Partial fingerprint matching based on SIFT Features

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***Abstract*— Fingerprints are being extensively used for person identification in a number of commercial, civil, and forensic applications. The current Fingerprint matching technology is quite mature for matching full prints, matching partial fingerprints still needs lots of improvement. Most of the current fingerprint identification systems utilize features that are based on minutiae points and ridge patterns. The major challenges faced in partial fingerprint matching are the absence of sufficient minutiae features and other structures such as core and delta. However, this technology suffers from the problem of handling incomplete prints and often discards any partial fingerprints obtained. Recent research has begun to delve into the problems of latent or partial fingerprints. In this paper we present a novel approach for partial fingerprint matching scheme based on SIFT (Scale Invariant Feature Transform) features and matching is achieved using a modified point matching process. Using Neurotechnology database, we demonstrate that the proposed method exhibits an improved performance when matching full print against partial print**

Keywords- partial fingerprint, SIFT features, pointwise matching, fingerprint identification

I. INTRODUCTION

Biometrics is one of the most widely used approaches for identification and authentication of individuals. It uses a person's physiological or behavioral characteristics such as fingerprint, face, iris, gait, and signature for authentication [1]. Most of the biometric systems use fingerprint for authentication as it is unique for every individual, easy to capture, and is universal. Law enforcement applications also involve identification using rolled and partial fingerprints obtained from different surfaces [2].

Fingerprint matching based on minutiae features is a well researched problem. Most of these algorithms assume that the two templates are approximately of the same size. This hypothesis is no longer valid. Miniaturization of fingerprint sensors has led to small sensing areas and can only capture partial fingerprints.

Matching partial fingerprints to full (relatively larger or rolled) pre-enrolled images in the database presents several challenges: (i) the number of minutiae points available in partial prints is few, thus discriminating power reduces; (ii) absence of singular points (core and delta) in partial prints is likely, therefore, a robust algorithm independent of these singularities is required; and (iii) uncontrolled impression environments result in unspecified orientations of partial fingerprints, and distortions like elasticity and humidity are introduced due to characteristics of the human skin.

The SIFT algorithm proposed by Lowe[3] is an approach for extracting distinctive invariant features from images. It has been successfully applied to a variety of computer vision problems based on feature matching including object recognition, pose estimation, image retrieval and many others[4]. Even though there have been a few studies using SIFT for face verification [5,6]. In fingerprint recognition system, the purpose of extending characteristic feature points of fingerprint beyond minutiae points, we adopt Scale Invariant Feature Transformation (SIFT) [7]. SIFT extracts repeatable characteristic feature points from an image and generates descriptors representing the texture around the feature points. In our work, we demonstrate the utility of SIFT representation for fingerprint-based identification for partial prints. Since the SIFT feature points have already demonstrated their efficacy in other generic object recognition problems, it is expected that this representation is also stable and reliable for many of the matching problems related to the fingerprint domain. Further, since SIFT feature points are based on texture analysis of the entire scale space, it is hoped that these feature points will be robust to the fingerprint quality and deformation variation.

Our implementation focuses on deriving SIFT features from both full and partial fingerprint image (Template and query image) and improving accuracy in matching full print against partial fingerprint. The paper is oraganised as follows. Section 2 describes the advantages of using SIFT features in fingerprint matching. Section 3 introduces the proposed method in detail. Section 4 gives our experimental results and section 5 provides conclusion and future work.

II. SIFT FEATURES IN FINGERPRINT IMAGES

SIFT was proposed to detect local image features the SIFT descriptor, which is invariant to scale, rotation and affine transforms, which is proved to be robust and efficient in object recognition and image retrieval [8]. There are four major stages in SIFT algorithm:

(1)scale-space peak detection. It means selection of candidates for feature points by searching peaks in the scale- space from a difference of Gaussian (DoG) function

(2) keypoint localization- localization of these points by using the measurement of their stability ;
(3) assignment of orientations based on local image properties
(4) generation of local descriptor.

Each feature point contains four types of information – spatial location (x, y), scale (s), orientation (θ) and keypoint descriptor (k).More formally, local image gradients are measured at the selected scale in the region around each keypoint for each fingerprint These keypoint descriptor vectors represent local shape distortions and illumination changes.

SIFT features have two major advantages compared with minutiae. First, SIFT generates a large number of features over a broad range of scales and locations, while the number of minutiae points appearing in a plain fingerprint image impression is limited to a small number (<100). Fig.1 shows the comparison of quantities of minutiae and SIFT points in a fingerprint.

(a) Minutiae points (b) SIFT Feature points
Figure.1 Minutiae and SIFT feature points extracted from the same image

III PROPOSED METHOD

In this paper SIFT features are extracted from the preprocessed fingerprint image. The extracted SIFT features are considered as points to proceed with an improved Point wise matching. Fig. 2 gives an overview of the proposed method.

A. Preprocessing

SIFT descriptor is used to detect stable invariant points for general object recognition and it does not require generally any image to be preprocessed. However, in the proposed work, few preprocessing operations are performed on fingerprint image to obtain better accuracy. In the first step, fingerprint images are normalized having adjustable gray level distribution. To make uniform distribution of gray levels, image intensity is measured in the central area and the distribution is adjusted accordingly. This is performed using adaptive histogram equalization technique. After normalization process, the fingerprint images are down scaled to 200x200 pixels. This high resolution to fingerprint image may increase the number of SIFT features.

