

Advances in Intelligent Systems and Computing 553

Sanjiv K. Bhatia
Krishn K. Mishra
Shailesh Tiwari
Vivek Kumar Singh *Editors*

Advances in Computer and Computational Sciences

Proceedings of ICCCCS 2016, Volume 1

 Springer

Advances in Intelligent Systems and Computing

Volume 553

Series editor

Janusz Kacprzyk, Polish Academy of Sciences, Warsaw, Poland
e-mail: kacprzyk@ibspan.waw.pl

About this Series

The series “Advances in Intelligent Systems and Computing” contains publications on theory, applications, and design methods of Intelligent Systems and Intelligent Computing. Virtually all disciplines such as engineering, natural sciences, computer and information science, ICT, economics, business, e-commerce, environment, healthcare, life science are covered. The list of topics spans all the areas of modern intelligent systems and computing.

The publications within “Advances in Intelligent Systems and Computing” are primarily textbooks and proceedings of important conferences, symposia and congresses. They cover significant recent developments in the field, both of a foundational and applicable character. An important characteristic feature of the series is the short publication time and world-wide distribution. This permits a rapid and broad dissemination of research results.

Advisory Board

Chairman

Nikhil R. Pal, Indian Statistical Institute, Kolkata, India
e-mail: nikhil@isical.ac.in

Members

Rafael Bello Perez, Universidad Central “Marta Abreu” de Las Villas, Santa Clara, Cuba
e-mail: rbellop@uclv.edu.cu

Emilio S. Corchado, University of Salamanca, Salamanca, Spain
e-mail: escorchado@usal.es

Hani Hagras, University of Essex, Colchester, UK
e-mail: hani@essex.ac.uk

László T. Kóczy, Széchenyi István University, Győr, Hungary
e-mail: koczy@sze.hu

Vladik Kreinovich, University of Texas at El Paso, El Paso, USA
e-mail: vladik@utep.edu

Chin-Teng Lin, National Chiao Tung University, Hsinchu, Taiwan
e-mail: ctlin@mail.nctu.edu.tw

Jie Lu, University of Technology, Sydney, Australia
e-mail: Jie.Lu@uts.edu.au

Patricia Melin, Tijuana Institute of Technology, Tijuana, Mexico
e-mail: epmelin@hafsamx.org

Nadia Nedjah, State University of Rio de Janeiro, Rio de Janeiro, Brazil
e-mail: nadia@eng.uerj.br

Ngoc Thanh Nguyen, Wroclaw University of Technology, Wroclaw, Poland
e-mail: Ngoc-Thanh.Nguyen@pwr.edu.pl

Jun Wang, The Chinese University of Hong Kong, Shatin, Hong Kong
e-mail: jwang@mae.cuhk.edu.hk

More information about this series at <http://www.springer.com/series/11156>

Sanjiv K. Bhatia · Krishn K. Mishra
Shailesh Tiwari · Vivek Kumar Singh
Editors

Advances in Computer and Computational Sciences

Proceedings of ICCCCS 2016, Volume 1

 Springer

Editors

Sanjiv K. Bhatia
Department of Computer Science
University of Missouri
Columbia, MO
USA

Shailesh Tiwari
Department of Computer Science
and Engineering
ABES Engineering College
Ghaziabad, Uttar Pradesh
India

Krishn K. Mishra
Department of Computer Science
and Engineering
Motilal Nehru National Institute
of Technology
Allahabad, Uttar Pradesh
India

Vivek Kumar Singh
Banaras Hindu University
Varanasi, Uttar Pradesh
India

ISSN 2194-5357

ISSN 2194-5365 (electronic)

Advances in Intelligent Systems and Computing

ISBN 978-981-10-3769-6

ISBN 978-981-10-3770-2 (eBook)

DOI 10.1007/978-981-10-3770-2

Library of Congress Control Number: 2017931526

© Springer Nature Singapore Pte Ltd. 2017

This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.

The use of general descriptive names, registered names, trademarks, service marks, 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.

The publisher, the authors and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, express or implied, with respect to the material contained herein or for any errors or omissions that may have been made. The publisher remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Printed on acid-free paper

This Springer imprint is published by Springer Nature

The registered company is Springer Nature Singapore Pte Ltd.

The registered company address is: 152 Beach Road, #21-01/04 Gateway East, Singapore 189721, Singapore

Preface

The ICCCS is a major multidisciplinary conference organized with the objective of bringing together researchers, developers and practitioners from academia and industry working in all areas of computer and computational sciences. It is organized specifically to help computer industry to derive the advances of next generation computer and communication technology. The invited researchers present the latest developments and technical solutions.

Technological developments all over the world are dependent upon globalization of various research activities. Exchange of information and innovative ideas are necessary to accelerate the development of technology. Keeping this ideology in preference, Aryabhata College of Engineering & Research Center, Ajmer, India has come up with an event—International Conference on Computer, Communication and Computational Sciences (ICCCS-2016) during August 12–13, 2016.

