Combined DCT, Radon Transform and 2DPCA Based Approach for Gait Recognition

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Abstract

In this paper, a method for gait recognition using DCT, Radon Transform (RT) and 2DPCA is proposed. DCT is used to extract the features of an image with reduced redundancy. RT is used to extract the features of the DCT transformed image, since RT provides information in polar coordinates. Then 2DPCA is applied on the DCT and Radon Transformed images to reduce the dimensionality. The obtained features are used to recognise the gait sequences by considering standard CBSR database. It is observed from the simulation results that the recognition rate is higher.

1. Introduction

Among the recent developments in biometrics, gait recognition is a powerful technique in identifying or verifying a person by considering the walking styles of the individuals. The main advantage of the gait based recognition is that the gait information can be captured easily. There are different biometric techniques used for person identification including face, iris, fingerprint recognition, etc. Unlike these techniques, gait can be captured by using a camera without the notice of the observed object and the image is processed with low resolution.

In gait based recognition, sensors are generally used to capture the walk of persons. Based on the sensors used, these systems are categorised into three types namely; wearable sensor based, floor sensor based and motion vision based. Motion vision techniques are employed in different conditions compared to wearable sensor and floor sensor based. Motion vision is used for various monitoring and surveillance purpose. In wearable sensor technique, the sensors can be placed on any part of the body as per the characteristics of the sensor. It is mainly used to detect the walking styles. Floor sensors are used calculate the necessary measurement. For this the sensors are placed into or on the floor.

This paper is organised into six sections. Section 2 reviews the literature about gait recognition methods. Overview on DCT, RT and PCA is presented in section 3. Section 4 discusses the proposed methodology. Simulation results are reported in section 5. Finally, conclusions drawn from this work are presented in section 6.

2. Literature Review

In the literature, there are many methods available for gait recognition.

E.Murat [2] proposed a view-invariant approach for human identification at a distance, using gait recognition. Their paper described a simple and efficient gait recognition method based on PCA. Huang and Boulgouris [3] proposed a gait recognition system using several views. In each view an unequal discrimination power. They used six views from MoBo database. Gait cycles which are combines resulted in improvised results. They obtained a recognition rate of above 95%. Q.Cheng, B.Fu, and H.Chen [4] proposed a gait recognition based on PCA and Linear Discriminate Analysis(LDA). PCA is used to reduce the dimensions and LDA is used to optimize the pattern class. Their experimental results show the PCA and LDA based gait recognition algorithm is better than that based on PCA. Chen, Yunhong [5] proposed a new method for gender recognition via gait silhouettes. For this they used radon transform and Relevant Component Analysis(RCA). Radon Transform is applied to obtain gait templates and RCA is employed on the radon transformed templates to get a maximum likelihood estimation of the within class covariance matrix. They calculated Mahalanobis distances and measured gender dissimilarity in recognition. The Nearest Neighbor (NN) classifier is adopted to determine whether a sample in the Probe Set is male or female. They obtained a recognition rate of 95%. H. Ali, Jamal Dargham, Chekima Ali, Moung [1] proposed a gait recognition system using Principle Component Analysis(PCA) and Radon transform and achieved the recognition rates. They have used the images of slow walk, fast walk and carrying a ball walk for recognition and obtained rate recognition that is above 95%.

In this paper, in order to obtain better recognition rate, we present a gait recognition method that combines DCT, RT
and 2DPCA. This technique provides the combined advantages of DCT, RT and 2DPCA.

3. Overview on DCT, Radon Transform, 2DPCA

A. Discrete Cosine Transform (DCT):

DCT is used to know frequency components present in the image[6]. DCT mainly reduces the redundant information present in the image. Orthogonality, symmetry, separability, decorrelation are the important properties of the DCT.

The DCT coefficients for the transformed output image \(Y(u,v)\) with an input image \(f(x,y)\) can be calculated by using the equation - (1). \(MxN\) is the pixel dimensions of the input image \(f(x,y)\). The intensity value of the pixel in row ‘M’ and column ‘N’ of the image is given by \(f(x,y)\) and \(Y(u,v)\) is the DCT coefficients in row ‘u’ and column ‘v’ of the DCT matrix.

\[
Y(u,v)=\sum_{x=0}^{M-1}\sum_{y=0}^{N-1} f(x,y) \cos \left(\frac{2\pi x u}{M}\right) \cos \left(\frac{2\pi y v}{N}\right)
\]

where

\[
\alpha_u = \begin{cases} 
1 & u = 0 \\
2 & u = 1, 2, \ldots, M-1 
\end{cases}
\]

\[
\alpha_v = \begin{cases} 
1 & v = 0 \\
2 & v = 1, 2, \ldots, N-1 
\end{cases}
\]

B. Radon Transform:

Among the various transforms available, the radon transform [7] is an effective one in identifying the feature required. The Radon transform maps the Cartesian image \(f(x,y)\) into the polar transformed image \(R(\rho,\theta)\). Radon transform on an image \(f(x,y)\) for a given set of angles computes the projection of the image along the given angles. The resulting projection is the sum of the intensities of the pixels in each direction. The resulting image after Radon transform is \(R(\rho,\theta)\).

