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VLSI Implementation of Identification of Human Faces

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ABSTRACT - In the proposed work, we offer multiple user face detection technology based on various deep learning techniques. The proposed work offers solutions to various real time applications. Principal Component Analysis (PCA) algorithm is used for classification and identification. Techniques like haar cascading, binarization, edge detection are used to obtain the result. To achieve the goal of face detection, the features are extracted in an elliptical area. These features can be further categorised into nose, mouth and lips localization. By using FPGA to implement the work, we can achieve better accuracy, reduced latency and low cost implementation at a larger scale.

KEYWORDS - Face detection, Principal Component Analysis, Facial features, Classification, facial template matching.

I. INTRODUCTION

With the increased research in deep learning algorithms, it is observed that these techniques can be used in various security systems. Many biometric systems including iris based detection, finger print based automation has successfully been implemented in various security checks. Facial feature based identification systems can provide even further comprehensive results because of the large scope it offers. Various researches reveal that face based recognition is suitable for many practical tasks including but not limited to attendance systems, National IDs, travel documents etc. Facial feature extraction, face detection and estimation of face direction are used for face recognition systems[1]. In many of the practical applications it becomes necessary to detect the face direction to provide accurate results. These detection technologies find its applications in teleconferencing, video surveillance etc. Various techniques have been proposed for feature extraction and face detection each with its own strengths and loopholes. Based on the task at hand, these systems can operate in two modes : verification and identification. Biometric verification provides authorization through a one-to-one biometric comparison. Whereas in identification, the data acquired in real time is compared with the set of data that is already available in the dataset. A search is conducted with the newly available data against the available dataset and if the new data matches with the one which is already available then the attributes of the trained data are returned which helps in identification. Here one-to- many comparison takes place[2]. In order to achieve better results, the software model is implemented using FPGA. Using FPGA, the results could be obtained with higher accuracy, reduced latency and better cost efficiency. Higher end FPGA modules offer increased memory storage and thus helps implementing the entire system through FPGA. At lower end, the testing process wherein the real time data is checked against the trained dataset can be implemented using FPGA while the loading and training images in the dataset can be carried out using Python or Matlab among other software.

II. EXISTING SYSTEM

The most common biometric systems use iris based recognition and fingerprint based authorization. In fingerprint based authorization, the fingerprint is matched against the available database and if its present in the database, the user is authenticated [7]. In Iris based identification, various frames of both eyes of a human are extracted from the captured video or image. Pattern recognition techniques are used to represent them in mathematical representation. This helps in checking the captured iris against the stored dataset to provide authentication[8]. Various algorithms are developed by various

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researchers to provide biometric recognition while also protecting user privacy. As privacy is seen as one of the major challenges in a biometric system[9].

III. PROPOSED MODEL

To provide a comprehensive system for facial feature recognition, we go beyond the common biometrics used such as iris, fingerprints, voice and build a system that can offer facial recognition with face direction estimation. Here all the features of a human face such as skin colour segmentation, nose, lips, eyes and other feature extraction algorithms are used.

From the block diagram fig 1, the flow of the model is understood. A camera is used as an input followed by various blocks of functional code defining the algorithms being used. A cascade object detector is used for face detection followed by preprocessing and a gray level co-occurrence matrix is used for feature extraction. The PCA algorithm is used for classification as authorized and unauthorized users.

The users who need to be authorized are captured in the camera. The captured video is split into 20 frames with its dimension being 128*128 and a 0.5s delay between frames. The frames and dimensions can be varied based on the camera in use.

The authorized user data is stored in a folder with an identifier. The folder is saved in the file location specified to train the dataset. The identifier is returned when the user face is captured after implementing the system.