Ajmer is situated in the heart of India; just over 130 km southwest of Jaipur, a burgeoning town on the shore of the Ana Sagar Lake, flanked by barren hills. Ajmer has historical strategic importance and was ransacked by Mohammed Gauri on one of his periodic forays from Afghanistan. Later, it became a favorite residence of the mighty Mughals. The city was handed over to the British in 1818, becoming one of the few places in Rajasthan controlled directly by the British rather than being part of a princely state. The British chose Ajmer as the site for Mayo College, a prestigious school opened in 1875 exclusively for the Indian Princes, but today open to all those who can afford the fees. Ajmer is a perfect place that can be symbolized for demonstration of Indian culture, ethics and display of perfect blend of wide plethora of diverse religion, community, culture, linguistics, etc., all coexisting and flourishing in peace and harmony. This city is known for the famous Dargah Sharif, Pushkar Lake, Brahma Temple and many more evidences of history.

This is the First time Aryabhata College of Engineering & Research Center, Ajmer, India is organizing International Conference on Computer, Communication and Computational Sciences (ICCCS 2016), with a foreseen objective of enhancing the research activities at a large scale. Technical Program Committee and

Advisory Board of ICCCCS include eminent academicians, researchers and practitioners from abroad as well as from all over the nation.

In this volume, selected manuscripts have been subdivided into various tracks named ‘Intelligent Hardware and Software Design’, ‘Advanced Communications’, ‘Power and Energy Optimization’, ‘Intelligent Image Processing’, ‘Advanced Software Engineering’, ‘IoT’, ‘ADBMS & Security’, ‘Evolutionary and Soft Computing’. A sincere effort has been made to make it an immense source of knowledge for all and includes 147 manuscripts. The selected manuscripts have gone through a rigorous review process and are revised by authors after incorporating the suggestions of the reviewers.

ICCCCS 2016 received 429 submissions from around 729 authors of 12 different countries such as USA, Iceland, China, Saudi Arabia, South Africa, Taiwan, Malaysia and many more. Each submission has been checked with anti-plagiarism software. On the basis of plagiarism report, each submission was rigorously reviewed by at least two reviewers with an average of 2.45 reviewers per review. Even some submissions have more than two reviews. On the basis of these reviews, 140 high-quality papers were selected for publication in this proceedings volume, with an acceptance rate of 32.6%.

We are thankful to the speakers, delegates and the authors for their participation and their interest in ICCCCS as a platform to share their ideas and innovation. We are also thankful to the Prof. Dr. Janusz Kacprzyk, Series Editor, AISC, Springer and Mr. Aninda Bose, Senior Editor, Hard Sciences, Springer for providing continuous guidance and support. Also, we extend our heartfelt gratitude to the reviewers and Technical Program Committee Members for showing their concern and efforts in the review process. We are indeed thankful to everyone directly or indirectly associated with the conference organizing team for leading it towards the success.

Although utmost care has been taken in compilation and editing, however, a few errors may still occur. We request the participants to bear with such errors and lapses (if any). We wish you all the best.

Organizing Committee
ICCCCS 2016

Organizing Committee

General Chair

Dr. Amit Shastri, Chairman, Aryabhata Academic Society, Ajmer, India

Program Chairs

Dr. Krishn K. Mishra, Motilal Nehru National Institute of Technology Allahabad, India

Dr. Munesh C. Trivedi, ABES Engineering College, Ghaziabad, India

Conference Chair

Dr. Shailesh Tiwari, ABES Engineering College, Ghaziabad, India

Conference Co-Chair

Mr. Ashish Guwalani, ACERC, Ajmer, India

TPC Chairs

Prof. Nitin Singh, Motilal Nehru National Institute of Technology Allahabad, India

Dr. Vishal Bhatnagar, IAICTR, Delhi, India

TPC Co-Chair

Dr. Sanjay Mathur, ACERC, Ajmer, India

Publication Chairs

Dr. Deepak Kumar Singh, Sachdeva Institute of Technology, Mathura, India

Dr. Pragna Dwivedi, MNNIT Allahabad, India

Publication Co-Chair

Mr. Gaurav Phulwari, ACERC, Ajmer, India

Publicity Chairs

Dr. Anil Dubey, Government Engineering College, Ajmer, India

Dr. Deepak Kumar, Amity University, Noida, India

Dr. Nitin Rakesh, Amity University, Noida, India

Dr. Ravi Prasad Valluru, Narayana Engineering College Nellore, AP, India

Dr. Sushant Upadyaya, MNIT, Jaipur, India
Dr. Akshay Girdhar, GNDEC, Ludhiana, India

