Abstract: Automated biometric systems are most popular to characterise a person for identification and verification purposes because of its robustness. Among biometric characteristics like face, fingerprint, iris etc, hand geometry is well known used because of its simplicity. In this paper, we propose an approach which combines hand geometry and palm print characteristics and Scale Invariant Feature Transform (SIFT) is used to extract features. To improve the performance optimization is performed using genetic algorithm which reduces the complexity as by this we can find more accurate feature dataset. In proposed work features extracted from scale invariant feature transform are invariant to scale are passed to genetic algorithm for optimization. The optimized features from both the hand and palm print are then classified individually using one of the distance classifier called hamming distance. Finally both the modalities are fused together for identification purpose. Experimental results are improved as compare to previous proposed work. Experiments have been taken under MATLAB software toolbox.

Keywords: Hand Biometrics, palm print, scale invariant feature transform, genetic algorithm, fusion information

1. Introduction

Biometric is a measurement of life and life is related to our characteristics which can be use for measurement. Biometric is a branch of digital image processing which deals with the processing of digital images. Biometric is a class divided into categories based on its characteristics like our physical appearance or it can be our behaviour. Generally biometrics is classified as physiological characteristics and behavioural characteristics. Former studies the life based on physical appearance like face, iris, fingerprint, hand, palm, retina etc measurements are taken from physical traits while latter studies the life based on behaviour like gait, keystroke, signature, voice etc measurements are taken form behavioural traits. Illustration of biometric characteristics is shown in figure 1 below.

Figure1: Biometric Characterization

The remainder of the paper is organised in following sections. Section 2 covers the related work done by other researchers and their evaluations. Section 3 describes methodology to be followed in the proposed approach and the algorithms which are used are explained in steps. Section 4 exhibits the experimental
results and Section 5 concludes the conclusion and future scope.

2. Related Work

Hand shape geometry is one of the mostly used characteristic [13][3] because of its simplicity. It is easily collected by using any sensor in a convenient way and any other biometric trait can integrate into existing system like palm print and fingerprints. Weather, skin textures are less prominently affect the system.

Biometric systems use hand images and extract palm print out of them as it has unique characteristics like wrinkles, ridges etc which can be used for identification. So[8] proposed method in which palm print are extracted from hand and then features are extracted then by dividing into blocks and standard deviations are used as feature set and classified using time warping. Another study [5] also uses hand and palm print where features are extracted making use of middle three fingers and region of interest. In an approach[1] made where fuse the hand and palm images by extracting features individually from both traits and passed to a classifier. Final decision is made by matching score function.

One of the feature extraction method called SIFT has been used in various researches. [19] Presents an efficient way by fusing features of ear and iris and uses SIFT to extract features from both modalities. Both modalities are first pre-processed differently and then SIFT extract features which are classified using Euclidean distance. Another biometric system [13] fuses hand geometry and palm print employ SIFT to extract features and apply sum fusion rule which provide highly accurate results. [6] Presents distinctive features which are invariant to scale using SIFT. He also proposes that SIFT can be used on large databases as features extracted are highly accurate. Matching is done using fast nearest neighbour method. Another application includes object recognition [7] which uses local features extracted by SIFT as these features are independent of scale, rotation, and noise. Nearest neighbour indexing has been used for matching. The results also perform well on partially occluded images and computation time of less than two seconds. A clustering algorithm employed [15] which uses SIFT points to clustering; further graphs are drawn using this information. Fusing graphs into groups and SIFT achieve good evaluation results.

Optimization is a major concern when deals with large number of features and databases. Such work has been proposed in[16] where hand geometry is used for verification and acquired without making any contact with surface. Extract features via segmentation are passed to genetic algorithm for dimension reduction to eradicate unnecessary features. The results produce almost accurate results. Another study includes genetic algorithm[2] approach is quite different where multiple palm images are integrate using fusion and gabor wavelet transform convolved image so it requires high space to store features which need to be optimized using genetic algorithm. SVM is used to train the features and results are checked on a number of classifiers.