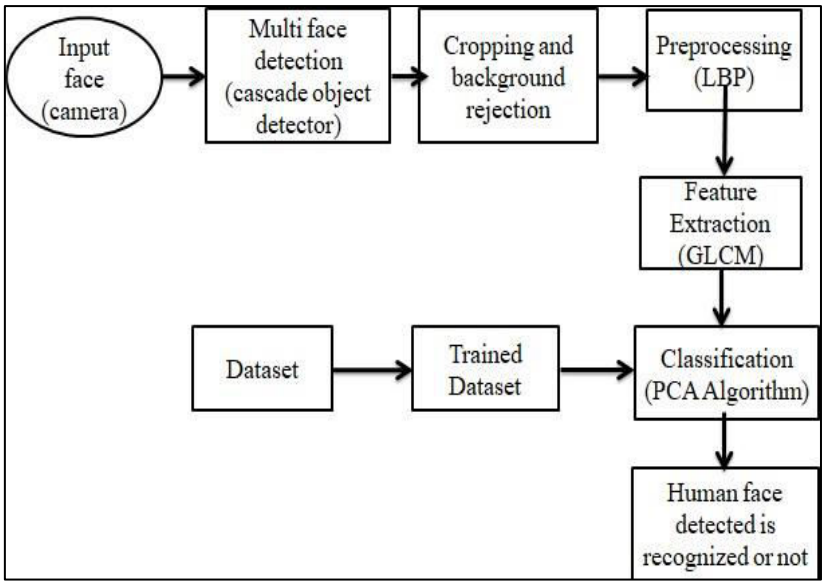

Fig 1 : Block Diagram

The vision.CascadeObjectDetector module provides us with many pre-trained classifiers for detecting various facial features. It uses the Viola-Jones algorithm to detect people's features including eyes, nose, lips and upper body[3]. The same is used for detection of the human faces for training the dataset. For feature extraction, the difference between the sum of image pixels present in the darker area and those that are present in the lighter area of the haar feature needs to be examined. To detect edges, the haar value is calculated. If there is an edge that separates lighter and darker pixels, it results in a haar value being closer to 1, and such a result indicates the presence of an edge.

Local Binary Pattern (LBP) can be used to achieve texture characteristics of the image acquired[4]. By using this technique, the texture pattern probability can be summarized into a form of histogram. It is necessary to determine LBP values for all the image pixels available. The features = extractLBPFeatures(I,Name,Value) is used to obtain the desired result.

For texture analysis purpose, we go for Gray Level Co- occurrence Matrix (GLCM) [5]. Two pixels called the reference and neighbor pixels are considered. A particular spatial relationship is defined between the reference and neighbor pixels before we proceed to calculate GLCM. For example, let us establish that the neighbor is 1 pixel to the

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left of the current pixel, or it can be 3 pixels below, or 2 pixels diagonal in direction from the reference pixel. After the spatial relationship is determined, a GLCM of size (Range of Intensities x Range of Intensities) where all the components of the matrix is initialized to 0 is created. Another example is that an eight bit image will have a 256x256 GLCM. After that, we proceed by traversing through the pixels of the image. For every pair of intensities that we find the defined spatial relationship, we have to continue with incrementing that cell of the matrix.

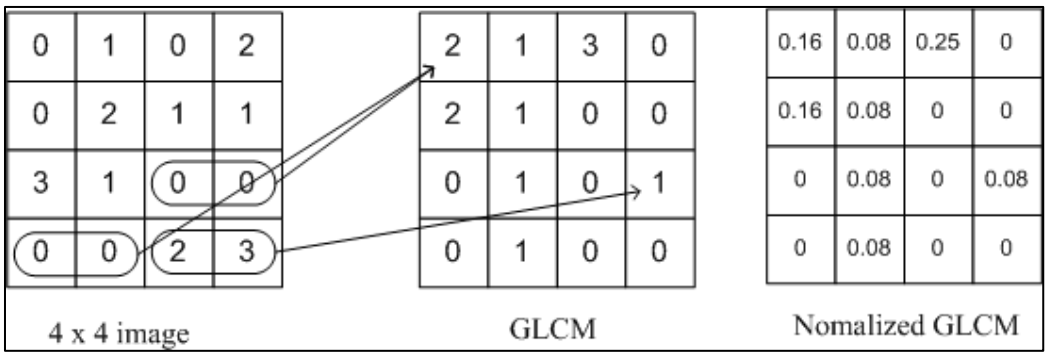

Fig 2 : GLCM matrix derivation

Once the GLCMs have been created using the command graycomatrix, we can then derive the needed statistics from them by using graycoprops. This will provide the required information about the texture of the image.

