

Feng-Hsing Wang, Jeng-Shyang Pan, and Lakhmi C. Jain

Innovations in Digital Watermarking Techniques

Studies in Computational Intelligence, Volume 232

Editor-in-Chief

Prof. Janusz Kacprzyk
Systems Research Institute
Polish Academy of Sciences
ul. Newelska 6
01-447 Warsaw
Poland
E-mail: kacprzyk@ibspan.waw.pl

Further volumes of this series can be found on our homepage:
springer.com

Vol. 211. Godfrey C. Onwubolu (Ed.)
Hybrid Self-Organizing Modeling Systems, 2009
ISBN 978-3-642-01529-8

Vol. 212. Viktor M. Kureychik, Sergey P. Malyukov,
Vladimir V. Kureychik, and Alexander S. Malyoukov
Genetic Algorithms for Applied CAD Problems, 2009
ISBN 978-3-540-85280-3

Vol. 213. Stefano Cagnoni (Ed.)
Evolutionary Image Analysis and Signal Processing, 2009
ISBN 978-3-642-01635-6

Vol. 214. Been-Chian Chien and Tzung-Pei Hong (Eds.)
*Opportunities and Challenges for Next-Generation Applied
Intelligence*, 2009
ISBN 978-3-540-92813-3

Vol. 215. Habib M. Ammari
*Opportunities and Challenges of Connected k-Covered Wireless
Sensor Networks*, 2009
ISBN 978-3-642-01876-3

Vol. 216. Matthew Taylor
Transfer in Reinforcement Learning Domains, 2009
ISBN 978-3-642-01881-7

Vol. 217. Horia-Nicolai Teodorescu, Junzo Watada, and
Lakhmi C. Jain (Eds.)
Intelligent Systems and Technologies, 2009
ISBN 978-3-642-01884-8

Vol. 218. Maria do Carmo Nicoletti and
Lakhmi C. Jain (Eds.)
*Computational Intelligence Techniques for Bioprocess
Modelling, Supervision and Control*, 2009
ISBN 978-3-642-01887-9

Vol. 219. Maja Hadzic, Elizabeth Chang,
Pornpit Wongthongtham, and Tharam Dillon
Ontology-Based Multi-Agent Systems, 2009
ISBN 978-3-642-01903-6

Vol. 220. Bettina Berendt, Dunja Mladenic,
Marco de de Gemmis, Giovanni Semeraro,
Myra Spiliopoulou, Gerd Stumme, Vojtech Svatek, and
Filip Zelezny (Eds.)
*Knowledge Discovery Enhanced with Semantic and Social
Information*, 2009
ISBN 978-3-642-01890-9

Vol. 221. Tassilo Pellegrini, Sören Auer, Klaus Tochtermann, and
Sebastian Schaffert (Eds.)
Networked Knowledge - Networked Media, 2009
ISBN 978-3-642-02183-1

Vol. 222. Elisabeth Rakus-Andersson, Ronald R. Yager,
Nikhil Ichalkaranje, and Lakhmi C. Jain (Eds.)
Recent Advances in Decision Making, 2009
ISBN 978-3-642-02186-2

Vol. 223. Zbigniew W. Ras and Agnieszka Dardzinska (Eds.)
Advances in Data Management, 2009
ISBN 978-3-642-02189-3

Vol. 224. Amandeep S. Sidhu and Tharam S. Dillon (Eds.)
Biomedical Data and Applications, 2009
ISBN 978-3-642-02192-3

Vol. 225. Danuta Zakrzewska, Ernestina Menasalvas, and
Liliana Byczkowska-Lipinska (Eds.)
Methods and Supporting Technologies for Data Analysis, 2009
ISBN 978-3-642-02195-4

Vol. 226. Ernesto Damiani, Jechang Jeong, Robert J. Howlett, and
Lakhmi C. Jain (Eds.)
*New Directions in Intelligent Interactive Multimedia Systems
and Services - 2*, 2009
ISBN 978-3-642-02936-3

Vol. 227. Jeng-Shyang Pan, Hsiang-Cheh Huang, and
Lakhmi C. Jain (Eds.)
Information Hiding and Applications, 2009
ISBN 978-3-642-02334-7

Vol. 228. Lidia Ogiela and Marek R. Ogiela
Cognitive Techniques in Visual Data Interpretation, 2009
ISBN 978-3-642-02692-8

