International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177
Volume 7 Issue V, May 2019- Available at www.ijraset.com

Review on Block Based Approach for Unconstrained Face Identification

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Abstract: Many approaches to unconstrained face identification exploit small patches which are unaffected by distortions outside their locality. A larger area usually contains more discriminative information, but may be unidentifiable due to local appearance changes across its area, given limited training data. We propose a novel block-based approach, as a complement to existing patch-based approaches, to exploit the greater discriminative information in larger areas, while maintaining robustness to limited training data. A testing block contains several neighboring patches, each of a small size. We identify the matching training block by jointly estimating all of the matching patches, as a means of reducing the uncertainty of each small matching patch with the addition of the neighboring patch information, without assuming additional training data.We further propose a multi-scale extension in which we carry out block-based matching at several block sizes, to combine complementary information across scales for further robustness. We have conducted face identification experiments using three datasets, the constrained Georgia Tech dataset to validate the new approach, and two unconstrained datasets, LFW and UFI, to evaluate its potential for improving robustness. The results show that the new approach is able to significantly improve over existing patch-based face identification approaches, in the presence of uncontrolled pose, expression, and lighting variations, using small training datasets. It is also shown that the new block-based scheme can be combined with existing approaches to further improve performance.
Keywords: Face Recognition, Image Processing, Normalized Cross Correlation (NCC), Convolutional Neural Network CNN, Face, FERET

I. INTRODUCTION

Patch-based image processing is common for dealing with variable lighting conditions. Because illumination varies slowly in natural images, it can be treated as piecewise constant. Therefore, globally variable lighting can be treated as constant lighting within small patches. For example, illumination normalization filters such as self-quotient images (SQIs) and Gradient faces are applied in small patches; local binary patterns (LBPs), and its variants are also used to code high frequency variations which represent facial structure in local regions (e.g, patches), while discarding the low frequency lighting. The NCC metric mentioned above is also invariant to linear transforms in image amplitude, and therefore provides an illumination-invariant match score between two patches with constant lighting difference. However, while the independent matching of small patches has the advantages of being easier to train and to normalize for lighting variation, small patches can be limited in their discriminative ability, which makes their matching prone to errors. Matching larger facial areas will improve discrimination, and hence the matching accuracy, but larger areas may be unidentifiable due to greater local appearance variations, given limited training data. In the past, several approaches have been taken to try to solve this problem. Mainly, these approaches include: 1) to include, or synthesize, diverse conditions or adaptive data in the training data to reduce the training and testing mismatch; 2) to prealign the images to alleviate the pose variation, by estimating the pose of an input image by fitting local patch-based features to 2-D or 3-D models; and 3) to use multiscale approaches to combine complementary information at several patch-sizes to help improve discrimination. Specifically, multiscale extensions have concatenated multiscale LBPs, and derived SRs over several dictionaries of patches, at several patch-sizes. Multiscale collaborative representations have also been proposed. More recent subspace-based approaches attempt to derive a locality preserving or part-based representation of the image, which still preserves the global geometric structure of the data, for robustness to corruptions in the data. We propose a new approach, as a complement to existing approaches, toward solving the problem of low discriminative ability with small image patches. Specifically, we study the problem of enlarging the matching areas, from the usual small patches to some larger regions, as a means of increasing the discrimination for unconstrained face image comparison, withoutnecessarily requiring extra training data. We call the larger matching regions blocks. A block is composed of a number of neighboring patches which are matched jointly, i.e., to capture the cross-patch dependence in a larger facial area for more discriminative matching. It might be expected that, to model the larger blocks, with potentially greater

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variations, we may require more training data than usually required for modeling smaller patches. But this is not necessarily the case. We do not assume additional training data, but present a novel algorithm that forms the matching training blocks by combining suitable small training patches from the available training data, to overcome the data sparsity problem. Our new approach extends the existing approaches, mentioned above, and the largest matching area approach by effectively breaking the patch-size barrier. That is, the new approach effectively allows blocks of any size, in theory up to whole images, to be matched holistically with limited training data. We demonstrate our new approach by using a simple metric, NCC, for comparing images. We show that the new approach improves over conventional approaches under similar training conditions, based on three face image datasets, two being considered to contain unconstrained face images.

