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Using Low Level Features -Fingerprint Liveness Detection from Single Image

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***Abstract**: Fingerprint-based authentication systems have developed rapidly in the recent years. However, current fingerprint-based biometric systems are vulnerable to spoofing attacks. Moreover, the single feature-based static approach does not perform equally over different fingerprint sensors and spoofing materials. In this paper, propose a static software approach. Propose to combine low-level gradient features from speeded-up robust features, pyramid extension of the histograms of oriented gradient and texture features from Gabor wavelet using dynamic score level integration. Extract these features from a single fingerprint image to overcome the issues faced in dynamic software approaches, which require user cooperation and longer computational time.*

***Keywords**: Finger Print Liveness, Low level Features, Gabor Filters, SURF, PHOG, SVM, Random Forest, PCA.*

I. INTRODUCTION

Biometric based authentication systems are getting more common in the security domain. Much research has been done in this field in recent years. The advantage of using biometrics for authentication purpose comes from the unique features of each individual. Iris and fingerprints are unique to every human. In addition, they are simple and difficult to copy. When compared to password based systems, biometrics can neither be easily hacked nor be visually seen and remembered. Thus, fingerprint based authentication systems are becoming increasingly common these days. However, due to the excessive use of fingerprint security systems, they have become a target of attacks.

The possibility to spoof a fingerprint based authentication system creates the need to develop a method which can distinguish between live and fake fingerprint images. Both hardware and software based approaches can be used to solve this problem. However, hardware based approaches require additional devices to measure finger temperature, odour, pulse, oxiometry, etc. On the other hand, software based approaches do not employ additional invasive biometric measurements. However, these approaches are more challenging as they require the identification of discriminative features to differentiate between fake and live fingerprint images. Software based approaches are further divided broadly into dynamic and static based approaches. Dynamic software based approaches require a minimum of two time series images resulting in additional computational time. Different sensors capture information differently. Various materials such as gelatine based fake fingerprint may not produce similar features as compared to other materials such as latex, playdoh or wood-glue. Fake fingerprints exhibit different intensity gradient and ridge shape due to the thickness of the material used. The process of creating fake fingerprint also introduces air bubbles. Furthermore, it is not practical for the authentication system to have prior knowledge of the types of material used to create the fake fingerprint in real world scenarios.

The method to overcome the limitations faced in the static software based approaches where a single feature set fails to perform equally over different fingerprint sensors and materials. Methodology extracts low level textural and gradient information for fingerprint liveness detection from a single image. Propose the use of SURF features in combination with PHOG to obtain gradient features that discriminate well between fake and live fingerprint images. SURF features have a concise descriptor length which is compact and takes less computational time as compared to LBP. In addition, SURF is also invariant to scale and image rotation.

PHOG feature descriptor extracts intensity gradient and edge directions to describe the shape and appearance of an image. The PHOG extractor is also invariant to geometric and photometric transformation. Thus, a combination of SURF and PHOG enables our method to perform similarly on various sensors and materials. Textural features, we propose the use of Gabor wavelets as they have optimal localization properties in both the frequency and spatial domain. They extract discriminative ridge feature maps and have performed well in discriminating between live and fake fingerprint images. The proposed method is one of the few works that performs well over a large open source dataset created using six different sensors and six different materials. The use of local discriminative feature space on live and spoof fingerprints by using PHOG, SURF, GABOR and their combinations. Experiments performed on six sensors demonstrate that the combination of PHOG and SURF always works better than PHOG and SURF individually for LivDet 2011 and 2013 databases. This indicates that these descriptors complement each other. Also, the combination of PHOG and SURF feature vector produces a strong discriminative feature vector which performs remarkably well in the field of fingerprint liveness detection.

II. LITERATURE SURVEY

1)"Fingerprint Liveness Detection from Single Image Using Low Level Features and Shape Analysis "Rohit Kumar Dubey, Jonathan Goh, and Vrizlynn L. L. Thing**[1]** Fingerprint-based authentication systems have developed rapidly in the recent years. However, current fingerprint-based biometric systems are vulnerable to spoofing attacks. Moreover, the single feature-based static approach does not perform equally over different fingerprint sensors and spoofing materials. Propose a static software approach. Propose to combine low-level gradient features from speeded-up robust features, pyramid extension of the histograms of oriented gradient and texture features from Gabor wavelet using dynamic score level integration. Extract these features from a single fingerprint image to overcome the issues faced in dynamic software approaches, which require user cooperation and longer computational time.

