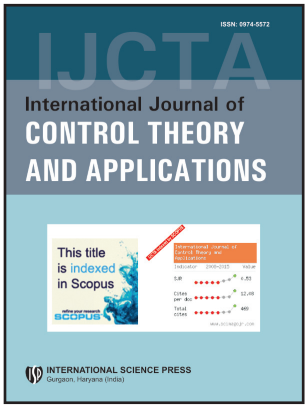

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An Object-Face Liveness Detection based on Local Feature Descriptors Using Fuz-SVM Classifier

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Abstract: In day to day life, the Object Face liveness detection of specific image became a critical task in user authentication and other security applications. However, it is important to develop a system which can improve in processing of user authentication and also accomplished with identification of spoofing object from its genuine objects. In practically, most of the existing systems were fails in distinguish of genuine and fake objects especially in case of blur images. In order to overcome this situations and identify genuine object live faces, we proposed An Object Face Liveness Detection based on Local Feature Descriptors using Fuz-SVM Classifier. In the proposed system we used Histogram of Oriented Gradients (HOG) combined with Local Phase Quantization (LPQ) so that the HOG will extract features from normal images and LPQ will extract from blurred images. The proposed system also concentrates on individual differences among several objects, allows to select specific part of whole object based on Region of Interest (ROI). One of the major advantage with this system is reduces the processing time, and increases recognizes rate of specific face of the object.

Keywords: Liveness Detection, Object-Face, Authentication, Original Objects, Fake Objects, Region of Interest, Local Feature Descriptor, HOG-LPQ, Fuz-SVM classifier.

1. INTRODUCTION

It is well known from all of security applications that face recognition systems try to validate whether the object matches with available database objects for identifying the users and provides the accessing. A practical face recognition system demands not only high recognition rate, but also the capability of anti-spoofing to differentiate faces from live faces and those from non-live objects faces. Earlier several techniques were proposed to find the live object face from all its spoofing attacks. These attacks can be considered in different ways like paper mask images, reply video s, and 3-D fake face images called mask attacks. Among the three types, the paper masks images are thought to be the easiest to be used as an attacking measure and thus relevant studies have been carried out in order to suppress those attacks. Countermeasures to defend the systems from paper mask images attacks can be divided into two approaches were intrusive approach requires the cooperation of the users while non-intrusive approach proceeds unnoticeably. In fact the non-intrusive approach provides better convenience to users than instructive approach. The non-intrusive approach can be categorized into single image-based methods and multiple image-based methods. The single image-based approach deal with the distinctive characteristics from the ideal images taken from live faces and masks, whereas multiple image-based approach is taken from 3-D facial information and/or from eye-blink information. The locations and distributions of images vary from object to object and factual image of one object overlap the fake image of another object. Therefore, it is difficult to find non-live object with a single anti-spoofing technique which can perform well on all objects. To tackle this situation, we propose an object-definite face liveness detection approach, in which each subject has a specific approach for face anti-spoofing.

In Object Face Liveness Detection based on Local Feature Descriptors using Fuz-SVM Classifier, the most challenging issue is blur images and partial number of images for training, especially all possible spoofing images. In our experiments, we develop anti-spoofing approach for each registered objects with database, each registered objects in database have its all fake samples. To train face anti-spoofing models for these objects, we propose a ROI based Object Face Liveness Detection with Combined HOG-LPQ using Fuz-SVM Classifier method to transfer the information provided by the objects which have both genuine images and fake images to the subjects having no fake images to synthesize fake images. In the following sections of this paper consisting of section 2, presents the existing and related work on liveness detection, anti-spoofing and face recognition systems with various techniques and methodologies Section 3 describes the proposed framework in detail, section 4, we discussed the experimental evaluations and results of proposed system, and finally conclusion in Section 5.

2. RELATED WORK

Most of the existing face recognition and anti-spoofing detection approaches are categorized into various groups and explained briefly as follows.

2.1.1. Frequency and Texture based Analysis

The texture information is taken as the images taken from the 2-D objects tend to suffer from the loss of texture information compared to the images taken from the 3-D objects. In many systems for feature extraction, frequency-based feature extraction, Texture-based feature extraction and Fusion-based feature extraction are being implemented. For extracting the frequency information, at first, the authors have transformed the facial image into the frequency domain with help of 2-D discrete fourier transform [1] then the transformed result is divided into several groups of concentric rings such that each ring represents a corresponding region in the frequency band and then, 1-D feature vector is acquired by combining the average energy values of all the concentric rings. Similarly for texture-based feature extraction [2], they used Local Binary Pattern (LBP) which is one of the most popular techniques for describing the texture information of the images. More over in fusion-based feature extraction, the system uses Support Vector Machine (SVM) classifier for learning liveness detectors with the feature vectors generated by power spectrum-based and LBP-based methods. The fusion-based method extracts a feature vector by the combination of the decision value of SVM classifier which are trained by power spectrum-based feature vectors and SVM classifier which are trained by LBP-based feature vectors.

