

Efficient K-Means Cluster Reliability on Ternary Face Recognition Using Angle Oriented Approach

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ABSTRACT

One of the major difficulties in face recognition system is an in-depth pose verification problem. Face recognition is a broad area of research over the last 25 years. However, the field is highly unsolved, largely due to variations in pose, illumination and expression. In this paper, a Ternary Angle Oriented Face Recognition algorithm is proposed. In this algorithm, the data is made into two clusters namely, Clock wise and Anti-clock wise rotations. The image is extracted using angle oriented DCT (Discrete Cosine Transform) that invokes certain normalization techniques. Face Matching is compared to the technique of k-means. Based on Image Recognition pattern, the reliability of clusters is studied. The experimental results are verified.

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1. INTRODUCTION

Face recognition falls into two categories as suggested by chellappa et al., 1995[1] and given as Feature based approach and Holistic approach. Feature based face recognition relies on detection and characterization of the individual facial features like eyes, nose and mouth etc., and their geometrical relationships. Whereas the holistic approach, involves encoding of the entire facial image. Earlier works on face recognition were proposed by various authors are as follows. Ziad M.Hafed and Martin Levine 2001[19] proposed a holistic approach to face recognition, an affine transformation was used to correct for scale, position and orientation changes in faces. Ting Shan et al., 2006 [16] developed a face model which can be used to interpret facial features and synthesize realistic frontal face images when given a single face novel image. Jagan Mohan R.N.V., and Subbarao R., 2011 [6] given a new computational approach that is converting the input image to database image using angle orientation technique and developed an algorithm for face recognition system using DCT and discussed various parameters which effects its performance. Napoleon., D. and Pavalakodi., S., investigated a new method for Dimensionality Reduction using K-Means Clustering Algorithm for High Dimensional Data set, 2011 [11]. A Fuzzy Clustering approach for face recognition based on face feature lines and Eigen Vectors, was introduced by Mario I. Chacon M., Pablo Rivas P., and Graciela Ramirez A., 2007 [10] also describes the Gath-Gheva fuzzy clustering algorithm to generate fuzzy rules. Y I WAN and Chengwen WU observed the Optimal Reliability Allocation for Modular Software Systems based on Support Vector Clustering and Fuzzy Decision, 2009 [18]. Yongsheng GAO and Leung studied Face Recognition using line edge map, 2002 [5].

In this paper, section one refers to a new approach of converting the database images into two classes called clusters and rotation of angles being segmented in each cluster. In Section two, the ternary approach of recognition of images in the database is mentioned, with an emphasis on the basis of face recognition system using DCT which includes the proposed algorithm. The impact of various face matching

methods that affects the performance of the recognition system is studied in section three. The efficiency of K-Means Cluster is highlighted in section four. The experimental results are discussed in section five. The conclusion and the future perspectives are dealt with in Section six.

2. TAXONOMY OF CLUSTERS

Classification is the task of assigning objects to one of several pre-defined categories. Classification techniques are a systematic approach for building classification models from an input dataset. Many authors discussed several approaches in classification and decision-tree based methods. Decision-tree is fast and easy-to-use approach for rule generation and classification problems. Kun-Che Lu and Don-Lin Yang proposed a general framework based on the decision-tree for mining and processing image data [9]. Association rule and Decision-tree based methods for fuzzy rule generation were offered by Ferenc Peter Pach and Janos Abonyi [4]. Many studies have considered positively the induction and analysis of decision trees [12], [7], [8] and [20].

In this paper, a cluster classification tree for clustering database images is introduced. Entire database of the images denoted as C which is the root node, divided into two groups of major similar objects called clusters C_1 and C_2 representing internal nodes. The similar image object groups being rotated in the clock-wise direction belong to the internal node, cluster C_1 . On the other hand, C_2 which has a group of similar image objects rotate in anti-clock wise direction. Again, the cluster C_1 is grouped into three terminal nodes (segments), C_{11} , C_{12} and C_{13} , called nested clusters. Likewise C_{21} , C_{22} and C_{23} are defined as nested clusters, the three terminal nodes of cluster C_2 . If θ is the angle of rotation in each cluster, the nested cluster C_{11} consists of images with angle 0 to 30° , C_{12} comprises the images in between 31° to 60° and C_{13} bears 61° to 90° . The same type of segmentation followed in internal node of C_2 in which the images rotate with an interval of 30° starts with 0 and ends at 90° in anti-clock wise direction. The cluster tree diagram is given in figure 1.1.