Publicity Co-Chair

Mr. Surendra Singh, ACERC, Ajmer, India

Tutorial Chairs

Prof. Lokesh Garg, Delhi College of Technology & Management, Haryana, India

Tutorial Co-Chair

Mr. Ankit Mutha, ACERC, Ajmer, India

Technical Program Committee

Prof. Ajay Gupta, Western Michigan University, USA
Prof. Babita Gupta, California State University, USA
Prof. Amit K.R. Chowdhury, University of California, USA
Prof. David M. Harvey, G.E.R.I., UK
Prof. Madjid Merabti, Liverpool John Moores University, UK
Dr. Nesimi Ertugrul, University of Adelaide, Australia
Prof. Ian L. Freeston, University of Sheffield, UK
Prof. Witold Kinsner, University of Manitoba, Canada
Prof. Anup Kumar, M.I.N.D.S., University of Louisville, USA
Prof. Prabhat Kumar Mahanti, University of New Brunswick, Canada
Prof. Ashok De, Director, NIT Patna, India
Prof. Kuldip Singh, IIT Roorkee, India
Prof. A.K. Tiwari, IIT, BHU, Varanasi, India
Mr. Suryabhan, ACERC, Ajmer, India
Dr. Vivek Singh, BHU, India
Prof. Abdul Quaiyum Ansari, Jamia Millia Islamia, New Delhi, India
Prof. Aditya Trivedi, ABV-IIITM Gwalior, India
Prof. Ajay Kakkar, Thapar University, Patiala, India
Prof. Bharat Bhaskar, IIM Lucknow, India
Prof. Edward David Moreno, Federal University of Sergipe, Brazil
Prof. Evangelos Kranakis, Carleton University
Prof. Filipe Miguel Lopes Meneses, University of Minho, Portugal
Prof. Giovanni Manassero Junior, Universidade de São Paulo, Brazil
Prof. Gregorio Martinez, University of Murcia, Spain
Prof. Pabitra Mitra, Indian Institute of Technology Kharagpur, India
Prof. Joberto Martins, Salvador University-UNIFACS, Brazil
Prof. K. Mustafa, Jamia Millia Islamia, New Delhi, India
Prof. M.M. Sufyan Beg, Jamia Millia Islamia, New Delhi, India
Prof. Jitendra Agrawal, Rajiv Gandhi Pradyogiki Vishwavidyalaya, Bhopal, M.P., India
Prof. Rajesh Baliram Ingle, PICT, University of Pune, India

Prof. Romulo Alexander Ellery de Alencar, University of Fortaleza, Brazil
Prof. Youssef Fakhri, Université Ibn Tofail, Faculté des Sciences, Brazil
Dr. Abanish Singh, Bioinformatics Scientist, USA
Dr. Abbas Cheddad, (UCMM), Umeå Universitet, Umeå, Sweden
Dr. Abraham T. Mathew, NIT, Calicut, Kerala, India
Dr. Adam Scmidt, Poznan University of Technology, Poland
Dr. Agostinho L.S. Castro, Federal University of Para, Brazil
Prof. Goo-Rak Kwon, Chosun University, Republic of Korea
Dr. Alberto Yúfera, Instituto de Microelectrónica de Sevilla (IMSE), (CNM), Spain
Dr. Adam Scmidt, Poznan University of Technology, Poland
Prof. Nishant Doshi, S.V. National Institute of Technology, Surat, India
Prof. Gautam Sanyal, NIT Durgapur, India
Dr. Agostinho L.S. Castro, Federal University of Para, Brazil
Dr. Alok Chakrabarty, IIIT Bhubaneswar, India
Dr. Anastasios Tefas, Aristotle University of Thessaloniki
Dr. Anirban Sarkar, NIT Durgapur, India
Dr. Anjali Sardana, IIIT Roorkee, Uttarakhand, India
Dr. Ariffin Abdul Mutalib, Universiti Utara Malaysia
Dr. Ashok Kumar Das, IIIT Hyderabad
Dr. Ashutosh Saxena, Infosys Technologies Ltd., India
Dr. Balasubramanian Raman, IIT Roorkee, India
Dr. Benahmed Khelifa, Liverpool John Moores University, UK
Dr. Björn Schuller, Technical University of Munich, Germany
Dr. Carole Bassil, Lebanese University, Lebanon
Dr. Chao MA, Hong Kong Polytechnic University
Dr. Chi-Un Lei, University of Hong Kong
Dr. Ching-Hao Lai, Institute for Information Industry
Dr. Ching-Hao Mao, Institute for Information Industry, Taiwan
Dr. Chung-Hua Chu, National Taichung Institute of Technology, Taiwan
Dr. Chunye Gong, National University of Defense Technology
Dr. Cristina Olaverri Monreal, Instituto de Telecomunicacoes, Portugal
Dr. Chittaranjan Hota, BITS Hyderabad, India
Dr. D. Juan Carlos González Moreno, University of Vigo
Dr. Danda B. Rawat, Old Dominion University
Dr. Davide Ariu, University of Cagliari, Italy
Dr. Dimiter G. Velev, University of National and World Economy, Europe
Dr. D.S. Yadav, South Asian University, New Delhi
Dr. Darius M. Dziuda, Central Connecticut State University
Dr. Dimitrios Koukopoulos, University of Western Greece, Greece
Dr. Durga Prasad Mohapatra, NIT-Rourkela, India
Dr. Eric Renault, Institut Telecom, France
Dr. Felipe RudgeBarbosa, University of Campinas, Brasil
Dr. Fermín Galán Márquez, Telefónica I+D, Spain
Dr. Fernando Zacarias Flores, Autonomous University of Puebla
Dr. Fuu-Cheng Jiang, Tunghai University, Taiwan

