Chapter 5
Knuckle Crease Patterns in Forensic Biometrics:
A Novel Trait for Identity Verification and Investigative Applications

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ABSTRACT

Knuckle crease patterns, formed by natural skin folds over finger joints, are emerging as a valuable biometric trait in forensic science and digital identity. Often visible in photographs and surveillance footage, they aid identification when fingerprints or DNA are unavailable. This chapter reviews their anatomical foundations, persistence, and distinctiveness, and examines automated recognition methods from handcrafted descriptors to deep learning, alongside manual classification approaches emphasizing reproducibility. Forensic applications include criminal investigations, child sexual abuse material analysis, disaster victim identification, and multimodal biometrics. Ethical, legal, and evidentiary issues are discussed, and future challenges for validation and responsible implementation are highlighted.

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INTRODUCTION

Human identification has always been at the heart of forensic science. From the earliest adoption of anthropometry in the nineteenth century to the revolutionary impact of fingerprinting and the later development of DNA profiling in the twentieth century. Forensic practice has consistently advanced through the search for markers that are both scientifically reliable and legally admissible. Each innovation has addressed the limitations of its predecessors, expanding the evidentiary base and improving accuracy and judicial trust.

In parallel, biometrics has developed as a scientific discipline dedicated to recognizing individuals based on measurable biological and behavioural traits. Initially rooted in applications for security, border control, and administration, biometrics has increasingly intersected with forensic science, particularly as the demands of investigation and security have grown more complex (Jain et al., 2016).

Within this converging landscape, traditional biometric modalities such as fingerprints, facial recognition, and iris patterns continue to dominate; yet, each presents its own limitations. Fingerprints may degrade due to occupational wear, scarring, or deliberate alteration; facial recognition is vulnerable to occlusion, poor lighting, or disguise; and iris recognition requires specialized capture devices. These constraints have motivated the exploration of alternative or "soft" biometric traits, features that may not rival fingerprints in uniqueness but can provide supplementary evidentiary value, especially when conventional modalities are unavailable or compromised.

Knuckle crease patterns (KCPs), the natural folds on the dorsal surface of the fingers formed over interphalangeal joints, have recently attracted attention as an emerging biometric modality. Anchored to skeletal articulation and established during intrauterine development (Kimura et al., 1990), these creases are assumed to persist throughout life with remarkable resilience against environmental and occupational influences. Unlike fingerprints, which require cooperative collection or specialized scanners, KCPs are often incidentally captured in real-world imagery, even under non-cooperative conditions. This makes them particularly relevant in forensic contexts such as child sexual abuse material (CSAM) investigations, covert surveillance analysis, and disaster victim identification.

The research trajectory of KCPs differs from traditional identifiers. While fingerprints and DNA initially gained forensic acceptance before the advent of computational adaptation, KCPs were initially explored as a biometric trait. Kumar and Ravikanth (2009) demonstrated their feasibility for automated recognition, and later studies refined these methods through transform-based techniques and multimodal fusion. Deep learning has since improved accuracy, while explainable AI approaches address the transparency needed for forensic use. Only afterwards did forensic studies examine KCPs manually, focusing on classification, reproducibility,