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FPGA Realization of FLSE Classifier Based Multiple Feature Extraction Technique for Face Recognition

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Abstract: Face Recognition is one of the biometric validation techniques and it has been extensively utilized for the real world applications. Although lots of techniques to recognize the face in real world applications, video based recognition techniques gives many challenge related utilization in most of places. In this paper, a novel classifier namely Fuzzy based Least Score Elimination (FLSE) classifier is introduced for efficient face recognition. This fuzzy based classifier gives important to the each frequency interval in an image; hence the accuracy of the recognition will improve. This process will be done on VHDL design language for FPGA realization.

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I. INTRODUCTION

The digital imagery is generally used in engineering and science fields and it introduced a request used for categorization and precise analysis of images [1]. In the optical structure and processing, the identification of image content is a strong operation [2]. To find an individual, the face is most significant identity and an individual is identified in terms of the peculiar aspects of face components [3]. Commonly, the objective of face recognition is to detect one or more individuals in video or still pictures of a scene based on a stored database. [4]. Four stages are used for recognizing the face match to a target face: i) find the face which present in an image; ii) alignment ensuring the detected face line with a target face or a model; iii) representation or feature definition transforms the aligned faces into some representation emphasizing assured characteristics; iv) categorization [5].

In common the similarity of faces between distinctive individuals and wide differences within the various sample images of the same person are the two important reasons to hard the task of Automated Face Recognition (AFR) [6]. The artificial neural networks have been used for the data fitting, function approximation, categorization and identification of pattern [7]. In the computer vision community the categorization based on image sets is mostly utilized [8]. The automotive environment operations used the Field Programmable Gate Array (FPGA) in the place of CPUs in PC or Digital Signal Processors (DSPs) [9]. The performance and capacity was enhanced, and the cost was decreased by FPGA and they have become a visible result for executing computationally intensive function, with the capability to hold applications used for programmable DSP apparatus and custom chips [10].

The normal characters of the difficult calculations are accomplished repetitively within the operation of face identification and are well suitable to an operation based on hardware using FPGAs [11]. Fisher Linear Discriminant (FLD) and two dimensional FLD has newly arise as a more proficient method for extricating features for several difficulties of pattern categorization as compared to the conventional principal component study [12-13]. The random projections-based features used in Sparse Representation-Based Categorization (SRC) can surpass a number of traditional systems for face identification, for example the Laplacianfaces and Fisher faces-based features are used in nearest-neighbor classifier [14]. The VHDL hardware description language is used for constructed optical flow estimator and to authorized migration and test among techniques [15]. A new Kernel Ridge Regression (KRR) and Ridge Regression (RR) methods used for multivariate sticky label and employ the techniques to the difficult of face identification [16].

The image of face is denoted as groups of Patch Pseudo Zernike Moments (PPZM) extricated from segregated pictures of face consist of moment statistics of local areas rather than the overall statistics depend on an Adaptively Weighted Patch Pseudo Zernike Moment Array (AWPPZMA) [17]. The required features presented in the face were extracted by an energetic transform called as Discrete Cosine Transform (DCT). The Discrimination Power Analysis (DPA) is a data dependent technique which used the statistical exploration to discover the best discriminant constants [18]. An Active Appearance model (AAM) is used to identify the structure of dynamic facial appearance [19]. An algorithm was developed based on fast Principal Component Analysis (PCA). In this algorithm the features of interest are utilized for sub-groups the database and one of these sub-groups are used in the PCA for image identification. The performance will be enhanced in the developed algorithm and it was compared with the Indian face database [20].

Contribution of the work is given below:
Major contribution to this work is to recognize the face from the video surveillance. For that we have introduced Fuzzy based Least Score Elimination Classifier (FLSEC); this classifier work is based on the fuzzy system. For that we use Takagi-Sugeno-Kang (TSK) model for the fuzzification of classifier input. Accuracy of the recognition is improved with this fuzzification and which is suitable for each interval of an image. Initial process to this recognition is preprocessing the video frames and feature extraction. This process is well suitable for the image with the large data size. Then recognition with this technique validates each score and eliminates the image with the least score and compares it with the test image to produce the face recognition.

The rest of the paper organized as follows: In section 2, the works related to the face recognition is presented. In section 3, the proposed face recognition approaches with a novel classifier are discussed. In section 4, the papers discusses the result analysis and compare the classifier approaches. Finally, in section 5, we conclude the paper.

