Face Detection Through Image Enhancement Under Non-Uniform Lighting Conditions

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ABSTRACT:

A new wavelet-based image enhancement algorithm is proposed to improve performance of face detection in non-uniform lighting environment with high dynamic range. Wavelet transform is used for dimension reduction so that dynamic range compression with local contrast enhancement algorithm is applied only to the approximation coefficients. The normalized approximation coefficients are transformed using a hyperbolic sine curve which achieves dynamic range compression. Contrast enhancement is realized by tuning the magnitude of each coefficient with respect to its surroundings. The detail coefficients are also modified to prevent the edge deformation. Experimental results on the proposed algorithm show improvement on the performance of the Viola- Jones face detector when compared to other prominent enhancement techniques.

INTRODUCTION

Biometrics related to human characteristics and traits. They are used as a form of access control, identification, etc. Biometrics is categorized into two different types, behavioral and physiological. The Physiological is based on the human body, such as Face Recognition, Iris Recognition, Fingerprint, etc. In the social life, face is an important role for identification. Number of faces can learn throughout the lives and after years of separation easily identify the faces. Behavioral category is based on the behavior of the human such as voice, speech recognition, etc.

The applications using biometrics are useful in surveillance cameras in airports, banks, railway stations, bus stand, industries, etc. Cameras are placed for monitoring the public. The huge amount of data is recorded. Some recorded data may not be clear, blur, smaller in size. In biometrics the face recognition is an integral part. In biometrics the face is matched with the existing data and with the matching result the human being is identified and also develop many intelligent applications which may provide security and identification. In this thesis face recognition from very low resolution images are focused.

Face recognition has lots of advantages over biometric that people use to recognize one another. Some of the earliest identifiable in biometric is authentication pattern. It is easily understood by people, and it is easy for a human operator to machine decision. The face images are used as a human verified backup to automated fingerprint recognition systems. There are large legacy systems based on face images that are currently being automated such as police records, passports and driving licenses. Another example of legacy data for which face recognition with speaker identification is a valuable tool based on a video index.

The face is one of the multidimensional complex structures and for face recognition a good computing technique is needed. After a year some variation may be in faces due to aging and distraction like beard, glasses or change of hairstyles. Facial features are extracted from the video or image and implemented through different efficient algorithms. Some modifications are done to improve the existing algorithms. Some difficulties are there in face recognition with respect to lighting, angle, and other factors. With regard to these factors a high quality image will display. Cameras are placed in order to obtain relatively controlled photographs. Fixing the cameras facing near the ways, at check-ins in

Face recognition technology is one of the best biometric technology. It works with the individual identifier (human face) from the image. Face recognition system analysis the features of the face images input from the digital camera. From the input image, the system measures the face structure, distances between eyes, nose, mouth, etc. With the help of the unique characteristic face recognition system store face into its database. Different methods are there for face recognition. The first method is to identify an individual image from the live image by comparing the image to the database. After identifying the face of the live image the facial features of the live image are also compared to facial features stored in the central database. Another method for facial recognition system is to detect the image of a person from live image or movie and compares the detected image with the database image. It does this by comparing structure, shape, the distance between the eyes, nose, mouth and jaw, etc. For facial recognition, several images are taken at different angles, pose and with different facial expressions. In the recognition phase the detected image is compared to those that have been previously stored in the database.

While recognizing the face some physical changes such as facial expression change, aging, personal appearance such as makeup, glasses, hairstyle and disguise. Geometry changes such as change in scale, location and in-plane rotation of the face, facing the camera, facing the camera obliquely, presentation of a profile, not in full-frontal face. Imaging changes such as lighting variation, camera variation, channel characteristics such as broadcast or compressed images.

In this literature survey, the existing face detection system and face recognition system by researchers are discussed. Face detection systems extract the face from the input facial image. A face recognition system uses the extracted face region from a digital image or video to identify a person.