2.1.2. Eye Blinking based Analysis

In blinking-based approach for liveness detection using Conditional Random Fields (CRFs) [3] to model blinking activities, for accommodating long-range dependencies on the observation sequence. By comparing CRF model with a discriminative model like AdaBoost and a generative model like HMM. The CRF's are probabilistic models for segmenting and labeling sequence data and mainly used in natural language processing for its accommodating long-range dependencies on the observation sequence. Blinking activity is an action represented by the image sequence which consists of images with close and non-close state.

2.1.3. 2-D Face based Analysis

Based on 2D face approach for anti-spoofing issue and propose three novel liveness clues in both temporal and spatial domain. Authors explains [4], the genuine faces can exhibit non-rigid facial motions, while many fake faces cannot and this difference forms first liveness clue named non-rigid motion clue. Furthermore, fake faces always reside on certain displaying medium. This reliance makes the fake facial motion [5] is highly consistent with the background motion and the second liveness clue named face-background consistency. These two clues are all explored in temporal domain. Since the 2D fake faces are usually printed by a printer or showed through LCD screens, banding effect, which is absent in a genuine face, probably will exist on the fake images, due to the quality degradation in reproduction.

2.1.4. 3-D Face Shape based Analysis

Same like 2-D face approach, the 3-D Face Shape based analysis [6] allows a biometric system to differentiate real face from a photo thus reducing the vulnerability and can be implemented in different scenarios either as an anti-spoofing tool, coupled with 2D face recognition systems and/or can be integrated with a 3D face recognition system to perform an early detection of spoofing attacks. These algorithm, authors computes the 3D features of the captured face data to determine if there is a live face is presented in front of the camera or not. Based on the computation of the mean curvature of the surface, a simple and fast method is implemented to compare the two 3D scans. An approximation of the actual curvature value at each point is computed from the principal components of the Cartesian coordinates within a given neighborhood. The mean curvature of the 3D points lying on the face surface is then computed.

3. PROPOSED METHOD

The basic block diagram of proposed system “An Object Face Liveness Detection based on Local Feature Descriptors using Fuz-SVM Classifier” is shown in Figure 1, and explained in detail as following.

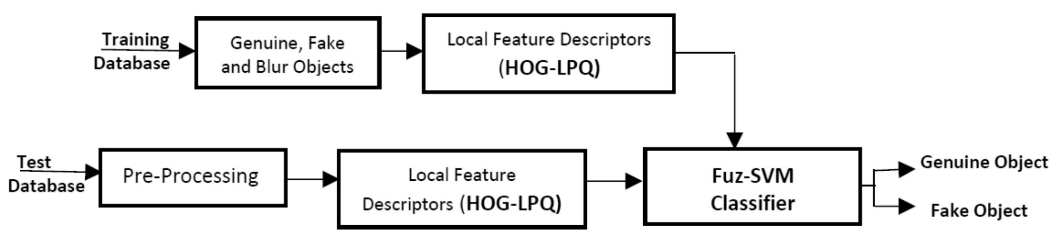


Figure 1: Proposed object face liveness detection

The proposed system mainly consisting of four steps namely various image collection both genuine and fake, feature extraction, feature comparison and finally decision. The proposed system is implemented in two stages, one is for existing data base and other is for real time data base. In the first stage, we capture various images consisting of genuine face in different angles and all its possible spoofing images like photograph images, reply video attacks and facial masks and etc. in order to reduce the processing time, we used Region of Interest (ROI) tool to extract only face from whole object. Then the features can be extracted for selected face images with Histogram of Orientation Gradients (HOG) and Local Phase Quantization (LPQ), labelled individually and stored separately in memory. Further the labelled image is divided into non-overlapping rectangular regions of equal size and a histogram of the labels in local regions is computed independently within each region. In the training stage, with the help of ROI, features can be extracted from several images of different categories in both genuine and spoofing images are used to train the Fuzzy logic combined with support vector machine (Fuz-SVM) classifier. For recognition and liveness detection, the selected region of interest of test object and the trained classifier is employed on the selected features.