II. RELATED WORK

Jose V. Frances-Villora *et al*. [21] had proposed a learning machine ELM for prediction and classification issue where the input and output nodes are connected directly and flow of process in a single direction. Field programmable ELM hardware was designed to allow wide range of applications with accurate, efficient and reconfigurable networks. The calculation and execution of ELM training was implemented in a Virtex 6 based system which requires sequential and parallel hardware designs. The resultant ELM training with FPGA was analyzed with training patterns and neurons. The performance of QR decomposition of square matrices for parallel version ELM v2 provides logic work and accuracy.

Kerem Seyid *et al.* [22] had proposed sum of absolute difference (SAD) block matching based optical flow algorithm and 2D reconfigurable systolic array to overcome the computational complexity and workload of optical flow calculation algorithm. In each level, block matching and local smoothness estimates optical flow and vectors respectively. This algorithm was evaluated with various ground truthoptical flow datasets. LUT based square root operation was used to reduce resource utilization without losing performance. The resultant architecture provides high quality and it can able to process 4 × 4 sized blocks.

Qi Yan Sun *et al*. [23] had proposed hierarchical spiking neural network to obtain features from optical pathways. This technique was based on a set of relative fields and integrated-and-fire models. To simulate visual system processing, spiking network contains various processing channels. Based on the color contrast, illumination and selective orientation, features are extracted from channels firing rate map. It improves the capability of feature recognition and enlarges the color features. SNN block sets were developed to implement the spiking neural network on FPGAs. Implementation result shows the ability of pattern recognition and low cost because of several spiking neurons on a single chip.

Aysegul Ucar *et al*. [24] had proposed online sequential extreme learning machine (OSELM) with radial basis function for expression recognition. In OSELM, face image is divided into sub regions and curvelet transform was applied to each sub regions to make it easy to classify. The entropy, standard deviation and curvelet coefficients are calculated to generate features. To determine the hidden node numbers from the feature set, spherical clustering technique was used. This technique was applied to Japanese Female Facial expression database and Kanade dataset. It increases accuracy against state of the art algorithm and reduces time required to reduce the hidden node numbers.

Christos Kyrkou *et al.*[25] had proposed hybrid processing hardware architecture with support vector machine to improve the speed of classification and to avoid data samples. This system was designed for online real time application of intelligent embedded system. Spartan-6 field-programmablegate array (FPGA) platform was used for object detection of high resolution images. By using this method 20% power reduction against baseline implementation, 25% less resource utilization and 40frames/s for face detection. The cascade classification structure and response evaluation method achieves required tradeoff between power resource utilization, accuracy and performance.

III. PROPOSED FACE RECOGNITION

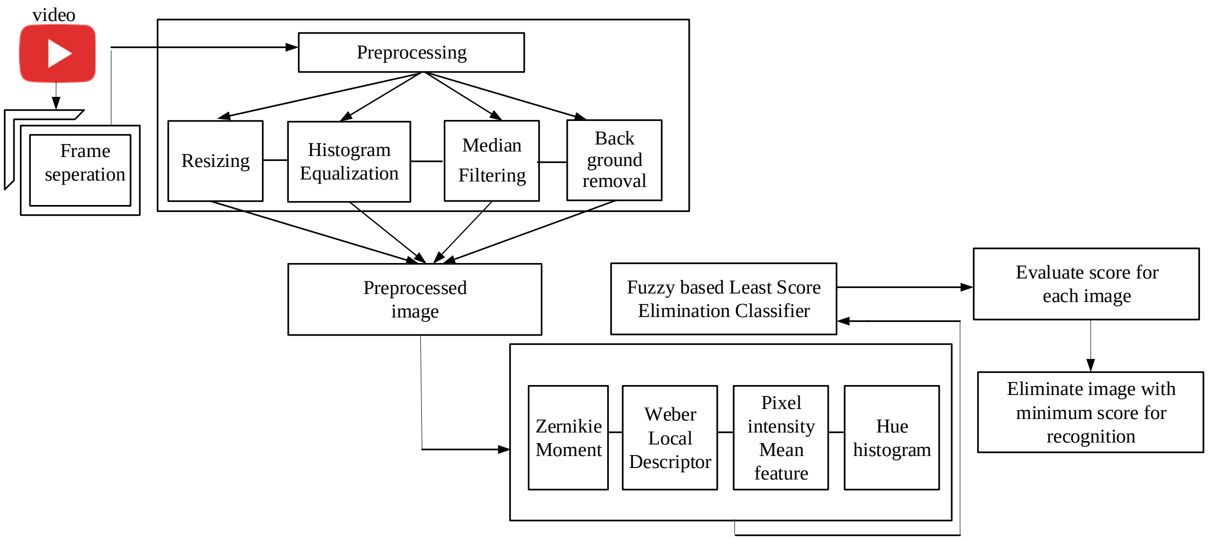


Fig 1: Schematic representation of proposed face recognition strategy

Proposed schematic representation of face recognition methodology is given in figure 1. In the proposed methodology, the frames from the video are taken for preprocessing. In the preprocessing step, the image can be resized, histogram equalization, median filtering and background removal. Once the preprocessing step is over then the image multiple features from the blocks are taken using Zernike Moment, Weber Local descriptor, Pixel intensity mean feature and Hue Histogram techniques. Then the novel classifier is introduced to recognize the face with the high score. Proposed methodology eliminates minimum score and it only takes the high score image as the face recognized image.