2) "Convolution Comparison Pattern: An Efficient Local Image Descriptor for Fingerprint Liveness Detection", Carsten Gottschlich [2], Present a new type of local image descriptor which yields binary patterns from small image patches. For the application to fingerprint liveness detection Achieve rotation invariant image patches by taking the fingerprint segmentation and orientation field into account. Compute the discrete cosine transform (DCT) for these rotation invariant patches and attain binary patterns by comparing pairs of two DCT coefficients. These patterns are summarized into one or more histograms per image. Each histogram comprises the relative frequencies of pattern occurrences. Multiple histograms are concatenated and the resulting feature vector is used for image classification. This type of descriptor convolution comparison pattern (CCP).

3)"Principal Component Analysis, Springer Series in Statistics", Second edition, 2002, Jolliffe, I.T [3],Principal component analysis (PCA) is a statistical procedure that uses an orthogonal transformation to convert a set of observations of possibly correlated variables into a set of values of linearly uncorrelated variables called principal components (or sometimes, principal modes of variation). The number of principal components is less than or equal to the smaller of the number of original variables or the number of observations. This transformation is defined in such a way that the first principal component has the largest possible variance (that is, accounts for as much of the variability in the data as possible), and each succeeding component, in turn, has the highest variance possible under the constraint that it is orthogonal to the preceding components. The resulting vectors are an uncorrelated orthogonal basis set. PCA is sensitive to the relative scaling of the original variables.

4)"Speeded-up robust features (surf)," Herbert Bay, Andreas Ess, Tinne Tuytelaars, and Luc Van Gool [4], This article presents a novel scale- and rotation-invariant detector and descriptor, coined SURF (Speeded-Up Robust Features). SURF approximates or even outperforms previously proposed schemes with respect to repeatability, distinctiveness, and robustness, yet can be computed and compared much faster. This is achieved by relying on integral images for image convolutions; by building on the strengths of the leading existing detectors and descriptors (specifically, using a Hessian matrix-based measure for the detector, and a distribution-based descriptor); and by simplifying these methods to the essential. This leads to a combination of novel detection, description, and matching steps. The paper encompasses a detailed description of the detector and descriptor and then explores the effects of the most important parameters. We conclude the article with SURF's application to two challenging, yet converse goals: camera calibration as a special case of image registration, and object recognition. Experiments underline SURF's usefulness in a broad range of topics in computer vision.

5)"Histograms of oriented gradients for human detection," N. Dalal and B. Triggs [5], Feature sets for robust visual object recognition, adopting linear SVM based human detection as a test case. After reviewing existing edge and gradient based descriptors, Show experimentally that grids of Histograms of Oriented Gradient (HOG) descriptors significantly outperform existing feature sets for human detection. Study the influence of each stage of the computation on performance, concluding that fine-scale gradients, fine orientation binning, relatively coarse spatial binning, and high-quality local contrast normalization in overlapping descriptor blocks are all important for good results. The new approach gives near-perfect separation on the original MIT pedestrian database, so we introduce a more challenging dataset containing over 1800 annotated human images with a large range of pose variations and backgrounds.

6) "Fingerprint recognition using robust local features," Richa Mishra Madhuri [6], Fingerprint recognition refers to the automated method of verifying a match between two human fingerprints which is used to identify individuals and verify their identity. A fingerprint sensor is used to capture a digital image of the fingerprint pattern.

The captured image is digitally processed to create a biometric template (a collection of extracted features) which is stored and used for matching. Investigate a fingerprint recognition approach by local robust features extraction and matching. In this approach, first, the local features are extracted using Speeded-Up Robust Feature (SURF) algorithm. Then the features of the test fingerprint image are compared against two or more exiting template image features for matching. The matching method uses a matching threshold. Two features match when the distance between them is less than the matching threshold. It also eliminates ambiguous matches in addition to using the matching threshold. Finally, it calculates the similarity index/matching score from the matching points and takes the decision on matching. Since SURF is a scale and rotation invariant algorithm, the fingerprint recognition system shows better recognition accuracy in presence of rotation, scaling and partial distortion of the test image.

The experimental results indicate its effectiveness and improved performance over the state of the art random decision forests are an ensemble learning method for classification, regression and other tasks, that operate by constructing a multitude of decision trees at training time and outputting the class that is the mode of the classes (classification) or mean prediction (regression) of the individual trees. Random decision forests correct for decision trees' habit of over fitting to their training set In machine learning, support vector machines (SVMs, also support vector networks) are supervised learning models with associated learning algorithms that analyse data used for classification and regression analysis. Given a set of training examples, each marked as belonging to one or the other of two categories, an SVM training algorithm builds a model that assigns new examples to one category or the other, making it a non-probabilistic binary linear classifier (although methods such as Platt scaling exist to use SVM in a probabilistic classification setting). An SVM model is a representation of the examples as points in space, mapped so that the examples of the separate categories are divided by a clear gap that is as wide as possible. New examples are then mapped into that same space and predicted to belong to a category based on which side of the gap they fall. Here these literature are analysed and proposed method developed based on these opinions of literature.

