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Latent Fingerprint Matching: Performance Gain via Top-Down Feedback

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Abstract: **A fingerprint is an impression left on the plain surface of an object by ridges of human finger. They are considered to be as sole keys that we can carry anywhere. In court of law, latent fingerprints serve as an important source of forensic evidence. In several applications, automatic matching of latent fingerprints to exemplar fingerprints is important. However, latent impressions are of poor quality, feature extraction and latent matching becomes a puzzling problem. This is due to difficult background noise in latent fingerprints. A top-down feedback from an exemplar is proposed which is used to refine the extracted feature from latents for enhancing accuracy. Ridge orientation and ridge frequency are the refined features from exemplars. Rolled and plain or slap fingerprints are collectively called exemplars. After feedback, the refined features are used to re-match the latent resulting top K candidate list. It is returned by the baseline matcher which is then resorted.**

Keywords: **Latent Fingerprint Matching, Exemplars, AFIS, Top-Down Feedback**

I. INTRODUCTION

The concept of distinctiveness and originality of the ridge patterns on palms of our hands and soles of our feet was introduced by Sir Francis Galton in the year 1892. The function of fingerprint was to determine the identity of a person or for some verification purposes in law enforcement and civilian applications. With this function, we can easily identify the suspects.

Fingerprints can broadly be categorized into following three types,

- Rolled fingerprints are obtained by rolling the finger from nail to nail. Maximum number of ridge details will be available in such fingerprints.
- Plain fingerprints also called, slap fingerprints are obtained by pressing the finger on a flat surface, and
- Latent fingerprints, a bit different from other two are incomplete impressions of the finger left behind on the surface of objects. They are usually obtained by taking photographs or by using some complex physical or chemical methods.

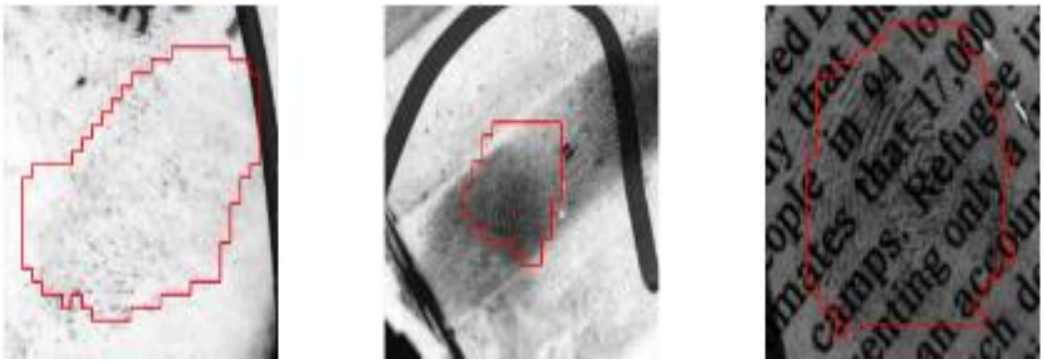

Fig 1.Latent Fingerprints

Rolled and plain fingerprints are collectively called as exemplars. Some of its features are listed below: they are of good quality, that are specially obtained under the supervision of experts, it contains maximum number of ridge valley patterns, no background noise, limited amount of non-linear alterations. Because of its good quality features, they can be easily matched with each other with high accuracy. The demerits that make latent fingerprints, a bit different from exemplars are:

- Minimum number of ridge valley patterns
- They are of poor quality
- Complex background noise
- Maximum amount of non-linear distortions

Because of its unwanted features like complex background noise and poor quality images, matching of latents with exemplar is considered as a puzzling problem. Automated Fingerprint Identification Systems shortly represented as AFIS works well in exemplar fingerprints matching, but it results in a considerable loss of performance in latent fingerprint matching.

II. EXISTING SYSTEM

The normal latent fingerprint matching works on the basis of ACE-V technology, where

- A for analysis, is the primary step that involves the observation of latent image. It is done to make sure that it contains necessary amount of features to carry out processing. It is done by keeping the latent image in isolation. The features that we usually mark include minutiae, orientation field etc.
- C for comparison, contains a comparison step that compares the extracted features from latent image with those features available from exemplars, thus analyzing the degree of similarity and dissimilarity between those features.
- E for evaluation identifies the strength of evidence between two based on the degree obtained. It is usually done by a latent examiner.
- Finally, V for verification again verifies the latent-exemplar pair with the help of a second examiner.

