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# An AFIS Candidate List Centric Fingerprint Likelihood Ratio Model Based on Morphometric and Spatial Analyses (MSA)

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Additional information is available at the end of the chapter

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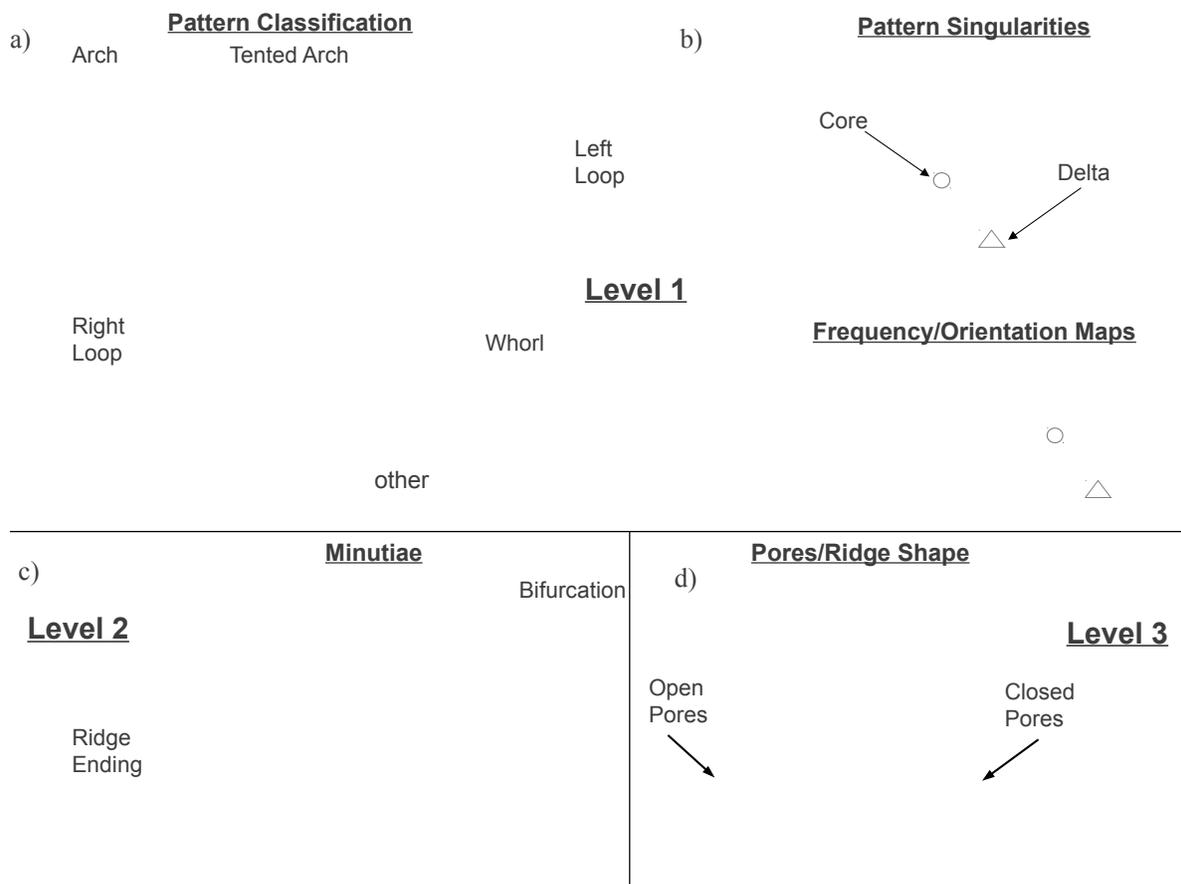
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## 1. Introduction

The use of fingerprints for identification purposes boasts worldwide adoption for a large variety of applications, from governance centric applications such as border control to personalised uses such as electronic device authentication. In addition to being an inexpensive and widely used form of biometric for authentication systems, fingerprints are also recognised as an invaluable biometric for forensic identification purposes such as law enforcement and disaster victim identification. Since the very first forensic applications, fingerprints have been utilised as one of the most commonly used form of forensic evidence worldwide.

Applications of fingerprint identification are founded on the intrinsic characteristics of the friction ridge arrangement present at the fingertips, which can be generally classified at different levels or resolutions of detail (Figure 1). Generally speaking, fingerprint patterns can be described as numerous curved lines alternated as ridges and valleys that are largely regular in terms orientation and flow, with relatively few key locations being of exception (singularities). A closer examination reveals a more detail rich feature set allowing for greater discriminatory analysis. In addition, analysis of local textural detail such as ridge shape, orientation, and frequency, have been used successfully in fingerprint matching algorithms as primary features [1] [2] or in conjunction with other landmark-based features [3].

Both biometric and forensic fingerprint identification applications rely on premises that such fingerprint characteristics are highly discriminatory and immutable amongst the general population. However, the collectability of such fingerprint characteristics from biometric scanners, ink rolled impressions, and especially, latent marks, are susceptible to adverse factors such as partiality of contact, variation in detail location and appearance due to skin elasticity (specifically for level 2 and 3 features) and applied force, environmental noises such



**Figure 1.** Level 1 features include features such as pattern class (a), singularity points and ridge frequency (b). Level 2 features (c) include minutiae with primitive types ridge endings and bifurcations. Level 3 features (d) include pores (open/closed) and ridge shape. These fingerprints were sourced from the FVC2002 [47], NIST4 [46], and NIST24 [48] databases

as moisture, dirt, slippage, and skin conditions such as dryness, scarring, warts, creases, and general ageing. Such influences generally act as a hindrance for identification, reducing both the quality and confidence of assessing matching features between impressions (Figure 2).

In this chapter, we will firstly discuss the current state of forensic fingerprint identification and how models play an important role for the future, followed by a brief introduction and review into relevant statistical models. Next, we will introduce a Likelihood Ratio (LR) model based on Support Vector Machines (SVMs) trained with features discovered via the morphometric and other spatial analyses of matching minutiae for both genuine and close imposter (or match and close non-match) populations typically recovered from Automated Fingerprint Identification System (AFIS) candidate lists. Lastly, experimentation performed on a set of over 60,000 publicly available fingerprint images (mostly sourced from NIST and FVC databases) and a distortion set of 6,000 images will be presented, illustrating that the proposed LR model is reliably guiding towards the right proposition in the identification assessment for both genuine and high ranking imposter populations, based on the discovered distortion characteristic differences of each population.