a) Pre-processing

At the lowest level of abstraction, image pre-processing is used for the purpose of enhancing the image data. In this case, both input and the output images are intensity images. During this process, distortions presented at the image will be suppressed. In addition to the distortion suppression, this preprocessing improves the features used for further processing.

Image resizing:

To increase or decrease the aggregate amount of pixels in an image will be done with the image resizing strategy and this leads to image interpolation. Image interpolation attains the finest estimation inpixel color and intensity.For example the image with the size $[m \times n]$ will be resized in to $[(m \pm k)(n \pm k)]$.

Histogram equalization:

Histogram equalization is the technique for enhancing the image quality.During this process image intensity will be distributed among the entire image. Thus the histogram equalization process spreading out the frequent intensity values over the entire image.General form of image histogram is given by the below equation (1)

$$HE = round\left(\frac{\vartheta(v) - \vartheta_{\min}}{(m \times n - 1)} \times (l - 1) \right) \quad (1)$$

In this above equation (1) $\vartheta_{\min}$ is the minimum cumulative distribution function of an image.

Median filtering:

Median filtering is an efficient pre-processing strategy to preserve edge while removing noise and smooththe image for further processing.The median filtering noise removal performance is given in the below equation (2).

$$\sigma^2{}_{med} = \frac{1}{4k\, f^2\left(\bar{n}\right)} = \frac{\sigma_1{}^2}{k + \frac{\pi}{2} - 1} * \frac{\pi}{2} \qquad (2)$$

Equation (2) deliberated the noise removal function in which $f\left(\bar{n}\right)$ is the noise density, $\sigma^2{}_{med}$ is the noise power density and k is the median filtering size. Median filtering performance is very effective in case of normal random noise removal.

Background Removal:

For the face recognition purpose, the important thought is to remove the background from the original image. Thus the facial features can be easily extracted from the original image and this is important for extracting primary features in an image. In our work, consider an Adaptive Thresholding technique for the background and foreground separation.

Next to preprocessing the features presented in the image will be extracted which is given in below section.

b) Feature Extraction

Feature extraction comprises reducing the amount of resources required to describe a large set of data.

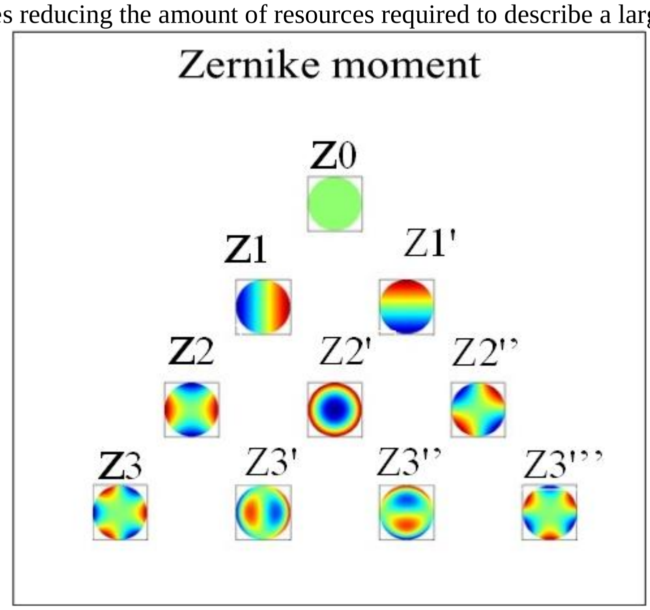


Fig 2: Zernike Feature Extraction

Above figure (2) represented the Zernike feature extraction method. In this process, edge and texture features are extracted for reducing complexity by processing with large data. Thus feature extraction reduces the amount of features by extracting edge and texture features.

