CHAPTER 5

GAIT RECOGNITION USING MULTI-OBJECTIVE ENHANCED ADAPTIVE FUSION TECHNIQUE BY BAT (GRMEAFBAT) ALGORITHM

5.1. OVERVIEW

This chapter discusses the gait recognition system using multi-objective enhanced adaptive technique based on the BAT algorithm. The extraction of features for recognition forms the major step in the recognition process which helps in improving the performance of the system. This chapter describes how the multi-objective based BAT algorithm improves the performance of the human gait recognition system by including additional features for recognition process.

5.2. INTRODUCTION

Gait recognition is generally a difficult process as the appearance varies with various co-factors. The gait actually considers the most effective parts and the less effective parts for recognizing the persons. But many techniques have never used the less effective parts as it meant that these parts do not contain necessary information. The human identification using gait does require these less effective parts as they contain some vital information. The normal procedure is collecting these features from the video sequence by segmenting it to many blocks. The features extracted are maintained as training set. This training set contains the biometric set of different persons in a locality. Using these data the original video sequence is compared and the human identification is performed efficiently.

In this work, the efficiency of using the multi-objective PSO for gait recognition (GRMAFPSO) is analyzed and it is found that the performance can be further improved if additional features are included in the recognition. The shape of gait has the potential in efficient identification. As a result, the shape features from the human body are considered especially from the lower parts including feet, knee, thigh, etc. Since the shape of human body that can be traced from camera images varies due to noise in the images and also due to motion, it becomes complex to extract these features. Moreover, some parts like fingers can move in different shapes and hence cannot be used for
identification. As a result only selective parts as mentioned above are considered in this work and BAT algorithm is introduced to select optimal features

5.3. PROPOSED EFFICIENT GAIT RECOGNITION SYSTEM

In this section, the previous research work namely GRMAFPSO is further improved by considering the shape features. In this work, recognition is further improved by taking the shape features into account. The shape features are fused along with the most effective parts and best informative less effective part using PSO. This work further explores the possibility of improving the recognition accuracy by using BAT algorithm in place of PSO for adaptive fusion of shape, best informative less effective part and most informative parts

5.3.1. Gait Recognition using MPSO with Shape Features

The identification of individuals using gait by considering the most effective parts and best informative less effective part is accurate but the recognition can further be improved when the shape descriptor feature is added. This leads to the inclusion of shape sequence descriptor to extract the shape features in the present recognition. First the silhouette segmentation is performed to derive the human image free of background. A bounding box is placed to fit the motion image and this feature is the complete image feature. From this image, the most effective and less effective features are extracted. The shape of the movable parts varies with motion and hence requires adaptive approach to trace the shape. The presented descriptor is maintained as adaptive to adjust to the features. The shape sequence descriptor presents the angular radial transform that performs the extraction of shape features. These shapes are converted from the frequency domain by using Fast Fourier Transform (FFT).

The following figure 5.1. shows the silhouettes of human gait sequence, in which x-axis and y-axis represents the rotated angle in degrees.
The shape features cannot be traced simply by using the extracted regions of the silhouette directly into the angular radial transform as they do not provide changes in shapes adequately. Hence the fixed region is used throughout gait sequence. The centre of region of the silhouette should be made to coincide with their respective silhouette.

The angular radial transform can be represented in a matrix form whose coefficients can be obtained by convolution between transform basis and regions of silhouette. In the silhouette the vertical axis represents the radial component index $n$ while the horizontal axis represents the angular component index $m$. Figure 5.2 shows the angular radial components of the given gait silhouette.
Figure 5.2. Results of Angular Radial Transform

From the equation (5.1) and (5.2), let $A_m$ be the angular component and $R_n$ be the radial component. $V_{nm}$ be the basis function and $f(\rho, \theta)$ is the region.