II. LITERATURE SURVEY

The main motivation behind pursuing automated face recognition is its growing interest in applications such as security, law enforcement, entertainment, gaming, and personal photo organization. Face recognition is commonly used as biometrics because of its ease of use, non-invasive nature, availability, and reasonable performance. A face biometric system typically uses two sets of images. One is the gallery that contains face images or models of the people made known to the system during enrollment. The other contains probe images. Probe images can be from the set of people known or unknown to the system. In face recognition systems such as in passport verification, access control, both the probe and gallery facial images are captured at controlled environments. The utility of face recognition in such security applications in a controlled environment has been realized for decades. However, the research in unconstrained face recognition such as in surveillance, personal photo collection, gaming, and human computer interaction began more recently. The challenges in unconstrained face recognition arise from various imaging conditions such as illumination variations, scale changes, resolution, noise, blur, occlusion and those due to the complex structure of a human face such as pose, expression and age. This work is a step towards a solution of the challenges in the unconstrained face recognition [1].

Histogram equalization is powerful method for image enhancement and it will increase the contrast of image. The enhanced image will give the full dynamic range of histogram. However, histogram equalization process tries to merge the adjacent gray levels together in order to force the uniformity of number of pixels in each appeared gray levels. Consequently, the intensity saturation will be presented in darkness regions and whiteness region. Histogram equalization assigns the intensity values of pixels in the input image such that the output image contains a uniform distribution of intensities. It improves contrast and obtain a uniform histogram. This technique can be used on a whole image or just on a part of an image. Digital Image Processing is a rapidly evolving field with the growing applications in science & engineering. Image Processing holds the possibility of developing an ultimate machine that could perform visual functions of all living beings. The image processing is a visual task, the foremost step is to obtain an image i.e. image acquisition then enhancement and finally to process. In this paper there are details for image enhancement for the purpose of image processing. Image enhancement is basically improving the digital image quality. Image histogram is helpful in image enhancement. The histogram in the context of image processing is the operation by which the occurrences of each intensity value in the image is shown and Histogram equalization is the technique by which the dynamic range of the histogram of an image is increased [2].

It is our opinion that research in face recognition is an exciting area for many years to come and will keep many scientists and engineers busy. In this paper we have given concepts of face recognition methods & its applications. The present paper can provide the readers a better understanding about face recognition methods & applications. Face recognition presents a challenging problem in the field of image analysis and computer vision. The security of information is becoming very significant and difficult. Security cameras are presently common in airports, Offices, University, ATM, Bank and in any locations with a security system. Face recognition is a biometric system used to identify or verify a person from a digital image. Face Recognition system is used in security. Face recognition system should be able to automatically detect a face in an image. This involves extracts its features and then recognize it, regardless of lighting, expression, illumination, ageing, transformations (translate, rotate and scale image) and pose, which is a difficult task. This paper contains three sections. The first section describes the common methods like holistic matching method, feature extraction method and hybrid methods. The second section describes applications with examples and finally third section describes the future research directions of face recognition [3].

This project has described FACE[put these kind of words as keywords and put mark over such words because these are not our own words], a new framework for face analysis including classification. FACE improves accuracy performance compared to state-of-the-art methods, for uncontrolled settings when the image acquisition conditions are not optimal. This is typical of applications such as photo tagging over social networks like Face book or cataloguing of celebrities' images in a magazine editorial office. FACE has