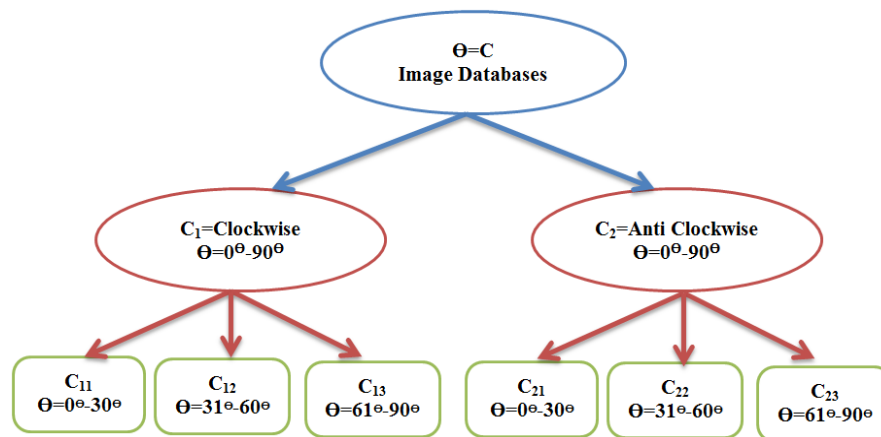


Figure 1.1: Cluster tree diagram

3. T-NARY ASSOCIATION WITH FACE RECOGNITION

In mathematics, a ternary relation or triadic relation is a finitary relation in which the number of places in the relation is three. Ternary relations may also be referred to as 3-adic, 3-ary, 3-dimensional, or 3-place. The process of recognizing database images is performed at three different places.

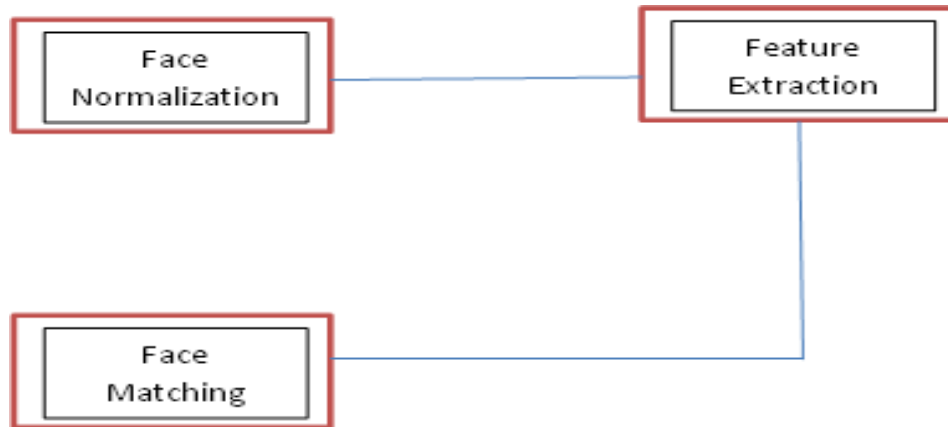


Figure: 3. 1. Ternary Relationship with Angle Oriented Face Recognition

3.1. Face Normalization

Image normalization is the first stage for all face recognition systems. In face recognition process, initially face area is detected. The face normalization process of figure 2.1 receives input image of size $N \times N$ and is compared to the size of database image; if the input image and database image are not equal, the input image is to be resized. If the pose of the selected image is required to rotate to obtain the database image, the face with an angle θ is to be rotated until it matches with the database image. The rotation of the image may be bidirectional; clock wise or anti-clock wise, depending on the selected pose of the image. Mathew Turk and Alex Pentland [12] discussed the idea of face recognition.