Rowley et al (1995) proposed a face detection system in visual scenes. It has very high detection rates and low false positive rates. The limitation of Rowley et al (1995) uses prior information for training. Osuna et al (1997) proposed an approach using Support Vector Machines for face detection. In this scheme, there is no prior information in order to obtain the decision surface. This system detects faces by scanning an image for face like patterns at many possible scales, by dividing the original image into overlapping sub images and classifying them using a sum to determine the appropriate class (face/non-face). Osuna et al (1997) not discussed about what face features are used to detect the face and also it will detect only grey level images. To overcome this problem Kotropoulos et al (1997) proposed an algorithm which is used only for frontal views extracted from the database named as European ACTS

M2VTS that contains video images of 37 different persons. The algorithm provides a correct facial candidate in all cases. The face features used here is eyes, nose and mouth. The detection rate is 86.5%. To improve the detection rate Rowley et al (1998) proposed a neural network-based face detection system. A connected neural network identifies and decides whether the window contains a face. For training the networks a bootstrap algorithm is used. In this algorithm the non-face image is taken for training. Identifying the non-face image is a difficult task. To avoid this limitation, Saber et al (1998) discussed a method based on facial features to estimate the location of the eyes. This method combines both the skin color detection and facial feature localization in the sequential manner for face detection. In this method identifying the face and non-face image is also difficult. To overcome the problem, Sung & Poggio (1998) uses clustering and distance metrics to identify the face and non-face. A neural network is used to classify a new pattern gives the measurement. This system uses a clustering and combined Mahalanobis, Euclidean metrics to measure the distance from a new pattern and the clusters. One drawback of this technique is that it does not provide to choose parameters like the number of clusters it uses.

To avoid the limitation of Poggio et al (1998), Nefian et al (1999) discusses about the Hidden Markov Model (HMM) based on face detection and frontal face image from top to bottom, and also the same left to right structure of states in each of these super states. It uses 240 X 256 resolution images. The detection rate is 86%. grey scale images with different face size, orientation, facial expression, skin color, lighting conditions and background. A simpler face detection method can be used to detect Regions Of Suspicion (ROS) and afterwards the proposed method can be used within these ROS for fine-tuning. To detect ROS, the color segmentation method can be used. The main drawback in this method is the image cropped and resized manually. Yang et al (2006) proposed low price detection system using Cyclone II MATLAB. Kun et al (2006) discussed the detection method based on SOFM (Self Organizing Feature Map) neural network. The skin regions can be segmented from the image and then human face regions can be located by the morphology.

Ye-Zhengchun et al (2007) proposed a detection technique to detect faces at any degree of rotation in the image plane, irrespective of their poses by using the wavelet invariant moments as input of the SCNN. It uses a neural network based technique. Gao et al (2008) proposed an approach for face detection using the Haar - classifier. The performance of the proposed system has very high detection rate and low false positives. Wang et al (2008) proposed a face detection method by using the template matching algorithm and 2DPCA algorithm. This method uses two classifiers. The first classifier is called as rough classifier, which is to filter the non-face. The second classifier is called as core classifier where in a color image. The elliptical skin model in YCbCr color space is constructed to segment skin color pixels from the background image in conjunction with edge information.

Kherchaoui et al (2010) proposed based on combining both skin color and geometrical face characteristics. It has two parts, the first one consists of skin color detection by a statistical method based on a Gaussian mixture model in the chromatic CbCr color space. The second part is for processing detected skin regions. A template matching is applied to reach the final decision depending on the degree of similarity between the template used and the region under analysis. Liu et al (2010) proposed an algorithm that improves the face detection. At first, a skin color model is used to extract the face region, then the Back Propagation neural network model is used to simulate the output of the possible human face region and Bayesian decision theory is used to classify the face or non-face pattern. Li et al (2010) described a face detection method combined with skin color detection and an improved AdaBoost algorithm. At first skin model segmentation and morphological operators are applied to detect skin regions in the image. According to the geometrical characteristics of the face, it screens the candidate face regions. The improved classifiers in a cascade structure based on AdaBoost are used to detect the face. Guo et al (2011) proposed a face detection algorithm based on PFMPF (Probability based Face Mask Pre-Filtering). This method can effectively filter out more than 85% of nonface in an image and filter with an Adaboost strong classifier. The review shows that it does not detect the face quickly and accurately.

Image/Scene Training (VISTA) is presented. It is applied to the Super Resolution problem. The limitation of this method is it required a large database to make it applicable to a wide range of images and also it uses a Complicated Statistical formulation. Cootes et al (2001) proposed a new method for face recognition based on the appearance of images. The matching algorithm is used for recognition. To overcome the problem of PCA, Bartlett et al (2002) presented a face recognition system based on Independent Component Analysis (ICA). It has two types of architecture, in the first architecture pixels are outcomes, and in the second the images as outcomes. By combining the two architectures it gives good performance. Duda et al (2002) proposed a method which combines the different methods such as neural networks, pattern recognition, the theory of machine learning, theory of invariance's for face recognition. The limitation of this method is it uses different methods so it increases the computation and time complexity. Baker et al (2002) proposed a super-resolution algorithm that uses different constraints with reconstruction constraints. But the limitation of this algorithm is it uses local features in the face recognition. Heisele et al (2003) proposed a face recognition method based on component based and global methods. In component-based system, the features are selected, then extract them and combined into a single feature which is done by using a support vector machine. Global systems are used to recognize the faces by classifying a single feature.

