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Developing a Novel Technique for Face Liveness Detection

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Abstract

Face recognition is an important tool in identifying a person. Due to existence of non-real faces, Spoofing attack weakens the Face Recognition process, which can be overcome byLiveness Detection. There are three approaches to perform liveness detection: by challenge and response based liveness detection technique, by face texture liveness detection and by joining two or more biometrics liveness detection. The existing techniques fail to give good results for Face Liveness Detection under unconstrained environment. Hence we have proposed Face Liveness Detection based on Image Quality Assessment (IQA) parameters. The proposed system is validated on a database having 70 images which are taken under unconstrained environment.

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Keywords: Face recognition; Spoofing attack; Liveness detection; Image Quality Assessment.

1. Introduction

In biometric authentication face recognition technology plays an important role to identify the person identity, but spoofing is a major cause for the failure if various face recognition systems[1]. By insertion of a photo/video/mask of an registeredindividual in front of the camera spoofing attack is performed during face recognition process [2-4].

To overcome this problem liveness detection is performed before face recognition [5-7]. The liveness detection module adds an additional layer of security, it uses macro features of face mainly eye and mouth actions. The consistency of liveness module is tested by using photo/video/mask of aregisteredindividual.

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There are three approaches to perform liveness detection: By utilizing challenge and response based liveness detection technique, by using face texture liveness detection and by joining two or more biometrics liveness detection. Based on the three approaches there are three existing methods which have been derived to perform liveness detection they are: Multispectral method, Client Identity Information Method, Single Image via Diffusion Speed Model.

2. Related work

Traditional method to perform liveness detection involves: Training process and Calculation of Mean, Covariance. Eigenvectors, Eigen face. Δ=P∗Q image is considered for training process, which is kept in a training database, where there are P number ofindividuals and eachindividual has Q images. Mean is calculated, Covariance is calculated to know the relationship between each features. Principal component such as Eigenvectors and Eigen face are calculated. This traditional approach was not found to be suitable to detect liveness in images under varying poses, hence three new methods been derived to perform liveness detection they are: Multispectral method, Client definite method, Single image via Diffusion speed model.

Authors in [1] present Multispectral method for livenessdetection; here a monochrome camera captures the ambient light and an image. Xenon lamp illuminates the scene. In order to provide required energy at various spectrums we use full-spectrum active light.

$$I_i^P = t \int_{\lambda^i min}^{\lambda^i max} L^P(\lambda) R^P(\lambda) T_i(\lambda) C(\lambda) d\lambda \quad (1)$$

The Table 1 shows True Positive Rate (TPR) and True Negative Rate (TNR) obtained using Multispectral method for liveness detection. Two orientations are considered: fontal face, 45° profile face. Among the two orientations 45°profile gives better results because in 45° viewpoint uniform hair styles are observed but in the front portion of face a change of hair styles consequence in numerous spatial scatterings of gradient values hence reducing the performance.

Table 1.Performance of Multispectral Method for Liveness Detection in Frontal and 45°Profile Face.

Orientations	TPR (%)	TNR (%)
Frontal face	94.3	98
45°profile face	100	99

Authors in [2] present Client-independent and Client-definite and methods for liveness detection. Client-definite method uses Probabilistic Graphical Model framework for anti-spoofing. Enrollment of samples for each of the clientsaremajor requirements of client definite anti-spoofing system. This information is utilized to create client definite model and train client-definite classifiers. Using enrollment samples a client-definite Support Vector Machine classifier is developed. Two protocols are used for testing: intra-protocol and cross- protocol, intra-protocol algorithm is trained and tested using same protocol but in cross-protocol algorithm is trained using one protocol and tested on another protocol.

Authors in [3] presentsingle Image through diffusion model of speed which uses Logarithmic Total Variation (LTV) model. LTV model differ from previous Total Variation (TV) model. In LTV the diffusion speed of the local pattern also named as Local Speed Pattern (LSP)is given as input into to linear Support Vector Machine classifier which determines if the given face image is fake. This method works well illumination invariant face images. The performance of diffusion speed model was found to be reliable under varying lighting conditions in different indoor and outdoor environments. Table 3 compares the Human-targeted Translation Error Rate (HTER) value of Local Binary Pattern (LPB), Local Binary Patter + Local Discriminant Analysis (LBP+LDA), Local Binary Patter + Support Vector Machine (LBP+SVM) and Local Speed Pattern (LSP). From table 2 we find that HTER value for LSP is the minimum when compared to other techniques.

Table 2.Performance Comparison of LBP, LBP+LDA, LBP+SVM and LSP for Liveness Detection.

