Assessing latent fingerprint distortion using forensic databases and minutiae paring by human experts

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Abstract

Large non-linear distortion in a finger mark, introduced at the time when a latent print was left in crime scenes, is one main difficulty in forensic fingerprint matching [1] compared to plain or rolled fingerprint matching. It is significant and desirable that AFIS systems in forensic applications have much higher distortion tolerance compared to those systems for civil purposes. Moreover, recent work [2] has highlighted the importance of distortion models to assess the evidential value of fingerprint comparison. Previous works [3, 4, 5, 6] on studying distortion in fingerprints mainly described two aspects. On the one hand, in [6], the flexibility of finger skin under different stresses based on the knowledge of the anatomy of the hand and skin was illustrated. On the other hand, researchers from the biometrics area studied quantitative (measurable) aspects of finger skin deformation by proposing distortion models [4, 5] aimed to enhance matching algorithms for AFIS systems.

However, those distortion models, heavily depending on the completeness of fingerprint images, will face problems when applied to forensic scenarios, mainly due to the serious partial overlap found between a finger mark and its paired fingerprint. To avoid the dependence on the completeness of fingerprint images, we focus on distortion assessment at feature level (generally minutiae features). This is inspired by the fact that when non-linear distortion is introduced at image level, consequently, it is the spatial location of minutiae confounding the matching process. Furthermore, to deal with non-linear distortion at matching stage, existing algorithms [3] essentially present local structure matching, which was deem to have high distortion tolerance. This motivates us to study distortion assessment through minutiae windows under different window shapes as a local structure.

Based on the motivations described above, in this work, we propose a method to assess distortion in latent fingerprints, which uses forensic databases of marks and mated prints. The method needs the information about minutiae paring provided by human examiners, i.e., which minutiae in the finger mark is paired to which minutiae in the fingerprint, and works with groups of minutiae in the mark and the print that define so-called minutiae windows, which are used for distortion assessment. We approach to the problem of distortion assessment in two stages. First, we compare different window shapes, selecting the one that presents less variation between the window in the mark and in the print. We call this measure of variation global distortion, or distortion at the window level. Second, we compute the variation of the minutiae points within a given window, namely local distortion or feature-level distortion. Thus, global distortion is a criteria to select the most stable comparison window, whereas the ultimate measure of distortion is the local one. In the experimental study, two forensic fingerprint databases are used, i.e., NIST SD27 [7] including 258 pairs of finger marks and fingerprints, and a casework database collected by Netherlands Forensic Institute (NFI) [8] including 58 pairs of finger marks and fingerprints. The information about the paring of minutiae in the mark and those in the print is provided by forensic examiners. The results show that the distortion of a circle window is the smallest among various types of window shapes tested, namely , i.e., rectangular, elliptic, and circular. Also, the distortion assessment of minutiae points under circle window can show non-linear distortion quantitatively, which can help with the design of forensic fingerprint comparison algorithms.

1. References

[1] A.K. Jain and J. Feng, "Latent fingerprint matching," *IEEE Trans. on Pattern Analysis and Machine Intelligence*, vol. 33, no. 1, pp. 88–100, 2011.

[2] C. Neumann, I. W. Evett, and J. Skerrett, "Quantifying the weight of evidence from a forensic fingerprint comparison: a new paradigm," *Journal of the Royal Statistical Society: Series A*, vol. 175, no. 2, pp. 371–415, 2012.

[3] Davide Maltoni, Dario Maio, Anil K. Jain, and Salil Prabhakar, Eds., *Handbook of Fingerprint Recognition*, chapter 4, Springer, London, UK, 2009.

[4] R. Cappelli, D. Maio, and D. Maltoni, "Modelling plastic distortion in fingerprint images," in *Advances in Pattern Recognition ICAPR 2001*, vol. 2013, pp. 371–378. Springer Berlin Heidelberg, Berlin, Germany, 2001.

[5] Arun Ross, Sarat Dass, and Anil Jain, "A deformable model for fingerprint matching," *Pattern Recognition*, vol. 38, no. 1, pp. 95–103, 2005.

[6] Alice V. Maceo, "Qualitative assessment of skin deformation: A pilot study," *Journal of Forensic Identification*, vol. 59, no. 4, pp. 390–440, 2009.

[7] National Institute of Standards and Technology, "Nist special database 27," 2000.

[8] Netherlands Forensic Institute, "Csi the hague project," 2013.