Wright et al (2009) proposed an algorithm for object recognition. This new framework provides for occlusion. The recognition algorithm is to select the training images to maximize robustness. Song et al (2009) discussed the face recognition technique based on biometrics. To detect the face, three regions in the human face are taken. The curve distance of two key feature points is added into the feature vector, which consists of Euclidean distance, curve distance, angle and volume. Youyi et al (2010) proposed the face recognition algorithm based on the wavelet neural network. This method recognizes the face very quickly. Razzak et al (2010) proposed a face recognition method based on Fisher's method. Comparing with the other method Fishers method recognizes the face very quickly. Zou et al (2010) proposed a method which learns about the nonlinear relationship between the low resolution face image and high resolution face image in kernel feature space. Ma et al (2010) proposed a hallucination method. It reconstructs a high resolution face image from a low resolution image by using training image pairs. The high resolution images are formed by integrating the hallucinated patches are reconstructed using the same weights. Wang et al (2010) proposed a method for 3D face recognition. First, an iterative closest point to align all 3D faces. Next, the noise is reduced, which is present in front of the face. After reducing the noise, the nose tip point is detected and cropped a region near to the image to recognize the face.

IMPLEMENTATION

Implementation Figure shows the face recognition architecture. Each module in the architecture is discussed in the following sections.

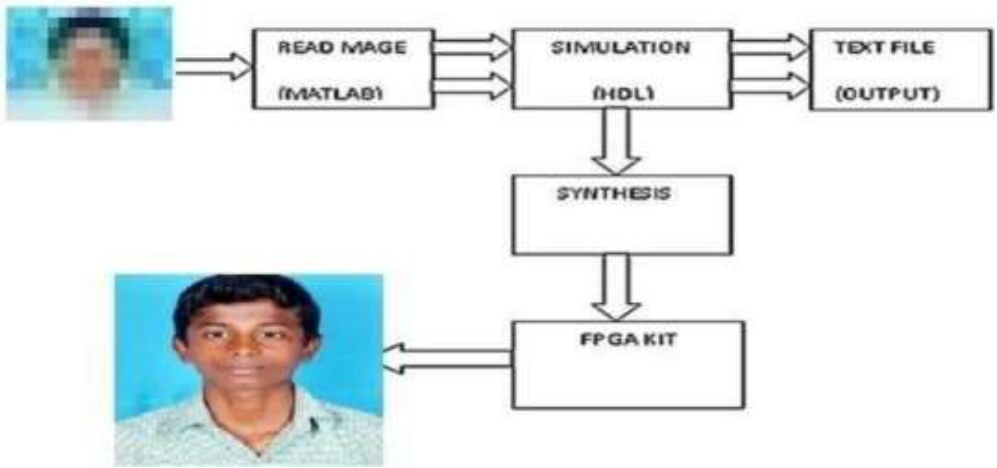

Figure: Face recognition architecture

It reads two images from database for comparison. One of which is a High Resolution (HR) image and another having noise image (i.e.) Low Resolution (LR) image. The two image files will generate a test input file which can use as input to Verilog module. The training phase consists of two steps, namely, clustering and proposed as a preprocessing step. After clustering, the Very Low Resolution (VLR) - High Resolution (HR) image pairs in each cluster are nearly linear, i.e., the relationship can be approximately represented by a matrix. In the second step, the relationship mapping from the VLR to the HR face image spaces within the cluster is determined. K-Means clustering is employed here, by which the linear relationship, that is expected to be there between the input and corresponding HLR is ensured in the clustered training image pairs. The block diagram, Figure shows the steps involved in the clustering algorithm. Clustering means grouping the objects (called clusters). The appropriate clustering algorithm and parameter settings depend on the individual data set and the intended use of the results. Here, a clustering algorithm is proposed to ensure that the clustered training image pairs have a linear relationship. This clustering algorithm reduces the complexity of the relationship learning process.

A standard High Resolution database is used. All the images are taken against a bright homogenous background with the subjects in an upright, frontal position. The files are in JPEG format. The size of each image is 10 x 10 pixels with 256 grey levels per pixel. Both male and female subjects are present in this database. To create the Very Low Resolution (VLR) image corresponding to the High Resolution (HR) images, then the HR images are resized to 64 x 48 pixels. The clustering algorithm utilizes the following two parameters: (a) The gradient of the low resolution image (b) The low resolution image. The contribution of the above two parameters is balanced by two constants - 11 and 1 2 .