Vol. 229. Giovanna Castellano, Lakhmi C. Jain, and
Anna Maria Fanelli (Eds.)
Web Personalization in Intelligent Environments, 2009
ISBN 978-3-642-02793-2

Vol. 230. Uday K. Chakraborty (Ed.)
*Computational Intelligence in Flow Shop and Job Shop
Scheduling*, 2009
ISBN 978-3-642-02835-9

Vol. 231. Mislav Grgic, Kresimir Delac, and
Mohammed Ghanbari (Eds.)
*Recent Advances in Multimedia Signal Processing and
Communications*, 2009
ISBN 978-3-642-02899-1

Vol. 232. Feng-Hsing Wang, Jeng-Shyang Pan, and
Lakhmi C. Jain
Innovations in Digital Watermarking Techniques, 2009
ISBN 978-3-642-03186-1

Feng-Hsing Wang, Jeng-Shyang Pan,
and Lakhmi C. Jain

Innovations in Digital Watermarking Techniques



Springer

Dr. Feng-Hsing Wang
Department of Electronic Engineering
National Kaohsiung University of Applied
Sciences
415 Chien-Kung Road
Kaohsiung 807
Taiwan
E-mail: jspan@cc.kuas.edu.tw

Prof. Lakhmi C. Jain
University of South Australia
Adelaide
Mawson Lakes Campus
South Australia SA 5095
Australia
E-mail: Lakhmi.jain@unisa.edu.au

Prof. Jeng-Shyang Pan
Department of Electronic Engineering
National Kaohsiung University of Applied
Sciences
415 Chien-Kung Road
Kaohsiung 807
Taiwan
E-mail: jspan@cc.kuas.edu.tw

ISBN 978-3-642-03186-1

e-ISBN 978-3-642-03187-8

DOI 10.1007/978-3-642-03187-8

Studies in Computational Intelligence

ISSN 1860-949X

Library of Congress Control Number: 2009935527

© 2009 Springer-Verlag Berlin Heidelberg

This work is subject to copyright. All rights are reserved, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilm or in any other way, and storage in data banks. Duplication of this publication or parts thereof is permitted only under the provisions of the German Copyright Law of September 9, 1965, in its current version, and permission for use must always be obtained from Springer. Violations are liable to prosecution under the German Copyright Law.

The use of general descriptive names, registered names, trademarks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

Typeset & Cover Design: Scientific Publishing Services Pvt. Ltd., Chennai, India.

Printed in acid-free paper

9 8 7 6 5 4 3 2 1

springer.com

Preface

With the widespread use of the Internet and the rapid development of digital technology, more problems such as information security and copyright protection are encountered in the digital world. Among the solutions for these problems, digital watermarking is one of the popular techniques which has been investigated widely by researchers. Many different kinds of watermarking schemes have been proposed. They provide varied features and functions which can be employed to solve the problems encountered. This research book aims to introduce some novel digital watermarking techniques for digital data stored in image formats, and to introduce intelligent techniques into the existing watermarking systems for performance improvement.

This book is divided into four parts. In the first part, the motivation for this book and the importance of digital watermarking and intelligent technology are described. The organisation of this book is also introduced. In the second part, different kinds of watermarking schemes based on spatial domain, transform domain, and vector quantisation domain are introduced. Also, the group optimization techniques are considered for those mentioned watermarking systems. Some training procedures using genetic algorithms or tabu search are illustrated. By introducing the training procedure into the existing watermarking systems, the performance, such as imperceptibility, capability, or robustness, can be improved. Simulation results are presented to show their superiority. In the third part, several hybrid watermarking systems are illustrated. They demonstrate that by taking the consideration of digital watermarking into account, traditional image coding systems can then possess the ability of digital watermarking. Finally, in the last part, we conclude this book and propose some possible direction for future study.

This book cannot be completed without the help, suggestions, encouragement, and support from many people. We are grateful to Professor C. P. Lim for contributing Sections 3.2 and 3.3. We also wish to thank Dr. H. C. Huang for contributing Section 3.5 and parts of the contents of Chapters 4 and 9. Their contributions do enrich the content of this book.

We wish to thank Springer-Verlag for the professional support.

We wish to thank the reviewers for their visionary feedback as well as the SCI Data Processing Team of Scientific Publishing Services for their excellent work during the preparation of the manuscript. Our sincere thanks to everyone else involved in the completion of this book.

