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Real-Time Face Detection and Tracking Using Binary Particle Swarm Optimization

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Abstract: - **In this research work proposes an innovative method of Real time face detection and tracking. These features used to detect the faces that are extracted from the pre-processed image using the combination of Discrete Fourier Transform (DFT) and Discrete Cosine Transform (DCT). Feature selection process is accomplished using Binary particle swarm optimization (BPSO). The individual stages of the Face Detection system are examined and an attempt is made to improve each stage. DFT and DCT are used for efficient feature extraction and BPSO-based feature selection algorithm is used to search the feature space for the optimal feature subset. The feature subset, representing each image is the face gallery that is used for similarity measurement in the detection stage. For this purpose, the Euclidean classifier is used. This proposed method has expected to produce higher performance under arbitrary variations in illumination, poses and backgrounds with slight occlusions too.**

I. INTRODUCTION

Image Processing and Analysis can be defined as the "act of examining images for the purpose of identifying objects and judging their significance". A major attraction of digital imaging is the ability to manipulate image and video information with the computer. Digital image processing is now a very important component in many industrial and commercial applications and a core component of computer vision applications. Image processing techniques also provide the basic functional support for document image analysis and many other medical applications. The field of digital image processing is continually evolving. Transform theory plays a key role in image processing. Image and signal compression is one of the most important applications of wavelets. Face detection has received an increasing interest as it represents an efficient way to protect personal data in electronic transactions. A detection system helps to prevent the fraud of identity cards, to control the access to banks and airports and to pursuit criminals by external systems of cameras. These innovations appeared thanks to the development of new 3D cameras able to solve specific problems such as illumination and face detection. Face detection is the real time processing of numerical person faces in order to identify, to verify or to categorize these persons. Face detection methods can be distinguished in two large axes: detection of predetermined images or detection of extracted images from video sequences. The detection of video faces is more useful since the use of simultaneous temporal and space information helps in many security systems such as pursuit of criminals or stealers. For example, a face detection system compares the stored criminal faces with those of suspects, which justify the difficulty of its automation.

II. MATERIALS AMD METHODS

A. BPSO

In phase 1, a spectrum-based approach for enhancing the performance of a Face Detection (FD) system [21], employed the unique combination of Discrete Fourier Transform (DFT), Discrete Cosine Transform (DCT) and Binary Particle Swarm Optimization (BPSO)[22]. Individual stages of the FD system are examined and an attempt is made to improve each stage. DFT and DCT are used for efficient feature extraction and BPSO-based feature selection algorithm is used to search the feature space for the optimal feature subset.

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Training and detection from the major stages are showed in FD process. Training stage involves pre-processing, feature extraction, feature selection and creation of face gallery. Detection stage involves pre-processing of the test images, feature extraction, feature selection and classification/identification of these images. Among these, feature extraction and feature selection greatly affect the performance of FD system. ORL database [12] consists of a set of face images taken at different times, varying the lighting and poses. All the images were taken against a uniform background with all the subjects in an upright, frontal position. There are 10 different images of each of the 10 distinct individuals. All images in the database are gray scale and the size of each image is 92×112 pixels.

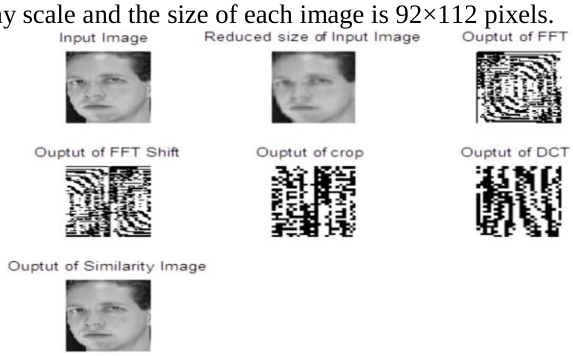

Fig 1 : Step by Step Procedure of Face Detection

The first input image is preprocessed. Then DFT is applied to the preprocessed image and center portion is extracted using rectangular mask to get crop image after that applied DCT to get the enhanced the input image. Finally, the BPSO is applied to the output of the DCT image. Hence, the BPSO is applied and then the similarity image is obtained.

