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Efficient Biometric Indexing and Retrieval Techniques for Large-Scale Systems

Springer

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ISSN 2191-5768 ISSN 2191-5776 (electronic)
SpringerBriefs in Computer Science
ISBN 978-3-319-57659-6 ISBN 978-3-319-57660-2 (eBook)
DOI 10.1007/978-3-319-57660-2

Library of Congress Control Number: 2017939089

Printed on acid-free paper

This Springer imprint is published by Springer Nature
The registered company is Springer International Publishing AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

To My Family and Teachers

Preface

In our daily life, we use certain characteristics of people such as facial features, voice, gait, etc., to recognize people who are familiar to us. Automatic identification of the people by the use of their physiological (such as face, fingerprint, iris, hand geometry, etc.) and/or behavioral (such as voice, signature, gait, etc.) characteristics is called biometrics. As biometric characteristics are distinctive, cannot be forgotten or lost, and the person to be authenticated needs to be physically present at the point of access, biometric-based identification systems are gaining popularity and deployed in many important applications. In biometric identification systems, the identity corresponding to a query image is determined by sequentially matching it against all enrolled images in the database. Typically this approach works well for small databases. However, in real-life scenarios, size of biometric databases are usually high (e.g., Unique Identification Authority of India) and this sequential search makes the identification process extremely slow and computationally expensive. Efficient indexing techniques are required that enable searches over large databases in real time without compromising accuracy. Three different indexing techniques are designed, developed, tested, and described in this book.

The fundamentals of biometric recognition, importance of indexing techniques in large-scale biometric systems and their challenges, current developments and benchmarking are discussed in Chap. 1. An efficient triangulation based indexing technique for minutiae based biometrics especially for fingerprints is described in Chap. 2. This technique use an efficient representation named extended Delaunay triangulation for the fingerprints to make the system robust against distortions. Further, the extended triangulation is classified based on the type of minutiae at the vertices of each triangle. Such classification provides better partitioning of the database, leading to a significant decrease in the number of potential matches during identification. Chapter 3 discusses an indexing technique using match scores. For each image in the database, its match scores (i.e., index code) against a set of pre-selected sample images are calculated. Then a new storage mechanism is designed for the biometric databases. Like traditional database records, the biometric images are arranged in sorted order based on their scores. A set of images which are very similar to query are retrieved during identification using a voting

scheme. This results in a rapid search that takes constant time, i.e., independent of the database sizes.

A novel clustering based indexing technique using decision-level fusion is described in Chap. 4. An adaptive clustering algorithm is used that computes set of clusters in the database where each cluster is represented with an image called a 'leader'. The set of leaders is used to compute the index code. During identification, a list of similar candidates is retrieved from the clusters as well as index table. This approach retrieves multiple evidences for identification with minimal resources. Conclusions and future scope of this work are discussed in Chap. 5. This book explores new and efficient storing structures for the biometric databases. The designed indexing approaches identify a query in less time with high level of confidence. Further, the proposed storage mechanisms prove to be effective for fast and accurate retrieval. It is suggested that future work can be done in the following areas:

- All of the existing indexing approaches are experimented over the databases which are relatively small because of the unavailability of the large biometric databases for the researchers. Hence, creating and experimenting with these techniques on such large databases may be a challenging problem.
- Securing the biometric data from theft is also another important research topic in the area of biometrics due to the limited availability of the biometric traits. Further, computing the cancelable index codes for biometric identification is also a challenging problem.

Acknowledgements

"I've been blessed to find people who are smarter than I am, and they help me to execute the vision I have."—Russell Simmons

First and above all, I praise God, the almighty for providing me this opportunity and granting me the capability to proceed successfully.

Foremost, I would like to thank my advisors, Dr. MVNK Prasad and Prof. Chakravarthy Bhagvati, for their invaluable guidance and encouragement throughout my research work. My sincere thanks to Prof. Arun K. Pujari, Dean, and all the faculty members of SCIS, UoH for their encouragement and helpful suggestions. I would like to acknowledge the financial support of IDRBT (Established by RBI), Hyderabad for my doctoral study.

I would like to express my sincere gratitude to all my teachers. Without their support and encouragement, it would not have been possible for me to continue the studies and do this research. Their hard work and positive attitude is my main source of inspiration. I wish to convey my special thanks to my friends, co-researchers for their constant support and help during this journey.

Nothing would have been possible without the moral support of my parents, brothers, and sisters who have been the pillars of strength in all my endeavors. I am always deeply indebted to them for all that they had given me. I am thankful to my wife Devi, without whom it would have been impossible for me to finish this work. I really have no words to express my gratitude for all her support, encouragement, understanding, and sacrifice. Finally, I am grateful to my children Rithvik and Nithya for allowing me to snatch their time and spending it in endless hours of research work.

Contents

Abbreviations

AMI	Acuity Market Intelligence
ATM	Automatic Teller Machine
B-tree	Binary tree
CCD	Charge Coupled Device
CMC	Cumulative Match Characteristics
DCT	Discrete Cosine Transform
dpi	Dots Per Inch
FBI	Federal Bureau of Investigation
FVC	Fingerprint Verification Competition
FVList	List of Feature Vectors
HR	Hit Rate
IAFIS	Integrated Automated Fingerprint Identification System
$I_{id}List$	List of Image Identities
kd-tree	*k* Dimensional tree
kdb-tree	k-dimensional B-tree
K-L	Karhunen–Loève
k-NN	K Nearest Neighbor
LBP	Local Binary Pattern
LSH	Locality Sensitive Hashing
MBC	Minutiae Binary Code
MCC	Minutiae Cylindric Code
MR	Miss Rate
PCA	Principal Component Analysis
PolyU	Hong Kong Polytechnic University
PR	Penetration Rate
SIFT	Scale-Invariant Feature Transform
SURF	Speed-Up Robust Features
UIDAI	Unique Identification Authority of India
USD	United States Dollar
VA+	Vector Approximation +

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