But the available existing system has some disadvantages:

- Tedious

- Time consuming, as it needs to process each latent image separately.

To overcome this, AFIS is used in the comparison step of ACE-V technology, which will retrieve a K candidate list from the exemplar database. It is done using a latent matcher. After that it is inspected by latent examiner. But this results in 5 outcomes:

-Correctly matches

-Erroneously matches

-Correctly matches the erroneous one

-Erroneously matches the correct one

-Result seems to be incomplete, as the examiner is not able to match the correct one from the available list.

To minimize the number of total outcomes occurred and also to avoid the disadvantages offered by existing system, proposed system using the top-down feedback methodology is developed.

III. PROPOSED SYSTEM

The proposed system is developed by obtaining bigger candidate list from the exemplar database using the same AFIS technique. Here each candidate is viewed as an output of a rough level match. It can then be used to refine the features that are extracted from the latent images. The similarityof these candidates are recomputed to re-rank the candidate list.

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Normally the latent matching system is based on the classical bottom-up matching approach. As we all know that bottom-up strategy constructs a system from several components. But this approach doesn't work well with latent matching system as the individual component in latent matching system suffers from heavy background noise and poor quality. Here comes the importance of top-down feedback mechanism. The feedback mechanism matches the latent fingerprints by incorporating a top-down data flow between the matching and feature extraction modules. This can be diagrammatically shown using diagram as follows:

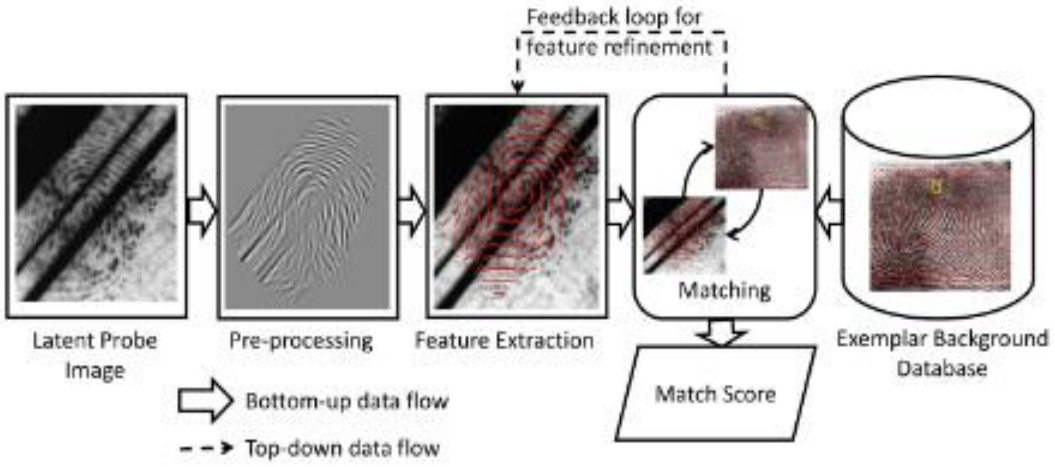

Fig 2. Typical bottom-up and top-down data flow in latent to exemplar matching systems.

Feedback Based Resorting Of Candidate List:

The implementation of feedback consist of consist of five major steps. They are:

- Dictionary Construction
- Initial matching and alignment
- Exemplar feature extraction
- Latent feature extraction and refinement
- Match score computation