B. BLOCK DIAGRAM OF PROPOSED METHOD

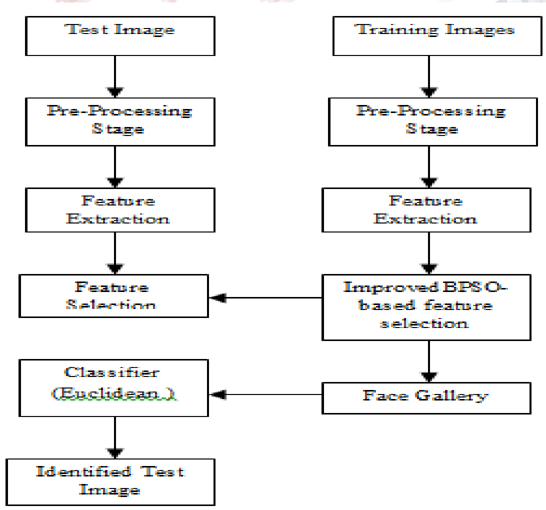

Fig 2: Block Diagram of Proposed Method

It shows the various steps involved in processing an input image. FD with constraints such as facial tilt, noise and illumination variations require certain basic tasks to be performed. These constraints are addressed in the pre-processing phase of detection. Training and detection form the major stages in FD process. Training stage involves pre-processing, feature extraction, feature selection and creation of a face gallery. Detection stage involves pre-processing of the test images, feature extraction, feature selection and classification/identification of these images. Among these, feature extraction and feature selection greatly affect the performance of FD system.

C. Improved Binary PSO (IBPSO)

An IBPSO is proposed for selecting a near-optimal (small) subset of genes [6]. It is proposed to overcome the limitations of BPSO and previous PSO-based methods. IBPSO in our work differs From BPSO and the PSO-based methods on two parts:

Step 1: Introduce a scalar quantity that called particles' speed (s); and

Step 2: Propose a rule for updating $x^d i(t + 1)$,

Whereas BPSO and the PSO-based methods have used the original rule (3) and no particles' speed implementation. The particles' speed and rule are introduced in order to

- increase the probability of $x^d i(t + 1) = 0$ $(P(x^d i(t + 1) = 0))$,
- reduce the probability of $x^d i(t + 1) = 1$ $(P(x^d i(t + 1) = 1))$.

The increased and decreased probability values cause a small number of genes are selected and grouped into a gene subset.

$x^d i(t + 1) = 1$ means that the corresponding gene is selected.

Otherwise,

$x^d i(t + 1) = 0$ represents that the corresponding gene is not selected.

Definition 1: s_i is a speed or length or magnitude of V_i for the particle i. Therefore, the following properties of si are crucial:

Step 1: non-negativity: $s_i \geq 0$;

Step 2: definiteness: $s_i = 0$ if and only if $V_i = 0$;

Step 3: homogeneity: _αVi_ = α _Vi_ = αsi

where $\alpha \geq 0$;

Step 4: the triangle inequality: _Vi + Vi+1_ ≤ _Vi_ + _Vi+1_

where _Vi_ = si and _Vi+1_ = si+1.

Calculation of the Distance of Two Particles' Positions

The number of different bits between two particles relates to the difference between their positions. For eg, Gbest(t) =[0011101000] and $X_i(t)$ = [1110110100]. The difference between Gbest(t) and Xi(t) is diff(Gbest(t) − $X_i(t)$) = [−1 −1010 − 11 − 100]. The value of 1 indicates that compared with the best position; this bit should be selected, but it is not

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selected, which may decrease classification quality and lead to a lower fitness value. In contrast, a value of−1 indicates that, compared with the best position, this bit should not be selected, but it is selected. The selection of irrelevant genes makes the length of the subset longer and leads to a lower fitness value. Assume that the number of 1 is a, whereas the number of −1 is b.We use the absolute value of a − b (|a − b|) to express the distance between two positions. In this example, the distance between Gbest(t) and Xi(t) is dist(Gbest(t) − X_i(t)) = |a − b| = |2 − 4| = 2.

