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Invariant Feature Encoding for Contact Handprints Using Delaunay Triangulated Graph

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Abstract: Contact-based biometric applications primarily use prints from a finger or a palm for a single instance in different applications. For access control, there is an enrollment process using one or more templates which are compared with verification images. In forensics applications, randomly located, partial, and often degraded prints acquired from a crime scene are compared with the images captured from suspects or existing fingerprint databases, like AFIS. In both scenarios, if we need to use handprints which include segments from the finger and palm, what would be the solution? The motivation behind this is the concept of one single algorithm for one hand. Using an algorithm that can incorporate both prints in a common processing framework can be an alternative which will have advantages like scaling to larger existing databases. This work proposes a method that uses minutiae or minutiae-like features, Delaunay triangulation and graph matching with invariant feature representation to overcome the effects of rotation and scaling. Since palm prints have a large surface area with degradation, they tend to have many false minutiae compared to fingerprints, and the existing palm print algorithms fail to tackle this. The proposed algorithm constructs Delaunay triangulated graphs (DTG) using minutiae where Delaunay triangles form from minutiae, and initiate a collection of base triangles for opening the matching process. Several matches may be observed for a single triangle match when two images are compared. Therefore, the set of initially matched triangles may not be a true set of matched triangles. Each matched triangle is then used to extend as a sub-graph, adding more nodes to it until a maximum graph size is reached. When a significant region of the template image is matched with the test image, the highest possible order of this graph will be obtained. To prove the robustness of the algorithm to geometrical variations and working ability with extremely degraded (similar to latent prints) conditions, it is demonstrated with a subset of partial-quality and extremely-low-quality images from the FVC (fingerprint) and the THUPALMLAB (palm print) databases with and without geometrical variations. The algorithm is useful when partial matches between template and test are expected, and alignment or geometrical normalization is not accurately possible in pre-processing. It will also work for cross-comparisons between images that are not known a priori.

Keywords: hand biometrics; Delaunay triangulation; invariant feature; fingerprint; palm print; minutiae

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1. Introduction

Hand biometrics include multiple modalities such as fingerprint, palm print, finger–knuckle print, and finger vein and palm vein images. Fingerprints have been rising as a popular biometric modality and are extensively used for many applications including access control. They are acquired using contact-based sensors for automated identifications, such as in smart phones, and by transferring from touched surfaces, such as in latent prints for forensic purposes. They can also be acquired in a contactless manner with cameras whose resolution is sufficiently high to show the ridge patterns in images captured at a distance [1].

Table 3. Comparison of performance between the DTG algorithm and the state-of-the-art SIFT features [16].

Palm Print Quality Type	EER Using DTG	EER Using SIFT [16]
Partially degraded impressions with geometrical variations (25 users)	5.76%	7.60%
Partially degraded impressions with geometrical variations (35 users)	5.69%	6.44%
Extremely degraded (low-quality) impressions with geometrical variations (40 users)	6.94%	10.85%

6. Conclusions

The investigation on the DTG algorithm gives a rationale for the methodology and validates the claims using impressions from handprints with a range of image quality and geometrical variations. It works well for fingerprint segments with geometrical variations. For the palm print segments, it demonstrates how far it works well with partial-quality and extremely-low-quality handprints while using only simple minutiae features. The handprint segments completely show geometrical variations, and the DTG is not very sensitive to similarity transformations present in the database. They resulted in comparatively better performance than the state-of-the-art method as well. Even though the performance with extremely degraded prints is comparatively less than the partial-quality prints, there is potential to use the DTG in extreme cases of the contact prints because extreme degradation is not always the majority case for contact prints. Further, it has an advantage to leverage the method in multiple regions of the handprints where poor quality regions would be merged with good quality regions of the hand. Therefore, the algorithm can be acceptable in algorithmic and application contexts.

In the algorithmic context, the proposed method uses only minutiae. However, there is a possibility for fusing other features if the quality of the images is good enough to show ridge information clearly. The processes of one-to-one minutiae match and false minutiae removal are replaced by graph match and graph validation that eliminate unnecessary computations for false minutia removal. In the application context, if any prints that show not only minutiae but any minutiae-like point-related information, that can benefit from the algorithm. As the method is invariant to geometrical transformations, any segment of the hand can be treated without manual alignment of the compared images.

The significance of the DTG is that it would be advantageous to adopt contact-based handprint system in access control and other civilian applications. On the other hand, the similar procedure can be adopted in forensic environment as it generally shows extremely-low-quality prints and forensic experts do not know which part of the hand the prints are obtained from. In that scene, the algorithm can produce some likelihood similarity for the matching images if they are too far degraded. In an overall context, the DTG is the output for the concept of one single algorithm for one hand.

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