Classification is an important aspect to check the feasibility of any algorithm. [20] presents an effective classifier called hamming distance. They have used texture based feature extraction for palm images using gabor filter and results are matched using hamming distance classifier which provide remarkable results. [17] make use of various pattern recognition techniques based on a number of classifiers. They have employed various distance classifiers such as hamming distance, Euclidean distance, neural networks and GMM. Almost all the classifiers used achieve good results. There are various surveys on hand biometric system. [14] They describe alignment algorithm like PCA, ICA etc and for matching a number of classifiers are described with their benefits and methodology like Euclidean, hamming, mahalanobis and absolute distance.

Various studies have been done on fusion strategies like [10] develops a system of various classifiers and combined them to make joint decision. They have used product, sum, median, max and min rule etc as combining rules. Gaussian, neural net and HMM classifiers find out classification rates. They proved that the sum rule outperforms others. Another study combine fusion of face and voice [11] and experiments are done using rules like sum rule and vote rule to check the results. In this case training is not required. In their work from the experimental results they have proved that simple rules provide better results than the rules which require training first. A biometric system described by[13] also uses sum rule at the matching score level. They have proved that simple rules performed well when fused at matching score level rather than at the representation level.
3. Methodology

The goal of the proposed approach is to achieve the performance by improving the efficiency of the system in terms of accuracy, complexity and dimensionality. It focuses on improving the performance of the system by following this methodology:

1. Input the image
2. Pre-processing on input image.
3. Feature Extraction By SIFT.
4. Optimization by Genetic algorithm.
5. Matching using Hamming Distance.
6. Fusion of features for decision.

The above objectives are to be met in the proposed approach. All the steps are to be followed one by one in this order. The figure 2 explains the flowchart of the methodology used in the proposed work. First the image is pre processed so that can be used for further processing and then Scale invariant features are extracted from the image and those features are reduced so that only necessary features remain which contains useful information.

![Flowchart of Proposed Methodology](image)

3.1 Input the Image

Required Hand and Palm Image is input into the system so as to start processing. These images can be captured using sensor and cameras. As soon as the image is input it is checked whether it is coloured or in gray scale. Try catch Function is applied to check the image, if it is in coloured format convert it into gray scale using the function rgb2gray. In this way conversion is performed. Figure3 and Figure4 shows the input images of hand and palm.

![Figure 3: Examples of Hand Images](image)

![Figure 4: Examples of Palm Images](image)

3.2 Preprocessing

After First step image is ready to process. As image need to be more represent able to execute further process so pre-processing is required where image is enhanced using contrast improvement and size change. So input image is filtered using a two dimensional filter created by fspecial which sharpens the image to improve contrast. Imfilter command applies the filter to process the image and size is controlled using imresize function. Now image is ready for arithematic operations. Figure5 shows pre-processed images of hand and palm.

![Figure 5: Examples of Hand and Palm Images after Pre-processing](image)
3.3 Feature Extraction

Scale Invariant Feature Transform is proposed by [6][7] allowing to describe local features of the image. Later it becomes an emerged algorithm in the field of object recognition and pattern recognition. SIFT features are distinctive in nature because they exhibit the properties like invariance to scale, rotation, noise and illumination changes. So, the features extracted by SIFT have high probability to match even in case of large databases. SIFT original formulation works to find interest points from gray scale image and around those interest points the whole structure is summarised. These interest points are also called key points.

Major steps of SIFT is as follows:

1. Scale Space Extrema Detection
2. Key point Localization
3. Orientation assignment
4. Key point Descriptor

Figure 6: SIFT feature Extraction on Hand Image

Scale-space extrema detection: Difference of Gaussian is used for implementing first step of algorithm which is subtracting one image from other and repeat this process for a number of times. So it searches for the scale and image locations. After getting difference values which are extremes compared to neighbourhood are selected as key points.

Key point localization: At this step key points are selected on some measurement which is defined in terms of threshold. Selected points must be free from noise sensitivity and edge of local texture. So, key points which are stable in measurement are selected for next step.

Figure 7: SIFT feature extraction of Palm Image

Orientation assignment: Aim is to provide invariance to orientations. For this to each key point location, an orientation is assigned. The most prominent orientation which are find by histograms is selected from collection made by gradient directions and magnitudes.