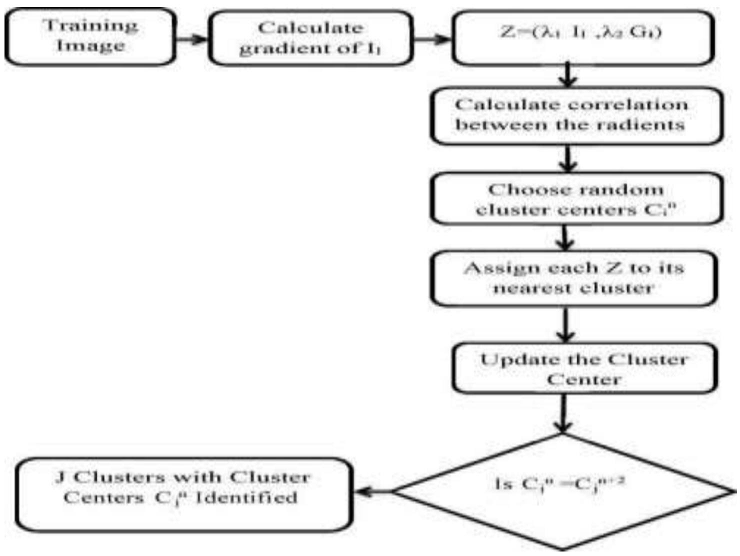

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Figure Clustering

Figure depicts the HR images paired with their corresponding Very Low Resolution image in the database. Once subjected to the clustering algorithm, the images showing maximum similarity between their gradients are clustered together. This is depicted in Figure. Each cluster holds the training image pairs, i.e., VLR - HR image pairs that have a linear relationship. Let ***R*** be the relationship mapping between the VLR to HR face image spaces within the cluster, then Ihi = R(Il i). The relationship being represented as above, from the image pair in each of the cluster, the relationship operator R can be derived asR = inverse (LR) * HR. From this, the relationship matrix corresponding to each of the image pair is determined. The clustering is obtaining a unique relationship operator for each of the clusters. So the relationship operators of the images in a particular cluster are extracted. The relationship operator corresponding each cluster - R cluster is selected such that a reconstruction error is minimized.

The reconstruction error is measured in the HR image space by the dataconstraint ***e*** R.

$$eR\ (Ih) = \|Ih - Ih\| \qquad (1.1)$$

Here, Ih and Il represent the HR and VLR image respectively. A minimum mean square error is employed to learn R is represented as

$$minR\ \|ihi - Rlli\| \qquad (1.2)$$

Utilizing the above two equations in the learning process ensures that the Rcluster chosen incurs a minimum reconstruction error. The test image is of dimensions 10 x 10 pixels with 256 grey levels in each pixel, i.e., a VLR image is given as the test image. The gradient of this image is then calculated as Gtest. Since the parameter of the clustering algorithm is used in the training phase is the gradient, Gtest can be used to classify the VLR image into the appropriate cluster 'i'. Once the cluster 'i' is identified, the corresponding R cluster 'i' is applied to the input testing image. The clustered data pairs is equivalent to minimizing the difference of thegradient between the data pairs.

RESULTS AND DISCUSSION

The training images on which clustering algorithm was applied is shown below in Figure. The well aligned training images are normalized to the resolutions of 64 x 48 (HR) and 10 x 10 (LR). Sincethere is no general method for aligning images with different poses, only frontal images are used.

Figure Sample of training images

The number of clusters is chosen to be three and the following Figure (a), Figure (b), Figure (c) shows the cluster membership of each image.

CLUSTER 1

(a)

CLUSTER 2

(b)

CLUSTER 3

Figure (a) Images in Cluster 1 (b) Images in Cluster 2 (c) Images in Cluster 3

The Figure shows the input query image. The Figure showsthe reconstructed output HR image.

Figure: VLR Test image

Figure: Reconstructed output HR image

The reconstruction of the HR image from the VLR by the proposed algorithm. If the number of Clusters = 5, the images in the training database is clustered as shown in Table. The Table in which each row represents a cluster group and their elements indicate the indices of the images present in the database. The reconstruction of the VLR test image, when the training images are grouped into five clusters is shown in Figure.

