN GAIT CLASSIFICATION BY COMBINED NEURAL NETWORK

In this work we collect 10 gait video sample for 10 person ,hence by following what mentioned in last sections finally earned 10 templates for each person's at our works. In this section to subspace projection and reduce the volume of each template's data we use PCA method as described in [9], hence for each person's templates calculating Eigen vectors and Eigen value and then select Eigen vectors respect to biggest Eigen values as a feature vector (transform),hence each person's template by multiplication with him respect earned feature vector will be reduce as bellow,

The reduced data for Each template's for each person's = him respect feature vector × respect template's for each person's

By following above method all of 10 templates for each 10 person's will be reduced and earned new data by lower volume. Final volume of data for each template's directly relate by Eigen value selection because if we want to make lowest final data ,we force to remove more Eigen values .

Consequently 10 earned reduced data vector for each 10 person train independently to respect BP neural network. Hence at this stage's each person's features trained by respect neural network .in next section another BP neural network will be use to compensate the errors that may be maked at last section. Hence first BP neural networks outputs feed to this final BP neural network. Final neural network will be train by using first trained neural networks output and each person's templates respectively.

Hence in the next of training stage, each new template's data will be recognize as depicted in the bellow,

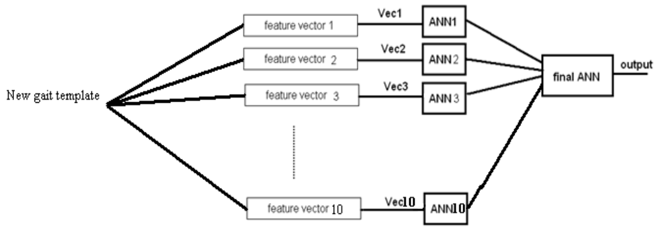

Fig8: Final recognition diagram

First each new data converted by 10 transform vector and result of each transformation feed to respect ANN, and then final decision will be making by following these 10 ANN outputs.

VI. CONCLUSION

An interest note was found in this paper "human gait recognition based on Radon transform and multi stages neural network". But this paper includes a new feature extraction, template construction and combined classifier To overcome the limitation of recognition performance rate, we proposed a system for gait feature fusion. Performance of each NNs for test samples was low (about 70% to 80%). Then we used a combined classifier for mixing the neural networks for the first time in gait recognition. Result of combination of neural network outputs was satisfiable and for our work mentioned in the bellow.

9	0	0	0	0	0	0	0	0	0
0	10	1	0	0	0	0	0	0	0
1	0	9	0	0	0	0	0	0	0
0	0	0	10	0	0	0	0	0	0
0	0	0	0	10	0	0	0	0	0
0	0	0	0	0	10	0	0	0	0
0	0	0	0	0	0	10	0	0	0
0	0	0	0	0	0	0	9	0	0
0	0	0	0	0	0	0	1	10	0
0	0	0	0	0	0	0	0	0	10

TABLE 1 : RESULT OF PROPOSED ALGORITHM

Where in above table each row and col allocated by each 10 person's and diagonal data show the correct result. Hence other data determine the wrong result for each row person's.

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