Fitness Functions

The fitness value of a particle (a gene subset) is calculated as follows:

$$\text{Fitness } \mathbf{(Xi) = w1 \times A(Xi) +\_w2\ (n - R(Xi))}$$

n_in which A(Xi) ∈ [0, 1] is leave-one-out-cross-validation (LOOCV) classification accuracy that uses the only genes in a gene subset (Xi). This accuracy is provided by support vector machine classifiers (SVM). R(Xi) is the number of selected genes in Xi . n is the total number of genes for each sample. w1 and w2 are two priority weights corresponding to the importance of accuracy and the number of selected genes, respectively. The accuracy is more important than the number of selected genes. Therefore, we select the value of w1 in the range [0.6, 0.9] and we set w2 = 1− w1 . The value of w2 is set to 1 − w1 in order to give the remain percentage of weights after the value of w1 has been chosen.

III. RESULTS AND DISCUSSION

3.1. RESULTS USING EXISTING SYSTEM (BPSO)

The BPSO method exhibited extremely good performance under frontal poses with variations in illuminations (ORL database). The experimental results indicated that the method had performed well under severe illumination variations with top detection rates. The input training images are shown below.

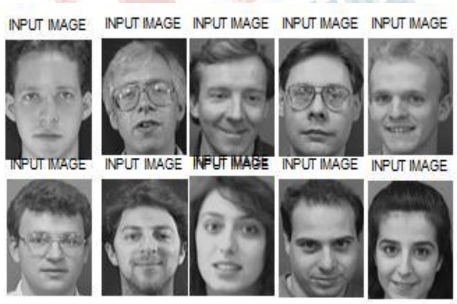

Fig : 3 Input images from the database

The following figure shows the best similarity test image. This is performed by BPSO from the given training images.

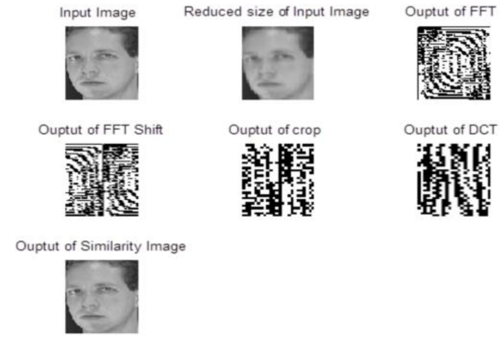

Fig : 4 Similarity Output of Test Image

The performance analysis is done for face detection of various trained input images are tabulated. Face Detection is done by Binary Particle Swarm Optimization (BPSO). This tabulation conveys about the number of best matches and execution time.

Table 1 Performance analysis of DFT & DCT+BPSO

Sl.No	Number of Classes	Number of Samples	Execution Time in Seconds	Number of Best Matches
1	4	6	5.7411	5
2	5	9	9.0351	6
3	5	7	6.2678	5
4	8	5	8.3370	4

This existing method provides less number of best matches and also high processing time. To overcome this problem, Improved BPSO is applied.

3.2. RESULTS USING IMPROVED BPSO (IBPSO)

The following results show the input training images which contain four persons with six samples.