Mathematically \(\rho\) is defines as \(\rho = x\cos\theta + y\sin\theta\).

Radon transform[7] of an image \(f(x,y)\) can be defined as,

\[
R(\rho,\theta) = \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} f(x,y) \delta(\rho - x\cos\theta - y\sin\theta) dx \, dy
\]

where \(\delta(\cdot)\) is the Dirac delta function.

C. Principal Component Analysis (2DPCA):

PCA is mainly used to recognise the patterns in high dimensional images without much loss of data[8]. This is a statistical method used for the image representation. The principal component analysis is also called as Karhunen-Loeve expansion. This is widely used in the areas of pattern recognition and computer vision.

There are two types of PCA namely, 1DPCA and 2DPCA. Compared to 1DPCA, 2DPCA is advantageous because in latter there is no need to transform the 2D image matrix into vector. Further, the image covariance matrix is calculated directly and eigen vectors are used for extracting the features in 2DPCA. Hence, 2DPCA [8] is used in this work and the details are as presented below.

Take an \(n\)-dimensional unitary column vector ‘P’. To project an image ‘I’ an \(m\times n\) random matrix; onto ‘P’ we use the following linear transformation,

\[
F = IP
\]

We obtain a projected feature vector ‘P’ of the image ‘I’. The trace of the covariance matrix of the projected feature vectors will result in the total scatter of the projected samples.

Let \(C_p\) denotes the covariance matrix of the projected feature vectors of sample images and trace of \(C_p\) is denoted as \(tr(C_p)\).

The covariance matrix \(C_p\) is denoted by

\[
C_p = E(F - EF)(F - EF)^T
\]

\[
= E(I - E(I)P)(I - E(I)P)^T
\]

Then,

\[
tr(C_p) = P^T[E(I - E)I^T](I - E)IP
\]

‘\(G_j\)’ be called as the image covariance matrix which can be extracted by using the sample images. Let us consider ‘\(N\)’ training sample images, the \(j\)th image is given by \(m\times n\) matrix \(I_j\) \((j=1,2,\ldots,N)\). The average of training images is given by \(\bar{I}\).

Therefore \(G_j\) is given by

\[
G_j = \frac{1}{N} \sum_{j=1}^{N} (I_j - \bar{I})^T(I_j - \bar{I})
\]

‘\(P_{opt}\)’ is unitary vector which maximizes the total scatter of the projected samples called as ‘optimal projection axis’ i.e., eigen vector of \(G_j\) corresponds to the largest eigenvalue g.
We take set of orthogonal projection vectors of 2DPCA i.e., $P_1, P_2, \ldots, P_g$ for feature extraction for the given image I, let

$$F_k = IP_k, \quad k=1,2,\ldots,g$$

Thus we get $F_1, F_2, \ldots, F_g$, a family of projected feature vectors called as principal component vectors. These vectors are used to form a matrix called feature matrix (or) feature image of sample image 'I' given by

$$B = [F_1, F_2, \ldots, F_g]$$

4. Proposed Methodology

In this paper, we make use of DCT, Radon transform and PCA based method for better results. Fig.1 shows the block diagram for gait recognition using DCT, Radon and PCA.

Firstly, DCT transform is applied to the 2-D gait images (silhouettes). The obtained DCT coefficients are applied to 2D Radon transform to obtain the features in the polar coordinates. PCA is used for finding the principal components of the DCT and Radon transformed images. This gives the required feature vector of the gait image. The test images are also processed in the same manner to evaluate the feature vector. To compare the feature of the test image with the features of the training images, we make use of Euclidean distance as the matching criteria. The distance between two feature matrices $B_i = [F_1^{(i)}, F_2^{(i)}, \ldots, F_g^{(i)}]$ and

$$B_j = [F_1^{(j)}, F_2^{(j)}, \ldots, F_g^{(j)}]$$

is defined by

$$d(B_i, B_j) = \sum_{k=1}^{g} \left| F_k^{(i)} - F_k^{(j)} \right|_2$$

Where $\left| F_k^{(i)} - F_k^{(j)} \right|_2$ denotes the Euclidean distance between the two principal component vectors $F_k^{(i)}, F_k^{(j)}$.

5. Simulation Results

In order to verify the proposed approach to gait recognition we have considered standard CBSR gait database[9]. This database consists of 20 persons walk sequences and four sequences captured with camera positioned at 0 degrees, 45 degrees and 90 degrees. Some of the silhouettes of this database is shown in Fig.2.

The method discussed in section 4 is applied on this database. We considered five frames for each gait sequence. DCT is computed for every frame and then radon Transform is computed for each of the DCT transformed image and then 2DPCA is used to extract the features of these five transformed images. Same procedure is followed for the test images also.