Later we use Fuzzy Logic which is combined with support vector machine called Fuz-SVM to learn these two features to compute confidence of HOG and LPQ. Finally, we calculate the HOG-LPQ features which can be well applicable to the case of the substructure of the object are not similar. In fact the object face structure consisting of various sub structures like eyes, nose, lips and chin having different depths and intensities, and the description ability of HOG and LPQ are not same compare to partial face.

Though our proposed method can be used in the detection of the Object face liveness detection and the system uses the advantages of these two features extractors.

3.1. Image Acquisition and Pre-processing

In object acquisition, we captured various objects in various aspects with high resolution electronic capturing devices called cameras. The captured images consisting both genuine objects and all its possible spoofing attack objects like 2-D photographs, reply video attacks and masks. As we discussed in earlier sections, we have focused not only on normal images and also on blur images, practically we have captured some possible blur images, stored in database separately and respective craped area of interest images were shown in Figure 2

Figure 2: Examples of various Genuine Object faces

After acquiring various objects, the pre-processing is required because the object can be captured under many surveillance situations, in order to avoid unnecessary feature extractions of the whole image, we used Region of Interest so that ROI will allow us to select particular area of interest from the object and also can remove background information in the same object.

Figure 3: Examples of video Reply of Genuine object faces

In order to detect and recognize particular object face, we use ROI tool, so that it can extract only the subset of samples within object resulting in reducing of processing time. Figure 4, show how the ROI will work on selected object, Figure 4 shows the video reply attack facial images and Figure 4 shows 2-D photograph facial images respectively.

Figure 4: Examples of photographs of genuine object faces

3.2. Histogram of Oriented Gradients

In these stage, we used two different kind of feature extractors, HOG and LPQ are fused to train a classifier for object recognition and liveness detection. From many of the existed systems, we trust that the description ability of Local phase quantization and Histogram of gradient orientation to the object is different. So, we determine the strength of HOG and LPQ descriptor ability on the objects of the definite object. The HOG features has a local object appearance and shape can often be characterized by the distribution of the local intensity gradients and/ or edge directions, and it works without specific knowledge of the corresponding gradient or positions of edges. The orientation analysis is robust to lighting changes since the histogram gives translational invariance.

The basic principal of Histogram of Oriented Gradient (HOG) is implemented by dividing the selected image window into small spatial regions called 'cells', for each cell accumulating a local 1-D histogram of gradient directions or edge orientations over the pixels of the cell and the combined histogram entries form the representation of each cell. For better invariance of the object, it is also useful to contrast-normalize the local responses before using them. This can be done by accumulating a measure of local histogram over somewhat larger spatial regions and using the results to normalize all of the cells in the block.

Initially, we need to compute the magnitude of selected ROI of the image with the help of horizontal gradient $\Delta_x(x_i, y_i)$ and vertical gradient $\Delta_y(x_i, y_i)$. Later the gradient can transformed to polar coordinates, with the angle $\theta(x_i, y_i)$ constrained to be between 0 and 180 degrees, so that gradients that point in opposite directions are identified. Therefore,

$$h(x_i, y_i) = \sqrt{(\Delta_x(x_i, y_i)^2 + \Delta_y(x_i, y_i)^2)} \quad (1)$$

$$\theta(x_i, y_i) = \arctan(\Delta_y(x_i, y_i)/\Delta_x(x_i, y_i)) \quad (2)$$

The second step of HOG extraction is to improve the orientation histogram from the orientations and magnitudes and then normalization will be takes place. HOG extraction is a single window approach, the ROI is divided into number of regions which is called as 'blocks' further each block can be divided into 'cells'. These extracted cells can be either rectangular called R-HOG or circular called C-HOG. In every histogram has the same certain number of bins, and determines its precision. The bins of histogram represent the gradient orientations $\theta(x_i, y_i)$ and must be equally spaced over 0° to 180° which is also known as 'unsigned gradients' or

0° to 360° also called 'signed gradients'. One histogram per cell is computed, each pixel in the cell contributes to the histogram adding its magnitude value to its corresponding orientation bin, and this weighting value is called 'vote', these vote can uses magnitude values so that it will produces the best results. The overlapping can be introduced between blocks to ensure consistency across the whole image reducing the influence of local variations.