3.2. Feature Extraction

In the figure 3.1 of feature extraction, the feature is defined as a function of one or more measurements, each of which specifies some quantifiable property of an object, and is computed such that it quantifies some significant characteristics of the object. All features can be classified into low-level and high-level features. Low-level features can be extracted from the original images, whereas high-level feature extraction must be based on low-level features [3]. Once the normalized face is obtained, it can be compared to other faces, under the same nominal size, orientation, position, and illumination conditions. This comparison is based on features extracted using transformation technique. One such popular transformation is DCT (Discrete Cosine Transform). DCT has been used as a feature extraction step in various studies on face recognition [1, 4, 5, 11 and 13]. The input images are divided into $N \times N$ blocks to define the local regions of processing. The $N \times N$ two-dimensional Discrete Cosine Transform (DCT) is used to transform the data into the frequency domain. Thereafter, statistical operators that calculate various functions of spatial frequency in the blocks are used to produce a block-level DCT coefficient. Subba Rao. R. and Jagan Mohan R.N.V., [4, 5] have used DCT feature extraction for Angle Oriented Face Recognition. Many more techniques are available for feature extraction. Some of them are KLT, Z-transformation, and Hough Transform.

3.3. Face Matching

The last part of T-nary relationship of Figure 3.1 is Face Matching. In this process, in order to recognize a particular input image, various distance nearest neighborhood classifiers [2] (Duda and Fart, 1973) are used to compare the input image feature vector to the database feature vectors. After obtaining the distances for $N \times N$ matrix, one needs to find the averages of each column of the matrix, and then the average of all these averages. If the overall average is zero or negative, there is a match between the input image and database image. The algorithm for this process of face matching is given below.

Algorithm

```

Start
Select normalized input image i.e., Clock wise rotation and Anti-clock wise
rotation.
For i=1 to number of image objects 'n'
  
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Repeat
Choose DCT based feature extraction of feature vectors in x (input) and y
(Database).
For each x and y calculate the distances (using any distance classifier method)
Calculate the mean of z
Verify mean value of z either positive or negative.
If  $z \leq 0$  then
    Return " we may say that match between images".
Else if  $z > 1$  then
    Return "No match between images".
End if
End for
End

```

4. DISTANCE CLASSIFIER METHODS

The feature vectors obtained by adopting any transformation algorithms like PCA, DCT etc., have certain limitations such as poor discriminatory power and ability to handle large computational load. In this section, various distance classifier methods for face matching are discussed. Face matching classification system analyzes the numerical properties of various image features and organizes data into categories. This classification includes a broad range of theoretic-decision approaches for the identification of images. All classification algorithms are based on the assumption that the input image depicts one or more features and each of these features belongs to one of several distinct and exclusive classes. In practice, the minimum (mean) distance classifier works well, provided the distance between means is large when compared to the spread (or randomness) of each class with respect to its mean. The minimum distance classifier is used to categorize unknown image data into classes and therefore, the minimum distance between the image data and the class in multi-feature-space exists. The distance is defined as an index of similarity and in consequence, the minimum distance is identical to the maximum similarity. The different types of distance classifiers studied in this paper are Euclidean, Cosine similarity and Tanimatto distance methods.

4.1. Euclidean Distance Classifier

For recognizing a particular input image, the system compares the image's feature vector to the feature vectors of the database image using a Euclidean distance nearest-neighbor classifier [2] (Duda and Hart, 1973). If the feature vector of the probe is x and that of a database face is y , where $x=(x_1, x_2, \dots, x_n)$ and $y=(y_1, y_2, \dots, y_n)$ are two points in Euclidean n -space, then the Euclidean distance between x and y or from y to x given by

$$\text{Euclidean Distance}(x \text{ and } y) = \sqrt{\sum_{i=1}^n (x_i - y_i)^2} \quad (1)$$

The position of a point in a Euclidean n -space is a Euclidean vector. So, x and y are Euclidean vectors starting from the origin of the space, and their tips indicate two points. The Euclidean norm, or Euclidean length, or magnitude of a vector measures the length of the vector.