The extracted features are thereby used to train the dataset with authorized users.

As the next step, when the user comes in front of the camera, the process repeats and the features are extracted and compared with the existing dataset by the use of Principal Component Analysis (PCA) algorithm. This deep learning technique is used for its feature that it provides us with reduced number of variables for face recognition systems[6]. In this technique, the images which are stored in the training sets are represented by a linear combination in form of weighted eigen vectors which are also called as eigenfaces. The major use of the PCA algorithm is that it helps in reducing the number of bits required for the process of classification.

The results are to be obtained in a way that the user present in the database has to be returned using their identifier and those who are not present to be returned as unauthorized access. These results are obtained using Matlab.

For FPGA Implementation, the Matlab code can be converted to Python. The major reason for the conversion is that to implement Matlab code for face recognition in FPGA, the requirement of FPGA specification is very high resulting in increased cost and the market availability of such FPGA modules are also significantly lower. Thus, the code is converted into python which supports lower end FPGA modules.

The same PCA algorithm and haar cascading techniques are used in Python as it was used in Matlab. The major techniques involved in VLSI design are Specification Analysis, Programming, Synthesis, Simulation, Performance analysis and Performance verification.

Here, SPARTANS 3A kit is used and Python is used as the Programming language. The first two steps of loading and training the dataset are completed using Python.

VHDL coding is done which determines the accuracy of the output along with the intention of reduced latency. The code is downloaded into the FPGA module which is connected to the PC through a USB to Serial converter.

When the testing code is implemented, it takes accuracy parameter input from the FPGA module and the new data is then compared with the available dataset to provide the output.

The result is obtained in such a way that when the user already available in the dataset appears in front of the camera, a box encasing their face appears with the identifier it is saved with. It is observed that it works for multiple users at the same time for real time applications. For the users not available in the dataset, no result is returned.

It is also observed that the latency is reduced and accuracy is improved while implementing using FPGA.

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IV. RESULTS AND DISCUSSIONS

The model system is implemented and the authorized user datasets are trained as the first step.

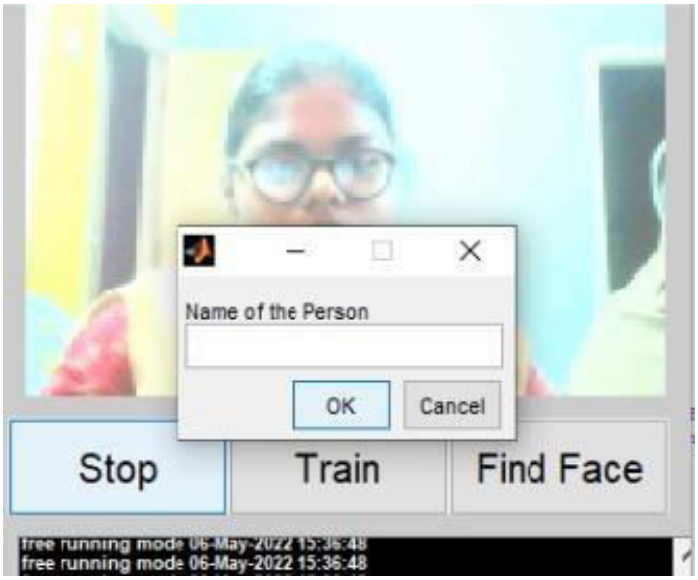

Fig 3 : Training the dataset

The identifier is set and the user face is stored in the database for authorized users.