Key point descriptor: Finally to generate feature in the region around each key point on selected scale local image gradients are measured. A representation has been transformed which defines significant levels of distortion and change in illumination.

In this way SIFT features are extracted from image and are shown in Figure 5 and Figure 6.

3.4 Optimization

Genetic Algorithm outperforms the conventional artificial intelligence due to its robustness and ability to solve constrained and unconstrained optimization problems. It also provide significant results when to work on high dimensional surface. Genetic algorithm works in a manner of cycle where firstly it is initialised and then fitness of all the individuals in the population is evaluated. On measuring the fitness of individuals, a new population is created using operations of crossover, mutation etc. Finally new population is used for iteration while discarding the old population [16].

In proposed approach all the features extracted using SIFT contains a large number of features that densely cover the image over the full range of scales and locations[7]. So optimization is required so reduce the complexity, we have to reduce dimension. For this SIFT features are
loaded for feature reduction process. Using the ‘optimset’ function genetic is initialized using its parameters. Now on the requirement of features at classification satge, fitness function is defined in that way and ‘ga’ function is used. Genetic works repeatedly while modifying data. Store the reduced set of features like this

\[ \text{ReducedFeature, Featurevalue} = \text{ga(FitnessFunction, numberOfVariables, 1, [], [], [], [], opts)}. \]

Parameters like Fs and Ft decide the fitness function where Fs is the current element of the feature value and Ft is the average feature value of the feature set of that stream. Consider the following set of example

Suppose we do have feature like: 4 2 3 1

8 5 7 6

Here when taken row 1 value of Fs will 4,2,3,1 and corresponding value of Ft for this row will be mean of all Fs values that is \((4+2+3+1)/4=2.5\). Similarly for second row Ft will be \((8+5+7+6)/4=6.5\). Defined fitness function applies the condition of if Fs<Ft then is not selected otherwise selected.

### 3.5 Matching

Hamming distance classifier has been used in the proposed work. There are various distance classifiers defined by various studies with their evaluations [14][17][20]. It used binary information for classification. Images to be compared must contain values of same size and it return binary value of 0 and 1 for match decision. Distinct process of hamming from other distance classifier like Euclidean is that it only uses discrete value of 0 and 1 for decision rather than choosing floating value like 0.4 0.78 etc so this makes matching process easy. So it compares test data with the images in stored database and on basis of matching points decide whether to return 0 or 1.

### 3.6 Fusion

Matching of hand and palm images are done individually and values of measurement parameters like FAR, FRR and RR are stored separately for both hand and palm images. Where FAR is false acceptance rate which means the illegitimate image is falsely accepted by the system. FRR is false rejection rate where legitimate image is falsely rejected by the system and RR is recognition rate in percentage which gives accuracy. Three values are calculated individually for hand image and for palm image. While doing this if test image is matched, variable named HR and PR store the result and return 1 for matching and 0 for non matched where HR is for hand and PR is for palm. It also stores index at which image is found as variable HRN and PRN. These variables are used as conditions when fusion is performed because at fusion stage if the values of HR=PR=1 and HRN=PRN then only the fusion result will be recognised otherwise system will display not recognised. The values of FAR, FRR and RR will be average of the values calculated at last stage of matching.

### 4. Experimental Results

The experiments are performed on MATLAB using IITD database. In proposed approach images of both hand and palm are required. Images are in jpeg format. In experiments 12 images of both hand and palm print has been used for testing and 15 images are trained for database. To compute the performance of biometric system several parameters are calculated such as false acceptance rate (FAR), false rejection rate (FRR) and recognition rate (RR) which represents accuracy of the system.

Now to access the performance of the system verification experiment is performed. The matching is carried out using two samples and values of FAR, FRR and RR is computed based on matching points of similar key points. Table 1 demonstrates the experimental evaluations in which all the 12 images are tested and values are recorded and shown in table 1. The results achieve results of 98.54%. Table is described in five columns where first represents the image number next columns presents FAR, FRR, RR and status tells matched for M and non matched for NM. The results are described below in table1.