III. PROPOSED METHOD

The low level features that are able to represent discriminating characteristics between live and fake fingerprints. The system architecture is illustrated in Fig. 1. Here divide the system into three main sequential blocks:

- Image Pre-processing Stage
- Feature Extraction Stage
- Image Classification Stage

Image Pre-Processing Stage: A poor quality fingerprint image is typically noisy, exhibits smudged line and has low contrasts between valleys and ridges. These effects can happen during image acquisition, due to the dry or wet skin. Since the image acquisition stage is not always monitored for accepting only high quality images, fingerprint image enhancement and noise reduction are, therefore, important pre-processing factors in accurately detecting fingerprint liveness. We enhanced the quality of the image by first cropping the fingerprint region in the image and then performing histogram equalization to increase the perception information. The Canny edge detector is first applied for the purpose of identifying the biggest contour in order to find the extreme ridge contours. Specifically, remove the non-relevant white region found in the borders prior to cropping the region of interest. In order to remove noise captured during image acquisition, median filtering is then applied to the cropped images without reducing the sharpness of the input image. Finally, histogram equalization is performed to improve the contrast in the image by diversifying the intensity range over the whole cropped image. The output achieved after this stage is an image with a reduced noise and improved definition of the ridge structure.

Feature Extraction Stage: In fingerprint authentication systems, the image is usually captured from multiple subjects using different scanners. Therefore, fingerprint images are typically found to be of different scales and rotations. In certain scenarios, the fingerprint images are partially captured due to human errors. In order to obtain features that are invariant to these problems, Use various features that capture properties of live fingerprint images. Here choose to use SURF as it is invariant to illumination, scale, and rotation. SURF is also used because of its concise descriptor length. SURF shrinks the descriptor length to 64 floating points whereas standard SIFT implementation uses a descriptor consisting of 128 floating point values thus reducing computational time. While SURF is invariant to object orientation and scale transformation, it is not invariant to geometric transformations. Hence, in order to compensate the limitations of SURF, PHOG descriptors are used to extract local shape information to obtain more discriminative features. In addition, Gabor wavelet features are also incorporated for texture analysis. Details of the above features are provided in the following content.

a) SURF: SURF is an in-plane rotation detector and descriptor. The detector locates the key points in the image and the descriptor describes the features of the key points to constructs the feature vectors of the key points. SURF then uses the determinant of the approximate Hessian-matrix on the integral image to locate the key feature points. For the key point descriptor, SURF uses the sum of the Haar wavelet responses to describe the feature of a key point.

Haar wavelet computes the responses in x and y directions to describe the intensity distribution of a key point. SURF has been proven to be distinctive and robust in representing local image information. Since SURF represents images using local features, it works well with occluded and partial fingerprint images.

b) PHOG: The local shape attributes are extracted and introduced using PHOG. HOG captures the intensity gradients and edge directions to describe the shape and appearance of an image. As HOG descriptor works on localized cells, it is invariant to geometric and photometric transformations and this is its main advantage over other descriptor methods. PHOG features are the extension of HOG and it has shown to produce good results in static facial expression analysis problem.
The image is divided into a spatial grid over all the pyramid levels. Sobel filter of 3x3 is applied to the edge contours for calculating the gradient angle and magnitude. Then the gradient is joined at the various pyramid level and the histogram is calculated for each grid.

c) Gabor: Use Gabor Wavelet to extract features from fingerprint images for texture analysis. Gabor filters have optimal localization properties in both the frequency and spatial domain and have been successfully used in many applications to extract discriminative features. In fingerprint images, the local ridge characteristics are extracted via a set of Gabor filters whose frequency corresponds to the inter-ridge spacing in fingerprints.

d) Feature Reduction Stage: While have identified key features to categorize live and fake fingerprint images, the resulting dimensionality of the data set is too large. Therefore, Principal Component Analysis (PCA) is applied to both GABOR and SURF+PHOG feature vectors in order to reduce its dimensionality. PCA is a statistical analysis method to extract the main contradiction of features among diverse features. It can parse out the main influencing factors, to reveal the essence and simplify complex and large feature sets to produce the most meaningful and powerful features. Principal features in a PCA are represented by Eigen Vectors. First, apply PCA to calculate the Eigen Vectors. The calculated Eigen Vectors represents the number of principal components (W) of the training dataset. The number of principal components (W) is selected based on 95% of the variance retained. Then we use W components to project the original training dataset to a lower dimensional subspace. We then utilize principal components (W) from the training dataset to reduce the dimension of the testing dataset separately. This is done to make sure that the information from the testing dataset does not leak into the training database and dilute the generalization. Moreover, the comparison has to be done on the same axes and hence the projection of the data is done on the same axes.