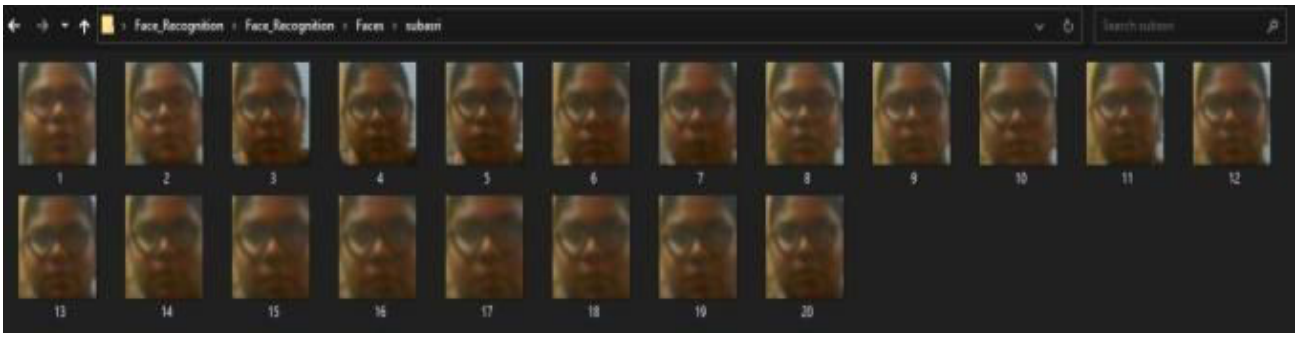

Fig 4 : Saved dataset

The system has the capability to detect and recognize multiple user faces depending on the camera range. The authorized users are returned with their identifiers and the unauthorized users are returned with “Unauthorized Access”

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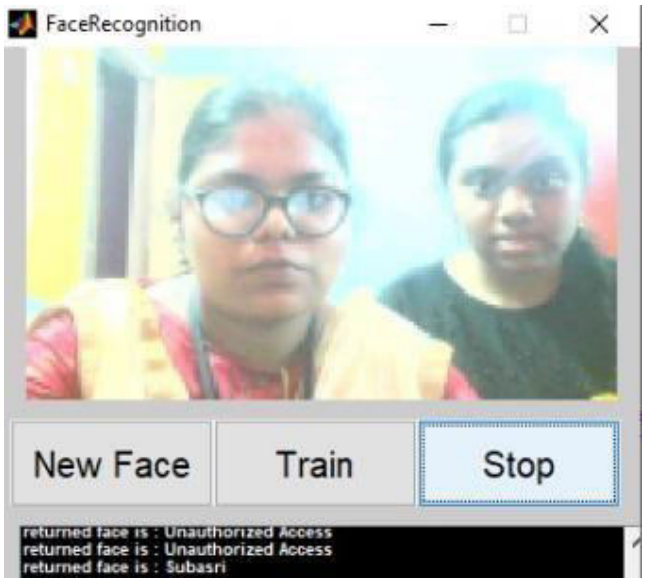

Fig 5: Multi user face detection and recognition

When the user who is not present in the dataset tries to access the system, they're returned with the message "Unauthorized Access"