Zernike Moment:

From the orthogonal Zernike polynomials are derived from the Zernike moments and it is an orthogonal moment. Thus the Zernike moment is given by the following equation (3).

$$Z_{yx}(m,n) = Z_{yx}(r\cos\theta, r\sin\theta) \\ G_{xy}(r)\exp(jx\theta) \qquad (3)$$

Where $G_{xy}(r)$ is the orthogonal radial polynomial and is given by

$$G_{xy}(r) = \frac{\sum_{s=0}^{(y-|x|)/2} (-1)^s (y-s)!}{s! \times \left(\frac{y-2s+|m|}{2}\right)! \left(\frac{y-2s+|m|}{2}\right)} \times r^{y-2s} \quad (4)$$

In this above equation (4) and the value of y is lies between 0 to x. Then this moment is given in the below equation (5).

$$Z_{yx} = \frac{y+1}{\pi} \sum r \sum \theta \; f(r\cos\theta, r\sin\theta) * G_{xy}(r) * e^{(jx\theta)} \quad (5)$$

In this above equation the value of radial polynomial is less than 1.Based on the above equation scaling, rotation, translation are not varied with respect to this moment.Then this moment is robust to little variation in noise and shape.

Weber Local descriptor:

The WLD is built starting from two dense fields of features, differential excitation and orientation.
Differential excitation is written as:
Two different features like differential orientation and excitation are deliberated in the Weber Local Descriptor (WLD). In this process initially we have to extract the differential excitation by the following equation (6).

$$\vartheta(x) = \arctan\left[\sum_{i=0}^{7} \frac{x' - x}{x}\right] \quad (6)$$

From this equation (6) it represented the difference among objective and the average objective of its neighboring pixels. Neighborhood pixels are selected within the range between radius one.Equation produce zero when it the excitation is flat otherwise it given the value as one. According to the Weber's rule this excitation has the value between $\left[-\frac{\pi}{2}, \frac{\pi}{2}\right]$.

Orientation calculation is written as:
Next to the differential feature excitation, orientation can be calculated by the below equation (7).This orientation calculation is nothing but the formation of angle in vector with respect to the reference axis.

$$\theta(x) = angle(x_n - x_{n-1})$$

$$\theta_{quan}(x) = \frac{2t}{T}\pi \quad (7)$$

$$t = \bmod\left(\left|\frac{\theta}{2\pi/T + \frac{1}{2}}\right|, T\right) \quad (8)$$

This orientation has the range between $[-0, 2\pi]$and it quantized in the dominant region. WLD feature extraction task attaining better accomplishment.

Pixel intensity mean feature

Pixel intensity mean feature is calculated by calculating six parameters (i.e.) median (μ), standard deviation (σ), smoothness (S), mode (M), variance $(\sigma^2)$and range (r). This can be calculated for both horizontal and vertical features.

$$\sigma^2{}_{horz} = \frac{1}{s-1}\sum_{i=1}^{m}\left(\mu_{horz} - M\right) \tag{9}$$

$$M = \frac{1}{s}\sum_{i=1}^{s}\mu_{horz}(i) \tag{10}$$

$$\sigma_{horz} = \sqrt{\sigma^2} \tag{11}$$

$$S_{horz} = 1 - \frac{1}{1+\sigma^2} \tag{12}$$

$$r_{horz} = \max\left(\mu_{horz}\right) - \min\left(\mu_{horz}\right) \tag{13}$$

These five parameters are calculated similar manner to the vertical features.Mean value for the horizontal feature is calculated by the average intensity of the row and for the vertical feature is calculated by taking average intensity of the column.

Hue Histogram:

Around the grey axis, Hue histogram is unstable and the analysis is calculated with the following equation (14)

$$\begin{aligned}(\partial h)^2 &= \left(\frac{\partial h}{\partial^1 g}\partial^1 g\right)^2 + \left(\frac{\partial h}{\partial^2 g}\partial^2 g\right) \\ &= \frac{1}{g^{1^2} + g^{2^2}} * \frac{1}{\varsigma^2}\end{aligned} \tag{14}$$

Above equation shows the derivatives of multiple grey level components in which ς represented the saturation of various component in the histogram. If the saturation is low means hue provides better certainty and thus hue is inversely proportional to the saturation.

c) Fuzzy based Least Score Elimination Classifier

Fuzzy Least Score Elimination (FLSE) Classifier consists of set of M^n class training images and N testing images. The important concept in this technique is to eliminate the classes with least scores. For that it checks scores on each iteration in which the values with minimum classes will be removed. Initially class parameters are set by the following method:

TSK Model:

In TSK model, pixel intensities to be multiplied to fuzzifies the newly generated factors and it gives important to each interval. Based on the relative frequency one interval can be changed another interval. Thus, small interval with high number of members will be changed into wide interval. In TSK, the fuzzy model is differentiated with input to make it monotonic. Fuzzy parameters conditions are differentiable at specific points of image. Consider 'u' is an input of the fuzzy system with interval X=(c, d) and V is calculated as V=F(u). If $c \le u^1 < v^2 \le b$ and $F(u^1) \le F(u^2)$ then F: X→Y increased monotonically. There is M number of fuzzy rules in fuzzy system. The rules are denoted as $R^1, R^2 ... R^m$.