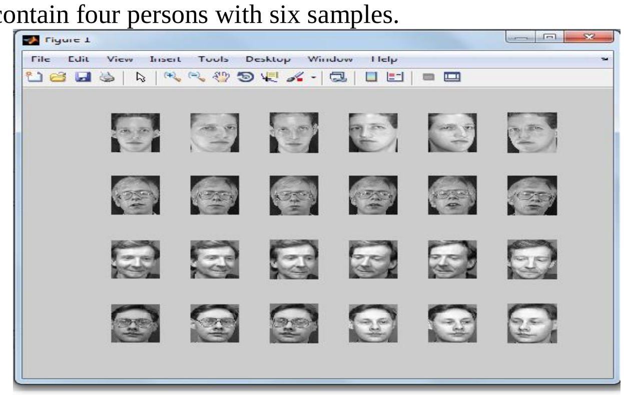

Fig : 5 Trained input Samples of 4 persons with 6 samples

The below output window shows the test images. This test images are selected from trained images randomly. These test images are shown below.

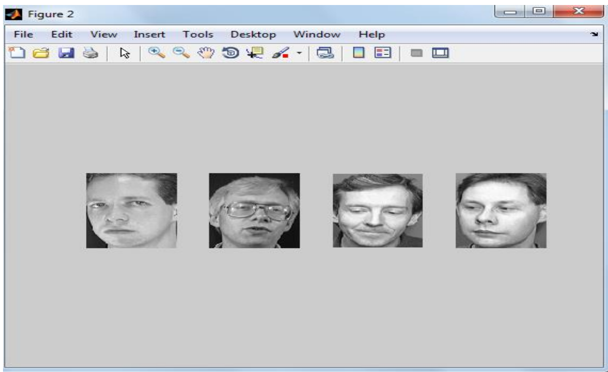

Fig : 6 Test images of 4 persons

The test images are identified with ten input samples. From these input samples features are extracted using DCT[4] and DFT transform. The feature subset is selected using improved BPSO. The subset of test image is compared with the training images subset and provided the best number of matches.

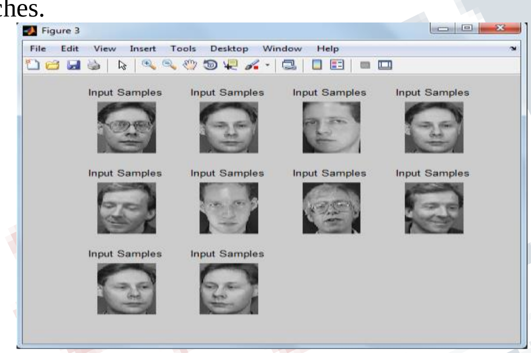

Fig : 7. Input Samples of 4 persons

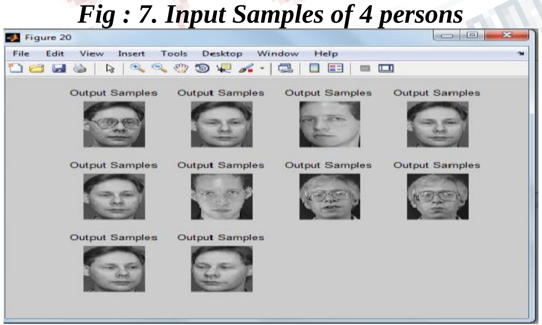

Fig : 8. Output Samples of 4 persons

The comparison is performed using Euclidean classifier. The input and similarity output samples are shown above. The Process is done for five iterations to get the base match. The command window shows the details of results in every iteration.

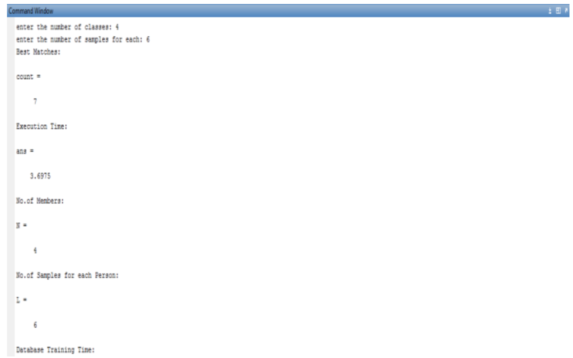

Fig :9.Command Window Output for Execution Time

Thus the process is done for different number of persons with different samples. Here, the following table shows the best matches and execution time for different number of input samples.