$$||X|| = \sqrt{X_1^2 + X_2^2 + \dots + X_n^2} = \sqrt{X \cdot X} \quad (2)$$

The distance between points x and y may have a direction (e.g. from x to y), so it may be represented by another vector, given by

$$Y-X = (y_1-x_1, y_2-x_2, \dots, y_n-x_n) \quad (3)$$

4.2. Cosine Similarity classifier

Another face matching distance classifier method is Cosine Similarity and can be calculated as follows. For any two given vectors x and y , the cosine similarity θ , is represented using a dot product and magnitude as

$$\text{Cosine Similarity} = \frac{x \cdot y}{||x|| \cdot ||y||} \quad (1)$$

For face matching, the attribute vectors x and y are usually the frequency vectors of the images. The cosine similarity can be seen as a method of normalizing image length during comparison. The resulting similarity ranges from -1 meaning exactly opposite to 1 meaning exactly the same, with 0 usually indicating independence, and the middle values indicating intermediate similarity or dissimilarity [10].

4.3. Tanimatto Distance classifier

The Tanimatto distance classifier is an extended jaccard coefficient and can be used for document data but reduces the jaccard coefficient in the case of binary attributes is suggested by Taffy T. Tanimoto,(1960) [9]. This is represented as T.

$$\text{Tanimatto Distance } T(X, Y) = \frac{X.Y}{||X||^2 + ||Y||^2 - X.Y} \quad (1)$$

If a "similarity ratio" is given over bitmaps, where each bit of a fixed-size array represents the presence or absence of a character being modelled. The definition of the ratio is the number of common bits divided by the number of bits set in either sample. The same calculation is expressed in terms of vector product and magnitude. This representation relies on the fact that, for a bit vector (where the value of each dimension is either 0 or 1) then

$$X.Y = \sum_i (X_i \wedge Y_i) \text{ and } |X|^2 = \sum_i (X_i) \quad (2)$$

5. CONCEPT OF K-MEANS CLUSTER RELIABILITY

K-means clustering is the most widely used clustering algorithm which is sensitive to the initialization, and is difficult in handling clusters with varying densities, sizes and shapes. This algorithm partitions the set of angles into specified numbers, k of disjoint subsets, called clusters. Extracted features with similar content must be grouped together through a classification of clock-wise and anti-clock wise rotations of input image angles. In the present study, an angle of same rotation belongs to the same class called 'cluster'. Existing clustering techniques can be classified into two main groups: distance based and model based (Zhong & Ghosh, 2003) [15] approaches. In this study, distance based clusters are considered. The methods adopted for distance based approach are Tanimatto, Euclidean and Cosine similarity. The k -means algorithm assigns each cluster by its center which is the attribute-wise average of all angles in the cluster, usually termed as centroid of the cluster. The k -means cluster algorithm is given below.

The Basic algorithm for K-Means

Step 1) choose the number of clusters, k .
 Step 2) randomly generate k clusters and determine the cluster centers, or directly generate k random points as cluster centers.
 Step 3) Select the database image from database as the initial centroid point.
 Step 4) the mean values to closest centroid having negative or zero considered from clock-wise and anti-clock wise clusters.
 Step 5) Re-compute the centroid of each cluster.
 Step 6) until the centroids don't change.

For finding the cluster reliability in each of the above distance classifier methods, a software reliability model called Nelson model is used. In this model, the software reliability is estimated by

$$R = 1 - \frac{n_f}{n} \quad (1)$$

Where n is total no.of runs and f is no. of failure runs.

6. EXPERIMENTAL RESULTS

6.1. Clock wise Rotation

The experimental results are observed for both clock wise and anti-clockwise rotations for various clusters. The three methods Tanimatto Distance, Euclidean Distance and Cosine Similarity are used for face matching. The Nelson model of software reliability is used for efficiency of the face recognition in all types of clusters. The mean recognition values of the above three methods for all the three clusters c_{11} , c_{12} and c_{13}

are calculated and the corresponding graphs for each of the three clusters are depicted in figures 1, 2 and 3 respectively.