Some of the test gait sequences are also shown in Fig.3. Euclidian distance calculations are done for each of the test images using the proposed method and the results are shown in the table 1 to 5. In order to compare our results the simulation are also carried out using the method discussed in [1]. It is observed from the simulation results given in tables 3 and 4 that the method proposed in [1] fails in recognizing the test gait sequences 3 and 4, whereas our method recognizes correctly.

It is found that the recognition rate using the proposed method is 98.2% and using the method discussed in [1] is 96.3%. The proposed method provides better recognition accuracy.

6. Conclusions

Gait recognition method using DCT, Radon Transform and PCA is proposed in this paper. DCT captures the features of an image by reducing the redundant information present in the image. Radon Transform provides mapping from Cartesian co-ordinates to polar co-ordinates. Finally PCA is applied on the DCT and Radon transformed image to reduce
the dimensionality. The use of DCT and Radon Transform provides better representation of the given silhouette sequences. From the simulation results it is observed that the recognition rate is higher. Further work in this direction will be to identify algorithm for faster computation. Further the same experiment is to be repeated by taking real time gait images.

Fig.2. Some sample image sequences (silhouettes) of 10 persons walk in CBSR database.

Fig.3. Some sample test image sequences (silhouettes) of 5 persons walk in the gait recognition experiment.

<table>
<thead>
<tr>
<th>Training image</th>
<th>Euclidian distance using RT and PCA</th>
<th>Euclidian distance using DCT, RT and PCA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Person 1</td>
<td>0.0064e+003</td>
<td>0</td>
</tr>
<tr>
<td>Person 2</td>
<td>5.8649e+010</td>
<td>963.1017</td>
</tr>
<tr>
<td>Person 3</td>
<td>5.4207e+009</td>
<td>387.9078</td>
</tr>
<tr>
<td>Person 4</td>
<td>3.2157e+003</td>
<td>69.7824</td>
</tr>
<tr>
<td>Person 5</td>
<td>2.4428e+010</td>
<td>2.1566</td>
</tr>
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</table>
Table 2: Euclidian distance calculations for test image 2.

<table>
<thead>
<tr>
<th>Training image</th>
<th>Euclidian distance using RT and PCA</th>
<th>Euclidian distance using DCT, RT and PCA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Person 1</td>
<td>5.86e+010</td>
<td>963.1017</td>
</tr>
<tr>
<td>Person 2</td>
<td>0.04e+008</td>
<td>0</td>
</tr>
<tr>
<td>Person 3</td>
<td>2.84e+010</td>
<td>128.5617</td>
</tr>
<tr>
<td>Person 4</td>
<td>5.86e+010</td>
<td>514.3957</td>
</tr>
<tr>
<td>Person 5</td>
<td>7.375e+009</td>
<td>874.1088</td>
</tr>
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Table 3: Euclidian distance calculations for test image 3.

<table>
<thead>
<tr>
<th>Training image</th>
<th>Euclidian distance using RT and PCA</th>
<th>Euclidian distance using DCT, RT and PCA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Person 1</td>
<td>169.46</td>
<td>238.919</td>
</tr>
<tr>
<td>Person 2</td>
<td>5.864e+010</td>
<td>242.638</td>
</tr>
<tr>
<td>Person 3</td>
<td>5.418e+010</td>
<td>17.963</td>
</tr>
<tr>
<td>Person 4</td>
<td>1.908e+003</td>
<td>50.458</td>
</tr>
<tr>
<td>Person 5</td>
<td>2.442e+010</td>
<td>195.677</td>
</tr>
</tbody>
</table>

Table 4: Euclidian distance calculations for test image 4.

<table>
<thead>
<tr>
<th>Training image</th>
<th>Euclidian distance using RT and PCA</th>
<th>Euclidian distance using DCT, RT and PCA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Person 1</td>
<td>63.553</td>
<td>121.320</td>
</tr>
<tr>
<td>Person 2</td>
<td>5.864e+010</td>
<td>400.774</td>
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<tr>
<td>Person 3</td>
<td>5.419e+009</td>
<td>75.356</td>
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<tr>
<td>Person 4</td>
<td>2.375e+003</td>
<td>7.080</td>
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<tr>
<td>Person 5</td>
<td>2.442e+010</td>
<td>91.125</td>
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Table 5: Euclidian distance calculations for test image 5.

<table>
<thead>
<tr>
<th>Training image</th>
<th>Euclidian distance using RT and PCA</th>
<th>Euclidian distance using DCT, RT and PCA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Person 1</td>
<td>1.876e+010</td>
<td>22.560</td>
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<tr>
<td>Person 2</td>
<td>1.106e+010</td>
<td>690.851</td>
</tr>
<tr>
<td>Person 3</td>
<td>4.016e+009</td>
<td>223.369</td>
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<tr>
<td>Person 4</td>
<td>1.815e+010</td>
<td>12.987</td>
</tr>
<tr>
<td>Person 5</td>
<td>3.273e+008</td>
<td>10.7688</td>
</tr>
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</table>

References:


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