Feng-Hsing Wang
Jeng-Shyang Pan
Lakhmi C. Jain

Contents

Part I: Introduction and Background

1	Introduction	3
1.1	Importance of Digital Watermarking	3
1.2	Importance of Intelligent Technology	4
1.3	Aims and Organisation of This Book	4
1.4	Test Images Used in Simulation	6
1.5	Note	10
2	Digital Watermarking Techniques	11
2.1	What Is Digital Watermarking?	11
2.1.1	Elements of a Watermarking System	12
2.2	Types of Digital Watermarking Techniques	12
2.2.1	Visible and Invisible	12
2.2.2	Detectable and Readable	14
2.2.3	Spatial, Transform, and Quantisation	14
2.2.4	Robust, Semi-Fragile, and Fragile	15
2.2.5	Blind and Non-blind	16
2.2.6	Public and Private	16
2.2.7	Symmetric and Asymmetric	16
2.2.8	Reversible and Non-reversible	17
2.3	What Can Digital Watermarking Do?	17
2.3.1	Data Hiding	17
2.3.2	Information Integration	18
2.3.3	Intellectual Property Rights (IPR) Protection	19
2.3.4	Ownership Demonstration	19
2.3.5	Tampering Verification	19
2.4	Benchmarks and Evaluating Functions	20
2.4.1	Benchmarks	20
2.4.2	Attack Schemes	22
2.4.3	Packages and Tools for Evaluation	25
2.5	Summary	26

3	Intelligent Techniques	27
3.1	Introduction	27
3.2	Neural Network (NN)	28
3.2.1	The Self-Organising Map (SOM)	28
3.2.2	The Batch-Learning SOM Model	29
3.2.3	Adaptive Resonance Theory (ART)	30
3.3	Evolutionary Artificial Neural Networks (EANN)	34
3.4	Genetic Algorithm (GA)	36
3.4.1	Individual, Chromosome, and Gene	36
3.4.2	Initialization	36
3.4.3	Evaluation	38
3.4.4	Selection	38
3.4.5	Crossover	40
3.4.6	Mutation	40
3.4.7	Convergence Test	41
3.5	Tabu Search (TS)	42
3.5.1	Forbidding Strategy	42
3.5.2	Aspiration Criteria and Tabu Restrictions	42
3.5.3	Freeing Strategy	43
3.5.4	Intermediate and Long-Term Learning Strategies	43
3.5.5	Short-Term Strategy or Overall Strategy	44
3.5.6	Best Solution Strategy	44
3.5.7	Termination	44
3.6	Summary	44

Part II: Intelligent Watermarking

4	Spatial-Based Watermarking Schemes and Pixel Selection	47
4.1	Introduction	47
4.2	Watermarking Schemes	48
4.2.1	LSB Method	48
4.2.2	Pixel Surrounding Method	51
4.2.3	Simulation Results	53
4.2.4	Comparison and Discussion	55
4.3	Genetic Pixel Selection (GPS)	55
4.3.1	Preprocessing	56
4.3.2	Training Scheme	57
4.3.3	Simulation Results	58
4.3.4	Discussion	60
4.4	Comparison	61
4.5	Summary	62

5	Discrete Cosine Transform Based Watermarking Scheme and Band Selection	63
5.1	Discrete Consine Transform (DCT)	63
5.2	DCT-Based Watermarking Scheme	64
5.2.1	Embedding Procedure	66
5.2.2	Extraction Procedure	70
5.2.3	Simulation Results	71
5.2.4	Discussion	72
5.3	Genetic Band Selection (GBS)	75
5.3.1	Training Procedure	75
5.3.2	Simulation Results	77
5.3.3	Comparison and Discussion	78
5.4	Summary	82
6	Vector Quantisation Based Watermarking Schemes and Codebook Partition	83
6.1	Introduction	83
6.2	Vector Quantisation (VQ)	84
6.2.1	Codebook Design	84
6.2.2	Encoding Procedure	85
6.2.3	Decoding Procedure	87
6.2.4	Summary	87
6.3	VQ-Based Watermarking Schemes	90
6.3.1	Lu-Sun's Method [52]	90
6.3.2	Jo-Kim's Method [43]	92
6.3.3	Wang et al.'s Method [97]	93
6.3.4	Simulation Results and Comparison	95
6.3.5	Discussions	99
6.3.6	Summary	102
6.4	Genetic Codebook Partition (GCP)	103
6.4.1	Training Scheme	103
6.4.2	Simulation Results and Comparisons	105
6.4.3	Discussion	106
6.5	Summary	107
7	Genetic Index Assignment	109
7.1	VQ-Based Gray Watermark Coding Procedure	109
7.1.1	Gray Watermark Coding	109
7.1.2	Index Assignment	110
7.1.3	Watermarking Scheme with Index Assignment	111
7.2	Genetic Index Assignment (GIA)	112
7.2.1	Steps	112
7.2.2	Details of the GIA Procedure	112
7.3	Simulation Results and Comparison	113
7.4	Summary	117

