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Face Recognition in a Wild "AnOptimized approach for embedded platform"

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***Abstract*—In this paper a review on various existing face detection and recognition algorithm is provided to compare the results of different approaches in terms of efficiency and processing time. Among them we present an efficient face detection and recognition technology which gives high detection and recognition rate in considerably lesser time using hardware-software codesign . We are using Viola Jones detector which is implemented on FPGA using Verilog HDL description on Xilinx as FPGA implementation consumes less power, requires low cost processor and faster as compared to other software based algorithms.**

Keywords—Face recognition, Face detection, FPGA, Verilog, VHDL, Viola-Jones detector.

I. INTRODUCTION

In recent years various face recognition and detection algorithms has been proposed and many of them has provided effective results in the same. Face recognition and detection are two terms and sometimes they have been used alternatively for the same purpose. Face detection tells whether there is any human face or not while face recognition identifies a particular face. Many face recognition algorithms are developed with assumptions of constrained and un-constrained environment but majority of them are designed to operate on high performance personal computer systems and realized by software implementations. However many applications demand a real-time, high speed, quick and secure response therefore an embedded platform is required to solve this issue. But many of the face detection techniques that run at high speeds on personal computers are not suited to run on an embedded system. Over the years a number of successful face-image data-sets have been published in an effort to facilitate research on face recognition. These include the Facial Recognition Technology (FERET) Database, Viola Jones object detector, the Face Recognition Grand Challenge (FRGC) facial images and depths along with accompanying benchmark tests and its successor, the Face Recognition Vendor Test (FRVT) database and benchmark, the CMU Pose Illumination and Expression (CMU-PIE) database and its extension, the multi-PIE database. This paper mentions some of the most recent algorithms developed for this purpose and attempts to give a comparative idea of face recognition technologies and will propose a robust face detection technique, which is able to run at a reasonable speed on an embedded platform with maximum feature support.

II. VARIOUS FACE RECOGNITION TECHNIQUES

Different surveys on various issues have been presented by various contributors for face recognition. There are various approaches like Feature based approaches, Holistic approaches and Hybrid approaches where feature based approach make use of specific facial features for face recognition, Holistic approach makes use of global data and take whole image of human face for recognition, Hybrid makes use of both the methods mentioned above. Some famous face recognition algorithms are Principal component analysis (PCA), Discrete cosine transform (DCT), Linear discriminant analysis (LDA), Local feature analysis (LFA), Local binary pattern (LBP), Independent component analysis (ICA), Competitive feature analysis (CFA).

PCA is one of the oldest and simplest methods. It uses mathematical calculations to extract parameters and can be used in combination with different techniques. But it has certain limitations at computational costs, accuracy and memory requirements. PCA is not scale invariant and requires correlated variables. The problem becomes more difficult when there is extreme change in pose, illumination and expressions. Shah J., Sharif M., Raza M. and Azeem A [14]

LDA[12] is used in the field of machine learning and statistics which can also be used for reducing dimensions and works as a classifier. LDA reduces singularity problem to some level and utilizes both global and local facial features. It provides better accuracy. Fisherfece projection solves illumination problem and it outperforms PCA as it projects data on low dimensional vector space. Limitations of LDA are singularity problem and in face recognition area it suffers small sample size problem.

The basic idea of ICA is to represent a set of random variables using basis functions. ICA is used with multivariate signals and it is more efficient than PCA because it uses higher order statistics. ICA basis vectors are more spatially local than PCA and gives better face representations than

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PCA. In ICA, independent components are extracted through an iterative optimization procedure hence at different point of times there is little variation in the answer.

LFA gives description of objects in terms of statistically derived local features and retains all advantages of PCA as well. This system relies on the accurate detection of the face and location of the features. If the quality of the image is too bad and the face cannot be found then the system fails.

Local binary pattern (LBP) [15] is simple multi-resolution approach to gray scale and rotation invariant texture. The most important property of the LBP operator in real-world applications is its robustness to monotonic gray-scale changes caused by illumination variations. Another important property is its computational simplicity. But it is highly sensitive to glasses and it is time consuming process. It is not suitable for shadow images and low contrast images.

Discrete cosine transform (DCT) [13] is an algorithm widely used for image compression which converts spatial domain signals into elementary frequency components by representing an image as sum of sinusoids of varying magnitude and frequencies. DCT is utilized in low dimension space and behaves well in changing illumination conditions. In face recognition 2D blocked DCT reduces the computational burden by segmenting image into non-overlapping blocks and apply DCT to each block which results in low and high frequency sub-bands. High frequency subbands are removed by compression and low frequency subbands contains recognition information.

CFA is designed to decompose the object into characteristic sub-patterns through the use of competing pattern detectors called features. It is hardware supportable and used with many machine learning techniques.

Kernal principal analysis (KPCA) is able to extract the non-linear features from the image. Using kernel methods, linear PCA exhibit non-linear characteristic i.e. non-linear mapping of data. KPCA is computationally intensive and takes a lot more time compared to PCA.