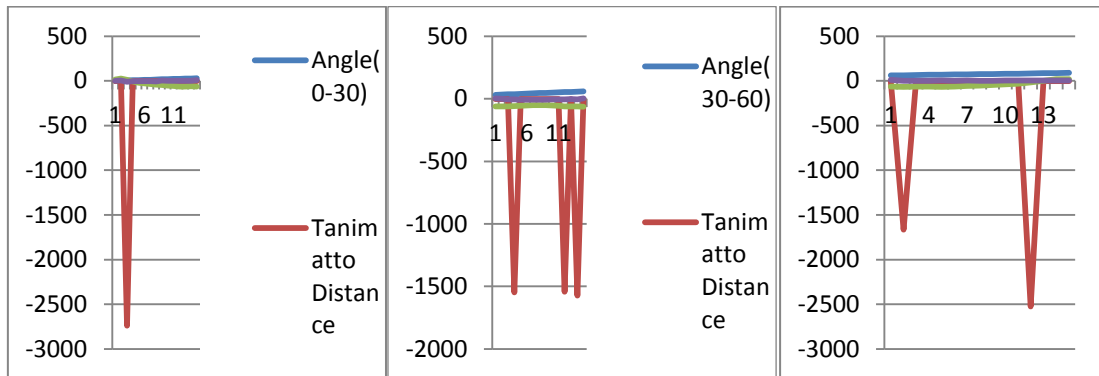


Fig: 1 C₁₁ (0-30)

Fig: 2 C₁₂ (30-60)

Fig: 3 C₁₃ (60-90)

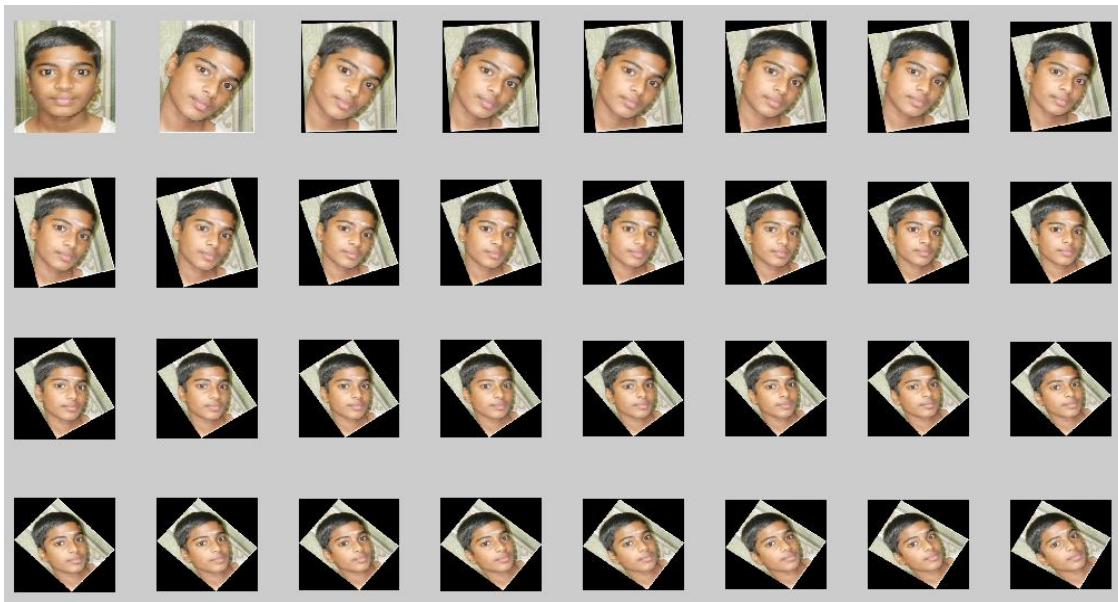


Fig: 4. Clock wise Image Rotations

6.2. Anti-Clock wise Rotation

As in the Clock wise rotation, the experimental results are calculated in anti-clock wise direction also. The same three methods along with Nelson model for reliability are adopted for face matching, and the mean recognition values using the algorithm given in section 2.3 for the three clusters c_{21} , c_{22} and c_{23} are calculated and their corresponding graphs of these results are given in figures 1, 2 and 3 respectively.