R^1: If u is F_1 then v is $a_1^1 u + a_0^1$, R^2: If u is F_2 then v is $a_1^2 u + a_0^2$ …

R^M : If u is F_m then v is $a_1^M u + a_0^M$ (15)

Where, a_1^l and a_0^l are constant parameters. In X, F_1 and C are complete fuzzy sets with 1≤l≤M. $\mu^1(x), \mu^2(x)...$ and $\mu^M(x)$ is a fuzzy membership function and which cover a point u in X. The output of the TSK model is

$$v = F(u) = \frac{\sum_{i=1}^{M}(a_1^l u + a_0^l)\mu^1(x)}{\sum_{i=1}^{M}\mu^1(x)} \tag{16}$$

When differentiating equation (16) the fuzzy system parameters are said to be monotonic with following conditions. First, In X, every function is continuous. Second, In X, every function is differentiable with some finite points. Thus one interval can be changed into another interval based on the relative frequency of its member.
This parameterrepresentation in the negative form will affect the performance of the accurate classification and thus it should be concluded in to the positive parameter representation.
The positive regulation equation is given as:

$$\psi_{0,i} = \frac{(\delta_{0,i} - \delta_{0,\min})}{(\delta_{0,\max} - \delta_{0,\min})} \tag{17}$$

$\delta_{0,\max}$ and $\delta_{0,\min}$ are the minimum and maximum parameter of the training and testing images. Then next to the positive regulation the elemental score will be calculated. Then the parameter with the minimum score will be eliminated from the classifier.

The parameter calculation is calculated with the following equation and it is the sum of regulated parameters.

$$S_0 = \sum_{i=1}^{n}\delta_0{}^{n} = s_0 = \sum_{i=1}^{n}\left|\delta_0{}^{n}\right| \tag{18}$$

In this above equation the class with minimum score is treated as the unlike one.Again the score for the nth iteration will be calculated until getting one classifier as remaining one. After that the high score image will be compared to the testing case to recognize the recognized image.
Below table shows the proposed process flow algorithm.

Thus overall proposed work classifies the video frame as recognized or not recognized image by the result of FLSEC classifier. Thus the classifier indices like true positive, true negative, false positive and false negative establishes the accurate classification of Honda/UCSD video database.

IV. EXPERIMENTAL RESULTS AND DISCUSSIONS

Face recognition in the biometric concept which takes the similarity establishment between the data base of the particular person. In this experimental comparison analysis we have to compare precision recall and F1-score.

a) Data set description:

We use the Honda/UCSD video database [26] for the face recognition process. Honda/UCSD video database contains 59 videos of 20 persons. Again these video sets are divided in to training and testing data set. It has the resolution of 640x480 and each one have the frame size of 15 frames per second. These videos are taken from an indoor environment and each set contain one to four videos per person. This significant in-plane and out-of-plane head rotations, some changes in expressions and partial occlusions. This type of data base can be used for both purposes such as face recognition also face tracking. With the user acquaintance only the data set will be created and the best performance can be achieved with this baseline results.

Table I: Proposed process Flow algorithm

Step1: Select the video data set from Honda/UCSD face recognition video database

Step 2: Extract the frames from the dataset

Step 3: Do preprocessing for each frames

- Resizing
- Histogram Equalization
- Median filtering
- Background removal

Step 4: Calculate the feature vectors from the preprocessed data

Step 5:Estimate face recognition using Fuzzy based Least Score Elimination Classifier

