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DESIGN AND EVALUATION OF NEW STRATEGY IN HUMAN GAIT RECOGNITION

Babak Mohammadi[1], Mehrdad Fojlaley[2], Sharzad Busaleiky[1], Rosa Modarres[1], Ehsa Yarionsorudi[1], Sasan Andik[1]

[1]Department of electrical engineering, college of technical and engineering,
Tabriz branch, Islamic Azad University, Tabriz, Iran
[2]PhD in mechanic of bio system, Urmia University, Urmia, Iran.

Abstract- In this paper considering a new human gait recognition system based on Radon transform which gives a high precision recognition rate. Feature extraction in this work 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 to make each related templates. Set of all templates is used to subspace projection by PCA method. Consequently feature vectors are used to multi layer perceptron 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.

Key words- 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 proposed system is illustrated in Fig. 1.As depicted, this step of our proposed algorithm composed by several complementary stages .first ,input images stream feed to background estimation and background omission stage to make silhouettes respect to each input images, then gait cycle is identified and radon transform is calculated for images which are situated in gait cycle .consequently gait images that transformed by radon are used to make each person's gait template. These templates keep all of dynamic and static information of gait. Meantime, should be mentioned that radon transform is calculated for each person's gait database independently, hence for each person we have some templates .in most of practical cases, there will be a need for denoising [5] prior to the application of a gait recognition algorithm, which radon transform solves this problem as well.

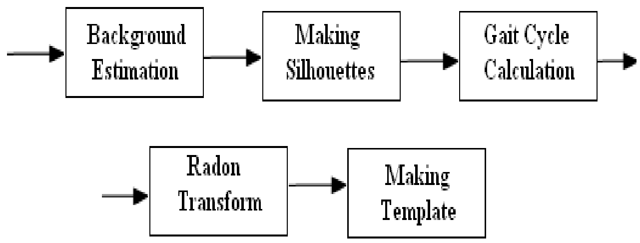

Fig1: First step of proposed algorithm

Hence by following first step of our work all of gait video samples for each person are converted to the templates (achieved templates can describe each person's gait as well as dynamic and static features).

Then at the second stage, 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 is achieved from multiplication of this transformation vectors by each person's template vector. In next section of this work each person's templates are reduced by transformations, hence all of templates are reduced in view point of data volume .consequently each set of templates for each person's is used to train an BP neural networks. so in this stage each person's features are trained by an especial neural network .At last another BP neural network is used to compensates the errors which produced in previous section. Hence first BP neural networks output feeds to this final BP neural network. Final neural network is trained by first trained neural networks and each person's templates respectively.

III. RADON TRANSFORM AND ITS APPLICATION 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.

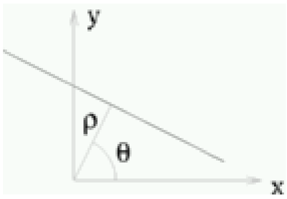

Fig2: Radon integral around the determined line by ρ, θ

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

or the identical expression,

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

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.

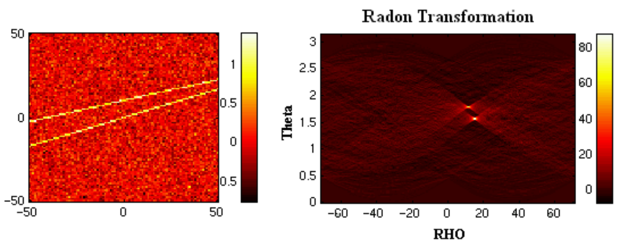

Fig3: Radon transform

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.

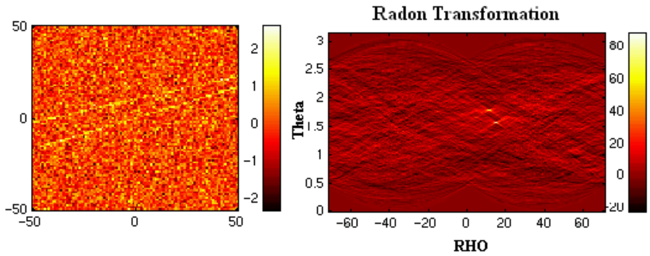

Fig4: Radon transform at noisy condition

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 linear integral calculation without noise effect, hence we are applied this transformation as feature extractor in our work which is superior than each other's work such as X-T plan or Y-T plan [10].

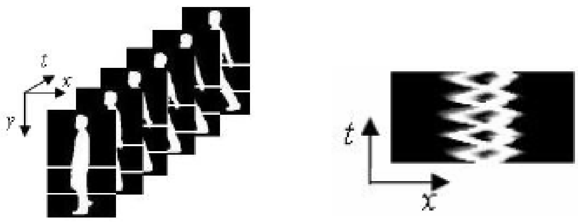

Fig5: X-T plan algorithm for making gait template

So radon transform is selected to extracts the gait features strongly after background removal stage (Example of these stages is depicted in the bellow).

