ISSN (Online) 2278-1021
ISSN (Print) 2319-5940

IJARCCE

International Journal of Advanced Research in Computer and Communication Engineering

nCORETech

LBS College of Engineering, Kasaragod

Vol. 5, Special Issue 1, Feburary 2016

ENHANCED FACE RECOGNITION IN RGB-D IMAGES

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Abstract: Face recognition is one of the challenging areas in Image Processing, especially in unconstrained environments. The challenges arise due to the variations in face pose, expressions, illuminations, occlusions etc. This paper introduces a novel enhanced face recognition algorithm using RGB-D images. The 3D face recognition algorithms are developed to achieve higher accuracy. While it is challenging to use specialized 3D sensors due to their high cost. RGB-D images can be captured by low-cost sensors such as Kinect. The performance and applicability of existing face recognition algorithms is bound by the information content or cost implications. This existing paper uses a RISE algorithm that utilizes the depth information along with RGB images. This algorithm uses a combination of entropy, visual saliency, and depth information of the images with HOG for feature extraction, identification and random decision forest for classification. The proposed algorithm using DCT with DPA instead of RISE algorithm. The DCT is applied to the entire image to obtain the DCT coefficients, and then only some of the coefficients are selected to construct feature vectors and the DPA method is used to select the coefficients with the highest discriminant power. Finally, the recognition step is executed using a SVM classifier. Further, the ADM algorithm is proposed to extract and match geometric attributes. Geometric facial attributes is extracted from the depth image and face recognition is performed by fusing both of these. Here ADM is then combined with the DCT with DPA for identification.

Keywords: Face recognition, saliency, entropy, RGB-D, Kinect, Discrete Cosine Transform, and Discriminant Power Analysis.

I. INTRODUCTION

Face is a multidimensional structure that plays an important role in identity of individual. We can recognize a number of faces using different techniques and it have great applications in our day today life. Face is our first focus of attention in our social life. Thus, face need good computing techniques and algorithms for face recognition [4],[10]. Biometrics is the process of authentication of a person by verifying or checking that a user requesting a network resource is who he, she, or it claims to be.It uses the property that a human trait associated with a person itself like structure of face, face details etc.There are many types of biometric system like fingerprint recognition, face detection and recognition, iris recognition, gender recognition, gesture recognition [2] etc. these traits are used for human identification in surveillance system, criminal identification etc. Advantages of using these traits for identification are that they cannot be forgotten or lost. These are different unique features of a human being which is being used widely for face recognition. In2D images the face recognition is very challenging due to the problem of covariates such as pose, brightness,lighting,facial expression, disguise, beard, and plastic surgery. These covariates are creating a high degree of variation in two 2D images of the same person and thereby reducing the performance of recognition algorithms. Therefore, it is desirable to perform face recognition using a representation which is less susceptible to such distortions. The3D images can capture more information about a face than a 2D image, thus enabling higher preservation of facial details under varying conditions. The 3D face recognition has been analyzed in literature and several algorithmshave been developed. Thehigh cost of the specialized 3D sensors limits their usage in large scale applications. With advancements in sensor technology, many low cost sensors have been developed that provide 3D information in the form of RGB-D images.

II. RELATED WORK

2.1RISE WITH ADM APPROACH

Major steps are: (a) pre-processing, (b) computing texture descriptor from both color image and depth map (c) extracting geometric facial features, and (d) combining texture and geometric features for classification.

2.1.1 Pre-processing

In this step, an automatic face detector (Viola-Jones face detector) is applied on the RGB image to extract the face region. Using the same detector the face region is also extracted from the depth map. Then cropping the face region of

ISSN (Online) 2278-1021
ISSN (Print) 2319-5940

IJARCCE

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nCORETech

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both RGB image and Depth image [8]. Then the images are resized to 100 x 100 to compute depth features while texture feature descriptor does not require size normalization. Depth map is then pre-processed to remove noise. Depth map of a face is resized into 25 x 25 blocks and each block is then examined for the existence of noise. Using linear interpolation the depth values identified as noise are rectified.

