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Research Article

Masked Face Detection based on Micro-Texture and Frequency Analysis

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Abstract

Recognition with biometric system is a vulnerable approach in security area. But face recognition approach is popular tone of them to spoofing attacks which can be done by falsifying data using craft faces and thereby gaining illegitimate access. An easy way to spoof face recognition system is to use past taken photographs instead of live person. Thus, Liveness detection is needed to design a secure system against like such illegal activities. Inspired from the facts that the images taken from the 2-D pictures and real faces have differences in characteristics like size, shape and detailedness, face prints having printing quality defects that can detected easily via using micro-texture analysis. We are proposing a novel approach analyzing texture and frequency analysis by using Local Binary Pattern (LBP) and frequency descriptor respectively. This provides a unique feature space for coupling spoofing detection and face recognition. Experiments which we were done on publicly available database produced fabulous result and we can clearly illustrate live faces and 2-D photographs.

Keywords: *Spoofing; Frequency Descriptor; Local Binary Pattern; Liveness Detection.*

1. Introduction

The general public has the increasing need for security measures against spoof attack. Despite the great deal of progress during the recent years 2D face biometric still a major concern in research area. Biometric is the technology providing the identity of an individual based on the unique properties like behavioral, physical of the person. There are various techniques for security but face recognition is best one of them which has rapidly developed in recent years. But in general it is not capable to differentiate real live faces pictures which is a major problem of concern for security purpose. Spoof attacks can be done in various ways such as presenting a picture, portrait, mask and video in front of the camera, one can also use makeup or plastic surgery as the other means of spoofing, photographs probably the most common sources of intruding because one can easily downloaded and captured. A secure system requires liveness detection in order to guard against such intruder activity. Liveness is the act of differentiating the feature space into real and masked ie. Live and nonliving. Thus it helps in biometric system to classify real faces from a photo and reducing vulnerability.

Spoofing attacks is occurs when a person provides a false data in front of camera for illegal access like using printed photographs or video of the real person. It is the common illegal activity done by the person for accessing in secured system. As shown in fig. 1, fake face pictures captured from 2D photographs may be look like similar to the live face images. Fig.1 shows some examples of the live face images and their fake pictures taken from their printed photographs. But fake face images lack texture richness as compared to the texture components of live face images due to the fact that live faces reflect light in a different way than that of a photograph. Moreover, sequential fake face images won't show any temporal changes in the facial appearance whereas, live human faces would depict changes in pose and expression which will result in changes in facial appearance.

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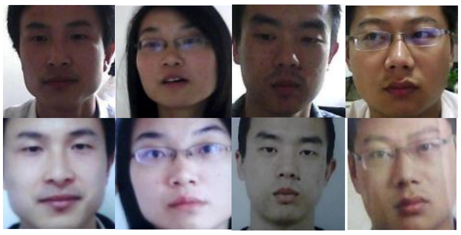

Fig.1 Examples of live faces (upper row) and fake face images (lower row)

In this proposed paper live face detection technique based on texture and frequency analysis is illustrate which can classify between the fake and live faces. For differentiating a live face and 2D photograph, we have used a thresholding operation based on the analysis of Fourier spectra and frequency descriptor. For analyzing the texture information, we have used Local Binary Pattern (LBP). The results of LBP are then fed to Support Vector Machine (SVM) classifier which determines whether the captured image is live face or not experiments done on publicly available database (NUAA Photograph Imposter Database) showed promising results.

In the next section, a discussion on related works on face liveness detection is presented. Our proposed approach is then described in section III. Result and Conclusion shown in section IV. and V. respectively

2. Related work

Without real face detection, most of the face recognition systems are insecure to spoof attacks. Spoof attack can be operate by using a 2D pictures, 3D mask, video etc. A short survey of 2D face realness detection was proposed by (Kahm *et al*. 2012). There are various live face detection techniques based on the type of liveness indicator used to assist the liveness detection of faces. On those indicators are live sign., texture and motion. (Jee *et al*. 2006) proposed an approach based on the movement of the eyes. The author have detected eyes in one by one sequential input images and then variation is calculated. Similarly, using life sign as an indicator, (Pan *et al*. 2008) introduced a technique of blinking-based liveness detection. They have used Conditional Random Framework (CRF) to detect eye blinking behavior. Another technique using lip movement classification and face detection based on face landmarks was introduced by (Kollreider *et al*. 2007). Support Vector Machine (SVM) was used for classification of lip dynamics once after recording the person speaking digits 0-9. (Bao *et al*. 2009) introduced a method based on optical flow field which analyzes the differences and properties of optical flow generated from 2-D planes and 3-D objects. Experiments were done on a private database which showed a 6% false alarm and 14% false acceptance. In a similar work (Kollreider *et al* 2007). presented a method based on optical flow field and used it to capture the movements of different facial parts.

