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Improved Edge Detection based Fast Face Detection Method using Enhanced Fourier Transform (IED-FFD) towards Facial Expression Recongnition

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Abstract - Facial expression recognition extends in various real world scenario that includes safety, scientific and many commercial applications. Face detection through edge detection is focussed in this research before recognizing facial expressions. Hence, in this paper, an improved sobel operator is employed. The improved sobel operator makes use of geodesic distance. To identify the position of edge, the minimum distance between the image and the elements of features with the help of geodesic distance are used. After that, an enhanced fast fourier transform (E-FFT) is employed for face detection. Performance metrics such as time taken for edge detection, time taken for face detection and accuracy are taken into account. From the results it is evident that the proposed work consumes less time for edge detection and face detection. Also it is noteworthy that the accuracy is improved significantly.

Keywords: *Facial expression recognition, edge detection, face detection, fast fourier transform, accuracy.*

1. INTRODUCTION

Face is a vital part is social communications. Ekman and Frisen [18] mentioned that, happy, sad, anger, fear, disgust and surprise are the six basic expressions that are freely documented across diverse cultures. A system developed for contemplating facial reactions mechanically through a human-computer interaction, is known as Facial expression recognition. Edges are basically the noticeable variation of intensities in an image. Edges help to identify the location of an object and the boundary of a particular entity in the image. It also helps in feature extraction and pattern recognition. Hence, edge detection is of great importance in computer vision. So far, most of the researchers have chosen software for implementation of basic edge detection algorithms and their variations [19]. But, it has been established that it is not an efficient approach for real time applications. Face detection helps in FER method for faster recognition of human expressions. This research article proposes Improved Edge Detection based Fast Face Detection Method using Enhanced Fourier Transform (IED-FFD) towards Facial Expression Recongnition. This paper is organized as follows. Section 2 gives a brief review of literature. Section 3 describes the proposed work. Section 4 provides results and discussions. Section 5 offers concluding remarks.

2. RELATED WORKS

Amer et al. [1] compared all the edge detection algorithms to study their performances. The results showed that Sobel and Canny edge detectors are not as much of sensitive to random noise in an image as compared to Robert’s and Prewitt operators. Cui et al. [2] deliberated the recompenses and difficulties of edge detection algorithms and matched them. The evaluationindicates that binary morphology operator attains better results. A system namely bordering close has also been used so as to achieve clear and integral image profile. [3] Deng et al. developed an algorithm in which fusion technology is used. In this an improved Sobel operator is introduced which is combined with wavelet transform, canny and prewitt operators. The algorithm effectively improved the results of edge detection. Chinu et al.[4] discuss a hybrid strategy for color based image edge detection. This approach has been mainly implemented for overcoming poor edge localization, high sensitivity to noise, edge detection of images with complex background and detecting color edges. Both sequential and parallel approaches have been used and compared which depicted that parallel strategy shows a performance gain of 68%. To measure the accuracy of edge detection various metrics are used like PSNR, speed up, efficiency etc. [5]. An algorithm is developed in which improved canny operator is used. In this improved operator, morphological filter replaces the Gaussian filter. The morphological filtering pre-treats the noise of image, keeps the edge strength and details, thus achieving better accuracy. Gao et al.[6] proposed a method in which Sobel edge detection is combined with soft-threshold wavelet de-noising on images which have White Gaussian noises. Firstly, soft-threshold wavelet denoising is used to remove the noises from the image and then Sobel operator is applied to it. The results show an improvement in the accuracy of edge detection.