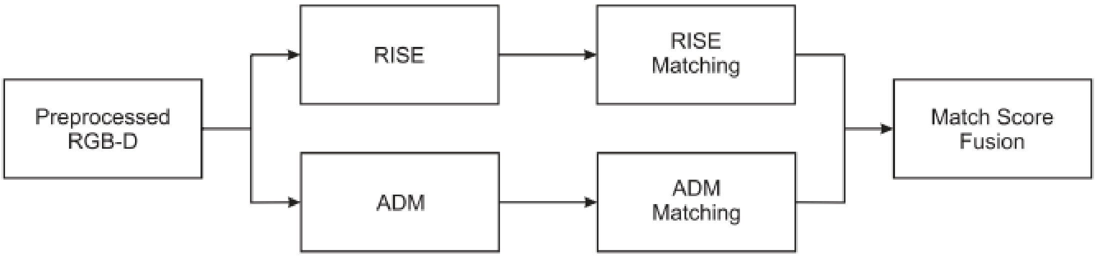

Figure 1: Steps involved in RGB-D face recognition algorithm

2.1.2 RISE Algorithm(RGB-D Image Descriptor Based on Saliency and Entropy)

The main motivation of the RISE descriptor lies in the nature of the RGB-D images produced by Kinect. Depth information of the Kinect has high inter-class similarity and those information may not be directly useful for face recognition. Four entropy maps corresponding to both RGB and depth information and a visual saliency map of the RGB image are computed. HOG descriptor [5], [7] is then used to extract features from these entropy/saliency maps. The concatenation of the HOG descriptors provides the texture feature descriptor which is used as input to the trained Random Decision Forest (RDF) classifier[9] to obtain the match score.

1) Entropy and Saliency:

Entropy is defined as the measure of uncertainty in a random variable. Similarly, the entropy of an image characterizes the variance in the grayscale levels in a local neighborhood. The entropy H of an image neighborhood x is given by Equation.

$$H(x) = -\sum_{i=1}^{n} p\,(xi)\log 2\, p\,(xi)$$

where p (x_i) is the value of the probability mass function for x_i. In the case of images, p (x_i) signifies the probability that grayscale x_i appears in the neighbourhood and n is the total number of possible grayscale values.

$$P\,(x_i) = n_{xi} / (\, M_H \,X\, N_H\,)$$

Here, n_{xi} denotes the number of pixels in the neighborhood with value x_i. $M_H \times N_H$ is the total number of pixels in the neighborhood. By controlling the size of neighborhood, entropy computation can be performed at a fine or coarse level. The neighborhood size for entropy map computation is fixed at 5 × 5 and RGB input images are converted to grayscale. The visual entropy map of an image is a characteristic of its texture and can be used to extract meaningful information from an image.

2) Extracting Entropy Map and Visual Saliency Map:

From the input RGB image corresponding entropy map is calculated using the equation of entropy and from the depth image saliency map is calculated. Two patches, P_1 and P_2 are extracted from RGB image. Similarly, two patches P_3 and P_4 are extracted from Depth image. Four entropy maps E_1 to E_4 are computed for patches P_1 to P_4 using Equation below:

$$E_i = H\,(P_i),\ \text{where } i \in [1, 4]$$

E_1, E_2 represent the entropy of the color image (I_{rgb}) and E_3, E_4 represent the depth entropy maps. This RISE algorithm also extracts visual saliency map S_1 of the color image I_{rgb} using Equation below.

$$S_1(x, y) = S\,(I_{rgb}(x, y)\ \forall\ (x \in [1, M], y \in [1, N]))$$

3) Extracting Features Using HOG:

In this step HOG descriptor [5], [7] produces the histogram of a given image. In many applications like gender detection, object detection etc. HOG has been successfully used as a feature and texture descriptor .It is also using in other computer vision problems. HOG of an entropy map or saliency map encodes the gradient direction and magnitude of the image variances in a length feature vector. The information from this entropy/saliency map can be represented with a HOG histogram. This Histogram based feature encoding enables non-rigid matching of the entropy/saliency characteristics which is not be possible otherwise.