<table>
<thead>
<tr>
<th>Image No.</th>
<th>FAR</th>
<th>FRR</th>
<th>RR</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.47</td>
<td>0.94</td>
<td>98.60</td>
<td>M</td>
</tr>
<tr>
<td>2</td>
<td>0.52</td>
<td>1.05</td>
<td>98.43</td>
<td>M</td>
</tr>
<tr>
<td>3</td>
<td>0.52</td>
<td>1.05</td>
<td>98.46</td>
<td>M</td>
</tr>
<tr>
<td>4</td>
<td>0.47</td>
<td>0.94</td>
<td>98.60</td>
<td>M</td>
</tr>
<tr>
<td>5</td>
<td>0.49</td>
<td>0.98</td>
<td>98.54</td>
<td>M</td>
</tr>
<tr>
<td>6</td>
<td>0.41</td>
<td>0.81</td>
<td>98.78</td>
<td>M</td>
</tr>
<tr>
<td>7</td>
<td>0.45</td>
<td>0.90</td>
<td>98.64</td>
<td>M</td>
</tr>
<tr>
<td>8</td>
<td>0.53</td>
<td>1.06</td>
<td>98.41</td>
<td>M</td>
</tr>
<tr>
<td>9</td>
<td>0.46</td>
<td>0.93</td>
<td>98.60</td>
<td>M</td>
</tr>
<tr>
<td>10</td>
<td>0.50</td>
<td>0.99</td>
<td>98.50</td>
<td>M</td>
</tr>
<tr>
<td>11</td>
<td>0.43</td>
<td>0.88</td>
<td>98.69</td>
<td>M</td>
</tr>
<tr>
<td>12</td>
<td>0.57</td>
<td>1.13</td>
<td>98.30</td>
<td>M</td>
</tr>
<tr>
<td>Average</td>
<td>0.49</td>
<td>0.98</td>
<td>98.54</td>
<td></td>
</tr>
</tbody>
</table>

Below is the figure8 representing the graph describing values of FAR and FRR of the input images. Accuracy graph is shown in Figure9.
In our proposed approach we have also compared our technique with others and experimental results are recorded in table2. Proposed approach is compared with two other evaluations one is when using the SIFT algorithm only and perform matching using fusion sum rules as described in work [13] on our database the results produce only recognition rate of 93.23% and in proposed work we also test applying SIFT+GA to simple fusion sum rule on database and it achieve results of about 96.01% which is better than using alone SIFT. By this experiment it becomes clear that optimization achieve remarkable accuracy and performance. Also hamming distance improves system too as it receive only discrete values so return more accurate results. All these three comparisons are shown in table2 Where FAR, FRR and RR are recorded for each technique. These experiments are also performed on 12 images of each hand and palm print. Proposed approach over perform the other two.

Table 2: Comparison Evaluation of Different Approaches

<table>
<thead>
<tr>
<th>Technique</th>
<th>FAR</th>
<th>FRR</th>
<th>RR</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIFT+ Sum rule[13]</td>
<td>5.01</td>
<td>1.76</td>
<td>93.23</td>
</tr>
<tr>
<td>SIFT+GA+Sum rule</td>
<td>1.51</td>
<td>2.48</td>
<td>96.01</td>
</tr>
<tr>
<td>Proposed Approach</td>
<td>0.49</td>
<td>0.98</td>
<td>98.54</td>
</tr>
</tbody>
</table>

Figure 8: Graph of FAR and FRR

Figure 9: Accuracy graph

Figure 10: Graph of FAR Comparison

Figure 11: Graph of FRR Comparison
As shown in table 2, our proposed approach clearly provides more encouraging results as compare to others with recognition rate of 98.54%. Also the graphs depicts the comparison of FRR, FAR and Accuracy.

5. Conclusion

In this paper, we proposed an approach for biometric fusion of hand and palmprint, the combination of which achieve significant results. SIFT descriptors are extracted from hand and palm images which are reduced using the optimization technique called genetic algorithm which plays an important role here as multiple features may complex the system hence affect the performance. Experiments are applied on images of IITD database. Hamming distance is used for the matching of test images. Experimental results exhibits the performance level of technique and it proves to achieve encouraging results. Future work may try the concept of fusing other biometric modalities like iris, fingerprint etc so as to improve efficiency more of our proposed approach.

References