Step 6: Calculate score for each fuzzified frames

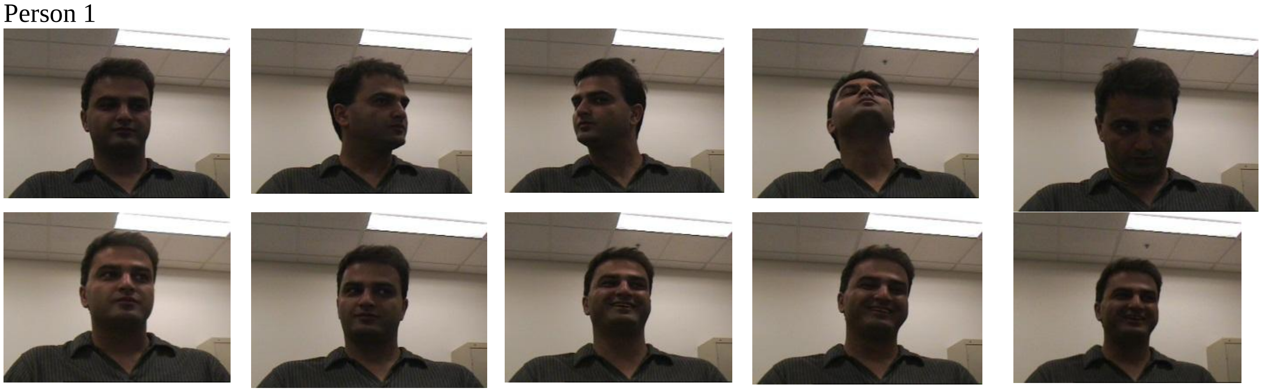
Step 7: Eliminate scores with least valued image

Step 8: Compare high score value with the test image

Step 9: Estimate parameters for the matching process

Step 10: End While.

Person 1



Person 2

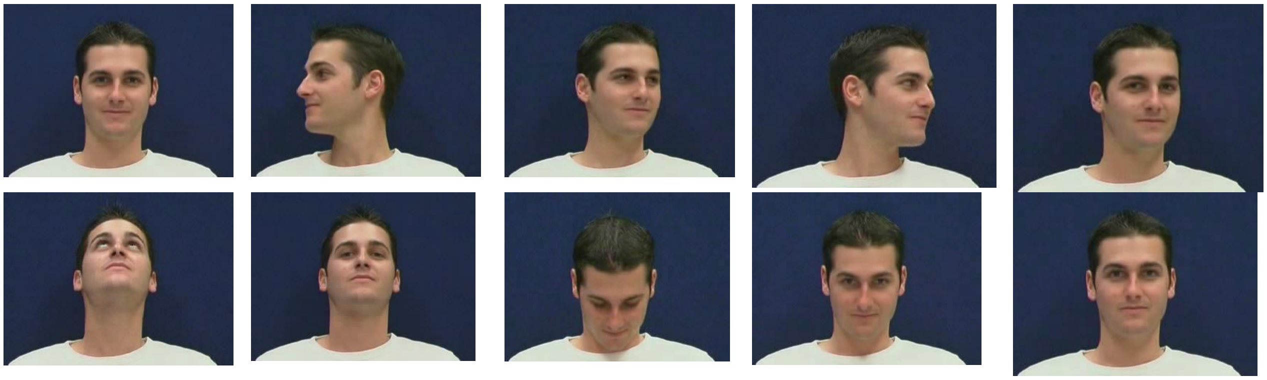


Fig 3: Some images selected from Honda/UCSD video database

Figure 3 represented the frames from the different videos. Here videos of two persons are taken for the face recognition process. From these two sets of frames with high score is taken as the face recognised image.Thus FLSEC technique provides better recognition ratio in case of various illumination of an each frame.

Some of the parameters are calculated to show the performance of the proposed work and which is given below:

Precision:

Precision means the positive predictive value and higher values of this precision means it attains more relevant values.

$$\Pr ecision = \frac{T_P}{T_P + F_P} \tag{19}$$

Recall:

Recall is the ratio of amount of appropriate data retrieved to the total amount of appropriate data.

$$\operatorname{Re} call = \frac{T_p}{T_P + F_n} \tag{20}$$

F-score:

It is the combination of precision and recall and it is the mean average value.

$$F_{Score} = \frac{\left(1+\beta^2\right)\operatorname{Re} call * \Pr ecision}{\beta^2\left(\operatorname{Re} call + \Pr ecision\right)} \tag{21}$$

Where T_p - Registered image is identified as registered image

T_n - Registered image is identified as not registered image

F_P - Actual not registered image is identified as not registered image

F_n - Actual not registered image is identified as registered image

b) Comparison with other Classifiers:

Graphical representation of comparison is given in the below section:

