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An FPGA based Face Recognition System using Gabor and Local Binary Pattern

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Abstract— **Face of a human being conveys a lot of information about identity and emotional state of the person. Nowadays, in many applications such as in the field of banking, surveillance, seminars halls and multimedia equipment are becoming more important, but almost all algorithms and approaches for face analysis are application dependent and so generalization becomes quite difficult. For that reason the face analysis research community is trying to cope with face detection and recognition challenges. In our research we are going to give more stress on well-known algorithms like Local Binary Pattern (LBP) and Gabor Filter for feature extraction, detection and recognition. Face recognition system involves LBP descriptors and Gabor filters that are used for extraction of the global and local facial features and then the Gabor Filter histogram is developed. In real world applications, to provide a higher level of robustness, hardware optimization, and ease of integration, it is desirable to have a stand-alone, embedded face recognition system. As such, we have chosen the FPGA as a reconfigurable platform to carry out our implementation.**

Index Terms— **Local binary pattern (LBP), Feature Extraction, LBP descriptors, Gabor Filter histogram, FPGA.**

I. INTRODUCTION

Face detection and recognition are playing a very important role in our current society, due to their use for a wide range of applications. Most new digital cameras have a face detection option for focusing faces automatically. Some companies have even gone further, which not only detect faces but also for detect smiles by analyzing "happiness" using facial features like mouth, eye lines or lip separation, which will only take pictures if persons smile. In addition, most consumer electronic devices such as mobile phones, laptops, video game consoles and even televisions include a small camera enabling a wide range of image processing functionalities including face detection and recognition applications.

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On the other hand, other demanding applications for face detection and recognition are in the field of automatic video data indexing to cope with the increase of digital data storage.

In the literature, two main forms of face recognition exist: still-image-based face recognition and video-based face recognition. Still image face recognition relies on classifying an individual based on a single image obtained from a still shot camera. Conversely, video based face recognition relies on a sequence of frames to extract more information about the face of a subject. An inherent advantage of using still-image-based face recognition over video based systems is that the images are of higher resolution. As a result, current face recognition algorithms are able to recognize a face more accurately. Further to this, still image based recognition is useful in controlled environments where pose and illumination are relatively fixed. One example of such an environment is while taking subjects photograph at the airport check in [1]. The disadvantages of still-image-based face recognition occur when such a controlled environment is not easily attainable. An example of this scenario would be a security camera used to identify a subject in a public place. In this case, video-based recognition yields better results.

A number of face recognition algorithms have been developed in the past decades [1] with various hardware implementations [2], [3], [4]. Up to now, many face representation approaches have been introduced, which include the well known Principal Component Analysis (PCA) [5], Linear Dis-criminate Analysis (LDA) [6], Independent Component Analysis (ICA) [7], etc.

II. EXISTING WORK

There are numerous FPGA based face recognition techniques that have been projected in the past 20 years. In the FPGA implementation using PCA method, done by H. Ando, N. Fuchigami, M. Sasaki, and A. Iwata [8], the first stages of implementation were tested on prototype software running on a PC. This software reads in an RGB image, reduced in size to 100 x 100 pixels. Face detection is then performed by detecting skin color, and the PCA algorithm is applied to the face area detected. The input to the system was a USB camera device connected to the PC [8]. The next step was to implement the face recognition system on an FPGA. The database of images was preprocessed, storing the average face and eigenvectors on the FPGA board memory. The processed image is then passed to a multiplier/accumulator unit that reads the eigenvectors from memory and performs the projection required by the algorithm. The next stage involves passing this Eigenspace projection into the matching circuit and performs the necessary Euclidean distance calculations. Finally, a decision unit reads in these distances and makes the face recognition decision based on the requirements of the algorithm.

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A second type of FPGA implementation relies on neural network. Neural network algorithms for face recognition have been applied extensively on FPGA boards. The face recognition system was implemented in two phases, a training phase and a testing phase. In the training phase, image data is sent to a Target Generator, which encodes the images and feeds them to the Learning System. The output of the Learning System is then compared to the output of the Target Generator, and the difference is “fed back to the Learning System to further decrease error.” [9].

Yasunaga, Nakamura, and Yoshihara [10] implemented the genetic algorithm on an FPGA chip with the intention of creating a personal identification system. After applying the chromosome evolution technique to the F-tables of the target individual and other people, the two tables were synthesized on an AND gate plane. That is, for each category, the input image is fed into an AND gate grid with both connected and disconnected nodes, representing bits and don’t-cares, respectively. The output of each AND gate category is then fed into a counter unit which is designed to keep track of the number of activated AND gates. Finally, a maximum detector unit selects the counter output with the highest value and classifies the face as belonging either to the target person or to an unknown person. Since the input image is fed to all the AND gates simultaneously, the matching process is carried out in parallel [10].