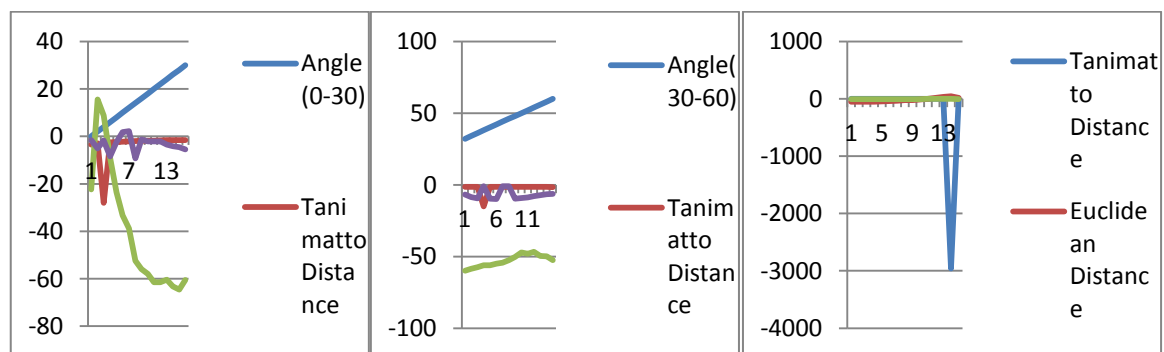


Fig: 1 C₂₁ (0-30)

Fig: 2 C₂₂ (30-60)

Fig: 3 C₂₃ (60-90)

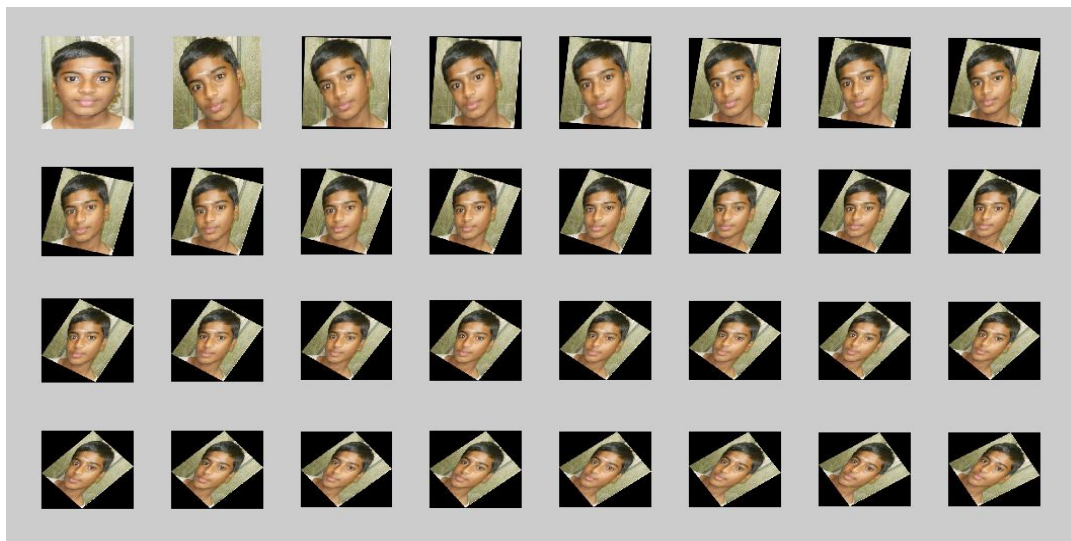


Fig. 4. Anti-Clock wise Image Rotations

7. CONCLUSION

The complete process of recognition of database images is introduced through ternary approach. The concept of face recognition is studied through cluster classification on the basis of rotation of images both clock-wise and anti-clock wise directions. Then, each cluster is segmented with respect to angles for face recognition using different distance classifier methods: Tanimatto, Euclidean and Cosine similarity. K-means cluster algorithm is developed and used for the three methods in each cluster. Nelson model of reliability approach is considered for comparing cluster reliability. It is proved through the experimental results that the Tanimatto method has high probability recognition than that of the remaining two methods. Again, it is critically observed that Euclidean distance classifier gives more recognition values when compared to cosine similarity. This approach has applications in cloud computing, grid computing, Intrusion detection and new technologies like Biometric systems etc. The authors view a random variable which indicates the magnitude of the recognition level of an image which follows some probability model.

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