

Preface

The last two decades have seen a dramatic increase in the number of stakeholders of biometric technologies. The quality of the technologies has increased due to an improvement in underlying data processing and sensor technologies. A growing and healthy marketplace has emerged, while the number of people using, operating, or impacted by these technologies has been growing exponentially. Several new disruptive technologies have emerged, along with the diversification of the devices and platforms where biometrics are provisioned. The ubiquity of mobile phones and the multiplicity and diversity of sensors available for biometric provisioning (e.g., webcam, fingerprint reader, touchscreen, accelerometer, gyroscope, etc.) is contributing significantly to this dramatic growth of the biometric ecosystem.

Gait biometrics is one of the new technologies that have appeared in the past few decades. Gait biometric technology consists of extracting and measuring unique and distinctive patterns from human locomotion. Different forms of gait biometrics are available based on how the gait information is captured (e.g., video cameras, floor sensor, smartphones, etc.). Gait based on the ground reaction force (GRF) is the most recent form of gait biometric technology, which although lesser known than its counterparts, has shown greater promise in terms of its robustness. GRF is a measure of the force exerted by the ground back on the foot during a footstep.

The GRF-based gait biometric is the central topic of this book. Theoretical and practical underpinnings of the GRF-based gait biometric are presented in detail. The main components and processes involved in developing a GRF-based recognition system are discussed from a theoretical and experimental perspective, by revisiting existing research and introducing new results.

While the central topic of the book is GRF-based gait biometric technology, its backdrop is machine learning. Several machine learning techniques used in the literature for GRF recognition are dissected, contrasted, and investigated experimentally.

The book covers the different dimensions required for developing a GRF-based system: theoretical models, experimental models, and implementation issues. It also covers in detail several machine learning algorithms which can be used broadly for

biometric recognition technologies and other similar pattern recognition problems (e.g., speech recognition). This book is intended for researchers, developers, and managers and for students of computer science and engineering, in particular graduate students at the Master's and Ph.D. levels, working or with interest in the aforementioned areas.

The book consists of 11 chapters outlined as follows.

Chapter 1 provides a brief introduction to gait biometrics and outlines the context, objectives, and main contributions of the book.

Chapter 2 gives a high-level overview of machine learning and presents the different factors that define gait biometric technology. A high-level discussion of the considerations and issues underlying the design of a gait-based biometric recognition system is conducted.

Chapter 3 describes the field of gait biometrics and provides a historical overview of work that has been done in the field to date. It goes on to explain where the footstep GRF fits into the field of gait biometrics, and reviews the footstep GRF recognition literature that forms the basis for the research presented in later chapters.

This chapter also presents the experimental setup and introduces the methodology used to achieve the research objectives. It covers the selection of a development dataset containing data of a single shoe type and proposes a biometric system composed of feature extractors, normalizers, and classifiers to perform GRF-based person recognition.

Chapter 4 outlines the purpose and mechanisms underlying feature extraction, and compares four different feature extraction techniques previously used for GRF-based recognition in other studies. Theoretical background is provided for each feature extractor together with a discussion of each implementation. Preliminary GRF recognition results are acquired using the development dataset and presented for the parameter optimization of each extractor.

Chapter 5 demonstrates the performance of various normalization techniques on the extracted feature spaces from Chap. 4. Two novel normalization techniques are introduced here and theoretical background is provided for these and several other well-known existing techniques that are also examined. To determine the effectiveness of normalization the results from applying these normalization techniques are compared with the non-normalized results of the previous chapter.

Chapter 6 presents the theoretical background and implementation for five different classifiers that were selected for analysis in this book. Each classifier is tuned across the best-performing feature spaces acquired from development dataset in Chaps. 4 and 5. Finally, the feature extractor-normalizer-classifier combinations that achieved the best results are summarized for comparison with the results over the evaluation dataset in Chap. 8.

Chapter 7 outlines the experimental method and dataset used to evaluate the proposed GRF-based gait biometric framework. Different evaluation criteria are presented and discussed.

Chapter 8 demonstrates the results obtained after applying the best footstep GRF-recognition systems, outlined in Chap. 6, to an evaluation dataset containing previously unseen data samples with different shoe types.

Chapter 9 discusses the findings behind the GRF footstep recognition experiment. The effects of various techniques are compared, with practical implications and explanations for possible sources of error presented. Finally, the chapter concludes by examining techniques that could potentially be used to improve upon the results discovered in our research.

Chapter 10 identifies various applications for gait biometrics, and discusses current usage of the biometric both commercially and in research.

Chapter 11 provides a final summary of the research presented in previous chapters. The major findings are highlighted and the remaining problems and areas for future work are discussed.

The above chapters present state-of-the-art GRF-based gait biometric research and expose different dimensions of this emerging field, by emphasizing both the theoretical and practical underpinnings. We hope that this will represent a useful resource for readers from academia and industry in pursuing future research and developing new applications.

Machine Learning Techniques for Gait Biometric
Recognition

Using the Ground Reaction Force

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