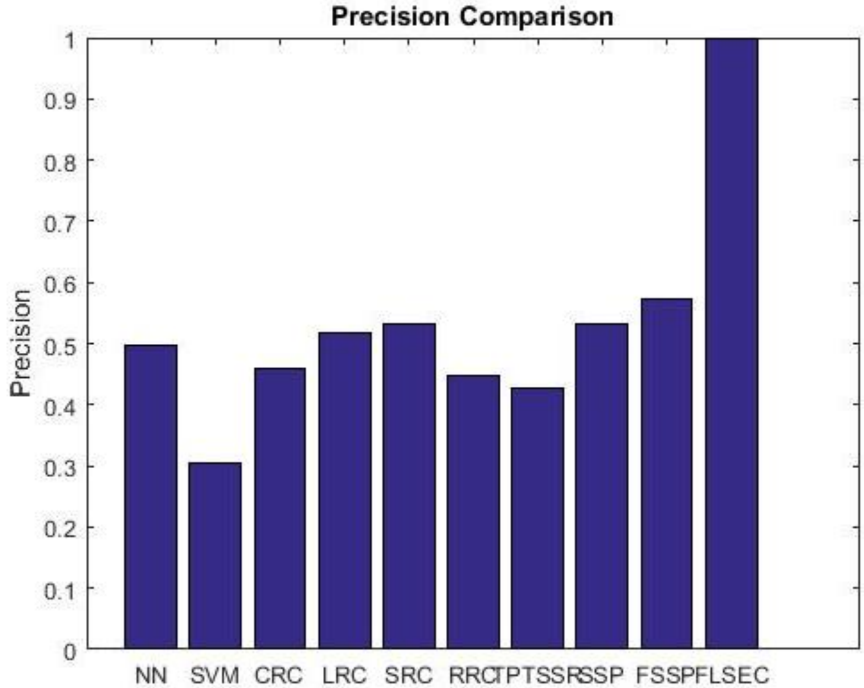


Fig 4: Precision comparison analysis

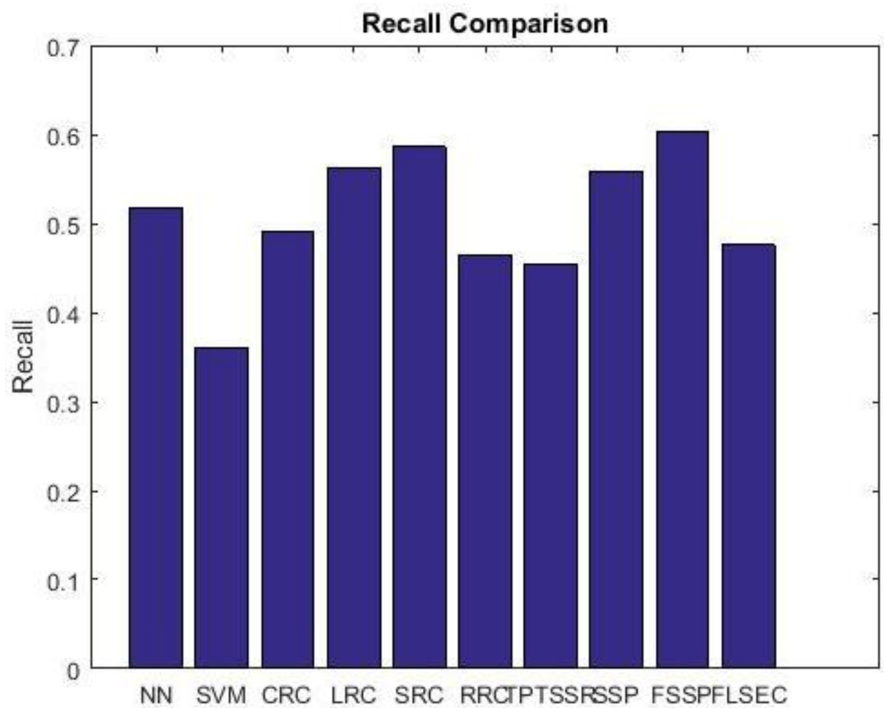


Fig 5: Recall comparison analysis

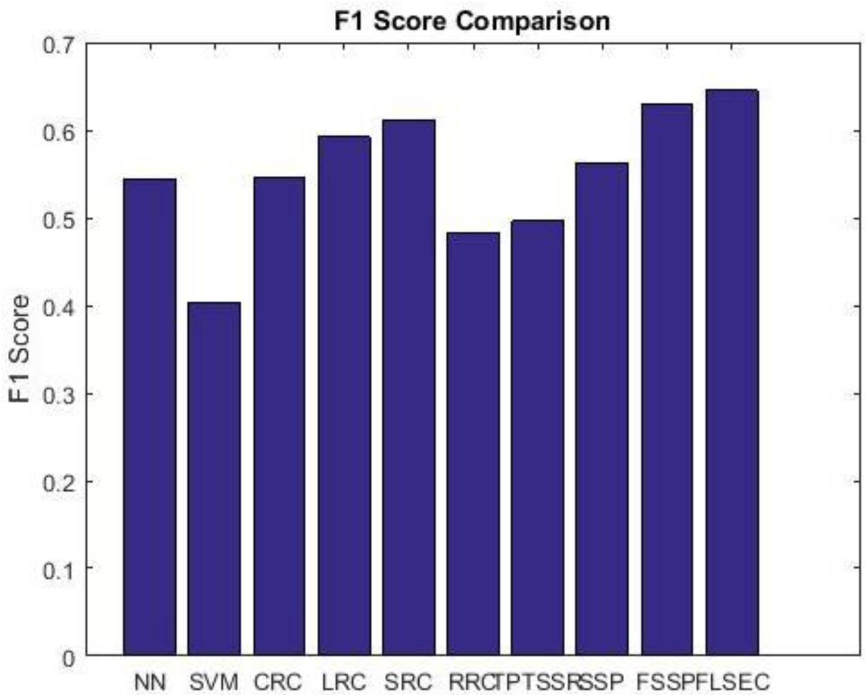


Fig 6: F1 score comparison analysis

Comparison analysis of various classifiers with the proposed technique for precision, recall and F1-score are given in figure 4, 5 and 6. In case of neural networks, the classification is possible with the calculation of distances among training and testing. Sparse parameters are calculated in case of SRC, TPTSSR and CRC classifiers depend upon the projection space or subspace. With this space only classification is possible and from the original prototype only this spaces were calculated. LRC classifier usesprojection samples to classify the test samples.However, other classifiers like SSP and FSSP have the complexity problem in the score calculation. Since sparse parameter calculation and more iteration needs time complexity. So our proposed work uses Fuzzy based Least Score Elimination Classifier reduces number of iteration and enhances an accuracy of the recognition.

Table II: Comparative analysis of proposed and existing methods

Classifiers	Precision	Recall	F1 Score
NN	0.498	0.518	0.544
SVM	0.306	0.36	0.404
CRC	0.46	0.49	0.546
LRC	0.518	0.562	0.592
SRC	0.532	0.586	0.612
RRC	0.448	0.465	0.482
TPTSSR	0.427	0.454	0.496
SSP	0.532	0.558	0.562
FSSP	0.572	0.609	0.63
FLSEC	1	0.476	0.645

The above table (II) represented the comparison analysis of proposed (FLSEC) with various classifiers like Neural Networks (NN), Support Vector Machine (SVM), Collaborative Representation based Classification (CRC), Linear Regression Classification (LRC), Two Phase Test Sample Sparse Representation (TPTSSR), Regularized Robust Coding (RCR), Superimposed Sparse Parameter (SSP) and FastSuperimposed Sparse Parameter (FSSP). Thus our proposed work yields 42% better precision rate than existing methods and 1.5% better recall rate.
Finally VHDL implementation is done for FPGA realization. Verilog is a HARDWARE DESCRIPTION LANGUAGE (HDL). It is a language used for describing a digital system like a network switch or a microprocessor