3.3. Local Phase Quantization

The local phase quantization (LPQ) is a method based on the blur invariance property of the Fourier phase spectrum uses the local phase information extracted using 2-D discrete Fourier transform or short term Fourier transform (STFT), computed over a rectangular region. The STFT over a region of $N \times N$ neighborhood of image $g(x)$ with each position of the pixel x is defined by

$$H(u, x) = \sum_{y} h(x - y) e^{-j2\pi u^{T} y} \tag{3}$$

$$= w_u^{T} h_x \tag{4}$$

where, w_u is the basis vector of the 2D discrete Fourier transform at frequency u while h_x stands for the vector containing all N^2 pixels.

From the above equation (3), we noticed that we can implement the STFT in efficient manner by using 2-D convolution $h(x) \times e^{-2\pi j u^{T} x}$ for all 'u'. In the LPQ by considering only complex coefficients, corresponding to frequencies $u_1 = [a, 0]^T$, $u_2 = [0, a]^T$, $u_3 = [a, a]^T$ and $u_4 = [a, -a]^T$, where 'a' is a small scalar frequency resulting

$$H_x^c = [H(u_1, x)\ H(u_2, x)\ H(u_3, x)\ H(u_4, x)] \tag{5}$$

gives each pixel location and is a vector.

Let,

$$H_x = [\mathrm{Re}\{H_x^c\}, \mathrm{Im}\{H_x^c\}]^T \tag{6}$$

Where Re{.} is real and Im{.} is imaginary parts of a complex number. The corresponding 8 x N^2 transformation matrix is

$$H_x = W h_x \tag{7}$$

where, $W = [\mathrm{Re}\{w_{u1}, w_{u2}, w_{u3}, w_{u4}\}, \mathrm{Im}\{w_{u1}, w_{u2}, w_{u3}, w_{u4}\}]^T$ (8)

Let us assume that the image function $h(x)$ is a result of a first-order Markov process, where the correlation coefficient between adjacent pixel values is ρ, and the variance of each sample is $\sigma 2$. Without a loss of generality we can assume that $\sigma 2 = 1$. As a result, the covariance matrix of the transform coefficient vector H_x can be obtained as

$$D = WCW^T \tag{9}$$

where, D is decomposition matrix and not a diagonal matrix for $\rho > 0$, meaning that the coefficients are correlating.

Assuming Gaussian distribution, independence can be achieved using a whitening transform

$$I_x = V^T H_x, \tag{10}$$

where, V is an orthonormal matrix derived from the singular value decomposition (SVD) of the matrix D that is

$$D = U \Sigma V^T \tag{11}$$

Once I_x is computed for all pixel positions, the information in the Fourier coefficients is recorded by binarizing the elements of H_x as $q_j = 1$, if $q_j \geq 0$, otherwise 0, Where, q_j is the j^{th} component of the vector H_x.

3.4. Matching

It is important to choose an appropriate method or classifier to match the extracted features with specific object. In these concern, one of the best classification method called Support vector machine (SVM) and has been commonly used for various classification application like feature matching with a high accuracy levels. In order to attain better classification results with minimum classification error we used Support Vector Machines combined with Fuzzy logic called here after Fuz-SVM classifier in order to achieve fast and accurate classification in real time.

In our training database consisting of S number of sample images includes both genuine images and its fake images. The basic working principle of SVM tries to separating hyperplane that maximizes the margin between two classes. Maximizing the margin is a quadratic programming problem, which determining the trade-off between maximizing margin and minimizing the number of misclassified instances. To solve nonlinear classification problems, a kernel function is introduced to replace the inner product, therefore, the SVM classifier can be represented as

$$H(x) = \text{sgn}\left[\sum_{i=n} \alpha_i y_i K(x_i \cdot x) + b\right] \quad (12)$$

where, $K(x_i \cdot x)$ is the kernel function which satisfies Mercer's theorem and Commonly used kernel functions are polynomials and Gaussian radial basic functions.

The basic idea of Fuzzy Logic (FL) is to allow not only the values 1 and 0, corresponding to 'true' and 'false' but the whole interval [0, 1] as degrees of truth. This leads to a radical extension of classical logic. The process of fuzzy logic is firstly, a crisp set of input data are gathered and converted to a fuzzy set using fuzzy linguistic variables, fuzzy linguistic terms and membership functions and the process is called fuzzification. Here the linguistic variables are the input or output variables of the system, a linguistic variable is generally decomposed into a set of linguistic terms. The Membership functions are used to map the non-fuzzy input values to fuzzy linguistic terms and vice versa and also used to quantify a linguistic term. Secondly, the inference is made based on a set of rules. A rule base is constructed to control the output variable and a fuzzy rule is a simple IF-THEN rule with a condition and a conclusion. The operations on fuzzy sets are different than the operations on non-fuzzy sets. Finally, the resulting fuzzy output is mapped to a crisp output using the membership functions, in the defuzzification step. Defuzzification is performed according to the membership function of the output variable.