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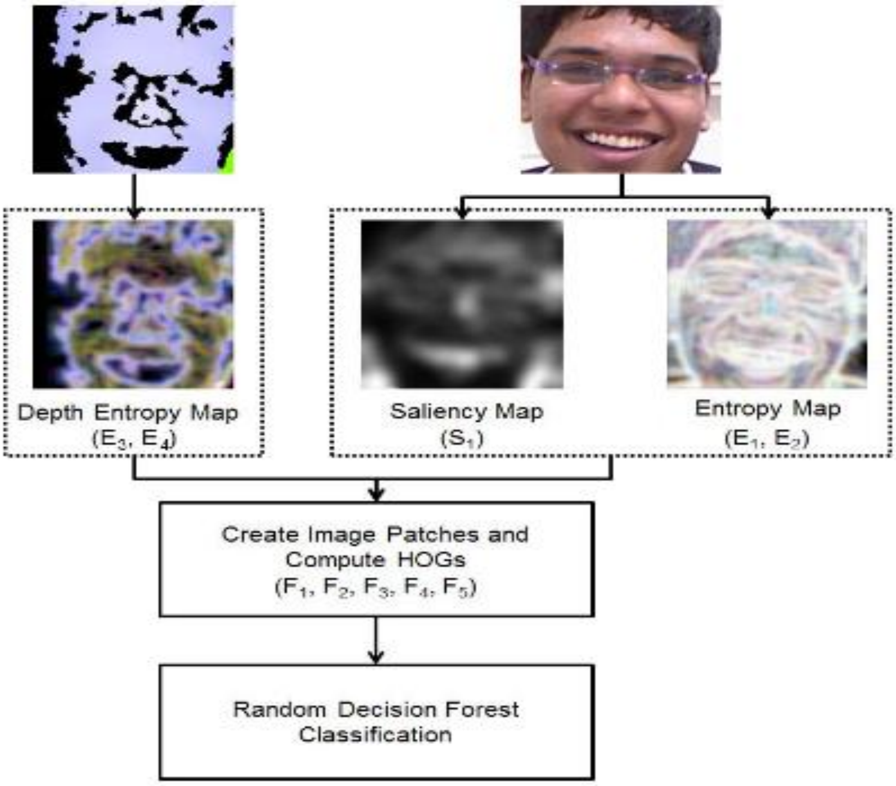

Figure 2: Steps of RISE algorithm

4) Classification:

The multi-class classifiers such as Nearest Neighbour (NN), Random Decision Forests (RDFs) [9], etc. can be used here. However, the classifier should be robust for large number of classes, computationally inexpensive and accurate. Thus RDF is used here. Since, RDF [9] can produce non-linear decision boundaries and handle multi-class classification. RDF is found to perform better than nearest neighbour classifier.

Algorithm 1 The RISE Algorithm

Data: Preprocessed RGB-D image, I_{rgb}, denotes the color image and I_d denotes the depth map

Result: The RISE descriptor for the given RGB-D image F

for $i \leftarrow 1$ ***to*** 2 **do**
    E_i = Entropy map of patch P_i of $grayscale(I_{rgb})$;
end
for $i \leftarrow 3$ ***to*** 4 **do**
    E_i = Entropy map of patch P_i of I_d;
end
S = Saliency map of I_{rgb};
E_5 = Entropy map of S;
for $i \leftarrow 1$ ***to*** 5 **do**
    F_i = HOG of E_i;
    F = Concatenation of H_i;
end

Figure 3: RISE Algorithm

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2.1.3 ADM: Attributes Based on Depth Map

Attribute based methods have been applied successfully in image retrieval and face verification. It is very useful additional feature in the RGB-D face recognition [1], [4]. However, instead of descriptive attributes (gender, age, and color) the ADM algorithm extracts geometric attributes. Multiple geometric attributes can be utilized to describe a face such as the distances between various key facial features including eyes, nose, and chin. By exploiting the uniform nature of a human face, key facial landmarks can be identified and used to extract geometric attributes that can be used for face recognition in addition with the entropy and saliency features.