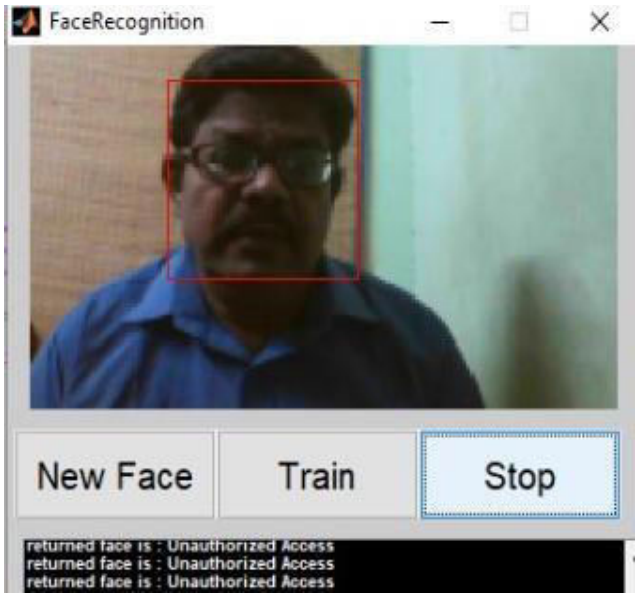

Fig 6 : Unauthorized user access

It is observed that the camera lighting plays a major role as the pictures of low quality may end up providing undesirable results. So while implementing the system, it has to be taken great care that the lighting is optimal and the picture is of high quality. With a much powerful camera that can span over more than a single user, the goal of the system can be further accomplished as we would be able to obtain multiple feature extraction and face recognition at the same time.

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TABLE 1 : PARAMETERS USED AND THEIR CORRESPONDING VALUES

Parameter	Value
N_components	100
Threshold	50
Svd_solver	randomized
Covariance matrix	c = le4
Gamma	0.005
Dimension N	50*50

The code is converted to Python and loading and training the dataset are done in the same way as it was in Matlab VHDL code is downloaded to FPGA and the FPGA kit is connected to the PC. Output is observed from PC. When the user who is trained in the dataset appears in front of the camera, their name is returned in real time.

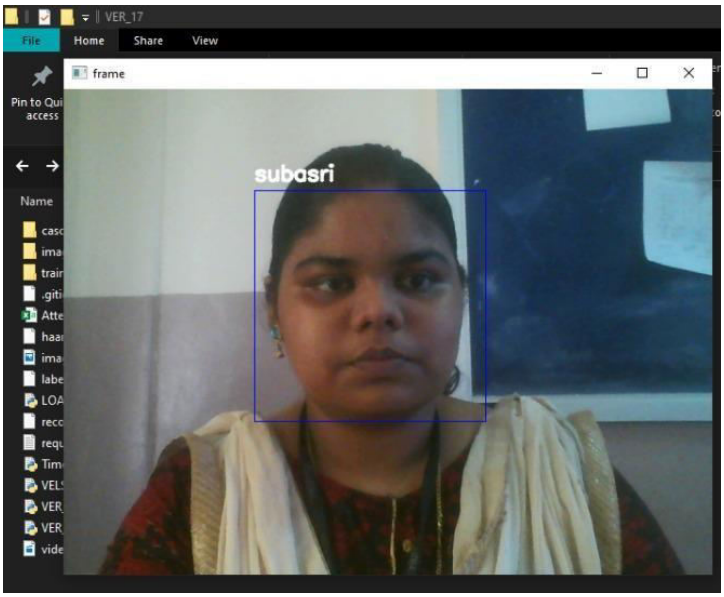

Fig 7 : Authorized user identification

It is also observed that the result is obtained under different conditions including while wearing spectacles, from different face directions etc.

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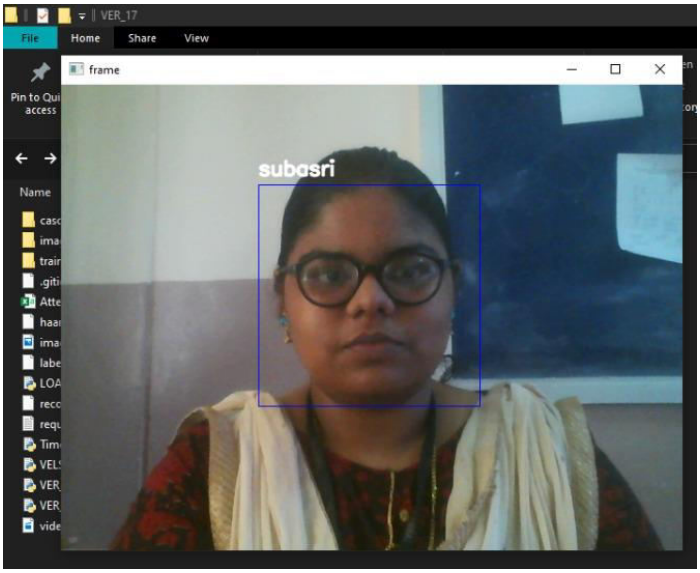

