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Biometrics has long been an active research field, particularly because of all the attention focused on public and private security systems in recent years. Advances in digital computers, software technologies, and embedded systems have further catalyzed increased interest in commercially available biometric application systems. Biometric authentication can be regarded as a special technical area in the field of pattern classification. Research and development on biometric authentication have focused on two separate fronts: one covering the theoretical aspect of machine learning for pattern classification and the other covering system design and deployment issues of biometric systems. This book is meant to bridge the gap between these two fronts, with a special emphasis on the promising roles of modern machine learning and neural network techniques.

To develop an effective biometric authentication system, it is vital to acquire a thorough understanding of the input feature space, then develop proper mapping of such feature space onto the expert space and eventually onto the output classification space. Unlike the conventional template matching approach, in which learning amounts to storing representative example patterns of a class, the machine learning approach adopts representative statistical models to capture the characteristics of patterns in the feature domain. This book explores the rich synergy between various machine learning models from the perspective of biometric applications. Practically, the machine learning models can be adopted to construct a robust information processing system for biometric authentication and data fusion. It is potentially useful in a broad spectrum of application domains, including but not limited to biometric authentication.

This book is organized into four related parts.

1. Part I—Chapters 1 and 2—provides an overview of the state-of-the-art in face and speaker biometric authentication systems.

2. Part II—Chapters 3, 4, and 5—establishes the theoretical pillars of machine learning methods adopted in the book. To facilitate the development of effective biometric authentication systems, several modern machine learning models are instrumental in handling complex pattern recognition and classification problems. Part II discusses the expectation-maximization (EM)
algorithm (Chapter 3); describes the fundamental theory on Fisher’s linear discriminant analysis (LDA) and support vector machines (SVMs) (Chapter 4); and offers comprehensive coverage of multi-layer learning models, in addition to well-known back-propagation (BP) algorithms (Chapter 5).

3. Part III—Chapters 6 and 7—proposes several flexible structural frameworks based on hierarchical and modular neural networks, under which machine learning modules can be incorporated as subsystems. The discussion introduces several expert-based modular networks, such as the so-called hierarchical mixture-of-experts (Chapter 6), as well as interclass learning strategies based on class-based modular networks (Chapter 7).

4. Part IV—Chapters 8, 9, and 10—presents the theoretical foundations behind the learning networks, which can find natural and fruitful applications in biometric authentication systems. The most important authentication application domains are face recognition and speaker verification. Specifically, Chapter 8 presents probabilistic neural networks for face biometrics, while Chapter 9 covers authentication by human voices. Several multicue data-fusion techniques are addressed in Chapter 10.

As suggested by the title, this book covers two main themes: (1) biometric authentication and (2) the machine learning approach. The ultimate objective is to demonstrate how machine learning models can be integrated into a unified and intelligent recognition system for biometric authentication. However, the authors must admit that the book’s coverage is far from being comprehensive enough to do justice to either theme. First, the book does not address many important biometric authentication techniques such as signature, fingerprint, iris pattern, palm, DNA, and so on. The focus is placed strictly on visual recognition of faces and audio verification of speakers. Due to space constraints, the book has likewise overlooked many promising machine learning models. To those numerous contributors, who deserve many more credits than are given here, the authors wish to express their most sincere apologies.

In closing, Biometric Authentication: A Machine Learning Approach is intended for one-semester graduate school courses in machine learning, neural networks, and biometrics. It is also intended for professional engineers, scientists, and system integrators who want to learn systematic, practical ways of implementing computationally intelligent authentication systems based on the human face and voice.

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