Methods	Dev	Test
$LBP_{3\times3}^{u2} + \chi^2$	31.24%	34.01%
$LBP_{3\times3}^{u2} + LDA$	19.60%	17.17%
$LBP_{3\times3}^{u2} + SVM$	14.84%	15.16%
LSP	13.72%	12.50%

All the 3 existing techniques fail to give good results for Face Liveness Detection under unconstrained environment. Hence we have proposed Face Liveness Detection based on Image Quality Assessment (IQA) parameters.

3. Proposed Method

To detect liveness of face we use Image Quality Assessment (IQA) parameters. IQA attempts to assess the errors in the input face image. The 8 IQA consider parameters considered are Peak Signal to noise Ratio (PSNR), Mean Square error (MSE), Normalized Absolute Error (NAE), Signal to Noise Ratio (SNR), Total Edge Difference (TED), Maximum Difference (MD), Structural Similarity Index (SSI), and Average Departure (AD). Each of these 8 IQA parameters is defined in Table 3.

Table 3.Description of 8 IQA parameter considered in the proposed system used for Face Liveness Detection

Acronym	Ref.	Description
PSNR	[4]	$\mathrm{PSNR}(I,\hat{I})=10\log\left(\frac{\max(I^2)}{\mathrm{MSE}(I,\hat{I})}\right)$
MSE	[5]	$\mathrm{MSE}(I,\hat{I})=\frac{1}{NM}\sum_{i=1}^{N}\sum_{j=1}^{M}\left(I_{i,j}-\widehat{I_{i,j}}\right)^2$
NAE	[6]	$\mathrm{NAE}(I,\hat{I})=\frac{\sum_{i=1}^{N}\sum_{j=1}^{M}\lvert I_{i,j}-\widehat{I_{i,j}}\rvert}{\sum_{i=1}^{N}\sum_{i=1}^{M}\lvert I_{i,j}\rvert}$
SNR	[7]	$\mathrm{SNR}(I,\hat{I})=10\log\left(\frac{\sum_{i=1}^{N}\sum_{j=1}^{M}(I_{i,j})^2}{\mathrm{N.M.MSE}(I,\hat{I})}\right)$
TED	[7]	$\mathrm{TED}(I,\hat{I})=\frac{1}{NM}\sum_{i=1}^{N}\sum_{j=1}^{M}\left\lvert I_{E_{i,j}}-\widehat{I_{E_{i,j}}}\right\rvert$
MD	[7]	$\mathrm{MD}(I,\hat{I})=\mathrm{Max}\left\lvert I_{i,j}-\widehat{I_{i,j}}\right\rvert$
SSI	[7]	$\mathrm{SSI}(x,y)=\frac{(2\mu_x\mu_y+C_1)(2\sigma_{xy}+C_2)}{(\mu_x^2+\mu_y^2+C_1)(\sigma_y^2+\sigma_y^2+C_2)}$
AD	[7]	$\mathrm{AD}(I,\hat{I})=\frac{1}{NM}\sum_{i=1}^{N}\sum_{j=1}^{M}\left(I_{i,j}-\widehat{I_{i,j}}\right)$

The activity diagram and class diagram are as in fig.1. The proposed schemecomprises of the following modules:

- Query image
- Preprocess
- Feature extraction
- Classification.

Query image: Query image is an input face image whose liveness needs to be detected.

Preprocess: Gaussian filter is used to eliminate the noise in the input face image and it is resized.

Feature Extraction: In this process, we use Image Quality Assessment. We have considered 8 IQA parameters: Peak Signal to noise Ratio (PSNR), Mean Square error (MSE), Normalized Absolute Error (NAE), Signal to Noise Ratio (SNR), Total Edge Difference (TED), Maximum Difference (MD), Structural Similarity Index (SSI), Average Departure (AD).

Classification: Quadratic Discriminant Analysis (QDA) is used to categorize if a given input image is live or fake. QDA models the propensity of each class, as a Gaussian distribution.

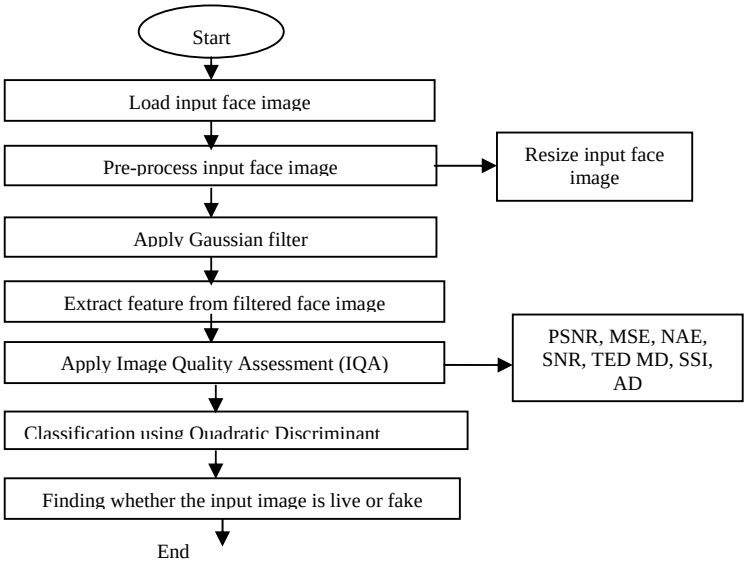

Fig.1. Activity figure of the Proposed Scheme used for Liveness Detection.