Prof. Aniello Castiglione, University of Salerno, Italy
Dr. Geng Yang, NUPT, Nanjing, People's Republic of China
Dr. Gadadhar Sahoo, BIT-Mesra, India
Prof. Ashokk Das, International Institute of Information Technology, Hyderabad, India
Dr. Gang Wang, Hefei University of Technology
Dr. Gerard Damm, Alcatel-Lucent
Prof. Liang Gu, Yale University, New Haven, CT, USA
Prof. K.K. Pattanaik, ABV-Indian Institute of Information Technology and Management, Gwalior, India
Dr. Germano Lambert-Torres, Itajuba Federal University
Dr. Guang Jin, Intelligent Automation, Inc
Dr. Hardi Hungar, Carl von Ossietzky University Oldenburg, Germany
Dr. Hongbo Zhou, Southern Illinois University Carbondale
Dr. Huei-Ru Tseng, Industrial Technology Research Institute, Taiwan
Dr. Hussein Attia, University of Waterloo, Canada
Prof. Hong-Jie Dai, Taipei Medical University, Taiwan
Prof. Edward David, UFS—Federal University of Sergipe, Brazil
Dr. Ivan Saraiva Silva, Federal University of Piau , Brazil
Dr. Luigi Cerulo, University of Sannio, Italy
Dr. J. Emerson Raja, Engineering and Technology of Multimedia University, Malaysia
Dr. J. Satheesh Kumar, Bharathiar University, Coimbatore
Dr. Jacobijn Sandberg, University of Amsterdam
Dr. Jagannath V. Aghav, College of Engineering Pune, India
Dr. Jaume Mathieu, LIP6 UPMC, France
Dr. Jen-Jee Chen, National University of Tainan
Dr. Jitender Kumar Chhabra, NIT-Kurukshetra, India
Dr. John Karamitsos, Tokk Communications, Canada
Dr. Jose M. Alcaraz Calero, University of the West of Scotland, UK
Dr. K.K. Shukla, IT-BHU, India
Dr. K.R. Pardusani, Maulana Azad NIT, Bhopal, India
Dr. Kapil Kumar Gupta, Accenture
Dr. Kuan-Wei Lee, I-Shou University, Taiwan
Dr. Lalit Awasthi, NIT Hamirpur, India
Dr. Maninder Singh, Thapar University, Patiala, India
Dr. Mehul S. Raval, DA-IICT, Gujarat, India
Dr. Michael McGuire, University of Victoria, Canada
Dr. Mohamed Naouai, University Tunis El Manar and University of Strasbourg, Tunisia
Dr. Nasimuddin, Institute for Infocomm Research
Dr. Olga C. Santos, aDeNu Research Group, UNED, Spain
Dr. Pramod Kumar Singh, ABV-IIITM Gwalior, India
Dr. Prasanta K. Jana, IIT, Dhanbad, India
Dr. Preetam Ghosh, Virginia Commonwealth University, USA

Dr. Rabeb Mizouni, (KUSTAR), Abu Dhabi, UAE
 Dr. Rahul Khanna, Intel Corporation, USA
 Dr. Rajeev Srivastava, CSE, ITBHU, India
 Dr. Rajesh Kumar, MNIT, Jaipur, India
 Dr. Rajesh Bodade, Military College of Telecommunication, Mhow, India
 Dr. Rajesh Kumar, MNIT, Jaipur, India
 Dr. Ranjit Roy, SVNIT, Surat, Gujarat, India
 Dr. Robert Koch, Bundeswehr University München, Germany
 Dr. Ricardo J. Rodriguez, Nova Southeastern University, USA
 Dr. Ruggero Donida Labati, Università degli Studi di Milano, Italy
 Dr. Rustem Popa, University “Dunarea de Jos” in Galati, Romania
 Dr. Shailesh Ramchandra Sathe, VNIT Nagpur, India
 Dr. Sanjiv K. Bhatia, University of Missouri—St. Louis, USA
 Dr. Sanjeev Gupta, DA-IICT, Gujarat, India
 Dr. S. Selvakumar, National Institute of Technology, Tamil Nadu, India
 Dr. Saurabh Chaudhury, NIT Silchar, Assam, India
 Dr. Shijo. M. Joseph, Kannur University, Kerala
 Dr. Sim Hiew Moi, University Technology of Malaysia
 Dr. Syed Mohammed Shamsul Islam, The University of Western Australia, Australia
 Dr. Trapti Jain, IIT Mandi, India
 Dr. Tilak Thakur, PED, Chandigarh, India
 Dr. Vikram Goyal, IIIT Delhi, India
 Dr. Vinaya Mahesh Sawant, D.J. Sanghvi College of Engineering, India
 Dr. Vanitha Rani Rentapalli, VITS Andhra Pradesh, India
 Dr. Victor Govindaswamy, Texas A&M University-Texarkana, USA
 Dr. Victor Hinojosa, Universidad Autónoma de Ciudad Juárez
 Dr. Vidyasagar Potdar, Curtin University of Technology, Australia
 Dr. Vijaykumar Chakka, DAICT, Gandhinagar, India
 Dr. Yong Wang, School of IS & E, Central South University, China
 Dr. Yu Yuan, Samsung Information Systems America—San Jose, CA
 Eng. Angelos Lazaris, University of Southern California, USA
 Mr. Hrvoje Belani, University of Zagreb, Croatia
 Mr. Huan Song, SuperMicro Computer, Inc., San Jose, USA
 Mr. K.K Patnaik, IIITM, Gwalior, India
 Dr. S.S. Sarangdevot, Vice Chancellor, JRN Rajasthan Vidyapeeth University, Udaipur
 Dr. N.N. Jani, KSV University Gandhi Nagar, India
 Dr. Ashok K. Patel, North Gujarat University, Patan, Gujarat, India
 Dr. Awadhesh Gupta, IMS, Ghaziabad, India
 Dr. Dilip Sharma, GLA University, Mathura, India
 Dr. Li Jiyun, Donghua University, Shanghai, China
 Dr. Lingfeng Wang, University of Toledo, USA
 Dr. Valentina E. Balas, Aurel Vlaicu University of Arad, Romania
 Dr. Vinay Rishiwal, MJP Rohilkhand University, Bareilly, India