Table: Cluster index table with 5 clusters

Cluster Index	Image indices
Cluster	11
Cluster	5,7,8
Cluster	6
Cluster	1, 2
Cluster	3, 4, 9, 10

If the number of Clusters = 10, the images in the training database is clustered as shown in Table. The Table where each of the rows represents a cluster and its elements represent the indices of the images presentin the database. The reconstruction of the VLR test image, when the training images are grouped into ten clusters is shown below in Figure.

Table Cluster index table with 10 clusters

Cluster index	**Image indices**
Cluster 1	7
Cluster 2	1
Cluster 3	2
Cluster 4	6
Cluster 5	9
Cluster 6	5, 8
Cluster 7	4
Cluster 8	10

The Peak Signal to Noise Ratio (PSNR) are the error metrics usedto compare the quality of the image based on compression. PSNR represents tomeasure the peak error. If the number of cluster size is 5 then the PSNR of this reconstructed image is computed to be 23 dB. If the number of cluster size is10 then the PSNR of this reconstructed image is computed to be 30.8 dB.

The code execution time in MATLAB for the two different relationship learning procedures adopted in proposed algorithm is compared below for different database sizes. The values of time mentioned in the Table are in seconds.

Table Comparison of time complexity

Procedure	**Database size = 11**	**Database size=21**
Average R	3.5	6.23
Minimum error R	146.56	500.3

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The following observations are made from the Figure;

- Database with two different sizes (11, 21) are taken forobservation.
- Calculate the average R and minimum error R for the two size database

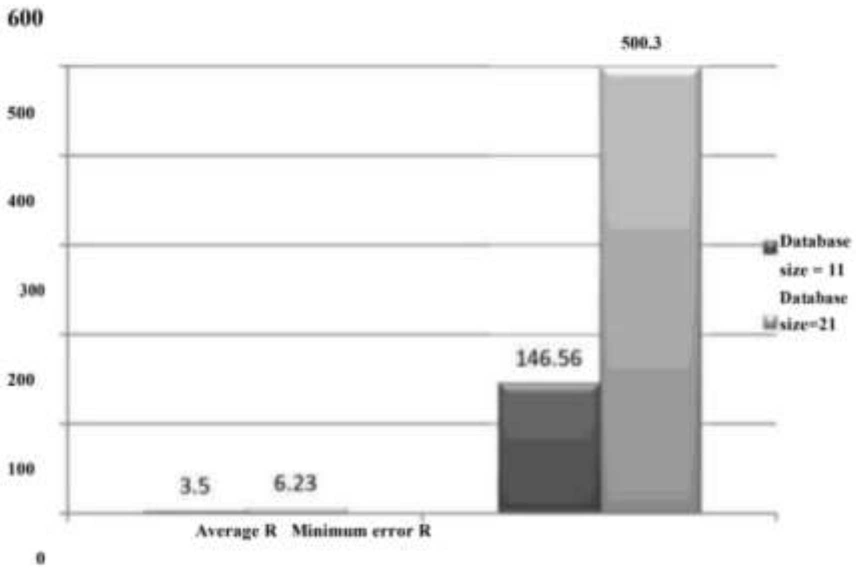

Figure: Comparison of time complexity for different database size

SUMMARY

In this paper, face recognition approach using the linearity clusterity and recognition algorithm is discussed. In clustering the imagesfrom the database are clustered into different clusters and easily recognizedthe face. For different database the cluster varies depends upon the size of the database. The 10 x 10 VLR images is taken and it is recognized by verifyingin the database and produce 64 x 48 HR image. This proposed method outperforms when compared with the other method. The face recognition system was implemented in MATLab.

EXPERIMENTAL RESULTS

The proposed algorithm has been applied to process numerous color images captured under varying lighting conditions. From our observations we can conclude that the algorithm is capable of removing shades in the high dynamic range images while preserving or even enhancing the local contrast well. Besides, the produced colors are always consistent with the colors of the original images. Two of these results are shown in Fig.4. The other advantage of the algorithm is its speed. Since the convolutions which take most of the processing time are only applied to the approximation coefficients, the processing time is reduced by more than two when compared to IRME which is known to be designed for real time video processing.

CONCLUSION

The enhancement of the visual quality of digital images is usually applied to improve the performance of computer vision algorithms. Therefore, we used our proposed image enhancement technique as an image preprocessor for a face detection algorithm. A wavelet based fast image enhancement algorithm which provides dynamic range compression preserving the local contrast and tonal rendition has been developed to improve the visual quality of the digital images. Experiments conducted for evaluating the improvement in face detection showed that proposed technique is more suitable as a preprocessor in face detection schemes when compared with MSRCR and IRME.

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