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Face Recognition using SURF, Median Filter and Particle Swarm Optimization

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Abstract: *This paper proposes classification-based face detection method using PSO, SURF and Median filter features. Considering the desirable characteristics of spatial locality and orientation selectivity of the PSO, SURF and Median filter, we design filters for extracting facial features from the local image. The feature vector based on PSO, SURF and Median filters is used as the input of the classifier, which is a Feed Forward on a reduced feature subspace learned by an approach simpler than principal component analysis. The effectiveness of the proposed method is demonstrated by the experimental results on testing a large number of images and the comparison with the state-of-the-art method. The image will be convolved with PSO, SURF and Median filters by multiplying the image by PSO, SURF and Median filters in frequency domain. To save time they have been saved in frequency domain before Features is a cell array contains the result of the convolution of the image with each of the forty PSO, SURF and Median filters. For the implementation of this proposed work we use Image Processing Toolbox under the Matlab software.*

Keywords: *Face Recognition, SURF Feature, Median and Particle Swarm Optimization (PSO)*

I. INTRODUCTION

Face recognition is one of the most important biometrics which seems to be a good compromise between actuality and social reception and balances security and privacy well. It has a variety of potential applications in information security law enforcement and access controls. Face recognition systems fall into two categories: verification and identification. Face verification is 1:1 match that compares a face images against a template face image. On the other hand face identification is 1: N problem that compares a probe face image against all image templates in a face database. Face recognition is a very difficult problem due to a substantial variations in light direction (illumination) , different face poses , diversified facial expressions , Aging (changing the face over time) and Occlusions (like glasses, hair, cosmetics). So the building of an automated system that accomplishes such objectives is very challenging. In last decades many systems with recognition rate greater than 90% has been done however a perfect system with 100% recognition rate remains a challenge. Face recognition algorithms are divided by into three categories as follows:

- **Holistic methods:** These methods identify a face using the whole face images as input and extract the overall features.
- **Feature based methods:** these methods used the local facial features for recognition (like eyes, mouths, fiducially points. etc.).
- **Hybrid methods:** these methods used both feature based and holistic features to recognize a face. These methods have the potential to offer better performance than individuals.

Face Recognition System is one of the most successful applications of enhanced computational ability and image processing. Automatic face recognition is intricate primarily because of difficult imaging conditions, ageing, facial expression, occlusion etc. Thus, image preprocessing is used to resize (to reduce the dimensionality of feature subset), adjust contrast, brightness and filter the noise in an image. The concept of preprocessing is applied to Face Recognition System and results are tabulated over ORL Database and YALE B Database.

Particle Swarm Optimization was basically designed to simulate the social behavior like bird flocking and fish schooling and later the algorithm was simplified and observed to perform optimization too. PSO has been extensively used in fields like Pattern Recognition, Fuzzy System etc. Binary PSO is very much suitable for selecting minimum number of features which can represent an image with least loss of information. In this thesis, a face recognition algorithm using a PSO-based feature selection approach is presented. The algorithm utilizes a novel approach effectively explore the solution space for the optimal feature subset. The selection algorithm is applied to feature vectors extracted using the DWT. The search heuristics in PSO is iteratively adjusted guided by a fitness function defined in terms of maximizing class separation. The proposed algorithm was found to generate excellent recognition results with less selected features.

II. TECHNIQUES USED

The three main techniques are used for proposed work which is explained below:

2.1. SURF

The SURF is used for object recognition, for it is of better speed and accuracy compared with other features. The database contains the extracted parameters. The proposed work presents a fast matching method, the method only select part of them to match. SURF algorithm is the feature point extraction algorithm. This algorithm is similar with SIFT algorithm. But at the same time, SURF algorithm is composed of the following two parts:

- **Feature point detection**

Much of the performance in SURF can be attributed to the use of an intermediate image representation known as the Integral Image. The integral image is computed rapidly from an input image and is used to speed up the calculation of any upright rectangular area. Integral image is defined by Jones M and Viola P and is represented by I L: (x). the value of point
X = (x, Y) is sum of pixels from the image origin to the X vertices.

$$I_{\Sigma}(x,y) = \sum_{i=0}^{i\le x}\sum_{j=0}^{j\le y} I(i,j) \quad (1)$$

The SURF detector is based on the determinant of the Hessian matrix. Based on Integral Image, we can calculate the Hessian matrix, as function of both space x = (x; y) and scale a.

$$H(x,\sigma) = \begin{matrix} L_{xx}(x,\sigma) & L_{xy}(x,\sigma) \\ L_{xy}(x,\sigma) & L_{yy}(x,\sigma) \end{matrix} \quad (2)$$

Here $L_{xx}(x,\sigma)$ refers to the convolution of the second d2g (cr) order Gaussian derivative dX2 with the image at point X = (x, Y) and similarly for L_{yy} and L_{xy}. If we use Weighted Box latter approximations in the x, y and xy-directions, the formula as an accurate approximation for the Hessian determinant using the approximated Gaussians:

$$\det(H_{approx}) = D_{xx}D_{xy} - (0.9D_{xy})^2 \quad (3)$$

In SURF, the lower level of the scale-space is obtained from the output of the 9 x9 filters shown in 2 levels. In this process each pixel in the scale-space is compared to its 26 neighbours, comprised of the 8 points in the native scale and the 9 in each of the scales above and below.