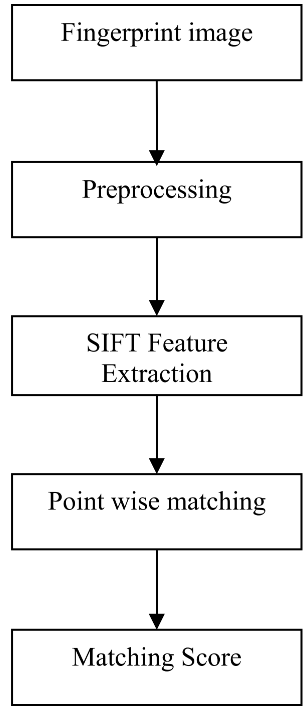


Figure. 2 Flowchart of the proposed method

B. SIFT Feature Extraction

SIFT was proposed to detect local image features invariant to image scaling, translation, and rotation. This is achieved by selecting key locations at local maxima and minima of a difference of Gaussian function applied in scale space, which is constructed by successively down sampling the input image. Maxima and minima of this scale space function are determined by comparing each pixel to its neighbors.

1. Scale-space extrema detection: The first stage of computation searches over all scales and image locations. It is implemented efficiently by using a difference-of-Gaussian function to identify potential interest points that are invariant to scale and orientation.

2. Keypoint localization: At each candidate location, a detailed model is fit to determine location and scale. Keypoints are selected based on measures of their stability.

3. Orientation assignment: One or more orientations are assigned to each keypoint location based on local image gradient directions. All future operations are performed on image data that has been transformed relative to the assigned orientation, scale, and location for each feature, thereby providing invariance to these transformations.

4. Keypoint descriptor: The local image gradients are measured at the selected scale in the region around each keypoint. These are transformed into a representation that allows for significant levels of local shape distortion and changes in illumination

C. Matching Process

Point wise matching is used for matching the objects in pattern recognition based on SIFT features. Generally, Euclidean distance is used as distance metric in point wise matching. In order to improve the efficiency, it is cheaper to compute dot product between unit vectors rather than Euclidean distance. Matching is performed by comparing each local extrema based on the associated descriptors. Suppose we want to match two images I_1 and I_2. Given a feature point p_{11} in I_1, its closest point p_{21}, second closest point p_{22}, and their distance ratio is calculated. A match is accepted only if its distance is less than the distance ratio (empirically chosen distance ratio is 0.6) times the distance to the second closest match. The matching score between two images can be decided based on the number of matching points and their geometric configuration.

D. Matching Score

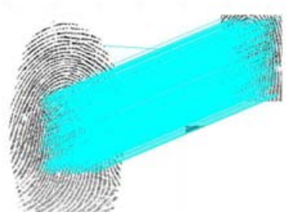
It is used to calculate the matching score between the input and template data is given in an equation

$$\text{Matching Score} = \frac{\text{Matching SIFT Features}}{\text{Max(NT, NI)}} \quad (1)$$

Where NT and NI represents the total number of SIFT Features in template and input matrices respectively. By this definition, the matching score takes on a value between 0 and 1. Matching Score of 1 and 0 indicates that data matches perfectly and data is completely mismatched respectively

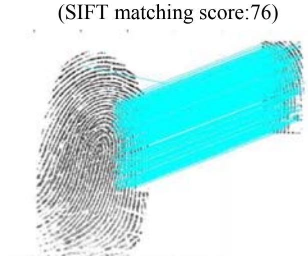
IV EXPERIMENTAL RESULTS

The proposed method has been evaluated in Neurotechnology database .The neurotechnology database consists of 408 images (51 distinct fingers, 8 instances each). The Table 1 shows that the average number of minutiae and SIFT features in different size of partial fingerprints. It is clearly evident from the fig. SIFT features are more sufficient for matching partial fingerprint against full fingerprint image



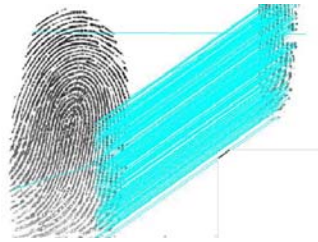
a)012_3_1 Vs 012_3_2 pair in Neurotechnology database

(SIFT matching score:76)



b) 012_3_1 Vs 012_3_7 pair in Neurotechnology database

(SIFT matching score:85)



c) 012_3_1 Vs 012_3_3 pair in Neurotechnology database

(SIFT matching score:87)

Figure.3. Example genuine pairs where partial fingerprint SIFT features are successfully matched with full fingerprints.

Table 1: Average number of minutiae and SIFT features in different size of partial fingerprints

%of Image size	Avg. no of Minutiae	Avg. no. of SIFT Features
50	37	540
40	32	425
30	27	300
20	14	210
10	7	190

V CONCLUSION AND FUTURE WORK

In this paper, we presented the partial fingerprint matching using the SIFT features. The original fingerprint involves normalization process using histogram equalization technique to obtain the better accuracy. We have shown that the SIFT operator can be used for fingerprint feature extraction. A modified Point wise matching method is used for matching SIFT key points between the fingerprints. The matching score shows that the proposed system performs better than minutiae matching. The proposed matching algorithm overcomes the drawbacks of conventional approaches (minutiae based) to partial fingerprint matching. The experimental results demonstrated that the SIFT based method can more accurately detect the corresponding feature points and hence estimate better alignment transformation. As future work it is necessary to consider the large number of SIFT features on fingerprints so as to reduce the dimension of the SIFT descriptors while not impairing the discrimination power and to speed up the comparison of features.

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