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access to multiple gallery instances for each subject and does not require expensive training to learn the face space, using instead straightforward correlation of local regions after proper pose and illumination normalization. FACE also has access to pose (SP) and illumination (SI) image quality indices, respectively, which can be used to *a priori* discard images whose quality is not sufficient to guarantee an accurate recognition response. Confidence in the system response is further assessed using SRR I and SRR II, two reliability indices based on the analysis of system responses in relation to the composition of the gallery. Experimental results show that FACE outperforms competing methods, with a significant increment in accuracy versus the next ranked methods. The improvement depends on the complexity of the data set at hand but is always worth of consideration. Due to its characteristics, FACE can be considered as a good candidate to support tagging. Face recognition has made significant advances in the last decade, but robust commercial applications are still lacking. Current authentication/identification applications are limited to controlled settings, e.g., limited pose and illumination changes, with the user usually aware of being screened and collaborating in the process. Among others, pose and illumination changes are limited. To address challenges from looser restrictions, this paper proposes a novel framework for real-world face recognition in uncontrolled settings named Face Analysis for Commercial Entities (FACE). Its robustness comes from normalization ("correction") strategies to address pose and illumination variations. In addition, two separate image quality indices quantitatively assess pose and illumination changes for each biometric query, before submitting it to the classifier. Samples with poor quality are possibly discarded or undergo a manual classification or, when possible, trigger a new capture. After such filter, template similarity for matching purposes is measured using a localized version of the image correlation index. Finally, FACE adopts reliability indices, which estimate the "acceptability" of the final identification decision made by the classifier. Experimental results show that the accuracy of FACE (in terms of recognition rate) compares favorably, and in some cases by significant margins, against popular face recognition methods. In particular, FACE is compared against SVM, incremental SVM, principal component analysis, incremental LDA, ICA, and hierarchical multi scale local binary pattern. Testing exploits data from different data sets: Celebrity DB, Labeled Faces in the Wild, SC face, and FERET. The face images used present variations in pose, expression, illumination, image quality, and resolution. Our experiments show the benefits of using image quality and reliability indices to enhance overall accuracy, on one side, and to provide for individualized processing of biometric probes for better decision-making purposes, on the other side. Both kinds of indices, owing to the way they are defined, can be easily integrated within different frameworks and off-the-shelf biometric applications for the following: 1) data fusion; 2) online identity management; and 3) interoperability. The results obtained by FACE witness a significant increase in accuracy when compared with the results produced by the other algorithms considered [4].

In this chapter, we surveyed image processing as a pre-processing step that can improve image analysis and feature extraction. We developed a taxonomy of image processing methods to frame the discussion, and applied the taxonomy to examples in the four fundamental vision pipelines, as will be developed in the taxonomy of Chapter 5, including (1) local binary descriptors such as LBP, ORB, FREAK; (2) spectra descriptors such as SIFT, SURF; (3) basis space descriptors such as FFT, wavelets; and (4) polygon shape descriptors such as blob object area, perimeter, and centroid. Common problems and opportunities for image pre-processing were discussed. Starting with illumination, noise, and artifact removal, we covered a range of topics including segmentation variations such as depth segmentation and super-pixel methods, binary, gray scale and color morphology, spatial filtering for convolutions and statistical area filters, and basis space filtering. This chapter describes the methods used to prepare images for further analysis, including interest point and feature extraction. Some of these methods are also useful for global and local feature description, particularly the metrics derived from transforms and basis spaces. The focus is on image pre processing for computer vision, so we do not cover the entire range of image processing topics applied to areas such as computational photography and photo enhancements, so we refer the interested reader to various other standard resources in Digital Image Processing and Signal Processing as we go along [5].

Most current methods for unconstrained face recognition are patch based. The method described in this paper, based on blocks of patches, is a complement to existing methods. This research aims to improve the robustness to uncontrolled pose, expression, and lighting variations by enlarging the matching areas without assuming additional training data. We extended the NCC metric, previously used in patch-based matching, to our block-based matching to demonstrate this feasibility. This paper described a realization of the block-based image matching for practical use. The core part of this realization is the solution of a constrained maximization problem, for jointly estimating the matching patches forming each matching block from the available training data with computational efficiency. We showed that the new algorithm is not only capable of dealing with pose or expression differences but also capable of compensating for uneven lighting differences across the blocks. Finally, we presented a multiscale extension, to further exploit the block-based matching at variable block sizes to improve the performance at larger scales. On three datasets we have shown the benefit of our contributions, and improved identification accuracy significantly over existing patch-based methods

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for unconstrained face identification with limited training data. We suggest that our approach to improving robustness for patch-based image processing can also be exploited in future to improve the quality of features and classifications produced by CNNs. More research is required to identify a suitable way to combine this idea with an appropriate CNN architecture. In future, we would also like to develop an algorithm for learning weights to combine scales more effectively, rather than manuallytuning. Many approaches to unconstrained face identification exploit small patches which are unaffected by distortions outside their locality. A larger area usually contains more discriminative information, but may be unidentifiable due to local appearance changes across its area, given limited training data. We propose a novel *block*-based approach, as a complement to existing *patch*-based approaches, to exploit the greater discriminative information in larger areas, while maintaining robustness to limited training data. A testing block contains several neighboring patches, each of a small size. We identify the matching training block by *jointly* estimating all of the matching patches, as a means of reducing the uncertainty of each small matching patch with the addition of the neighboring patch information, without assuming additional training data. We further propose a multiscale extension in which we carry out block-based matching at several block sizes, to combine complementary information across scales for further robustness. We have conducted face identification experiments using three datasets, the constrained Georgia Tech dataset to validate the new approach, and two unconstrained datasets, LFW and UFI, to evaluate its potential for improving robustness. The results show that the new approach is able to significantly improve over existing patch-based face identification approaches, in the presence of uncontrolled pose, expression, and lighting variations, using small training datasets. It is also shown that the new block-based scheme can be combined with existing approaches to further improve performance [6].