- **Feature Matching**

The purpose of feature point matching is to find up the feature point from the same location in two images and match a couple of feature points. SURF adopts nearest neighbor. A SURF descriptor is a 64-dimensional vector which need new data structure to place. So, we use KD-tree to make matching.

- **KD-Tree**

KD-tree (k-dimension tree) is a balanced binary tree. It has two parameters: one is set for which we want to build KD-tree, initially this set P; second parameters is the depth of the root of the sub tree. Initially the depth is zero. General K-D tree construction process is as follows:

Procedure KD-TREE (P,depth)
Input: A set of points P and the current depth.
Output: The root of the kd-tree storing P.
a: if P contains only one point
b: then return null
c: else if depth is even
d: then Split P into two subsets with a vertical line 1 through the median x-coordinate of the points in P. Let PI be the set of points to the left of 1 or on 1, and let P2 be the set of points to the right of l.
e: else Split P into two subsets with a horizontal line 1 through the median y-coordinate of the points in P. Let PI be the set of points to the below of 1 or on 1 and let P2 be the set of points above l.
f:P.location:=median.
g: P.leftChild:=KDTREE(pl , depth +1).
h: P.rightChild:= KDTREE(P2, depth + 1).
i: return P

2.2. Median Filter

The median filter is a nonlinear digital filtering technique, often used to remove noise. Such noise reduction is a typical pre-processing step to improve the results of later processing (for example, edge detection on an image). Median filtering is very widely used in digital image processing because, under certain conditions, it preserves edges while removing noise. Digital images are prone to a variety of types of noise. Noise is the result of errors in the image acquisition process that result in pixel values that do not reflect the true intensities of the real scene. There are several ways that noise can be introduced into an image, depending on how the image is created.

- **Syntax**

A=image
B = medfilt2(A);
B = medfilt2(A) performs median filtering of the matrix A in two dimensions. Each output pixel contains the median value in a 3-by-3 neighborhood around the corresponding pixel in the input image. medfilt2 pads the image with 0's on the edges, so the median values for points within one-half the width of the neighborhood ([m n]/2) of the edges might appear distorted.

2.3. Particle Swarm Optimization (PSO)

Particle Swarm Optimization (PSO) is a swarm intelligence technique developed by Dr. Eberhart and Dr. Kennedy in 1995. In PSO, the swarm consists of particles which move around the solution space of the problem. These particles search for the optimal solution of the problem in the predefined solution space till the convergence is achieved.

PSO algorithm:

- Initialize the particle position by assigning location p = (p0, p1…., pN) and velocities v = (v0,v1, …,vN).
- Determine the fitness value of all the particles: f (p) = (f (p0), f (p1)… f (pN)).
- Evaluate the location where each individual has the highest fitness value so far: p= ($p0^{best}$, p1best… pNbest).
- Evaluate the global fitness value which is best of all p^{best}: G (p) = max (f (p)). The particle velocity is updated based on the p^{best} and g^{best}.
- v_i new = v1 + c1 × rand ( ) × (p_i^{best} - pi) + c2 × rand ( ) × (p_g^{best} - pi) For 1 < i< N. (1)
- Where c1 and c2 are constants known as acceleration coefficients and rand () are two separately generated uniformly distributed random numbers in the range [0, 1].
- Update the particle location by: p_i^{new} = pi + v_i^{new} for 1 < i < N.
- Terminate if maximum number of iterations is attained or minimum error criteria is met.
- Go to step 2.

Binary PSO:

For binary discrete search space, Kennedy and Eberhart have adapted the PSO to search in binary spaces by applying a sigmoid transformation to the velocity component in the equation to squash the velocities into a range [0,1] and force the component values of the positions of the particles to be 0's or 1's. The sigmoid expression is given by:

$$sigmoid\left(p_{id}^{k}\right) = \frac{1}{1-e^{-v_{id}^{k}}} \qquad (1)$$

$$\left(p_{id}^{k}\right) = \begin{cases} 1 & if\ rand(\ ) < sigmoid\left(p_{id}^{k}\right) \\ 0 & otherwise \end{cases} \qquad (2)$$

Feature Extraction:

In pattern recognition and in image processing, feature extraction is a special form of dimensionality reduction. When the input data to an algorithm is too large to be processed and it is suspected to be notoriously redundant (e.g. the same measurement in both feet and meters) then the input data will be transformed into a reduced representation set of features (also named features vector). Transforming the input data into the set of features is called feature extraction. If the features extracted are carefully chosen it is expected that the features set will extract the relevant information from the input data in order to perform the desired task using this reduced representation instead of the full size input. The first step in any face recognition system is the extraction of the feature matrix. A typical feature extraction algorithm tends to build a computational model through some linear or nonlinear transform of the data so that the extracted feature is as representative as possible.