e) Image Classification Stage: In this section, describe the dynamic score level integration algorithm for the purpose of selecting the best classifier during decision making. Performed experiments on the LivDet 2013 for approximately 97% of the test samples, the prediction score above 0.6 and below 0.4 is a correct score for live and fake fingerprints respectively. Fig 2 [1] explained the score level calculation algorithm.

Image Pre-processing

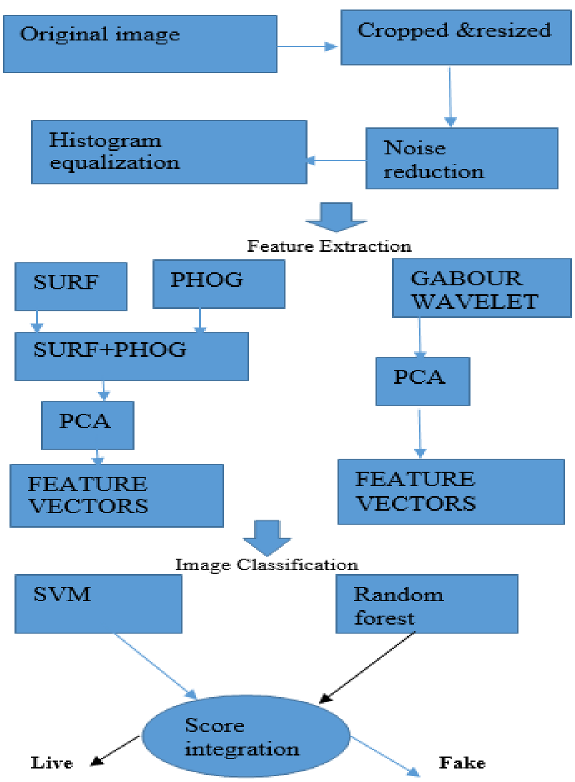

Figure 1: System Architecture

Datasets:-Experiments were carried out on the publicly available fingerprint liveness database for LivDet 2011 and 2013 competitions four optical sensors, Biometrika, Digital Persona, ItalData, and Sagem were used to collect the fingerprints. Similarly, four optical sensors, Biometrika, Digital Persona, ItalData, and Swipe were used to collect fingerprints for the LivDet 2013 database. Classifier

Parameters: - For the SVM classifier, the linear kernel is selected for its computational efficiency and better performance over nonlinear kernels. For the RT classifier, the maximum number of trees is 100, and the maximum depth for each tree is 15.
Results and comparison: - Average Classification Error (ACE) equation (4) and Equal Error Rate (ERR).
Error =FLR + FFR/2
FLR-false living rate
FFR-false fake rate

```
Algorithm 1: Dynamic Score Level Integration
  Input: scoreLow(i), scoreHigh(i), testLabel(i), N;
  Output: finalScore(i);
  Initialization, finalScore, diffInScore;
  for i ← 0 to N do
      finalScore = scoreHigh(i);
      diffInScore = abs(scoreHigh(i) - scoreLow(i)) ;
      if scoreHigh(i) ≥ 0.4 and scoreHigh(i) ≤ 0.6
      then
          if diffInScore ≤ 0.2 then
              finalScore = scoreHigh(i);
          else
              finalScore = scoreLow(i);
          end
      if finalScore ≤ 0.5 then
          result = 0;
      else
          result = 1;
      end
  end
```

Figure 2: Score level Algorithm

Based on this algorithm decide the fingerprint is live or note. Since after image preprocessing stage, there is include to calculate DCT value of binary notation of image .based on the coefficient value understand the primary notation of fingerprint. If it is 2 coefficient it is live otherwise fake. It will reduce the run time.

IV. CONCLUSION

Here proposed a novel method for fingerprint liveness detection by combining low level features, which includes gradient features from SURF, PHOG, and texture features from Gabor wavelet. In addition, an effective dynamic score level integration module is proposed to combine the result from the two individual classifiers. Carried out experiments on two most popularly used databases from LivDet competition 2011 and 2013. In future, this applied to a real time system and extend the properties of the security system. Applicable to forensic studies enhancement.

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