The combined Fuz-SVM for pattern classification, which is a realization of a new idea for the adaptive kernel functions used in the SVM. The use of the proposed fuzzy kernels provides the SVM with adaptive local representation power, and thus brings the advantages of Fuzzy Logic into the SVM directly, moreover the SVM provides the advantage of global optimization to the Fuzzy logic system and also its ability to minimize the expected risk.

4. EXPERIMENTS

To test the effectiveness of the proposed system for Object Face Liveness Detection, we performed experiments with our own dataset consisting of genuine face images and all its possible respective fake images. We also study the influence of various factors like image acquisition, image region, database size and etc. All of our experiments, we crop the selected face images from all of training images includes blur images, so that we can remove back ground of the object, then cropped image converted to grayscale and scaled to specific size. Further the images are divided into 6 categories for selecting object specific features. Here we selected 5 to 12 % of features out from all features with combined HOG-LPQ algorithm to represent input face image. This low number of features helps to reduce the computation processing time and storage requirement of the system. In selection of window size, the HOG plays an important role compared to other descriptors like LBP, ILBP and DoG shown in Table 1. The local and non-overlapping windows in HOG are used directly for encoding local information. All training images from each category are used to train category-specific Fuz-SVM classifier using SVM library.

In the same manner, we have extracted features for fake samples and combined all these features and saved with labels in training dataset. We have considered three possible spoofing attacks and tests were conducted on photo graph images. Initially we crapped face image from whole image of the object and took color printout/ photograph of face in 2-D, then display this photograph face image for authentication.

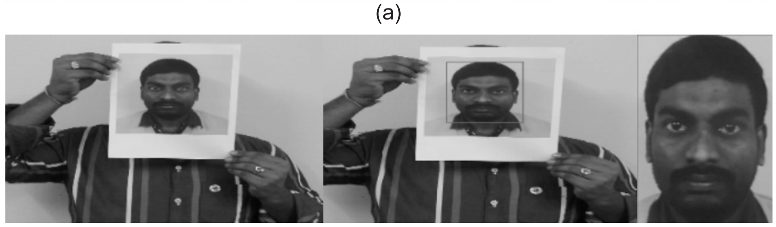
Table 1
Recognition rates of images with increasing Gaussian blur

Length (σ)	*Accuracy (%)*			
	HOG	*LBP*	*LPQ*	*HOG-LPQ*
0	97	98.3	98.5	98.97
0.25	96	97.5	98.3	98.7
0.5	95.9	97.2	98.35	98.6
0.75	94.1	96.3	98.2	98.4
1	89.3	91.7	96.6	97.5

4.1. Experiment on Self Collected Anti-spoofing Database

In our own database consisting of 30 objects in total, collected three kinds of imaging qualities. Each object has its genuine and its respective fake photograph image with good image quality and also video reply. The genuine object are captured in laboratory surroundings, while the spoof facial object were captured by exhibiting high resolution 2-D photographs. Since all the captured objects have very complex background, with the help of ROI, we only extract face from the background. The model is trained on randomly selected 10 objects, and the remaining 20 objects are used for testing. Figure 5 shows self collected object data base with genuine object and its ROI and photograph object with its ROI respectively.

(a)



(b)

Figure 5: Self collected object database: (a) Genuine object facial images and (b) 2-D photograph spoofing facial images

As it can be seen from the Figure 6, HOG-LPQ produces better results for blurred images and non-blur images than LBP and HOG even with no blur.

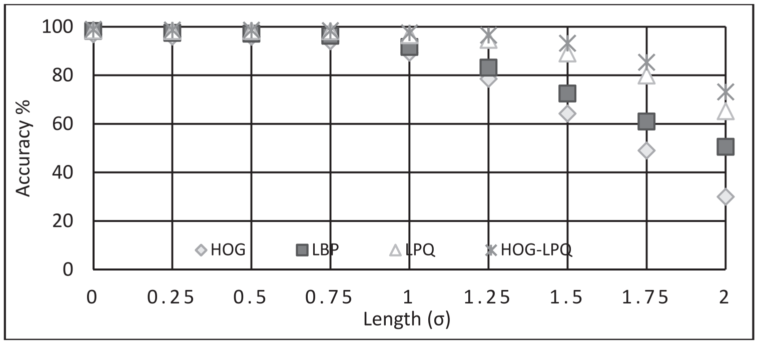


Figure 6: Accuracy Vs Length

After performing HOG-LPQ description on both training dataset and test dataset, the Fuz-SVM classifier used to identify the liveness of the test image. The Fuz-SVM classifier which is a binary classifier which helps in discriminating the genuine object face and spoofed object face. As discussed in section 3, the classification is based on the various parameters used both Fuzzy logic (FL) and Support Vector Machine (SVM) classifier methods.