Next category of live face detection is based on the analysis of texture.(Li *et al*.) proposed a real face detection approach based on the analysis of Fourier spectra of a single face image. Their method was based on the assumption ie. size of the photo is smaller than that of the live face and frequency components of photo images is less than that of live face picture. But the effect of illumination was ignored by the authors which would affect the results in a great way. In another work (Kim *et al*. 2013) proposed a technique using variable focusing. Based on the assumption that there is no movement, the authors utilize the variation of pixel values of two images taken sequentially in different focuses. Focused regions of real faces will be clear and blurred in case of fake pictures. Their main constraint was that it relies on Depth of Field (DoF) which determines the range of focus variation.

Another live face detection technique based on 3D structure of the face was presented by (Lagorio *et al* 2013). Their technique was based on the computation of mean curvature of the surface and the authors have showed that the surface variation is low when the picture is taken from a 2D source. The problem of anti-spoofing was introduced by(Tan *et al*. 2010) as a binary classification problem. The authors have used the Lumberton reflectance to differentiate 2D face prints from 3-D real faces. By using a variation retina-based method and difference-of-Gaussians (DoG) based approach, they retrieve latent reflectance features which are then used for classification.

It has been observed that most of the live face detection methods are very complex and some of them using non-conventional parameter and devices and image system. Our proposed technique is computationally easy and fast and does not require old devices. Furthermore it does not require user cooperation.

3. Proposed Technique

Real live picture which are captured from live faces may look like similar to the masked pictures being captured from 2D photos etc. The pose and expression of real live face will vary in one by one captured images sequence but in the case of picture captured from fake faces, the expression and the pose will be invariant. There is a difference in size and detailedness which is caused by surface reflections and shades. In addition, the images taken from masked faces shows flat surfaces compared to real live faces.

Our proposed technique describes texture and frequency based analysis to differentiate between masked that of real face pictures. The images captured from 2D photographs do not have that much of texture richness as compared to images captured from real live faces. Furthermore, there is a difference of micro-texture in the images taken from live faces and masked faces. The main point for using frequency based analysis is that the difference in shapes and detailedness of real faces and masked faces leads to the discrepancy in low frequency regions and high frequency information respectively (Fig. 2).

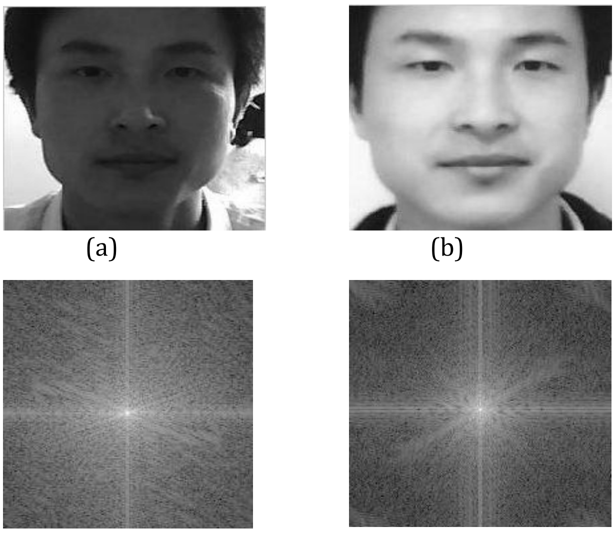

Fig.2 Difference between live face and fake face image in domain: (a) live face image; (b) fake face image; (c) Log magnitude Fourier spectra of (a); (d) Log magnitude Fourier spectra of (b).