Feature selection using binary PSO:

Feature selection is performed to reduce the dimensionality of facial image so that the features extracted are as representative as possible. Method employed here is Binary PSO. Consider a database of L subjects or classes, each class W1, W2, W3… WL with N1, N2, N3,…NL number of samples. Let M1, M2, M3... ML is the individual class mean and M0 be mean of feature vector. Fitness function is defined so as to increase the class separation equation. By minimizing the fitness function, class separation is increased. For iteration the most important features are selected. Binary value of 1 of its position implies that the feature is selected as a distinguishing feature for the succeeding iterations and if the position value is 0 the feature is not selected.

III.METHODOLOGY

There are some main phases of proposed work of this thesis. These phases are discussed in below points:

Phase 1:

Firstly code is developed for the loading the face image in the database of the MATLAB. This is done for the loading the face image value in the workspace of the MATLAB.

Phase 2:
After that a code is developed for the Particle Swarm Optimization (PSO). Code is developed for Median Filter.

Phase 3:
Code is developed for the applying the feature extraction techniques using SURF and Median to extract the feature of the image.

Phase 4:
After that code is developed for analysis of result using parameter like accuracy and it is then compared with base paper.

IV. RESULTS AND DISCUSSION

The following figures are highlighted the results of proposed work:

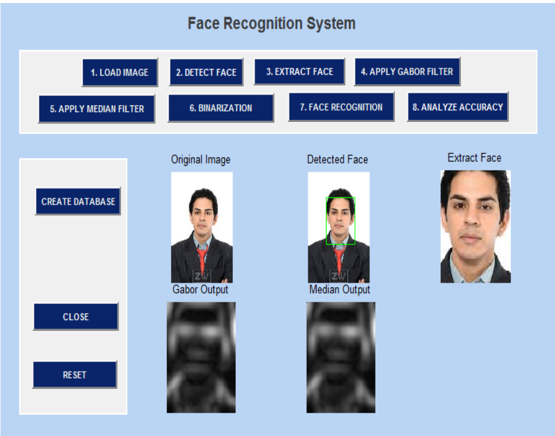


Figure 1: Face recognition system

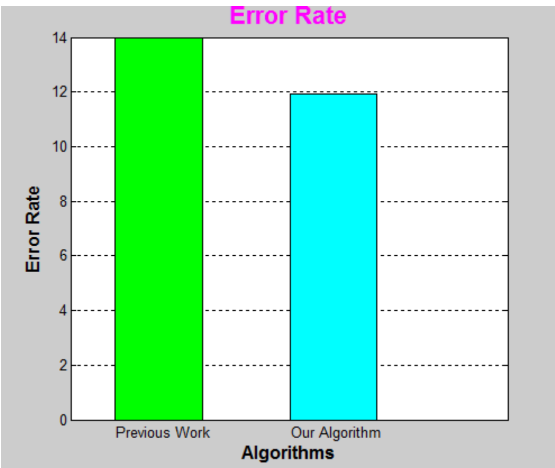
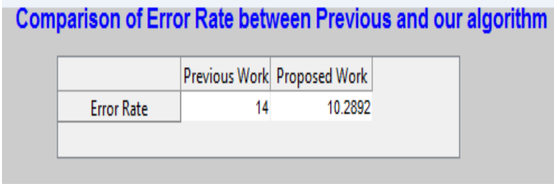


Figure 2: Error rate of previous and proposed work


Comparison of Error Rate between Previous and our algorithm

	Previous Work	Proposed Work
Error Rate	14	10.2892

Figure 3: Values of error rate

CONCLUSION

This research indicates directions for further research. The proposed framework can be analyzed in terms of feasibility and acceptance in the industry. Trying to improve the performance of existing methods and introducing the new methods for face reorganization based on today's software project requirements can be future works in this area. So the research is on the way to combine different techniques for calculating the best estimate. According to the findings of the research, it should be stated that having the appropriate combine SURF, Median with PSO technique to find the best method for face reorganization. Face recognition is a non-intrusive biometric, tolerated for users, and employed in numerous important applications. A face recognition system is usually trained off-line with a training dataset, and, based on the learned features, the gallery images from users are transformed into templates. In on-line usage, new images are taken with or without the candidate's knowledge and fed into the system for matching against a database of templates corresponding to a group of individuals. The images are transformed by the same procedure that the templates are generated, and they are compared with the templates for final identification.

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