or a memory or a flip−flop. It means, by using a HDL we can describe any digital hardware at any level. Designs, which are described in HDL are independent of technology. This process needs some components for FPGA realization.

Some of the components are given below:

Table III: Components description of VHDL

Components	Description
Registers in count	288
Flip-flop in count	288
Clock Buffers in count	1
I/O Buffers in count	68
Selected Device	7a100tcsg324-3
Total memory usage	427728 kilobytes
Number of errors	0
Time utilization after clk	0.640ns
Fully used LUT-FF pairs	35%
I/O utilization	32%
Delay	21.554ns

Table III shows the components description of the proposed verilog conversion. This description explains the comparison about the time utilization and the memory usage and input outpi-ut conponent utilization. Time utilization before clocck is 7.632ns (6.664ns logic, 0.968ns route) in terms of percentage it is (87.3% logic, 12.7% route). But after clock time consumption is reduced and it has the range of 0.640ns (0.361ns logic, 0.279ns route) in terms of percentage it is (56.4% logic, 43.6% route). In case of device utilization it utilized only 35% since number of work load will reduced. Proposed FLSEC face recognization strategy have 0% error and it yields accurate performance for the recognization.

V. CONCLUSION

In this paper, a novel classifier namely FLSEC is introduced which produces an efficient recognition ratio with the TSK model. So this proposed work can be implemented with different data base. In our experimental result we have compared the performance with different classifiers to show our enhanced performance in case of face recognition. Precision, recall and f-score values are evaluated which deliberate the performance efficiency of the proposed work. With theHonda/UCSD video databaseFLSEC method gives important to the each frequency interval of an image. This fuzzy system takes all the features as fuzzified input and gives classifier parameter output for the score calculation. Thus the accuracy of the recognition is improved with this fuzzification. Finally the performances are by VHDL provided by Xilinx.

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