Support vector machine (SVM) [3] are supervised learning algorithms that analyzes the training data and then predicts the correct output categorization for given data-set input. SVM avoid overfitting in high dimensional spaces and generalize well using a small training set. Limitations of SVM are speed, size and complexity. Selection of kernel function parameter is also one of the biggest challenges. SVM is more efficient in using face space information than PCA.

Neural networks are types of computational structures found in human brain. These networks incorporate “units” such as input units, hidden units and output units. Mlp neural networks are more robust in the presence of wide facial variations than rbf neural networks. The advantage of using neural networks is that it can train a system to capture complex class conditional densities of face patterns and provides non-linearity in the network. But it has one drawback that network architecture has to be extensively tuned.The authors reported 96.2% correct recognition on orl database of 400 images of 40 individuals. And take time less than 0.5 seconds but it increases as the number of persons increases.

Labeled faces in the wild (LFW) is a database of face photographs for studying problems of unconstrained face recognition. The dataset contains more than 13,233 images of face collected from web. The name of person pictured is given at the center of the image.

Milti-Pie database is most extensive database which deals with various parameters including expressions. This database includes 750,000 images of 337 people taken under 18 illumination conditions and six facial expressions for a span of five months. Multi-Pie is collected under controlled settings while LFW is close to real life setting since its faces are collected from new images. Hence a large difference exists between Multi-Pie and LFW considering pose, illumination, expressions and resolutions.

TABLE I: COMPARISON OF ACCURACY OF DIFFERENT FACE RECOGNITION APPROACHES

Sr. No.	Approaches	Working domain	Hardware support	Efficiency	Failure	Speed of operation
1.	PCA	Realtime	No	87%	13%	Moderate
2.	LDA	Integrated	No	90.8%	9.2%	Moderate
3.	ICA	Integrated	No	91%	9%	Moderate
4.	LFA	Realtime	Yes	91.5%	8.5%	Low
5.	LBP	Multi-Pie database	No	99.3%	.07%	Moderate
6.	DCT	Integrated	No	97%	3%	Low
7.	CFA	Integrated	Yes	90%	10%	High
8.	KPCA	Realtime	No	98%	2%	Slow
9.	SVM	Realtime	Yes	93%	7%	Moderate
10.	Neural Networks	Realtime	Yes	96.2%	3.8%	High
11.	LFW	Realtime	Yes	95%	5%	High

In hybrid approaches various face recognition techniques are combined to get better results in terms of higher recognition rates and accuracy.

TABLE II: COMPARISON OF RECOGNITION RATE OF VARIOUS HYBRID APPROACHES

Sr. No.	Method	Recognition rate
1.	Eigenface	90.5% [3]
2.	PCA+LDA (Fisherface)	95% [3]

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3.	KPCA+SVM	95.40% [4]
4.	DCT+LDA	97.5% [3]
5.	DCT+SVM	98.90% [6]
6.	LDA+SVM	95.3% [17]
7.	PCA+SVM	95.8% [17]

III. PROPOSED MODEL FOR FACE RECOGNITION

In computer vision face recognition is a very complex and challenging task. The problem becomes more difficult due to large intra-class variations caused by appearance, lighting, expressions, pose, orientation, etc. Heuristics or knowledge based face detectors are faster but less robust to large face variances and background interfaces while statistical or learning-based face detectors are robust but involves high processing complexities. So the main challenge is to find a balanced design between accuracy and efficiency. In this paper we present an effective and balanced face recognition "in a wild" technique.

We use Viola-Jones face detection algorithm which is one of the most popular techniques for real-time face detection. The system is implemented on OpenCv [19]. Speed of frame detection lies on three components. Firstly, the image is transformed into "Integral Image" which allows the features used by the detector to be computed very quickly. Secondly, the used classifier is simple and efficient which is build using the AdaBoost learning algorithm to select a small number of critical visual features from a very large set of potential features. And thirdly, the classifier is formed by combining weak classifiers in a "cascade" which allows background regions of the image to be quickly discarded while spending more computation on promising face-like regions.In this algorithm window scans the image looking for features of human face. If enough of these features are found then particular window is said to be a face [18]. Fast and accurate detection requires careful selection of features and every window doesn't require computation of all features therefore detection is performed in stages. We compute initial stages of sub-windows in FPGA. Windows that will pass these imitial stages will be given to the software to reduce computational load. Feature database changes with training parameters and is different for different classifiers. These feature databases are coded in Verilog HDL and implemented on FPGA. FPGA based systems have become attractive solution for real-time image processing and computer vision problems. They have high density, high performance and support specific applications. We are going to implement our model of face detection of Viola-Jones detector on FPGA. Coding of this task is done using Verilog HDL description on Xilinx which can have 84 × performance gain over an equivalent software solution [9].

IV. CONCLUSION

We have studied various holistic, feature-based and hybrid approaches for face detection and recognition process and given a comparative chart. Some techniques are giving better accuracy at the output but they take a lot more time than others some are faster but accuracy is low. As software based approaches takes more computational time than hardware based techniques. Therefore, we have proposed a technique which is giving better accuracy in considerably lesser time. Due to processing distribution between software and hardware utilization of resources becomes more efficient and optimal. FPGA is considerably cheaper, less complex and faster than other software based algorithms.

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