David Zhang · Zhenhua Guo
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Multispectral Biometrics

Systems and Applications

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Preface

Recently, biometrics technology has been one of the hot research topics in the IT field, because of the demands for accurate personal identification or verification to solve security problems in various applications, such as e-commence, Internet banking, access control, immigration, and law enforcement. In particular, after the 911 terrorist attacks, the interest in biometrics-based security solutions and applications has increased dramatically.

Although a lot of traditional biometrics technologies and systems such as fingerprint, face, palmprint, voice, and signature have been greatly development in the past decades, they are application dependent and still have some limitations. Multispectral biometrics technologies are emerging for high security requirement for their advantages: multispectral biometrics could offer a richer information source for feature extraction; multispectral biometrics is more robust to spoof attack since it is more difficult to be duplicated or counterfeited.

With the development of multispectral imaging techniques, it is possible to capture multispectral biometrics characteristics in real time. Recently, multispectral techniques have been used in biometrics authentication, such as multispectral face, multispectral iris, multispectral palmrpint, and multispectral fingerprint recognition, and some commercial multispectral biometrics systems have been pushed into the market already.

Our team certainly regards multispectral biometrics as a very potential research field and has worked on it since 2008. We are the first group that developed the multispectral hand dorsal technology and system. We built a large multispectral palmrpint database (PolyU multispectral Palmprint Database), which contains 6,000 samples collected from 500 different palms, and then published it online since 2010. Until now, this database has been downloaded by many researchers. This work was followed with more extensive investigations into multispectral palmprint technology, and this research has now evolved to other multispectral biometrics field. Then, a number of algorithms have been proposed for these multispectral biometrics technologies, including segmentation approaches, feature extraction methodologies, matching strategies, and classification ideas. Both this explosion of

interest and this diversity of approaches have been reflected in the wide range of recently published technical papers.

This book seeks to gather and present current knowledge relevant to the basic concepts, definition, and characteristic features of multispectral biometrics technology in a unified way, and demonstrates some multispectral biometric identification system prototypes. We hope thereby to provide readers with a concrete survey of the field in one volume. Selected chapters provide in-depth guides to specific multispectral imaging methods, algorithm designs, and implementations.

This book provides a comprehensive introduction to multispectral biometrics technologies. It is suitable for different levels of readers: Those who want to learn more about multispectral biometrics technology, and those who wish to understand, participate in, and/or develop a multispectral biometrics authentication system. We have tried to keep explanations elementary without sacrificing depth of coverage or mathematical rigor. The first part of this book explains the background of multispectral biometrics. Multispectral iris recognition is introduced in Part II. Part III presents multispectral palmprint technologies. Multispectral hand dorsal recognition is developed in Part IV.

This book is a comprehensive introduction to both theoretical and practical issues in multispectral biometrics authentication. It would serve as a textbook or as a useful reference for graduate students and researchers in the fields of computer science, electrical engineering, systems science, and information technology. Researchers and practitioners in industry and R&D laboratories' working security system design, biometrics, immigration, law enforcement, control, and pattern recognition would also find much of interest in this book.

December 2014

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Part I
Background of Multispectral Biometrics

Chapter 1
Overview

Abstract Recently, biometrics technology is one of the hot research topics in the IT field because of the demands for accurate personal identification or verification to solve security problems in various applications. This chapter gives an all-around introduction to biometrics technologies, and the new trend: multispectral biometrics.

Keywords Biometrics · Multispectral biometrics · Identification · Verification

1.1 The Need for Biometrics

Biometrics lies in the heart of today's society. There has been an ever-growing need to automatically authenticate individuals at various occasions in our modern and automated society, such as information confidentiality, homeland security, and computer security. Traditional knowledge-based or token-based personal identification or verification is so unreliable, inconvenient, and inefficient, which is incapable to meet such a fast-pacing society. Knowledge-based approaches use "something that you know" to make a personal identification, such as password and personal identity number. Token-based approaches use "something that you have" to make a personal identification, such as passport or ID card. Since those approaches are not based on any inherent attributes of an individual to make the identification, it is unable to differentiate between an authorized person and an impostor who fraudulently acquires the "token" or "knowledge" of the authorized person. This is why biometrics identification or verification system started to be more focused in the recent years.

Biometrics involves identifying an individual based on his/her physiological or behavioral characteristics. Many parts of our body and various behaviors are embedded such information for personal identification. In fact, using biometrics for person authentication is not new, which has been implemented over thousands years, numerous research efforts have been put on this subject resulting in developing various techniques related to signal acquisition, feature extraction, matching, and classification. Most importantly, various biometrics systems, including fingerprint,

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iris, hand geometry, and voice and face recognition systems have been deployed for various applications (Jain et al. 1999).

According to the report of Acuity Market Intelligence (The Future of Biometrics 2009), the market for biometrics technologies increased around 20 % each year in the past years. Figure 1.1a shows predicted total revenues of biometrics for 2009–2017. Figure 1.1b shows comparative market share by different biometrics technologies for the year 2009.

1.1.1 Biometrics System Architecture

A biometric recognition system is a pattern recognition system. During biometric recognition, biometric traits are measured and analyzed to establish a person's identity. This process involves several stages.