A. Frequency Based Analysis

In a sequentially captured image sequence, the expression and pose of a real face will vary whereas, in case of masked faces, the pose and expressions will be invariant. An effective way to detect real genuine face is to monitor temporal changes of facial pose and expression over the time. Facial expression can be represented by an energy value defined in frequency domain. At first, four random images are selected from an input image sequence and a subset is constructed. The images are then transformed into the frequency domain by using 2D discrete Fourier transform. An energy value of each image as defined in (2) in the subset is computed. The standard deviation of the resulting values, called frequency descriptor (FD), is calculated to determine the temporal changes of the face. The frequency descriptor is defined in (1).

$$FD = \left(\frac{1}{n}\sum_{i=1}^{n}(x_i - x_m)^2\right)^{\frac{1}{2}} \quad (1)$$

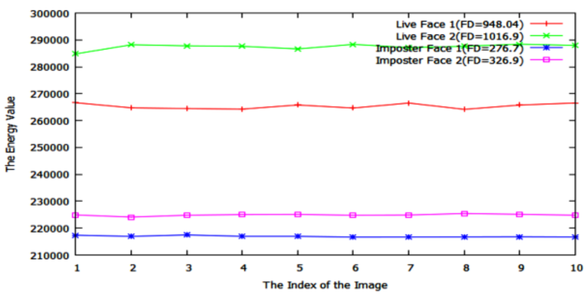

Fig.3 Energy value curves of four different images

$$x = \iint |F(u,v)|du\,dv \quad (2)$$

where, *xi* corresponds to the energy of the *i*th image, *xm* indicates the mean of the energy values and *n* denotes the total number of energy values. The energy value curves (fig. 3) of four different sequences of face image and their corresponding frequency descriptor shows that the energy and frequency descriptor of fake face image sequence are less than that of the image sequence of live faces. Thus, the frequency descriptor of live faces should be more than a threshold value *td*.

B. Texture based analysis

The method based on tentative unfixed changes using frequency based analysis will fail if there are no temporal changes of facial expression of the real live face. Thus, we have also considered differences in micro texture. When the frequency descriptor of a facial image is greater than the threshold value, those images were passed on to the second phase of the algorithm, micro-texture based analysis. For analyzing micro texture differences of the pictures captured from real live faces and masked faces (2D photographs), we have used the LBP. As introduced by (Ojala *et al.* 2002), the LBP texture analysis operator is a gray-scale invariant texture measure. It is one of the most popular and powerful method of texture description and some of its advantages are its discriminative power and its simplicity in computation. Equation (3) shows that by considering the relative intensity, the LBP assigns a code for each pixel and its neighbors.

$$LBP_{P,R} = \sum_{P=0}^{P-1} s(g_P - g_C)2^P; S(x) = \begin{cases} 1 & x \geq 0 \\ otherwise\ 0 & x = 0 \end{cases} \quad (3)$$

where, *P* corresponds to the number of neighboring pixels and *R* is the radius of the corresponding circle i.e. the distance from the center to the neighboring pixels. And, *gc* and *gp* corresponds to the grayscale value of the center pixel and the grayscale value of the *p* equally spaced pixels on the circle of radius *R* respectively and *s(x)* denotes the threshold function of *x*. To calculate the micro texture resolution we have used various values of P and R were set to 8 and 1, respectively.

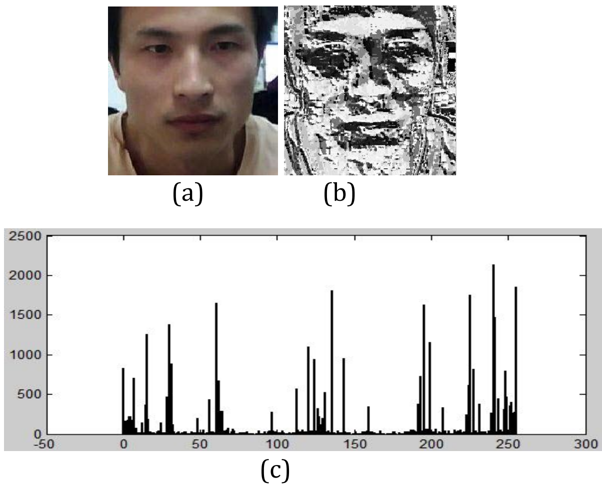

Fig.4 Feature vector extraction based on texture: (a) Live face image; (b) LBP coded image of (a); (c) Feature Histogram of (b).

The process of obtaining the feature vector of local vector pattern from a given input picture is shown in fig. 4(a) depicts the original facial image and the LBP coded image of fig. 4(a) is shown in fig. 4(b). Fig. 4(c) shows the resultant feature histogram of fig. 4(b) which is being used as the feature vector for the classification. For classification, we have used Support Vector Machine (SVM) classifier with radial basis function kernel. To train the SVM classifier, we have used real faces as positive and fake faces as negative samples. Finally, it is used to determine whether the input facial image is live or not.