Consider $A_m$ is the angular component and $R_n$ is the radial component, $V_{nm}$ is the basis function and also $f(\rho, \theta)$ is the region. These are defined by the following equations (Jeong et al., 2013):

$$A_m(\theta) = \frac{1}{2\pi} \exp(jm\theta) \quad (5.1)$$

$$R_n(\rho) = \begin{cases} 1, & n = 0 \\ \frac{1}{2} \cos(\pi n \rho), & n \neq 0 \end{cases} \quad (5.2)$$

$$V_{nm}(\rho, \theta) = A_m(\theta) R_n(\rho) \quad (5.3)$$

The $nm^{th}$ coefficient is given by $F_{nm}$ from the equations (5.4) and (5.5) as follows:
The shapes along with the movable parts specifically the leg parts are traced since noise is the major factor for deciding the shape features which increases with the motion. Only the shape features of the movable parts are considered. These involve the shape of thigh and knee which provides the variation in motion but within the fixed limit and these are determined by the threshold. These shapes are utilized for the gait recognition including with the most effective and best informative less effective parts. Once the features are extracted then the fusion of the features are required. The fusion of the shape features along with the most effective and best informative less effective parts are achieved by using the multi-objective adaptive PSO algorithm. The shape features are not entirely required for tracing the identity since only few parts retain the similar shape while many body parts are varies during motion. Hence, it is required for selecting the best shape features for improving the recognition accuracy.

5.3.2. Algorithm: Gait Recognition using MPSO

1. Initialize the particle.
2. Create the training data.
3. Utilize the shape descriptor sequence for shape features.
4. Extract the shape features based on angular radial transform along with less effective parts and threshold $t_i$.
5. For each particle do
6. Determine the recognition accuracy, true positive, true negative as fitness values. The fitness is calculated by fusion of most effective parts and shape features with adaptively selected best informative less effective part.
7. If calculated fitness value of particle is higher than the current fitness value, then set the current position (threshold and less effective part) as local best.
8. Select the particle with the best fitness value as global best (gbest).
9. Calculate the particle velocity
10. Update particle position
11. While maximum iteration until the best fitness value occurs with the best threshold and best less effective parts.
12. Return the best less effective parts, and best threshold with shape feature.
13. End
14. Obtain Recognition results of an individual using Euclidian distance between fused feature (most effective and best less effective with shape feature) of probing and gallery sequences.

5.3.3. Gait Recognition using BAT Algorithm with Shape Features

In this section, the gait recognition using BAT algorithm including with the shape features is discussed. The gait recognition using BAT algorithm (Yang 2011) is proposed since the fusion of shape features including with the effective parts are not sufficiently achieved by using the multi-objective adaptive PSO. The effective features are extracted from the silhouettes and the best features are selected based on the BAT algorithm. The effective features including with the most effective parts, best informative less effective parts are obtained by the effect of different cofactors and the most informative less varying shape features. The shape features are extracted by using the shape descriptors in terms of employing the angular radial transform. Hence, the shape features are extracted and FFT is utilized for converting them from the frequency domain. The most informative and less varying shape features are utilized in identification since the other parts are varying with the motion and do not fix in the limit. The features are extracted and the required features are selected based on the adaptive technique. The best features are selected including with the threshold value and the best fitness value. The efficient features are required for identifying an individual which are considered for constructing the training database.

The fusion is achieved by using the BAT algorithm based on an adaptive manner. The utilization of BAT algorithm is combining the features together effectively. The BAT algorithm operates perfectly since its productive behavior. Initially, it sorts the features and then selects the best feature among them. After the selection of features, the algorithm compares its efficiency of features other than the best features. Hence, the best results are obtained including with the reduced effort or input.

5.3.4. Algorithm: Gait Recognition using BAT Algorithm

1. Initialize threshold, less effective features as training set \( \{ x_1, x_2, \ldots, x_n \} \).
2. Initialize the bat population \( b_i, i = 1, \ldots, n \).
3. Define gait recognition accuracy as objective function (fitness value) \( f(x), x = (x_1, \ldots, x_d)^T \).
4. Define the pulse frequency \( f_i \in [f_{min}, f_{max}] \).

5. Initialize the pulse rate \( r_i \) and loudness \( A_i \).

6. Evaluate recognition accuracy, true positive, true negative as fitness values \( f(x) \) of each BAT. The fitness is calculated by Fusion of most effective parts shape features with adaptively selected best informative less effective part.