Enrollment
During enrollment, a user's physical or behavioral trait is captured with a camera or sensor and placed in an electronic template. This template is securely stored in a central database or a smart card issued to the user.

Recognition
During recognition, a sensor captures a biometric trait. The trait is then analyzed with an algorithm that extracts quantifiable features, such as fingerprint minutiae or face shape. A matcher takes these features and compares them to an existing template in the enrollment database.

1.1.2 Operation Mode of a Biometrics System

A biometrics system is usually operated in three modes: enrollment, identification, and verification. But some systems only have either identification or verification modes.

Enrollment—Before a user can be verified or identified by the system, he/she must be enrolled by the biometrics system. The user's biometrics data are captured, preprocessed, and feature extracted as shown in stages 1–3 of Fig. 1.2. Then, the user's template is stored in a database or file system.

Identification—This refers to the identification of a user based solely on his/her biometrics information, without any prior knowledge about the identity of a user. Sometimes, it is referred to one-to-many matching, or recognition. It will go through stages 1–3 to create an identification template. Then, the system will retrieve all the templates from the database for the feature matching. A result of success or failure is given finally. Generally, accuracy decreases as the size of the database grows.

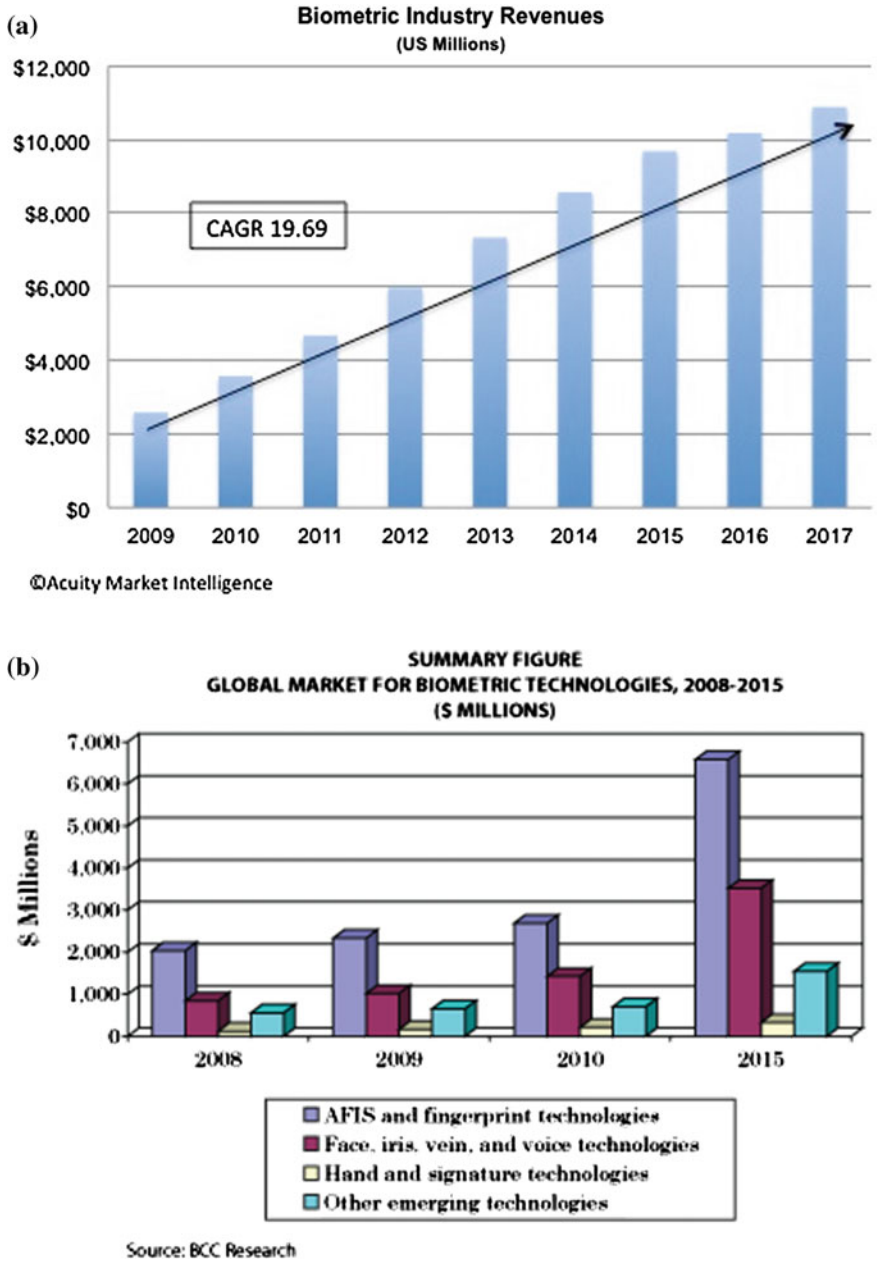

Fig. 1.1 **a** Total biometrics revenues prediction in 2009–2017 (The Future of Biometrics 2009). **b** Comparative market sharing by BCC research (Biometrics: Technologies and Global Markets 2010)