A final implementation strategy for face recognition algorithms on an FPGA involves using an evolutionary reconfigurable architecture. This approach is used in order to enhance the functionality of face recognition in situations where the environment varies. Under this architecture, there are three main stages to face recognition: a reconfigurable filter module (RFM), a reconfigurable feature space module (RFSM), and an evolutionary module (EM) [11]. The RFM is first used in order to enhance the quality of the image. This module consists of four different filters that operate on the image. The first filter is a median filter that is used in order to remove impulse noise in the image. Next, a histogram equalization filter is used to improve the contrast of an image. In the third filtering stage, a homomorphic filter is used in order to improve the reflectance effect of an image and reduce the effect of lighting. It does so by “reducing brightness and emphasizing contrast in a frequency domain” [11]. In the final filtering stage, an illumination compensation filter is used to improve the brightness of the image.

III. PROPOSED SYSTEM

In this system, we aim to design a face recognition system using local binary pattern and Gabor filter algorithm.

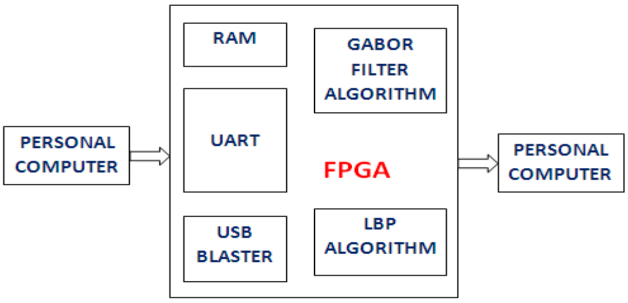


Figure 1. Block diagram of Complete System

In feature extraction phase the unique features of face images are extracted. The database is reserved for storage of actual face images with which the comparison of extracted face image is done. The extracted face image is compared with the images from the database. We evaluate face recognition which considers both shape and texture information to represent face images based on Local Binary Patterns. The face area is first divided into small regions called as LBP operator. The LBP operator is an image operator which transforms an image into an array or image of integers. From this LBP histograms are extracted and concatenated into a single feature vector. These will be done by using MatLab as well as FPGA. A set of Gabor filter with different orientation is helpful for extracting useful features from an image.

In the FPGA the user has to give input using personal computer and after recognition the output image will be displayed on personal computer itself.

IV. SYSTEM ALGORITHMS

A. LOCAL BINARY PATTERN (LBP)

This topic introduces a discriminative feature space that can be applied for both face detection and recognition challenges.

Local Binary Patterns (LBP) is a texture descriptor that can be also used to represent faces, since a face image can be seen as a composition of micro-texture-patterns. Briefly, the procedure consists of dividing a facial image in several regions where the LBP features are extracted and concatenated into a feature vector that will be later used as facial descriptor.

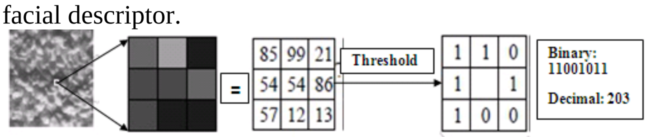


Figure 2. The basic LBP Operator

The LBP operator [12] is one of the best performing texture descriptors and it has been widely used in various applications. It has proven to be highly discriminative and its key advantages, namely its invariance to monotonic gray level changes and computational efficiency, make it suitable for demanding image analysis tasks.

In this work, the LBP method used for face description consists of using the texture descriptor to build several local descriptions of the face and combining them into a global description. Instead of striving for a holistic description this approach is motivated by two reasons: the local feature based or hybrid approaches to face recognition have been gaining interest lately [13].

Figure 3. A facial image divided into 7x7, 5x5,5 and 3x3 rectangular regions

Based on the psychophysical findings, which indicate that some facial features (such as eyes) play more important roles in human face recognition than other features [14], it can be expected that in this method some of the facial regions contribute more than others in terms of extra personal variance. Utilizing this assumption the regions can be weighted based on the importance of the information they contain. For example, the weighted Chi square distance can be defined as

$$x_w^2\ (x, \xi) = \sum_{j,i} wj\ \frac{(xi,j - \xi i,j)^2}{xi,j - \xi i,j}$$

in which x and ξ are the normalized enhanced histograms to be compared, indices i and j refer to i-th bin in histogram corresponding to the j-th local region and w j is the weight for region j.