III. PROPOSED WORK

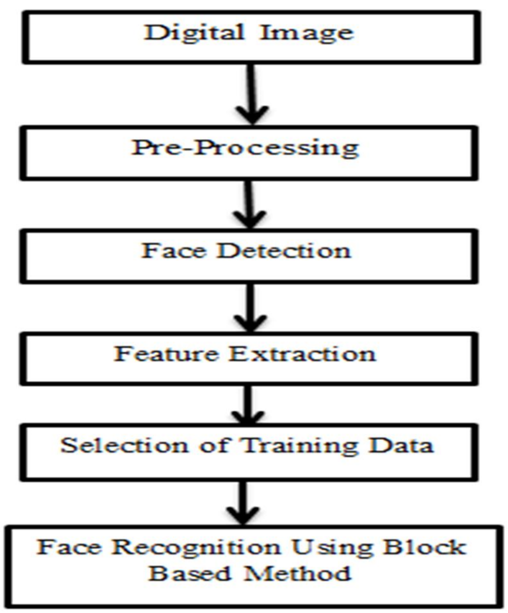

Fig.1. Block diagram of Overview of the Proposed Method

A. *Image Preprocessing*

In image preprocessing, image data recorded by sensors on a satellite restrain errors related to geometry and brightness values of the pixels. These errors are corrected using appropriate mathematical models which are either definite or statistical models. Therefore we need to do some image enhancements. Image Enhancement is the modification of image by changing the pixel brightness values to improve its visual impact. Image enhancement involves a collection of techniques that are used to improve the visual appearance of an image, or to convert the image to a form which is better suited for human or machine interpretation.

B. *Image Pre-Processing Steps*

1) Gray Scale Conversion
2) Noise Filtering
3) Contrast Stretching
4) Histogram Equalization

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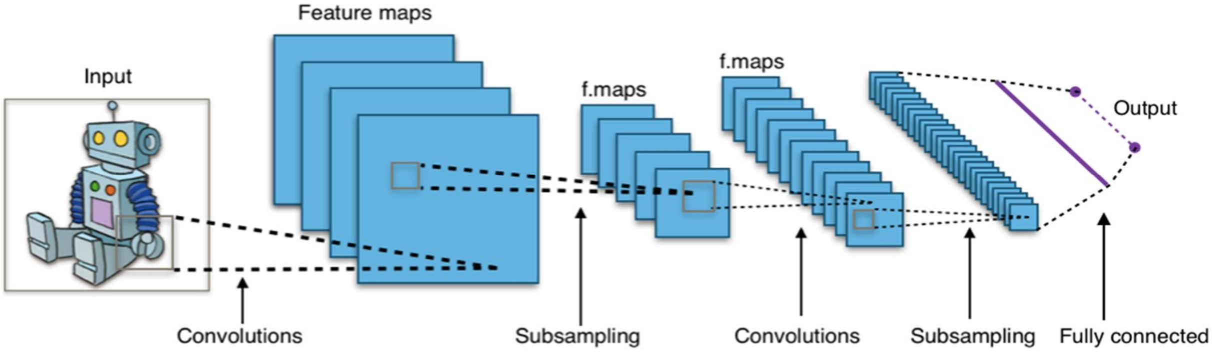
C. Convolutional Neural Network Architecture

There are three main types of layers to build CNN architectures: Convolution (CONV) Layer, Pooling Layer, and Fully-Connected Layer.