Dr. Vishal Bhatnagar, Ambedkar Institute of Technology, New Delhi, India
Dr. Tarun Shrimali, Sunrise Group of Institutions, Udaipur, India
Dr. Atul Patel, CU Shah University, Vadhwan, Gujrat, India
Dr. P.V. Virparia, Sardar Patel University, VV Nagar, India
Dr. D.B. Choksi, Sardar Patel University, VV Nagar, India
Dr. Ashish N. Jani, KSV University Gandhi Nagar, India
Dr. Sanjay M. Shah, KSV University Gandhi Nagar, India
Dr. Vijay M. Chavda, KSV University Gandhi Nagar, India
Dr. B.S. Agarwal, KIT Kalol, India
Dr. Apurv Desai, South Gujrat University, Surat, India
Dr. Chitra Dhawale, Nagpur, India
Dr. Bikas Kumar, Pune, India
Dr. Nidhi Divecha, Gandhi Nagar, India
Dr. Jay Kumar Patel, Gandhi Nagar, India
Dr. Jatin Shah, Gandhi Nagar, India
Dr. Kamaljit I. Lakhtaria, Auro University, Surat, India
Dr. B.S. Deovra, B.N. College, Udaipur, India
Dr. Ashok Jain, Maharaja College of Engineering, Udaipur, India
Dr. Bharat Singh, JRN Rajasthan Vidyapeeth University, Udaipur, India
Dr. S.K. Sharma, Pacific University Udaipur, India
Dr. Akheela Khanum, Integral University Lucknow, India
Dr. R.S. Bajpai, Ram Swaroop Memorial University, Lucknow, India
Dr. Manish Shrimali, JRN Rajasthan Vidyapeeth University, Udaipur, India
Dr. Ravi Gulati, South Gujarat University, Surat, India
Dr. Atul Gosai, Saurashtra University, Rajkot, India
Dr. Digvijai sinh Rathore, BBA Open University Ahmadabad, India
Dr. Vishal Goar, Government Engineering College, Bikaner, India
Dr. Neeraj Bhargava, MDS University Ajmer, India
Dr. Ritu Bhargava, Government Womens Engineering College, Ajmer, India
Dr. Rajender Singh Chhillar, MDU Rohtak, India
Dr. Dhaval R. Kathiriya, Saurashtra University, Rajkot, India
Dr. Vineet Sharma, KIET Ghaziabad, India
Dr. A.P. Shukla, KIET Ghaziabad, India
Dr. R.K. Manocha, Ghaziabad, India
Dr. Nandita Mishra, IMS Ghaziabad, India
Dr. Manisha Agarwal, IMS Ghaziabad
Dr. Deepika Garg, IGNOU New Delhi, India
Dr. Goutam Chakraborty, Iwate Prefectural University, Iwate Ken, Takizawa, Japan
Dr. Amit Manocha Maharaja Agrasen University, HP, India
Prof. Enrique Chirivella-Perez, University of the West of Scotland, UK
Prof. Pablo Salva Garcia, University of the West of Scotland, UK
Prof. Ricardo Marco Alaez, University of the West of Scotland, UK
Prof. Nitin Rakesh, Amity University, Noida, India
Prof. Mamta Mittal, G. B. Pant Engineering College, Delhi, India
Dr. Shashank Srivastava, MNNIT Allahabad, India