As far as related works in face detection is concerned, recently, many appearance based face recognition systems are developed. Such systems aimsto lessen the computation time that is required for detection of face images [13]. The appearance based face recognition systems use face image pixel intensity values directly as the feature values for recognition and are represented using single valued variable. But such single valued variables may not be able to capture the variation of feature values of the images of the same subject and will also have high dimensional features data. One of the techniques adapted by researchers to develop efficient system with reduced number features is method- ology of feature learning. Feature learning or active learning plays a major role to discriminately represent or construct training image data (extracted feature) to improve the performance of classification task [7–10]. Hence, recently a number of active learning methods have been proposed which combine representiveness and informativeness of training samples to attain better classification accuracy [8]. Chong Peng et al. propose a supervised feature learning model for classification of both low and high dimensional data [11]. The technique estimates regression vector using a dis- criminative regression approach to estimate the similarity between the test data and training data. However, classification task be- comes challenging, when low or high dimensional image data are affected by distortions such as illumination, pose variation, presence of occlusion and geometrical variations etc. [12]. To handle such a class of distortions, a mathematical framework for multi- class classification of high dimensional image data has been pro- posed. The minimax framework estimates an optimal representation model that minimizes the fitting error under listed distortions to the data in an application of interest. Further, categorical information is derived based on the estimated model and regression models used for classification [12].

During the contemporary years several research works are carried out as far as face recognition is concerned. Many researchers aim to reduce the time complexity in terms of computation time taken for facial image detection. It is to be noted that there are face recognition systems that make use of face image pixel intensity values directly as the feature values for recognition. Such systems / methods the representation made use of single valued variable. In some literature, it is mentioned that single valued variables are not capable enough to seizure the variation of feature values of the facial images that has high dimensional features.

3. PROPOSED WORK

3.1. Improved Sobel Operator for Edge Detection in Facial Expression Recognition Images

The sobel operator is a famous edge detection mechanism and can be applied to wide variety of images that includes digital color images and grayscale images. In this section, a brief introduction about sobel operator for edge detection is presented and then the improvement work is presented later. The sobel operator has a couple of 3×3 convolution kernels and is depicted in Fig.1.

-1	0	+1
-2	0	+2
-1	0	+1

Gx

+1	+2	+1
0	0	0
-1	-2	-1

Gy

Fig.1. Convolution kernel in Sobel operator

The Sobel operator's kernel structure helps to retort in the best way to edges running vertically and horizontally based on the pixel grid, one kernel for each of the two perpendicular orientations. These kernels are applied distinctly to the input facial expression image in order to obtain discrete measurements of the incline component in each orientation and represented as G_x and G_y. In this work, these are embeeded together for discovering the complete magnitude of the incline at each point and the orientation of that incline. The incline magnitude is mathematically represented as

$$|G| = \sqrt{Gx^2 + Gy^2} \ldots \quad (1)$$

Inorder to quickly process, the equation (1) is modified as

$$|G| = |G_x| + |G_y| \ldots \quad (2)$$

The angle of direction of the edge for spatial incline is represented as,

$$\theta = \arctan\left(\frac{G_y}{G_x}\right) \ldots \quad (3)$$

It is considered that $g_i$is the i[th] image where $i \in [0,1]$. In order to identify the position of edge, the minimum distance between the image and the elements of features are used and is given as,

$$d^*_{pos} = \arg\min p(d_{pos} \,|dist(F_n, \varphi_{img}) \ldots \quad (4)$$

In this work, the geodesic distance is used. In the input facial expression image $I(x)$, the geodesic distance $D(x_i, x_j)$ between the pixels x_i and x_j is defined as the shortest path that connects x_i and x_j. It is mathematically represented as,

$$D(x_i, x_j) = \min_{\Gamma \in P_{x_i, x_j}} \int_0^{l(\Gamma)} \sqrt{1 + \gamma^2 (\nabla I(s).\Gamma'(s))^2 ds} \ldots \quad (5)$$

In the equation (5), P_{x_i, x_j} is the set of all available paths between x_i, x_j, Γ is the parameterized depiction by arclength on the path, $\nabla I(s)$ is the incline value, $\Gamma'(s)$ is the unit vector tangent to the direction of the path. The factor γ weights the influence of the image incline versus spatial distance. The input facial expression image is the main processing target, and the geodesic distance is computed only by accumulating neighboring pixel values as in equation.6.