D. Face Detection Using CNN

Face detection is a process where, given an image, the system detects the presence of faces and their corresponding regions in the image. This is a two class problem where face regions represent the first class, conveniently referred to as a positive class, and non-face regions represent the second class. Once the face regions are detected and pre-processed, they are used for recognition. The face detection stage may not always be required in face recognition. For example, in law enforcement and passport verification systems, images are required to conform to a certain set of specifications. Such specifications are also applied while capturing the images. In such systems, it is ensured that all gallery and probe images contain face images, and they have similar settings. However, in systems like surveillance and consumer photo gallery collection, face detection is a required stage before face recognition.

E. Feature Extraction

Feature extraction is a process in which meaningful and discriminative descriptors are extracted from face images. This is also the process in which a high dimensional facial image space can be reduced to a low dimensional facial feature space. A gray scale face image of size 100 x 100 contains 10^4 pixels, and pixel values range from 0 to 255. This makes the face image space of the dimension 10^4 x 256. However, a face lies in a much lower subspace than this space. Not all the image pixels or parts contribute to identifiability. Therefore, it is very important to define the features in a face images which are sufficient to describe a person. The ideal features should handle the intra-class variations while enhancing the inter-class differences despite pose and other degradations, such as noise, lighting, and blur. The feature extraction process consists of defining meaningful features, extraction, and selection of such features.

F. Block Based NCC Algorithm for face Identification

The following summarizes multiscale block-based NCC algorithm for face recognition:

Given a testing image, we divide it into small over-lapping patches Y = (y1, y2, . . . ,yK) as normally done in other patch based approaches. Assume that we are given a set of training images for each person to be identified. These are also divided into over-lapping patches, each training image taking a form X = (x1, x2, . . . ,xL).

Given the testing image, for each person perform the following

1) *Initialization:* We first find an initial matching image from the training data for the whole testing image Y, in which each matching training patch is selected by maximizing the patch-based NCC $R(y_k, x_l)$ over all the subject's training patches xl that satisfy $\|l - (k + d)\| \leq k$, assuming gaining factor g= 1.
2) *Multiscale, Iterative Block Matching:* At each testing block location k1, for each block size Q, we form a testing block $Y_{k1,kQ}$ from patch k_1 to k_Q. Then, we estimate the optimal matching training block by iteratively reestimating each of the matching training patches by solving (11). Specifically, for each iteration n ($n \geq 1$), for each initial training patch of the matching block to be reestimated, for each possible training patch candidate x_{lq}, solve equation to obtain a new optimal estimate, by using the above initial estimates based on independent patch matching to start the iteration. Stop iterating when there is no change in the matching block estimate between successive iterations.

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3) *Multiscale Combination:* Having derived convergent, block-based scores $RH(Y_{k1,kQ}, X\^_{l1,lQ})$ for each block size Q at each testing block location k1 for each person, carry out a weighted sum of the scores at the variable sizes at each location for each person, to derive an average score for the blocks at the location for each person.
4) *Classification:* The above location-specific matching scores are summed over all the locations, for each person, to form the overall score of that person for identification. It should be noted that the patched-based NCC approach is a special case of our approach, which just corresponds tostep 1) of the above algorithm. Step 2) of the algorithm, iterative block matching, takes most of the computation time. In experiments, we accelerate the computation in step 2) by only considering in step 2) the most-likely training patch candidates x_{lq} for each testing patch y_{kq} . The most likely training patch candidates for each testing patch are selected in step 1). The selected candidates satisfy $R(y_{kq} ,x_{lq}) \geq$ Rmin, subject to the appropriate geometric semantic constraint, where Rmin is a threshold used to prune unlikely matching training patches because of their extremely low correlation values.

IV. CONCLUSION

Most current methods for unconstrained face recognition are patch based. The method described is, based on blocks of patches, is a complement to existing methods. This research aims to improve the robustness to uncontrolled pose, expression, and lighting variations by enlarging the matching areas without assuming additional training data. The NCC metric, previously used in patch-based matching is extended to block-based matching to demonstrate this feasibility. It describes a realization of the block-based image matching for practical use. The core part of this realization is the solution of a constrained maximization problem, for jointly estimating the matching patches forming each matching block from the available training data with computational efficiency. It is shown that the new algorithm is not only capable of dealing with pose or expression differences but also capable of compensating for uneven lighting differences across the blocks. Also a multiscale extension is presented to further exploit the block-based matching at variable block sizes to improve the performance at larger scales.

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