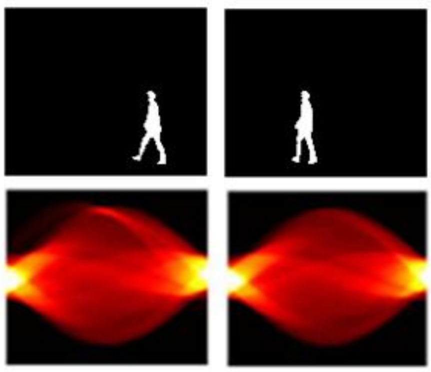

Fig6: Silhouettes radons transform

As described previously, above figure depicted based on ρ and θ.hence linear integral in all directions is calculated and

is showed here as a graphical point. In above images, Regions which are closest to yellow represent large dynamic and information in ρ and θ.
After that, we make an continuous transformation for gait templates as bellow,

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

Where the g and g' denote each frame radon transform and next frame radon transform respectively. n denotes frame number as gait cycle (n=1...N). In fact, above equation converts transformed images into continuous transform images.
The achieved continuous transform have two type of information: static and dynamic. Hence to extract this features use bellow filter,

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

Where a and b are constant value for time invariant and time variant part of our feature selector filter and are adjusted in this work based on noise ratio. a and b determine which part (static or dynamic) is more reliable to choose it as feature. Static part is identified by some fix features as width and dynamic part is identified by features which are resulted by gait. W in above equation is adjusted by $\frac{2\pi}{4T}$. If describe T as gait cycle, our proposed gait template is formed as bellow,

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

Templates which are produced by above equation have two controllable static and dynamic part .Static part is extracted by mean calculation over transformed image and dynamic part is extracted by filtering over gait frequency .
Although radon transform is isolated from noise but may be effected by the algorithm which is used to make silhouettes such as background estimation and morphology tools, hence a and b in Eq.4 are controlling the effect of silhouette noise as bellow,

- a And b are chosen between zero and one.
- a is increasing when silhouette's noise ratio growing up
- a and b are equal when silhouette's noise ratio is low

Experimentally we choose a and b by following silhouette's vertical profile standard deviation as bellow,

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

And

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

IV. PERIPHERAL DETAILS

In this section some of peripheral methods that are used over this work are described.

A. BACKGROUND ESTIMATION

Silhouettes are made in this work 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 in this several frames only fix background exist.
Gaussian PDF, equation (8), (9) is used which can accept scene variations.

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

$$\sigma_t^2(x,y) = (1-\alpha)\sigma_{t-1}^2(x,y) + \alpha(I_t(x,y) - \mu_t\ (x,y))^T(I_t(x,y) - \mu_t\ (x,y))$$
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 :

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

Where k is a threshold value.

B. 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 and save this as column of a matrix.
Then by calculating the vertical profile from achieved matrix gait determinant curve is produced. Hence in this curve distance between to peak shows the gait cycle. Meantime, horizontal axis in this curve determines the silhouette's frame number. Hence by following silhouette's frame number and distance between to peak we can take all of silhouettes which are placed in gait cycle. Such human determinant curve is depicted in the bellow figure.

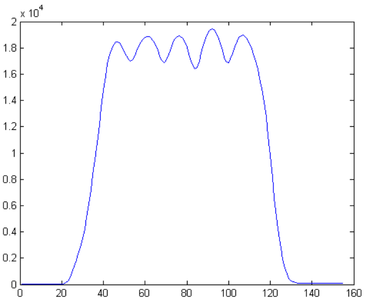

Fig7: Human determinant gait curve

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

In this work we collect 10 gait video samples for 10 people. So, 10 templates are achieved for each person in our work. In this section for subspace projection and reduction of data we use PCA method as described in [9], hence for each person's templates calculating Eigen vectors and Eigen values and choose Eigen vectors respect to larger Eigen values as a feature vector (transformation).hence reducing each person's templates by multiplication between data and achieved transformation as bellow,

Reduced data for each template of each person = feature vector × template for each person

Consequently, 10 reduced data vectors are used to train first stage BP neural network independently and compensate the recognition performance in the next section by another BP neural network.

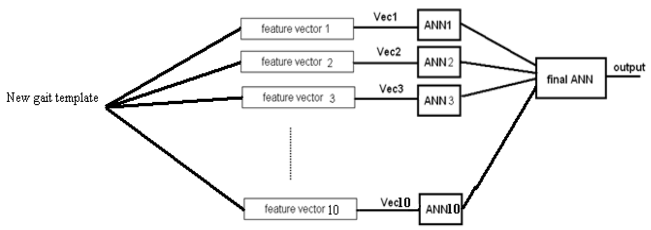

Fig8: Final recognition diagram

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 and diagonal data show the correct result. Hence other data determine the wrong result for each row person.

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