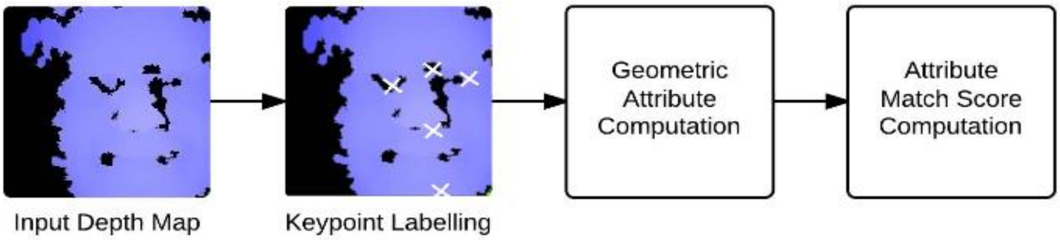

Figure 4: Steps involved in ADM approach

The ADM approach consists of the following steps:

1) Key point Labeling: First a few facial key points are located with the help of depth map. The points such as nose tip, eye sockets, and chin can be extracted by using a rule template. Utilizing these key points, some other landmarks such as the nose bridge and eyebrow coordinates are also located. By using these landmark points for all faces, geometric measurements of these are computed.

2) Geometric Attribute Computation: Various distances between these landmark points are computed here such as inter-eye distance, eye to nose bridge distance, nose bridge to nose tip distance, nose tip to chin distance, nose bridge to chin distance, nose tip distance to both ends of both eyebrows ,chin to eye distance, eyebrow length, and overall length of the face. Since the measured value of these parameters may vary across pose and expression, multiple gallery images are utilized to extract the facial features.

3) Attribute Match Score Computation: The attributes for a probe are computed similar to gallery images. Once the attributes are computed, the match score is computed for each subject in the gallery.

2.1.4 Combining RISE and ADM

Combining can be done two types different type:1) Match Score Level Fusion: Match score level fusion is performed using the weighted sum rule. 2) Rank Level Fusion: Rank level fusion is performed usingWeighted Borda Count approach. Weighted Borda count allocates a score to a subject depending on its rank in both the ranked lists and then creates a new ranked list for identification based on these scores.

2.2 Principal Component Analysis

Principal component analysis (PCA) is used to decrease the dimension of the data. It is the process of identifying patterns present in data, and expressing the data. Since it is hard to find the patterns present in data of high dimension, where it cannot be represented graphically, PCA is another powerful tool for is multi-dimensional face detection. The purpose of PCA [3] is to reduce the large dimension of data space to a smaller intrinsic dimension of feature vector.PCA is used when the images of the faces we have are in two dimension. Our aim here is to find the Principal components which can represent the faces present in the training set in a lower dimensional space. But in PCA, it suffers from Background, Lighting conditions, Scale, Orientations etc.

III. PROPOSED WORK

The proposed work of human face recognition system, deals with the problem of illumination variations through Local Contrast Enhancement (LCE) and improves the classification performance by an adaptive feature selection using the DPA. Important unobservable texture are highlight by LCE. The contrast of the image is enhanced by representing the pixel’s intensities in the logarithmic domain.