8	Genetic Watermark Modification	119
8.1	Watermark Modification	119
8.1.1	Lossless Method	119
8.1.2	Lossy Method	121
8.2	Genetic Watermark Modification (GWM)	123
8.3	Simulation Results and Comparison	125
8.3.1	Results of Lossless Method	125
8.3.2	Results of Lossy Method	126
8.4	Discussions and Summary	127
 Part III: Hybrid Systems of Digital Watermarking		
9	Watermarking Based on Multiple Description VQ	131
9.1	Multiple Description Coding (MDC)	131
9.1.1	Introduction	131
9.1.2	Index Assignment and Inverse Index Assignment	134
9.1.3	MDVQ	136
9.2	MDVQ-Based Watermarking Scheme	138
9.2.1	Watermark Embedding	138
9.2.2	Watermark Extraction	140
9.3	Codebook Partition	143
9.4	Simulation Results	143
9.5	Discussion and Summary	148
10	Fake Watermark Embedding Scheme Based on Multi-Stage VQ	151
10.1	Introduction	151
10.1.1	Multi-Stage Vector Quantisation (MSVQ)	152
10.1.2	MSVQ-Based Watermarking Scheme	153
10.2	Fake Watermark Embedding System	156
10.2.1	Encryption and Decryption for Watermarks	156
10.2.2	Embedding and Extraction Procedures	157
10.3	Simulation Results	158
10.4	Summary	161
11	Watermarking with Visual Cryptography and Gain-Shape VQ	163
11.1	Introduction	163
11.1.1	Visual Cryptography	164
11.1.2	Gain-Shape Vector Quantisation (GSVQ)	166
11.2	Watermarking Method	167
11.2.1	Modified Splitting Procedure and Stacking Procedure	167
11.2.2	Watermarking Algorithm	169
11.3	Simulation Results	171
11.4	Summary	172

Part IV: Summary

12 Conclusions and Future Directions	175
12.1 Conclusions of This Book	175
12.2 Future Directions	176
12.2.1 New Watermarking Algorithms	177
12.2.2 New Applications and Utilities	177
12.2.3 Performance Improvement	177
12.2.4 Others	178
References	179
Index	185

List of Abbreviations

ANN	= Artificial Neural Network
ART	= Adaptive Resonance Theory
BCR	= Bit Correct Rate
BER	= Bit Error Rate
DCT	= Discrete Cosine Transform
DWT	= Discrete Wavelet Transform
EA	= Evolutionary Algorithm
EANN	= Evolutionary Artificial Neural Network
ED	= Euclidean Distance
GA	= Genetic Algorithm
GCP	= Genetic Codebook Partition
GIA	= Genetic Index Assignment
GPS	= Genetic Pixel Selection
GSVQ	= Gain-Shape Vector Quantisation
GWM	= Genetic Watermark Modification
JPEG	= Joint Photographic Experts Group
LBG	= Linde-Buzo-Gray (Algorithm)
LSB	= Last Significant Bit

MDC	= Multiple Description Coding
MDSQ	= Multiple Description Scale Quantisation
MDVQ	= Multiple Description Vector Quantisation
MSE	= Mean Squared Error
MSVQ	= Multi-Stage Vector Quantisation
NC	= Normalized Correction
NN	= Neural Network
PSNR	= Peak Signal-to-Noise Ratio
QF	= Quality Factor
SNR	= Signal-to-Noise Ratio
SOM	= Self-Organising Map
TS	= Tabu Search
VC	= Visual Cryptography
VQ	= Vector Quantisation
VSS	= Visual Secret Sharing