C. Algorithm

The flow chart of the designed technique is shown in fig. 5 the designed algorithm uses both temporal changes using frequency analysis and difference in micro-texture using LBP.

4. Experiments And Result

A. Database

In this paper, we are using the publicly available NUAA Photograph Imposter Database. The database contains both real images and masked photographs.

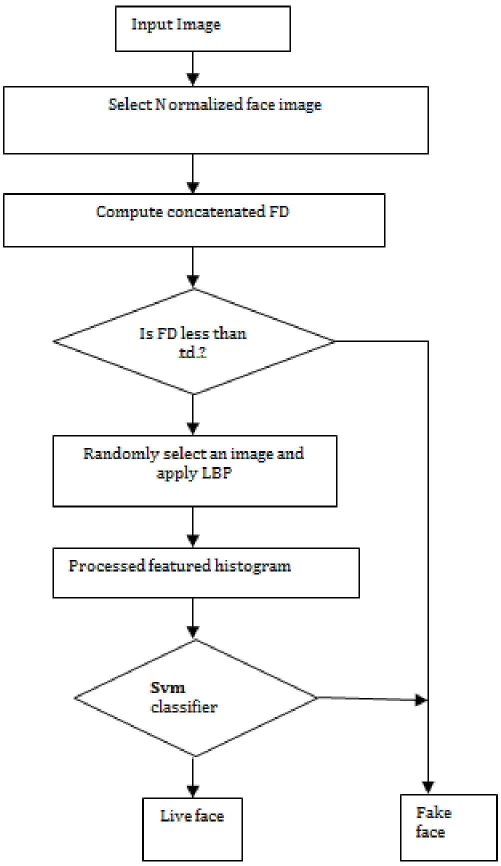

Fig.5 Flow chart of the proposed algorithm

The database was collected using cheap webcams and in three sessions with about 6 weeks interval between two sessions. The illumination conditions of each session of the database are also different. The examples of both live face and imposter photograph images from the database are shown in fig. 1. The resolution of all the images in the database is of 640 x 480 pixels. The images were captured in a sequential manner with a frame rate of 20 fps and altogether of 500 images of each subject. For collecting photograph samples, high definition photos of each subject were taken using a Sony camera.

B. Experimental Result

For the frequency based analysis part, we have considered the threshold value, *td* = 600. In our experiments, the performance of the frequency descriptor was found to be better and it was able to distinguish between fake faces and live faces quite well. The values of frequency descriptor of both real live faces and masked faces images are shown in table I. If the frequency descriptor of a facial image is greater than the threshold value, the picture were analyzed on the basis of micro-texture difference. Now for the texture based analysis, we have divided the database into two parts for training and testing of SVM classifier. There were a total of 835 face images of real clients and 955 false images in the training object set. The testing set was composed of 2075 real face images and 1000 imposter photographs. In all experiments of SVM, we are using Lib SVM Library for the implementation. We have also compared the method of LBP with previous traditional methods such as Local Phase Quantization (LPQ) and Gabor wavelets, the results of which are shown in table II. Table II indicates that Equal Error Rates (EER) of LBP is 2.7% which is less than that of LPQ (4.6%) and Gabor Wavelets (9.5%). Optimal SVM parameters were used for texture descriptor for fair comparison. Our proposed algorithm is also compared with the approach of (Tan *et al.*). Our approach performed well in comparison to the approach of (Tan *et al.*) (0.97 versus 0.94).

Table 1 Results of Frequency Descriptors

Sr.No.	Images	Frequency Descriptor Values		
		Max	Min	Mean
1	Live Face	512	1278	986
2	Masked Face	220	424	270

Table 2 Performance Comparison between three texture operators

Sr.No.	Descriptor	LBP	LPQ	Gabor Wavelets
1	Equal error Rate	2.70%	4.60%	9.50%

Conclusions

The gossip shows In this paper, an effective results, we have discussed a real live face liveness detection technique using frequency and texture based analysis for discriminating 2D paper masks from masked faces . For frequency information, we have used scenario based on frequency descriptor and for texture based differences; we have used multi scale local binary pattern(LBP) technique to encode the micro-texture pattern into an featured histogram and result fed in to SVM. The experimental results showed that our assumption can efficiently clarify between live face images and masked face images. The results of performance comparison with the previous works also turned out to be very good. In the future, we are planning to do liveness detection against video and 3D masks and the biometric system more secure against such spoofing attacks.

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