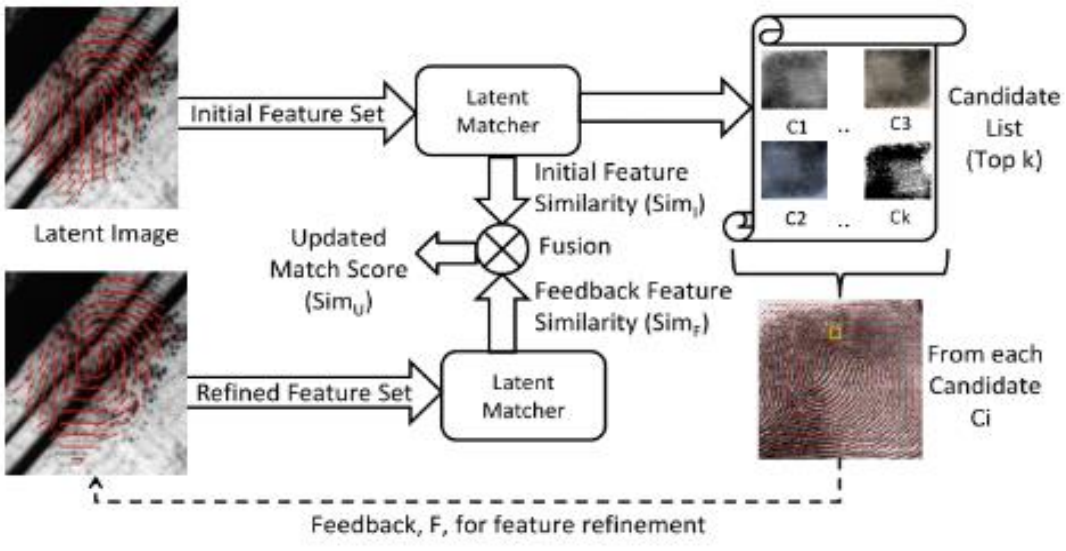

Fig 3. Feedback based resorting of candidate list

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Dictionary Construction:

Feature extraction of high quality exemplar fingerprints is essential for dictionary construction. minutiae features and orientation are usually extracted as features. Ridge bifurcations and ridge endings are the features that are extracted from minutiae. The performance of minutiae extraction algorithm is based on the quality of image that we fed as input. But in the case of exemplar image, this will not affect as it of pure quality. the construction includes the following steps such as:

- Image binarization: It is the process of transforming gray fingerprint image to a bit image, thus obtaining a black and white image. A binarization method, locally adaptive is used for image binarization.
- Image segmentation: After binarization, segmentation is performed for finding the region of interest.
- Ridge thinning: It is done to eliminate the duplicate pixels of ridges till the ridges become one pixel wide.
- Marking minutiae points: marking minutiae point is the next step to be done. It is done using 3ways:
- Ridge branch
- Ridge ending
- Triple counted branch

If the central pixel is one which is followed by exactly three neighbours with value one, then the central pixel is said to be a ridge branch. If the central pixel is 1 and has only one neighbour with value one, then the central pixel is a ridge ending. A special case occurs when a branch is triple counted. If both the uppermost and rightmost pixel with value 1 have another neighbour that is outside the window, then the two pixels will also be marked as branches.

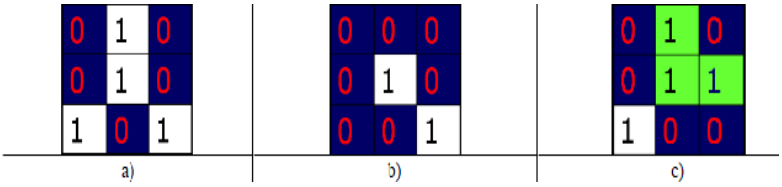

Fig 4. three ways of minutiae marking

Orientation field plays a very important role in fingerprint matching. The extracted minutiae features and orientation are stored in a database. The locations of the minutiae are also recorded in the form of numerical coordinates such as: x-coordinates y-coordinates and orientations, which is defined as the local orientation of the corresponding ridge.

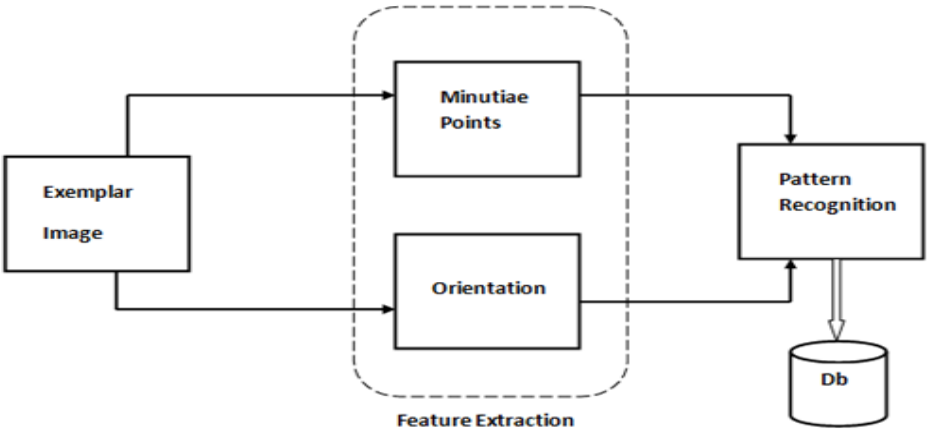

Fig 4. Dictionary Construction

Initial matching and alignment:

The initial matching and alignment is done using latent matcher. Inorder to obtain the initial match score, physically marked minutiae in the latent image and mechanically extracted minutiae from the exemplar image are fed as an input to the latent matcher, which is followed by the alignment process. Usually one to on matching is used to pair the minutiae

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points. The alignment of fingerprint is done with the calculation of parameters such as translation, scaling and rotation. Descriptor Based Hough Transform is used to align fingerprints. After the alignment, the minutiae correspondences between the two sets is found out.