$$d(\Gamma) = \sum_{i=1}^{n} d_{i,i-1} = \sum_{i=1}^{n} I(p_i) - I(p_{i-1}) \ldots \quad (6)$$

3.2. Face Detection using Enhanced Fast Fourier Transform for Facial Expression Recognition

In this section the face detection for facial expression recognition is presented. Once after the edges are detected in the given facial image, local variations in spatial domain is extracted by making use of frequency domain transform. The unalike brightness, expression dissimilarities and constrictions of face images are denoted in frequency domain by making use of Enhanced Fast Fourier Transform (E-FFT) that produces the features. The E-FFT is represented as,

$$\Gamma(k,l) = \sum_{m=0}^{M-1} \sum_{n=0}^{N-1} \tau(m,n) e^{-j\frac{2\pi}{M}mk - \frac{2\pi}{N}nl} \ldots \quad (7)$$

In the equation (7), $\Gamma(k,l)$ denotes the image co-efficient; (m,n) denotes the position of RGB value of image Γ.Additionally, low frequency components are saved for excerpting discerning features that are required for face detection. The maximum magnitude value is taken as the feature descriptor of the facial image. This research work makes use of altered feature representation when comapred with other facee recognition systems as described in the related work. This work also incorporates a single feature value to represent the entire face image. Moreover, symbolic items which fit to the same course are denoted by a interval valued variable i.e. by maximum and minimum magnitude values of N symbolic course of the corresponding face class. For the symbolic similarity analysis between trained symbolic objects and test object, a new symbolic similarity measure is devised and employed in this work.

4. Results and Discussions

Table – 1: Overall Performance Analysis of the proposed IED-FFD with existing works

Image Title	Elapsed Time for Edge Detection (in seconds)		Elapsed Time for Face Detection (in seconds)		Image Title	Accuracy (in %)	
	GETF [14]	IED-FFD	LS-KC-SVM [15]	IED-FFD		LS-KC-SVM [15]	IED-FFD
Image 01	0.563	0.279	0.640	0.405	Image 01	81.63	89.88
Image 02	0.562	0.284	0.678	0.394	Image 02	83.27	90.70
Image 03	0.538	0.238	0.649	0.398	Image 03	81.00	90.45
Image 04	0.556	0.285	0.662	0.423	Image 04	81.99	90.00
Image 05	0.522	0.268	0.640	0.413	Image 05	83.00	90.78
Image 06	0.559	0.236	0.666	0.405	Image 06	82.89	90.50
Image 07	0.512	0.247	0.646	0.438	Image 07	83.55	90.31
Image 08	0.529	0.263	0.669	0.421	Image 08	83.06	89.81
Image 09	0.513	0.288	0.671	0.419	Image 09	83.63	90.90
Image 10	0.517	0.288	0.675	0.444	Image 10	81.21	90.22
Image 11	0.568	0.240	0.657	0.400	Image 11	82.68	91.76
Image 12	0.559	0.288	0.635	0.433	Image 12	82.99	89.13
Image 13	0.532	0.287	0.644	0.433	Image 13	83.18	90.45
Image 14	0.577	0.259	0.685	0.407	Image 14	81.60	89.79
Image 15	0.512	0.278	0.639	0.420	Image 15	82.63	90.24
Image 16	0.541	0.239	0.680	0.385	Image 16	81.70	89.84
Image 17	0.537	0.255	0.662	0.384	Image 17	81.69	89.38
Image 18	0.564	0.285	0.690	0.417	Image 18	81.65	91.33
Image 19	0.566	0.278	0.635	0.435	Image 19	83.65	89.64
Image 20	0.523	0.288	0.657	0.445	Image 20	82.96	89.34
Image 21	0.544	0.269	0.636	0.389	Image 21	81.92	91.06
Image 22	0.541	0.232	0.688	0.420	Image 22	83.80	89.46
Image 23	0.555	0.281	0.630	0.413	Image 23	81.64	91.09
Image 24	0.560	0.286	0.677	0.381	Image 24	81.94	91.52
Image 25	0.563	0.271	0.679	0.404	Image 25	82.08	90.22
Average Time Taken (in seconds)	***0.544***	***0.268***	***0.660***	***0.413***	***Average Accuracy***	***82.45***	***90.31***