Through this method, the image contrast is significantly improved. Then, image is partitioned into blocks and DCT features are extracted. The coefficients with more discrimination power are selected using the DPA technique. Finally, a SVM classifier [7] is used for the recognition step. The DCT [3], [12] is applied in image and the coefficients of higher power discrimination can be selected for the formation of feature vectors. It is a statistical approach, to associate

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a number of coefficients, related with power discrimination, called Discrimination Power Analysis (DPA). Illumination changes is one of the most important problems in face recognition. The main reason of this, is the fact that illumination, together with pose variation, is the most significant factor that alters the perception of faces. Even though algorithms that recognize faces across illumination changes have made important progress, there still remain some problems that affect the recognition rate.

Thus, a pre-processing step is applied to images, where the light variation is treated using the LCE. After the pre-processing step, the feature extraction process is can be executed using the DCT, this process can be done as two different stages. In the first stage, the DCT is applied to the entire image to obtain the DCT coefficients [6], and then some of the coefficients are selected to construct feature vectors in the second stage. Next, the DPA method is used to select the coefficients with the highest discriminant power. Finally, the recognition step is executed using a SVM classifier [7].

3.1 Discrete Cosine Transform

The DCT is a method that is used to extract feature of images to recognition. In 2D image where the size is M × N, the DCT coefficients arecalculated. The coefficients the low-frequency represent lighting conditions, the high frequency represent noise, and the average frequency variations and image detail.There are two ways to implement the DCT. In the first, the DCT [3], [12] is directly applied in the entire image, while the second, the image is divided in blocks and the DCT is calculated in each block.

Here, we use a block-based approach, dividing the image into regular blocks. The features are selected from all DCT coefficients of partitioned blocks. After applying the DCT, some coefficients are selected and other are discarded in the dimensionality reduction.

3.2Discrimination power analysis

After the DCT application, the selection of the coefficient with the highest discrimination power is done and consequently the dimension is reduced. To perform this process a technique is called DPA is used and its results points a better recognition when utilized. While approaches like PCA and LDA try to obtain a transform that maximizes the discrimination of the features in the transformed domain, DPA searches for the best features in the original domain. Besides that the DPA has no singularity problem and can be used as a feature reduction algorithm or combined with other approaches. In order to calculate the DPA of each coefficient, a great variation inter-class and low variation intra-class are considered.

IV. DISCUSSION

Depth data obtaining from Kinect can be utilized to increase robustness towards covariates such as expression and pose after relevant processing or feature extraction. On the other hand, 2D color images can provide inter-class differentiability which lacks the depth data. Since the color images contain visible texture properties of a face and the depth maps contain facial geometry. Soit is important to utilize both RGB and depth data for feature extraction and classification.The 3D images are less sensitive to covariates while comparing with the 2D images. RISE algorithm used in previous work needs large computations thus it is too complex and time consuming.

It takes both images as the input .So, here proposed work using DCT[3], [6], [12]with DPA instead of the RISE algorithm [1]. DPA searches for the best features in the original domain. DCT can show best performance and best results for illumination variation, position and expression. DPA-based approaches can achieve better performance with less complexity.

V. CONCLUSION

Generally the existing face recognition algorithms uses 2D or 3D information for recognition. But the information content or cost implications effects the performance and applicability of the existing face recognition algorithms. RISE algorithm is fusing with the ADM method in the previous work. But RISE algorithm is computationally complex. So here introducing the DCT with DPA and fusing it with ADM method.So, here face image is first transformed from spatial domain to frequency domain using DCT transformations.

DCT [3], [6], [12] is found to be the powerful transformation for feature extraction due to its data compaction property. The DCT is applied to the entire image to obtain the DCT coefficients, and then some of the coefficients are selected to construct feature vectors and the DPA method is used to select the coefficients with the highest discriminant power. Finally, the recognition step is executed using a SVM classifier [7]. Further, the ADM algorithm is proposed to extract

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ISSN (Print) 2319-5940

IJARCCE

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Vol. 5, Special Issue 1, Feburary 2016

and match geometric attributes. Geometric facial attributes is extracted from the depth image and face recognition is performed by fusing both and SVM classifier is used for classification.

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