Prof. Lalit Goyal, JMI, Delhi, India
Dr. Sanjay Maurya, GLA University, Mathura, India
Prof. Alexandros Iosifidis, Tampere University of Technology, Finland
Prof. Shanthi Makka, JRE Engineering College, Greater Noida, India
Dr. Deepak Gupta, Amity University, Noida, India
Dr. Manu Vardhan, NIT Raipur, India
Dr. Sarsij Tripathi, NIT Raipur, India
Prof. Wg Edison, HeFei University of Technology, China
Dr. Atul Bansal, GLA University, Mathura, India
Dr. Alimul Haque, V.K.S. University, Bihar, India
Prof. Simhiew Moi, Universiti Teknologi Malaysia
Prof. Vinod Kumar, IIT Roorkee, India
Prof. Christos Bouras, University of Patras and RACTI, Greece
Prof. Devesh Jinwala, SVNIT, Surat, India
Prof. Germano Lambert Torres, PS Solutions, Brazil
Prof. ByoungHo Kim, Broadcom Corporation, USA
Prof. Aditya Khamparia, LPU, Punjab, India

Contents

Part I Intelligent Hardware and Software Design

Biogeography-Based Optimization for Cluster Analysis	3
Xueyan Wu, Hainan Wang, Zhimin Chen, Zhihai Lu, Preetha Phillips, Shuihua Wang and Yudong Zhang	
BTpower: An Application for Remote Controlling PowerPoint Presentation Through Smartphone	13
Md. Asraful Haque, Abu Raihan and Mohd. Danish Khalidi	
Crowd Monitoring and Classification: A Survey	21
Sonu Lamba and Neeta Nain	
A Roadmap to Identify Complexity Metrics for Measuring Usability of Component-Based Software System	33
Jyoti Agarwal, Sanjay Kumar Dubey and Rajdev Tiwari	
Smart Bike Sharing System to Make the City Even Smarter	43
Monika Rani and O.P. Vyas	
Effects of Mean Metric Value Over CK Metrics Distribution Towards Improved Software Fault Predictions	57
Pooja Kapoor, Deepak Arora and Ashwani Kumar	
Feedforward and Feedbackward Approach-Based Estimation Model for Agile Software Development	73
Saru Dhir, Deepak Kumar and V.B. Singh	
Investigation of Effectiveness of Simple Thresholding for Accurate Yawn Detection	81
Viswanath K. Reddy and K.S. Swathi	
A Survey to Structure of Directories in File System	91
Linzhu Wu and Linpeng Huang	

A User-Mode Scheduling Mechanism for ARINC653 Partitioning in seL4	105
Qiao Kang, Cangzhou Yuan, Xin Wei, Yanhua Gao and Lei Wang	
Vectorizable Design and Implementation of Matrix Multiplication on Vector Processor	115
Junyang Zhang, Yang Guo and Xiao Hu	
Construction of Test Cases for Electronic Controllers Based on Timed Automata	123
Xiaojian Liu, Junmin Li and Ting Jiang	
‘X’ Shape Slot-Based Microstrip Fractal Antenna for IEEE 802.11 WLAN	135
Ram Krishan and Vijay Laxmi	
Performance Enhancement of an E-shaped Microstrip Patch Antenna Loaded with Metamaterial	145
Akshit Kalia, Rohit Gupta, Gargi Gupta, Asmita Rajawat, Sindhu Hak Gupta and M.R. Tripathy	
Narrow Channel Multiple Frequency Microstrip Antenna with Slits	155
Manshi Nisha, Sindhu Hak Gupta, Asmita Rajawat, Monica Kaushik and Devesh Kumar	
 Part II Advanced Communications	
An Analysis of Resolution of Deadlock in Mobile Agent System Through Different Techniques	167
Rashmi Priya and R. Belwal	
Robustness Analysis of Buffer-Based Routing Algorithms in Wireless Mesh Network	177
Kanika Agarwal, Nitin Rakesh and Abha Thakral	
The Security Challenges and Opportunities of New Network Under the Hybrid Cloud Environment	191
Yuxiang Dong, Huijun Zhang and Linong Zhao	
A Linguistic Rule-Based Approach for Aspect-Level Sentiment Analysis of Movie Reviews	201
Rajesh Piryani, Vedika Gupta, Vivek Kumar Singh and Udayan Ghose	
Implementation and Statistical Comparison of Different Edge Detection Techniques	211
Deepali Srivastava, Rashi Kohli and Shubhi Gupta	

CALDUEL: Cost And Load overhead reDUCTION for route discovery in LOAD Protocol. 229
 A. Dalvin Vinoth Kumar, P.D. Sheba Kezia Malarchelvi and L. Arockiam

AASOP: An Approach to Select Optimum Path for Minimizing Data Transfer Delay in Mobile Ad-Hoc Networks 239
 R. Nismon Rio and P. Calduwel Newton

Resource Factor-Based Leader Election for Ring Networks 251
 Tarun Biswas, Anjan Kumar Ray, Pratyay Kuila and Sangram Ray