The dataset are obtained from the openly available dataset [16]. 25 images are taken for testing the effectiveness of the proposed IED-FFD. Performance metrics such as time taken for edge detection, time taken for face detection and accuracy are taken for comparing the proposed IED-FFD method. In order to compare the time taken for edge detection, GETF [14] method is chosen for comparison. LS-KC-SVM method is chosen for comparing the effectiveness of the proposed IED-FFD in terms of time taken for face detection and accuracy.

Table – 1 presents the overall performance analysis of the existing works and proposed work. From the presented results it is evident that the proposed work IED-FFD consumes less time for edge detection when compared with GETF [14] method. The average time taken for edge detection of IED-FFD is 0.268 when compared with GETF [14] method which consumes 0.544 seconds. The results are presented in Fig. 2.

As far as the average time taken for face detection is concerned, the existing LS-KC-SVM [15] had taken 0.660 seconds whereas the proposed IED-FFD consumes 0.413 seconds. The graphical results are presented in Fig. 3. It is noteworthy that the average accuracy of IED-FFD is 90.31 % which is better when compared with LS-KC-SVM [15] method that obtains 82.45 %. The results are presented in Fig. 4.

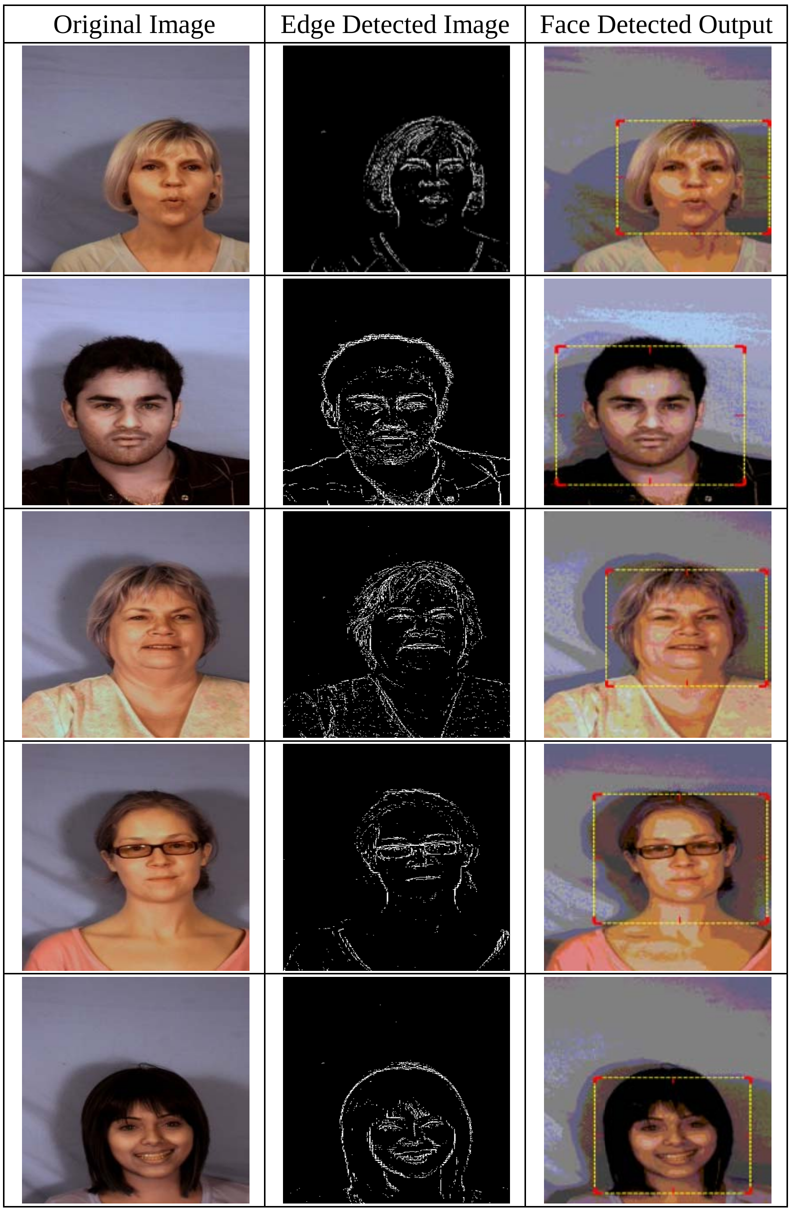

Fig.1. (a) Original Image (b) Edge Detected Image (c) Face Detected Output

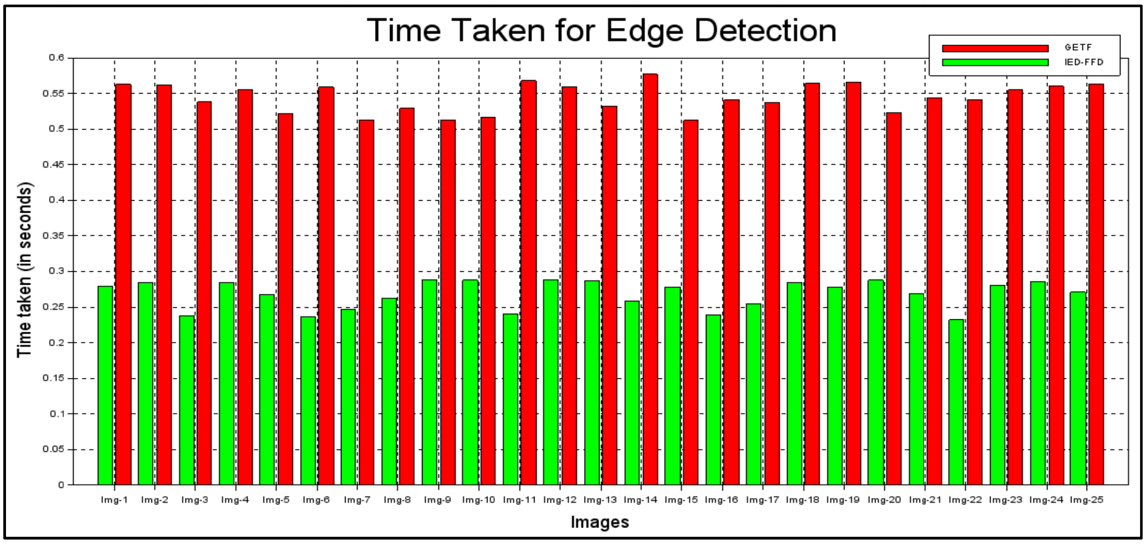

Fig. 2. Performane Analysis: Time Taken for Edge Detection

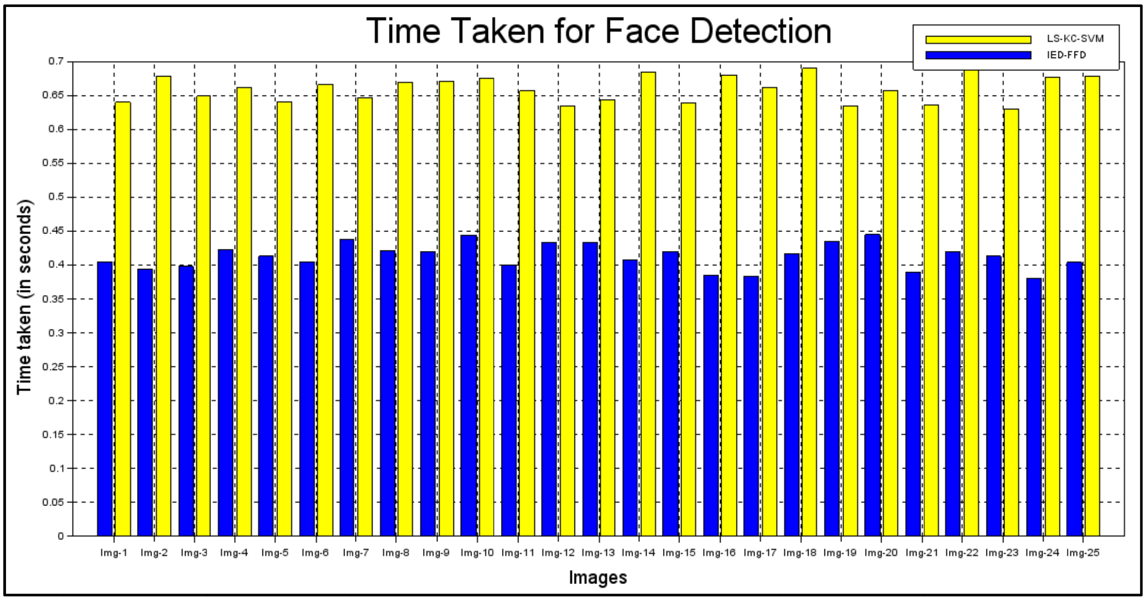

Fig. 3. Performane Analysis: Time Taken for Face Detection

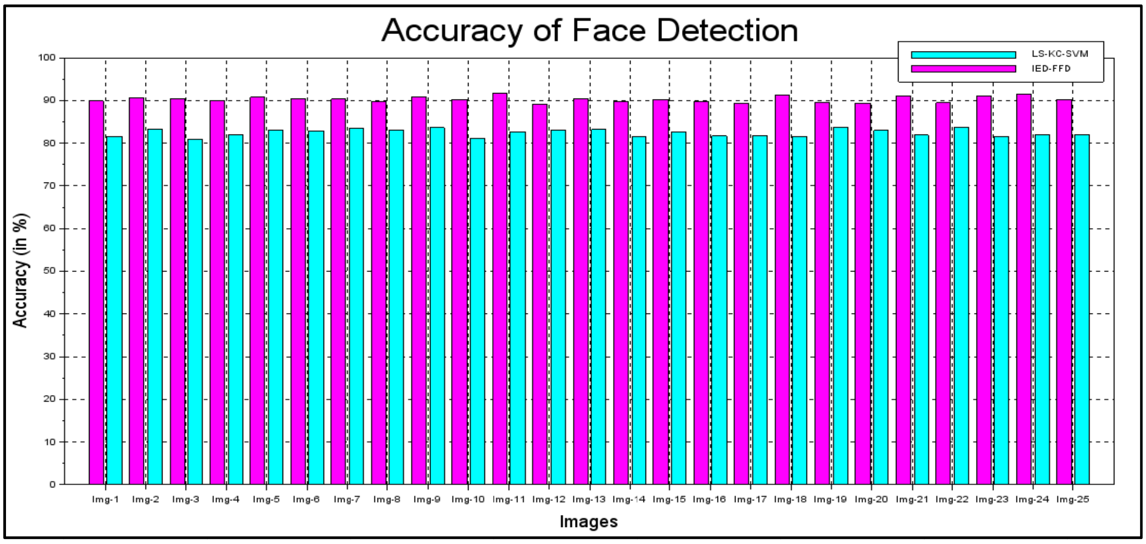

Fig. 4. Performane Analysis: Accuracy

5. Conclusion

Facial expression recognition system can be developed through schematic process. Usually the images obtained possibly will have noises in it. Hence the previous work focusses on unaffected serial prophecy based filter technique for noise removal in facial expression recognition images. In this second phase of research improved edge detection based fast face detection method using enhanced fourier transform (IED-FFD) towards facial expression recongnition is proposed. 25 images are taken for evaluating the performance. IED-FFD has two folds. First, an improved edge detection mechanism is used that consumes less time. Next, fast face detection is performed with improved accuracy upto 91.76 % with less time.

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