4. Results and Discussion

To confirm the proposed system used for face liveness detection we have created a database which contains 70 photos. These photos contain genuine and imposter poster. The graphical representation of the various IQA parameters for 70 input images used for Face Liveness Detection is shown in fig. 2 to fig. 9. Fig. 10 shows step by step implementation of the proposed scheme used for face liveness recognition when the input image is a genuine photo. Fig. 11 shows step by step implementation of the proposed scheme used for face liveness recognition when the input image is an imposter photo. Demo version of the code along with input face images and results obtained for all the 70 images can be downloaded from https://goo.gl/aDhYyA.

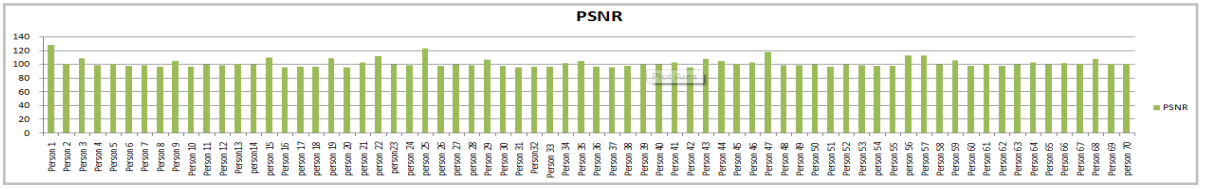

Fig.2. PSNR values obtained for 70 input images from the proposed method

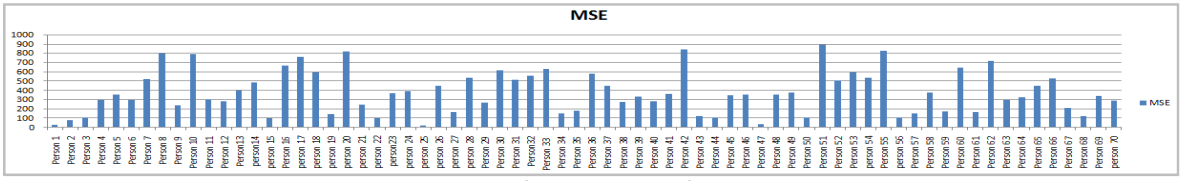

Fig.3. MSE values obtained for 70 input images from the proposed method

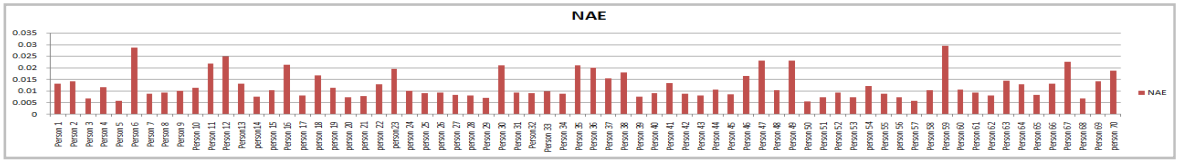

Fig.4. NAE values obtained for 70 input images from the proposed method

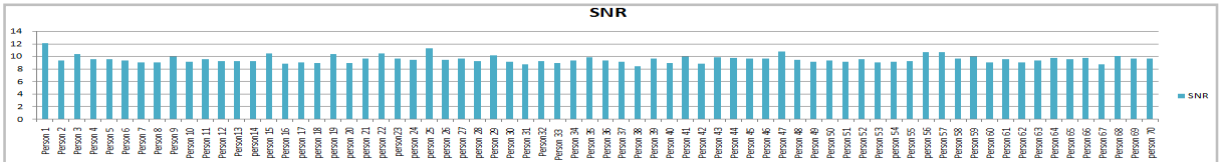

Fig.5. SNR values obtained for 70 input images from the proposed method

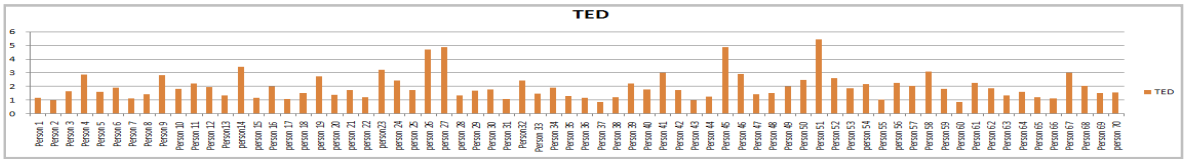

Fig.6. TED values obtained for 70 input images from the proposed method

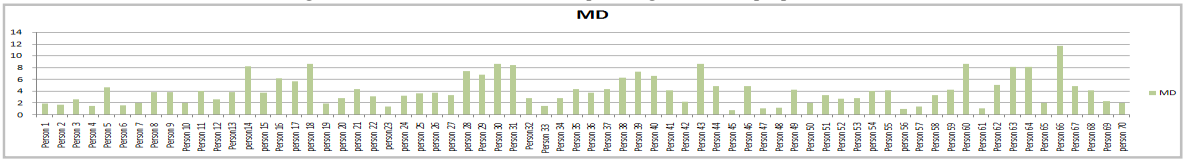

Fig.7. MD values obtained for 70 input images from the proposed method

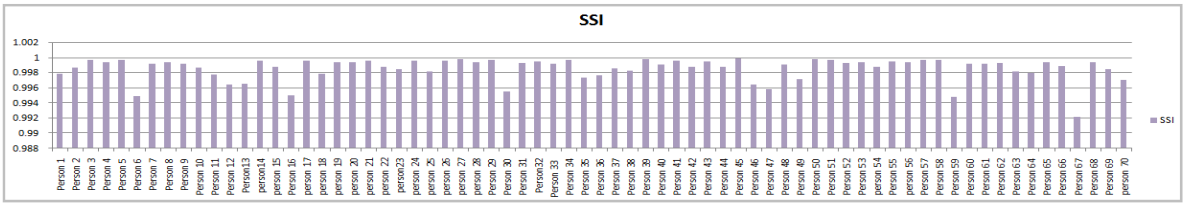

Fig.8. SSI values obtained for 70 input images from the proposed method

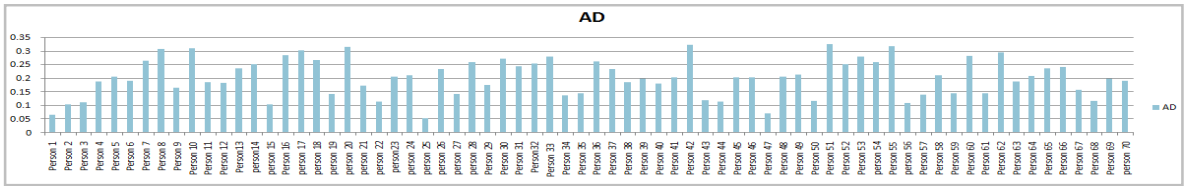

Fig.9. AD values obtained for 70 input images from the proposed method

Fig.10. Step By Step Implementation of the Proposed System used for Face Liveness Detection when the input image is genuine photo

Fig.11. Step By Step Implementation of the Proposed Scheme used for Face Liveness Recognition when the input image is imposter photo

5. Conclusion