TACA: Throughput Aware Call Admission Control Algorithm for VoIP Users in Mobile Networks. 259
 P. Calduwel Newton and K. Ramkumar

A Literature Survey on Detection and Prevention Against Vampire Attack in WSN 271
 Richa Kumari and Pankaj Kumar Sharma

Cloud-Based on Agent Model for Mobile Devices 281
 Amel Beloudane and Ghalem Belalem

Node Mobility Issues in Underwater Wireless Sensor Network. 293
 Kanika Agarwal and Nitin Rakesh

Bit Error Rate (BER) Performance Enhancement for Wireless Communication System Using Modified Turbo Codes. 305
 Garima Mahendru, Monica Kaushik, Monika Arora, Utkarsh Pandey, Apoorv Agarwal and Jagjot Singh Khokhar

A Timestamp-Based Strong Designated Verifier Signature Scheme for Next-Generation Network Security Services 311
 Asif Uddin Khan, Bikram Kesari Ratha and Srikant Mohanty

Motion Estimation Enhancement and Data Transmission Issue Over WiMAX Network. 321
 K. Sai Shivankita and Nitin Rakesh

A Reliable Tactic for Detecting Black Hole Attack in Vehicular Ad Hoc Networks 333
 Isha Dhyan, Neha Goel, Gaurav Sharma and Bhawna Mallick

On Solutions to Vehicle Routing Problems Using Swarm Optimization Techniques: A Review 345
 Ashima Gupta and Sanjay Saini

Scrutiny of VANET Protocols on the Basis of Communication Scenario and Implementation of WAVE 802.11p/1609.4 with NS3 Using SUMO	355
Arjun Arora, Nitin Rakesh and Krishn K. Mishra	
Efficient Module for OHM (Online Hybrid Model)	373
Akash Agarwal, Nitin Rakesh and Nitin Agarwal	
SANet: An Approach for Prediction in Music Trends	383
Fei Hongxiao, Chen Li, He Jiabao, Xiao Yanru and Liu Han	
Multichannel Dual Clocks Two-Dimensional Probability Random Access Protocol with Three-way Handshake Mechanism	391
Hongwei Ding, Shengjie Zhou, Kun Yue, Chunfen Li, Yifan Zhao, Zhijun Yang and Qianlin Liu	
Labeling and Encoding Hierarchical Addressing for Scalable Internet Routing	399
Feng Wang, Xiaozhe Shao, Lixin Gao, Hiroaki Harai and Kenji Fujikawa	
Link Utilization in Hybrid WiMAX-Wi-Fi Video Surveillance Systems	405
Smart C. Lubobya, Mqhele E. Dlodlo, Gerhard De Jager and Ackim Zulu	
Part III Power and Energy Optimization	
Short Term Price Forecasting Using Adaptive Generalized Neuron Model	419
Nitin Singh and S.R. Mohanty	
Design and Performance Comparison of CNTFET-Based Binary and Ternary Logic Inverter and Decoder With 32 nm CMOS Technology	429
Mayuri Khandelwal and Neha Sharan	
Optimized Route Selection on the Basis of Discontinuity and Energy Consumption in Delay-Tolerant Networks	439
Lokesh Pawar, Rohit Kumar, Swinky Arora and Amit K. Manocha	
Remote Fuel Measurement	451
Garv Modwel, Nitin Rakesh and Krishn K. Mishra	
Design and Implementation of “Reassurance Broiler Project” Traceability Platform	465
Xiao-hua Xu and Chang-xi Chen	
Implementation of Low-Power 6T SRAM Cell Using MTCMOS Technique	475
Tripti Tripathi, D.S. Chauhan, S.K. Singh and S.V. Singh	

Short-Term Electricity Price Forecasting Using Wavelet Transform Integrated Generalized Neuron 483
 Nitin Singh and Soumya R. Mohanty

Part IV Evolutionary and Soft Computing

Multiple Instance Learning Based on Twin Support Vector Machine 497
 Divya Tomar and Sonali Agarwal

Optimized Task Scheduling Using Differential Evolutionary Algorithm 509
 Somesh Singh Thakur, Siddharth Singh, Pratibha Singh and Abhishek Goyal

Adaptive Krill Herd Algorithm for Global Numerical Optimization 517
 Indrajit N. Trivedi, Amir H. Gandomi, Pradeep Jangir, Arvind Kumar, Narottam Jangir and Rahul Totlani

Sliding Mode Control of Uncertain Nonlinear Discrete Delayed Time System Using Chebyshev Neural Network 527
 Parmendra Singh, Vishal Goyal, Vinay Kumar Deolia and Tripti Nath Sharma

Artificial Bee Colony as a Frontier in Evolutionary Optimization: A Survey 541
 Divya Kumar and Krishn K. Mishra

Selection of Best State for Tourism in India by Fuzzy Approach 549
 Shalini Singh, Varsha Mundepi, Deeksha Hatwal, Vidhi Raturi, Mukesh Chand, Rashmi, Sanjay Sharma and Shwetank Avikal