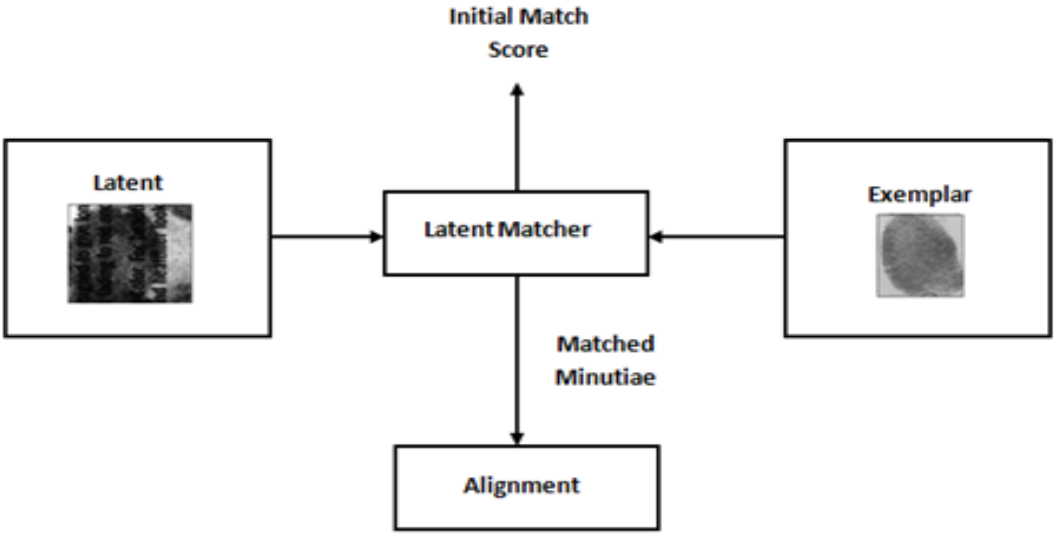

Fig 5. Initial matching and alignment

Exemplar feature extraction:

As it is of good quality, we are able to extract features from exemplars without any difficulties. For this, a skelton image is firstly generated from available image. it is developed in the first phase that is dictionary construction. this image is then divided into pixel blocks. for each block, ridge orientation and frequency are computed. these features are then extracted from each block of the exemplar.

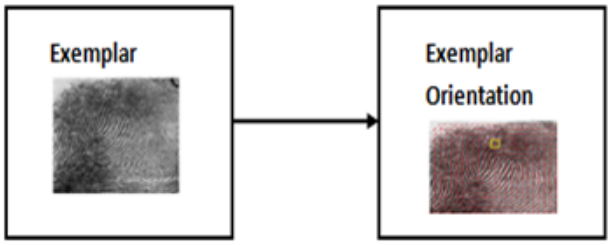

Fig 6. Exemplar feature extraction

Latent Feature Extraction and refinement:

Fourier domain is used to derive the latent features. This is due to complex background noise in the latent images. The latent image is divided into blocks of size 16 ×16. From all blocks, a sub-image is extracted and smoothened I properly using the Gaussian mask inorder to get the weighed image. Magnitude spectrum is then produced from which peak points of the highest magnitude values were taken. Next is to find orientation levels corresponding to that peak points. It also consist of series of steps:

- Image enhancement using histogram equalization
- image binarization
- ridge thinning
- image segmentation
- latent feature refinement

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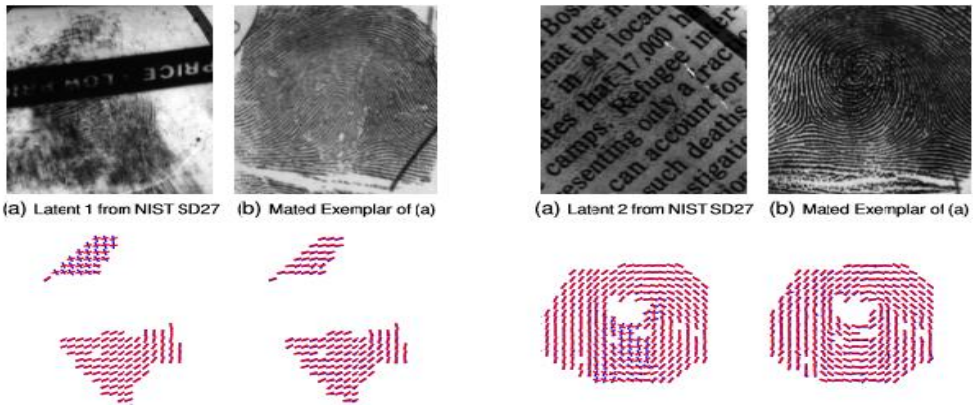