7. \( While(t < T_{max}) \) //Number of iterations

8. Select most effective feature shape features, less effective feature with new threshold by adjusting pulse rate of BAT

   Update the velocities, positions and frequencies as follows:

   \[
   f_i = f_{min} + rand(0,1)(f_{max} - f_{min})
   \]

   \[
   v_i(t) = v_i(t-1) + f_i(x_i(t) - x(t))
   \]

   \[
   x_i(t) = x_i(t-1) + v_i(t)I{[r_{rand}(0,1) > r_i]}
   \]

9. Select the best feature with the best threshold \( t_i \) for higher fitness value.

10. Generate the suitable features around the best feature.

11. End if

12. Select most effective feature shape features, less effective feature with new threshold by adjusting loudness of BAT

   \[
   If\left( r_{rand}(0,1) < A_i and f(x_i) < f(x) \right) \]

13. Accept the new feature with the threshold \( t \).

14. Increase \( r_i \) and reduce \( A_i \) as follows:

   \[
   A_i(t+1) = aA_i(t)
   \]

   \[
   r_i(t+1) = r_i(t)[1 - \exp(-\gamma t)]
   \]

15. End if

16. Rank the bats and obtain the current best feature as local best.

17. End while

18. End

19. Obtain Recognition results of an individual using Euclidian distance between fused feature (most effective and best less effective) of probing and gallery sequences.
Chapter 5

5.4. PERFORMANCE EVALUATION

In this section, the performance of the proposed gait recognition system including with the shape features based on the multi-objective adaptive particle swarm optimization algorithm and BAT algorithm are illustrated. The effectiveness of the proposed system is compared with the previous techniques in terms of precision, recall, recognition accuracy and ROC curve. According to the experimental results, the efficiency of the proposed system is demonstrated.

5.4.1. Precision

Precision is calculated based on the retrieval of information at true positive prediction and false positive. It is the fraction of fraction of recognition of parts that are similar. The comparison of precision values for proposed GRMEAFPSO, GRMEAFBAT with GRMAFPSO approach is shown in table 5.1.

Table 5.1. Comparison of Precision

<table>
<thead>
<tr>
<th>Rank</th>
<th>GRMAFPSO</th>
<th>GRMEAFPSO</th>
<th>GRMEAFBAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>0.67</td>
<td>0.69</td>
<td>0.72</td>
</tr>
<tr>
<td>4</td>
<td>0.72</td>
<td>0.731</td>
<td>0.76</td>
</tr>
<tr>
<td>6</td>
<td>0.77</td>
<td>0.795</td>
<td>0.80</td>
</tr>
<tr>
<td>8</td>
<td>0.83</td>
<td>0.86</td>
<td>0.871</td>
</tr>
<tr>
<td>10</td>
<td>0.875</td>
<td>0.881</td>
<td>0.918</td>
</tr>
</tbody>
</table>

Figure 5.3. Comparison of Precision
Figure 5.3 shows the comparison of precision of gait recognition techniques and it is proved that the GRMEAFBAT outperforms other techniques and resulted in accurate gait recognition. In the x axis, number of ranks is taken and in the y axis, precision value is taken. For example, if the rank is 10, then the precision value of GRMEAFBAT is 0.918 which is 4.9% higher than the GRMEAFPSO and 4.1% higher than GRMAFPSO. This result illustrates that the GRMEAFBAT has high precision than all other techniques.

5.4.2. Recall

Recall is measured based on the retrieval of information at true positive prediction and false negative. The comparison of recall values for proposed GRMEAFPSO, GRMEAFBAT with GRMAFPSO approach is shown in table 5.2.

**Table 5.2. Comparison of Recall**

<table>
<thead>
<tr>
<th>Rank</th>
<th>GRMAFPSO</th>
<th>GRMEAFPSO</th>
<th>GRMEAFBAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>0.66</td>
<td>0.683</td>
<td>0.717</td>
</tr>
<tr>
<td>4</td>
<td>0.715</td>
<td>0.73</td>
<td>0.75</td>
</tr>
<tr>
<td>6</td>
<td>0.77</td>
<td>0.792</td>
<td>0.798</td>
</tr>
<tr>
<td>8</td>
<td>0.828</td>
<td>0.859</td>
<td>0.87</td>
</tr>
<tr>
<td>10</td>
<td>0.87</td>
<td>0.88</td>
<td>0.915</td>
</tr>
</tbody>
</table>

**Figure 5.4. Comparison of Recall**
Figure 5.4. shows the recall comparison of different gait recognition techniques and it is clear that the GRMEAFBAT outperforms other techniques and resulted in accurate gait recognition with low recognition time. In the x axis, number of number of rank is taken and in the y axis, recall is taken. When the rank value is 10, the recall of GRMEAFBAT is 0.915 which is 5.1% greater than GRMEAFPSO and also 3.9% higher than GRMAFPSO. This result illustrates that the GRMEAFBAT has high recall rate than all other techniques.