Fig 8 : Authorized user identification with other factors

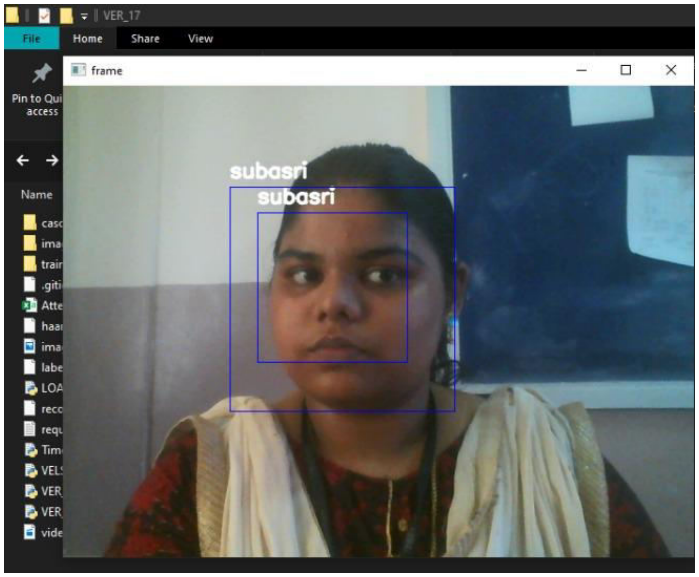

Fig 9 : Authorized user identification involving tilted face direction

Some of the major reasons to implement using FPGA are to prove reduced latency and improved accuracy. Both of them are achieved by the proposed work.

The frequency and latency of the implemented work is observed as follows

- Latency - 5.840ns
- Frequency -171.233MHz

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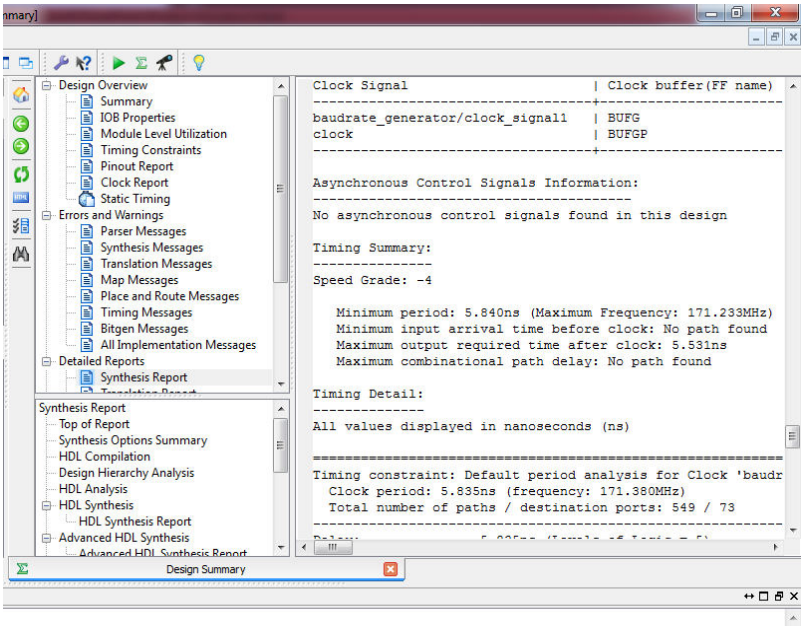

Fig 10 : Latency and frequency analysis report

V. CONCLUSION

Facial feature extraction and recognition is a complex process but with recent advancement in technology, it might end up replacing biometric systems as it can provide much more reliable results. Multi user face recognition is superior to recognizing human faces one at a time as the latter may end up more time consuming. And it is further noticed that the performance of the system can be improved based on the components in use. By implementing this system using FPGA, it provides solutions to many real time security related applications and reduces latency and provides increased accuracy.

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