

# Recent Advances in Fingerprint Verification

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More than a century has passed since Alphonse Bertillon first conceived and then industriously practiced the idea of using body measurements for solving crimes [18]. Just as his idea was gaining popularity, it faded into relative obscurity by a far more significant and practical discovery of the uniqueness of the human fingerprints<sup>1</sup>. Soon after this discovery, many major law enforcement departments embraced the idea of first “booking” the fingerprints of criminals, so that their records are readily available and later using leftover fingerprint smudges (latents), they could determine the identity of criminals. These agencies sponsored a rigorous study of fingerprints, developed scientific methods for visual matching of fingerprints and strong programs/cultures for training fingerprint experts, and applied the art of fingerprint identification for nailing down the perpetrators [6].

Despite the ingenious methods improvised to increase the efficiency of the manual method of fingerprint indexing and search, the ever growing demands on manual fingerprint identification quickly became overwhelming. The manual method of fingerprint indexing resulted in a highly skewed distribution of fingerprints into bins (types): most fingerprints fell into a few bins and this resulted in search inefficiencies. Fingerprint training procedures were time-intensive and slow. Further, demands imposed by painstaking attention needed to visually match the fingerprints of varied qualities, tedium of monotonic nature of the work, and increasing workloads due to a higher demand on fingerprint identification services, all prompted the law enforcement agencies to initiate research into acquiring fingerprints through electronic medium and automatic fingerprint identification based on the digital representation of the fingerprints. These efforts have led to development of automatic/semi-automatic fingerprint identification systems (AFIS) over the past few decades.

While law enforcement agencies were the earliest adopters of the fingerprint identification technology, more recently, increasing identity fraud has created a growing need for biometric technology<sup>2</sup> [9] for positive person identification in a number of non-forensic applications. Is this person authorized to enter this facility? Is this individual entitled to access the privileged information? Is the given service being administered exclusively to the enrolled users? Answers to questions such as these are valuable to business and government organizations.

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<sup>1</sup> In 1893, the Home Ministry Office, UK, accepted that no two individuals have the same fingerprints.

<sup>2</sup> Biometric authentication, or simply biometrics, refers to use of distinctive physiological (e.g., fingerprints, face, retina, iris) and behavioral (e.g., gait, signature) characteristics for automatically identifying individuals

Since biometric identifiers cannot be easily misplaced, forged, or shared, they are considered more reliable for personal identification than traditional token or knowledge based methods. The objectives of biometric authentication are user convenience (e.g., money withdrawal without ATM card and PIN), better security (e.g., difficult to forge access), and higher efficiency (e.g., lower overhead for computer password maintenance). Tremendous success of the fingerprint based identification technology in law enforcement applications, decreasing cost of the fingerprint sensing devices, increasing availability of inexpensive computing power, and growing identity fraud/theft have all ushered in an era of fingerprint-based person identification applications in commercial, civilian, and financial domains.

Our objective is to present current state-of-the-art in fingerprint sensing and identification technology and to provide some insights into the strengths and limitations of the automation in matching fingerprints. There is a popular misconception in the pattern recognition and image processing academic community that automatic fingerprint verification is a fully solved problem since it was one of the first applications of machine pattern recognition almost fifty years ago. On the contrary, fingerprint verification is still a challenging and important pattern recognition problem. Here, we will focus only on the core technology underlying fingerprint verification rather than the details of the commercial systems. In particular, we will discuss on fingerprint sensing, representation, classification, and matching. With the increase in the number of commercial systems for fingerprint-based verification, proper evaluation protocols are needed. The first fingerprint verification competition (FVC2000) was a good start in establishing such protocols. In order to improve the verification performance, methods for integrating multiple matchers, multiple biometrics and mosaicing of multiple templates are being investigated. As fingerprints (biometrics) get increasingly embedded into various systems (e.g., cellular phones), it becomes increasingly important to analyze the impact of biometrics on the overall integrity of the system and its social acceptability. We will also summarize some of the security/privacy research issues related to fingerprint (biometrics) authentication systems. A selection of fingerprint related research is cited below to provide the audience some useful pointers for their further exploration of this topic.

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