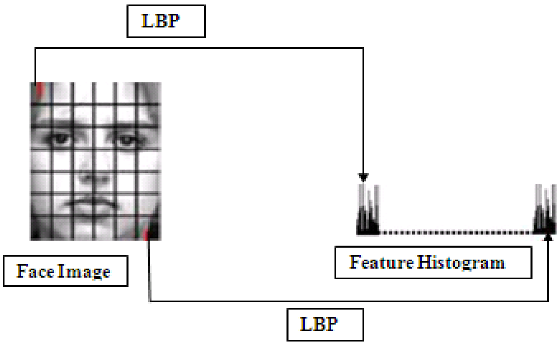


Figure 4. A face image is divided into small regions from which LBP histograms are extracted and then concatenated into a single, spatially enhanced feature histogram

B. GABOR FILTER ALGORITHM

The features of the face are extracted using two filters, i.e., local filters focused on accuracy and global filters focused on processing time. Real time applications require both these features.

Gabor filters are used for extraction of the global and local facial features. These local features are combined when the global features represented are not clear. These features are fused to form a feature vector to be used as a face descriptor for recognition. Gabor filter is pose robust and this filter works with sub blocks and hence it is highly illumination tolerant. The fusion of local and global features gives good representation for recognition.

Gabor filter capture the local structure in image space, scale and orientation. Here we use Gabor filters of multi-scale and multi-orientation which have been extensively and successfully used in face recognition to encode the local structure attributes embedded in face images. Gabor filter (kernels) with orientation μ, scale υ are defined as

$$\psi_{\mu,\upsilon} = \frac{k^2_{\mu,\upsilon}}{\sigma^2}\ exp\ \left(-\ \frac{k^2_{\mu,\upsilon} z^2}{2\sigma^2}\right) * \left[exp\left(ik_{\mu,\upsilon} z\right) - exp\left(\frac{\sigma^2}{2}\right)\right]$$

where Z = (x, y),

wave factor $k_{\mu,\upsilon}$ is defined as

$$k_{\mu,\upsilon} = k_{\upsilon}\ e^{i\phi\mu}$$

where $k_\upsilon = \frac{k_{max}}{f^\upsilon}$, $k_{max} = \frac{\pi}{2}$, $f = \sqrt{2}$,

$$\psi_\mu = \frac{\pi\mu}{8}$$

Each kernel is a product of a Gaussian envelope and a complex plane wave. These representation results display scale, locality, and orientation properties corresponding to those displays by the Gabor wavelets.

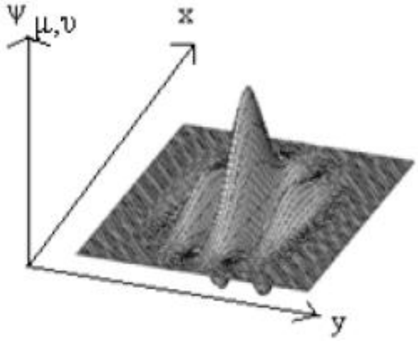


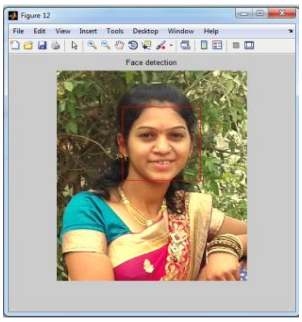
Figure 5. Gabor Filter

V. RESULTS AND CONCLUSIONS

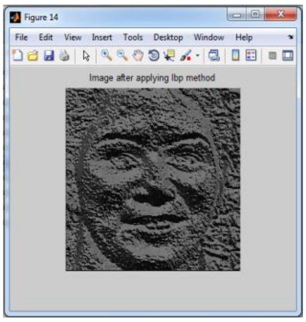
In this paper, an efficient method of facial detection and representation is proposed. In this, we have divided a facial image into small regions and computed a description of each region using local binary patterns. These descriptors have then combined into a spatially enhanced histogram or feature vector. The texture description of a single region describes the appearance of the region and the combination of all region descriptions encodes the global geometry of the face. This is also done by the Gabor Filters.

The entire system has been implemented on FPGA hardware platform, synthesized and analyzed using Xilinx software and programming is done in MatLAB for implementation of algorithms.

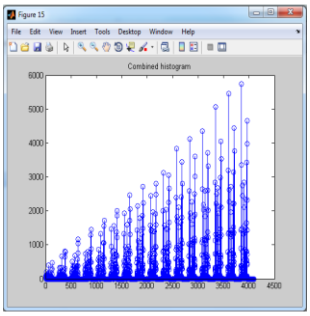
Image1 Image2 Image3
Figure 6. Images stored in database



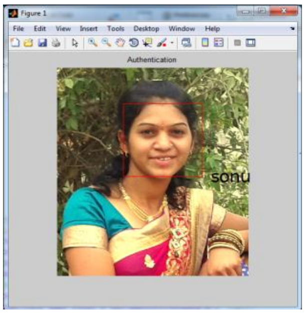
a) Detected Face



b) LBP application



c) Combined Histogram



d) Authenticated Face

Figure 7. Face Detection and Recognition Results

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