Table 2
Performance of the Face Spoof detection using Face images

No. of Users	*Training Images*	*Tested Images*	*FAR*	*FRR*	*TIR*
10	80	75	20.00	4.00	93.33
20	100	98	18.37	4.08	97.96
30	130	120	24.17	6.67	96.67
40	145	125	16.80	7.20	92.00

For each of the above three test scenarios, the data should then be selected from the corresponding training and test sets for model training and performance reporting.

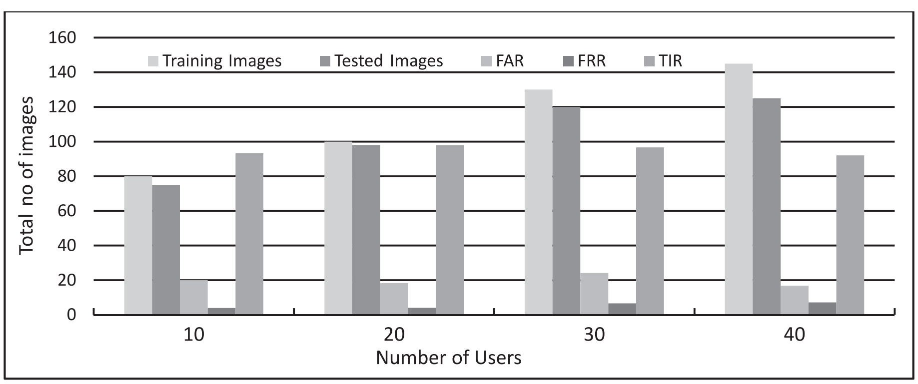


Figure 7: Performance of the proposed system

In order to find accuracy of the proposed system, we need to evaluate False Acceptance Rate (FAR), False Rejection Rate (FRR) and Equal Error Rate (EER) is reported and depicted in Table 2, and the respective performance of the system is shown in below Figure 7.

Table 3 shows the True Identification Rate (TIR) tested for number of images and its respective graph for number of images versus true identification rate is showed in Figure 8

Table 3
True Identification

Tested Images	*TIR*
75	93.33
96	96.88
98	97.96
115	96.52

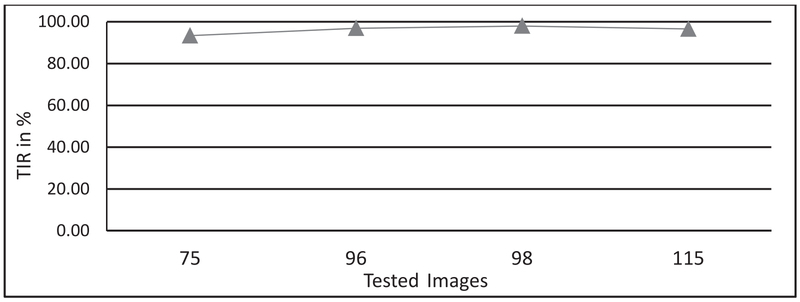


Figure 8: Tested images vs TIR

5. CONCLUSION

A new proposed "An Object Face Liveness Detection based on Local Feature Descriptors using Fuz-SVM Classifier" for object face liveness detection of normal and blur images. In these proposed system, we tried avoid unnecessary processing time and improves true identification rate for all kind of objects. The system will function on genuine, fake and blur invariant features separately using HOG and LPQ feature descriptors. Most of the existing systems for liveness detection and anti-spoofing ignored fails in identifying blur images leads to increase in false identification rate. So here we concentrated particularly on it and achieved good results. One of most considerable advantage with proposed system consisting of combination of HOG and LPQ features selection proven experimentally to be very efficient in recognizing of genuine live objects from various fake objects. The combination of Fuzzy and SVM classifier provided high accuracy in identifying of genuine and fake objects from the various attacks. Further we can increase accuracy and true identification rate in future by considering of various generous of objects.

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