5.4.3. Recognition Accuracy

Accuracy means the proportion of true positives and true negatives among the total number of features examined.

The comparison of recognition accuracy values for proposed GRMEAFPSO, GRMEAFBAT with GRMAFPSO approach is shown in table 5.3.

Table 5.3. Comparison of Recognition Accuracy (%)

<table>
<thead>
<tr>
<th>Rank</th>
<th>GRMAFPSO</th>
<th>GRMEAFPSO</th>
<th>GRMEAFBAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>67</td>
<td>69</td>
<td>72</td>
</tr>
<tr>
<td>4</td>
<td>72</td>
<td>73.1</td>
<td>76</td>
</tr>
<tr>
<td>6</td>
<td>77</td>
<td>79.5</td>
<td>82</td>
</tr>
<tr>
<td>8</td>
<td>83</td>
<td>85</td>
<td>86.5</td>
</tr>
<tr>
<td>10</td>
<td>87.5</td>
<td>88.1</td>
<td>91.8</td>
</tr>
</tbody>
</table>

Figure 5.5. Comparison of Recognition Accuracy (%)
Figure 5.5. shows the comparison of recognition accuracy of gait recognition techniques and it is proved that the GRMEAFBAT outperforms other techniques and resulted in accurate gait recognition. In the x axis, number of subjects is taken and in the y axis, recognition accuracy is taken in percentage. If the rank is 10, then the recognition accuracy value of GRMEAFBAT is 91.8% which is 4.9% higher than GRMEAFPSO and 4.1% higher than GRMAFPSO. This result illustrates that the GRMEAFBAT has high recognition accuracy than all other techniques.

5.4.4. ROC Curve

The gait recognition is evaluated by using the Receiver Operating Characteristics (ROC) curves. The ROC curve is defined as the relation between the False Rejection Ratio (FRR) and False Acceptance Ratio (FAR).

The comparison of FAR versus FRR values for proposed GRMEAFPSO, GRMEAFBAT with GRMAFPSO approach is shown in table 5.4.

<table>
<thead>
<tr>
<th>FAR</th>
<th>GRMAFPSO</th>
<th>GRMEAFPSO</th>
<th>GRMEAFBAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
<td>0.48</td>
<td>0.451</td>
<td>0.427</td>
</tr>
<tr>
<td>0.2</td>
<td>0.41</td>
<td>0.398</td>
<td>0.37</td>
</tr>
<tr>
<td>0.3</td>
<td>0.35</td>
<td>0.341</td>
<td>0.316</td>
</tr>
<tr>
<td>0.4</td>
<td>0.29</td>
<td>0.27</td>
<td>0.25</td>
</tr>
<tr>
<td>0.5</td>
<td>0.24</td>
<td>0.218</td>
<td>0.19</td>
</tr>
</tbody>
</table>

Figure 5.6. Comparison of ROC Curve
Figure 5.6. shows the ROC curves comparison of different gait recognition techniques and it is clear that the GRMEAFBAT outperforms other techniques and resulted in accurate gait recognition with low recognition time. ROC curve determination depends on the values of FAR and FRR. In the x axis, FAR is taken and in the y axis, FRR is taken. If the FAR is 0.5, then the FRR value of GRMEAFBAT is 0.19 which is 20.8% lesser than the GRMEAFPSO and 12.8% lower than GRMAFPSO. This result illustrates that the GRMEAFBAT has better performance than all other techniques.

5.5. CHAPTER SUMMARY

In this chapter, the proposed work of gait recognition using adaptive fusion technique which considers the shape features along with both most effective and best informative less effective parts from human gait is discussed. In this work, shape features along with the most effective and BILE parts are selected based on the proposed MPSO and BAT algorithm. The shape features are extracted by using the shape descriptors and the obtained shape features, most effective and BILE parts are fused by using adaptive fusion technique and recognition is achieved. The experimental results illustrate that the proposed GRMEAFBAT method has better accuracy than other methods.