There are three approaches to perform liveness detection: By utilizing challenge and response based liveness detection technique, by using face texture liveness detection and by joining two or more biometrics liveness detection. Based on the three approaches there are three existing methods which have been derived to perform liveness detection they are: Multispectral method, Client Identity Information Method, Single Image via Diffusion Speed Model. All the 3 existing techniques fail to give good results for Face Liveness Detection under unconstrained environment. Hence we have proposed Liveness Recognitionof face based on Image Quality Assessment (IQA) parameters. In the proposed system we have considered eight IQA parameters: Peak Signal to noise Ratio (PSNR), Mean Square error (MSE), Normalized Absolute Error (NAE), Signal to Noise Ratio (SNR), Total Edge Difference (TED), Maximum Difference (MD), Structural Similarity Index (SSI), and Average Departure (AD) to find if a given input image is genuine or fake. The proposed system is validated on a database having 70 images which are taken under unconstrained environment. Table 4 compares the performance of Multispectral method, Client Identity Information Method, Single Image via Diffusion Speed Model and Proposed Method using IQA for Liveness Detection on 70 images taken under unconstrained environment. Table 4 shows that the proposed method using IQA gives better EER, FAR, FRR, HTER values when compared to existing methods for Face Live Detection.

Table 4. Performance Comparison of Multispectral method, Client Identity Information Method, Single Image via Diffusion Speed Model and Proposed Method using IQA for Liveness Detection on 70 images taken under unconstrained environment

	Dev EER	FAR	Test FRR	HTER
Multispectral method	24.96	14.98	7.23	18.34
Client Identity Information Method	13.94	11.96	14.78	21.98
Single Image via Diffusion Speed Model	17.43	9.23	6.27	11.23
Proposed Method using IQA	6.23	4.27	2.19	4.78

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