Table 2 : Performance Analysis of DFT&DCT + IBPSO

Number of Persons	Number of Samples	Number of Best Matches	Execution Time in seconds
4	6	7	3.6904
5	9	7	6.9430
5	7	6	5.3488
8	5	6	6.3323
7	8	7	8.5670
8	9	7	10.8765
7	9	7	9.6553

3.3. COMPARISON RESULTS

Comparison of Execution Time and Number of Best Matches

Comparative analysis is shown between the proposed and existed method. The Proposed method contains two parts. One part is Gabor wavelet with IBPSO. Second part is DFT& DCT with IBPSO. The Existed method is DFT & DCT with BPSO.

Table 3 : Comparison between Proposed and Existed Method

No. of Persons	No. of Samples	DFT&DCT+BPSO		DFT&DCT+IBPSO	
		No.of Best Matches	Execution Time	No.of Best Matches	Execution Time
4	6	5	5.7411	7	3.6904
5	9	6	9.0351	7	6.9430
5	7	5	6.2678	6	5.3488
8	5	4	8.3370	6	6.3323

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The above comparative values are represented as a bar graph. The bar graph shows the analysis of number of best matches and execution time between both the proposed method and existed method .This bar chart shows that the number of matches improves than the existing methods and also shows that the execution time decreases in proposed method.

Number of Best Matches

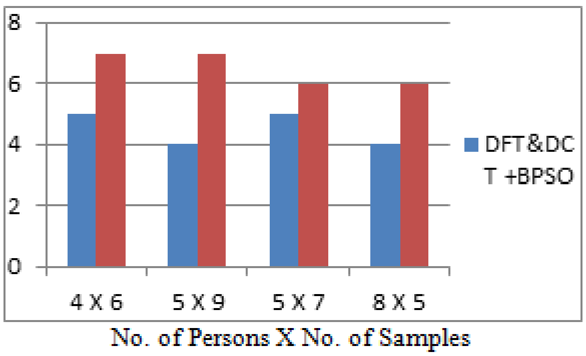

Fig : 10. Representations for Number of Matches

Execution Time

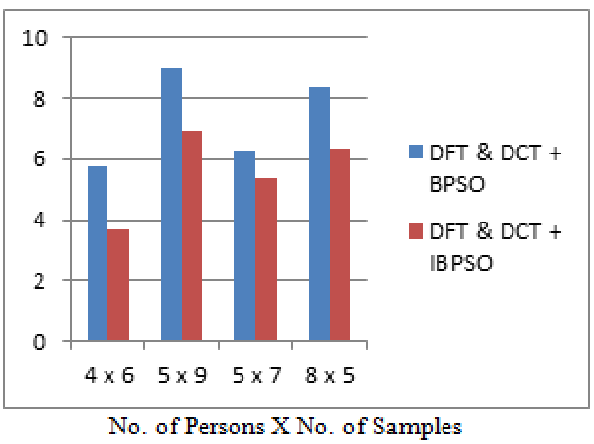

Fig : 11. Representations for Execution Time

IV. CONCLUSION

A novel approach for a flexible Face Detection system is proposed which uses Improved Binary Particle Optimization. Improved Binary Particle Swarm Optimization has been proposed for feature selection. Overall, based on the experimental results, the performance of IBPSO is superior to BPSO. BPSO-based methods are used for classification accuracy and the number of selected subset. IBPSO is excellent because the probability of $xdi(t + 1) = 0$ has been increased by this particles' speed and the introduced rule. The particles' speed and the introduced rule are applied in order to yield a near-optimal subset of features for better classification. IBPSO also obtains lower running times because it selects the less number of feature subset compared to BPSO. IBPSO Wavelet is used to improve the number of best matches.

Successful attempts have been made to equally handle all image with variations. This method exhibits extremely good performance under frontal poses with variations in illuminations (ORL database). The experimental results indicate that this method has performed well with top detection rates and reduced execution times.

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