Fig 7. Latent feature refinement

Match score computation:

After feedback process, the similarity score computation between latent and exemplar for improving the matching accuracy is done. It is done using the following fusion operator as:

$$\mathbf{SimU = SimI \times Sim_{\alpha} \times Sim_{f}}$$

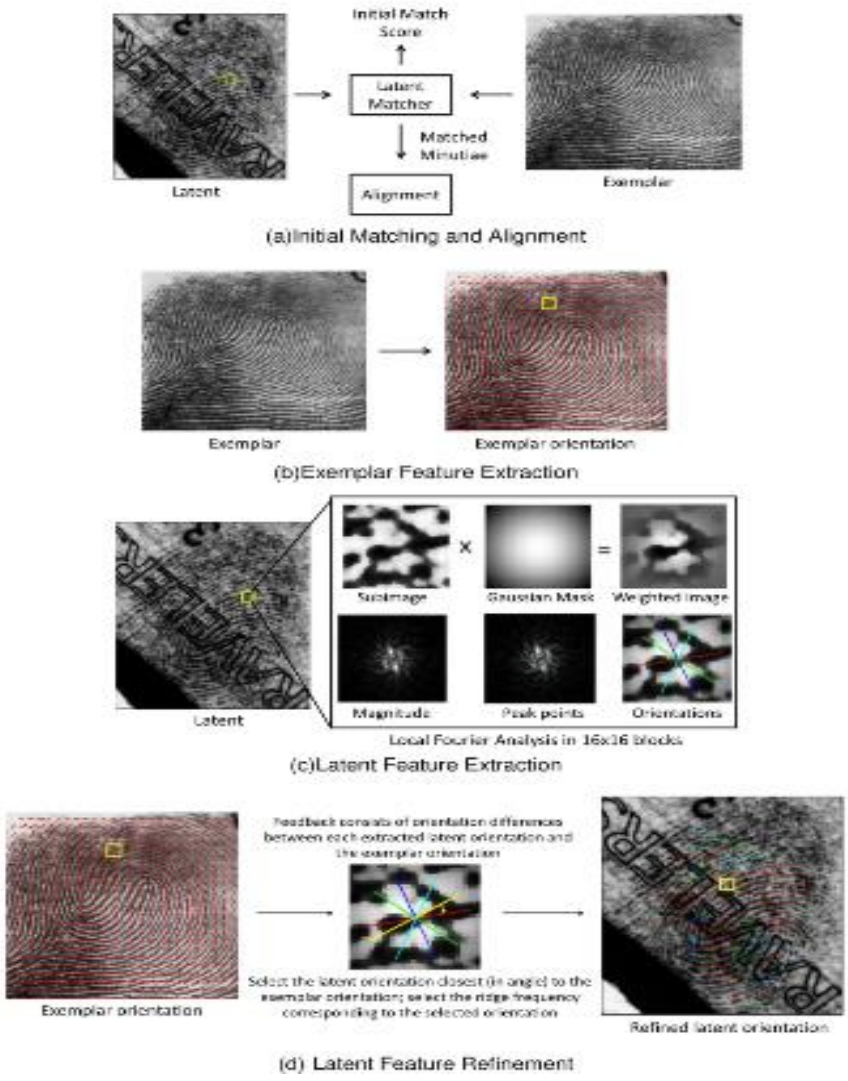

Fig 8.steps in latent matching systems

IV. CONCLUSION

Feature extraction in the latent image is considered as a major challenge in latent matching system. In order to deal with difficult background noise, here a top-down feedback methodology is proposed by taking feedback from exemplar fingerprint. This is done to refine extracted feature in latent image with the ultimate goal of improving the accuracy. As part of future enhancement, here level-2 fingerprint features such as ridge skeleton and minutiae are considered by taking all into the feedback paradigm for further improvement of latent matching accuracy.

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