Impact of Memory Space Optimization Technique on Fast Network Motif Search Algorithm 559
 Himanshu and Sarika Jain

A Novel Hybrid Approach Particle Swarm Optimizer with Moth-Flame Optimizer Algorithm 569
 R.H. Bhesdadiya, Indrajit N. Trivedi, Pradeep Jangir, Arvind Kumar, Narottam Jangir and Rahul Totlani

Differential Evolution Algorithm Using Population-Based Homeostasis Difference Vector 579
 Shailendra Pratap Singh and Anoj Kumar

Cost Effective Parameter Analysis of Real-Time Multi Core Algorithms 589
 Avantika Agarwal and Nitin Rakesh

Variant of Differential Evolution Algorithm	601
Richa Shukla, Bramah Hazela, Shashwat Shukla, Ravi Prakash and Krishn K. Mishra	
Novel Apparition Attributes to Improve Interactive Visualization	609
Khushbu Gulabani and Anil Kumar Dubey	
Five-Layered Neural Fuzzy Closed-Loop Hybrid Control System with Compound Bayesian Decision-Making Process for Classification Cum Identification of Mixed Connective Conjunct Consonants and Numerals	619
Santosh Kumar Henge and B. Rama	
UMEED-A Fuzzy Rule-Based Legal Expert System to Address Domestic Violence Against Women.	631
Chandra Prakash, Gour Sundar Mitra Thakur, Natasha Vashisht and Rajesh Kumar	
Medical Image Defects Investigation Through Reliability Computing.	639
Reshma Parveen, Satyanarayan Tazi and Anil Kumar Dubey	
An Improved Apriori Algorithm with Prejudging and Screening	649
Xuejian Zhao, Dongjun Li, Yuan Yuan, Zhixin Sun and Yong Chen	
Design and Implementation for Massively Parallel Automated Localization of Neurons for Brain Circuits.	659
Dan Zou, Hong Ye, Min Zhu, Xiaoqian Zhu, Liangyuan Zhou, Fei Xia and Lina Lu	
Research on Cross-Connect Technology for Large-Capacity and High-Speed SDH Signal	667
Zhen Zuo, Qi Lu, Yi-Meng Zhang and Yang-Yi Chen	
Design and Optimization of an Intelligent Evacuation Light System	675
WenXia Liu and Chenfei Qu	
Forty Years of BioFETOLOGY: A Research Review	687
Jiten Chandra Dutta, Purnima Kumari Sharma and Hiranya Ranjan Thakur	
Domain Based Assessment of Users' Dependency on Search Engines.	699
Nidhi Bajpai and Deepak Arora	
Literature Review on Knowledge Harvesting and Management System	711
Shachi Pathak and Shalini Nigam	

Adaptive Network Based Fuzzy Inference System for Early Diagnosis of Dengue Disease 721
Darshana Saikia and Jiten Chandra Dutta

Empowering Agile Method Feature-Driven Development by Extending It in RUP Shell. 729
Rinky Dwivedi and Vinita Rohilla

Social Media Trends and Prediction of Subjective Well-Being: A Literature Review 741
Simarpreet Singh and Pankaj Deep Kaur

Chattering Free Trajectory Tracking Control of a Robotic Manipulator Using High Order Sliding Mode 753
Ankur Goel and Akhilesh Swarup

Extraction and Enhancement of Moving Objects in a Video. 763
Sumati Manchanda and Shanu Sharma

Author Index. 773

About the Editors

Dr. Sanjiv K. Bhatia received his Ph.D. in Computer Science from the University of Nebraska, Lincoln in 1991. He presently works as Professor and Graduate Director (Computer Science) in the University of Missouri, St. Louis. His primary areas of research include image databases, digital image processing, and computer vision. He has published over 40 articles in those areas. He has also consulted extensively with industry for commercial and military applications of computer vision. He is an expert in system programming and has worked on real time and embedded applications. He serves on the organizing committee of a number of conferences and on the editorial board of international journals. He has taught a broad range of courses in computer science and was the recipient of Chancellor's Award for Excellence in Teaching in 2015. He is a senior member of ACM.

Dr. Krishn K. Mishra currently works as a Visiting Faculty, Department of Mathematics & Computer Science, University of Missouri, St. Louis, USA. He is an alumnus of Motilal Nehru National Institute of Technology Allahabad, India, which is also his base working institute. His primary area of research includes evolutionary algorithms, optimization techniques, and design and analysis of algorithms. He has published more than 50 publications in international journals and proceedings of international conferences of repute. He has served as a program committee member of several conferences and also edited Scopus and SCI-indexed journals. He has 15 years of teaching and research experience during which he made all efforts to bridge the gaps between teaching and research.

Dr. Shailesh Tiwari currently works as Professor in Computer Science and Engineering Department, ABES Engineering College, Ghaziabad, India. He is also administratively heading the department. He is an alumnus of Motilal Nehru National Institute of Technology Allahabad, India. He has more than 15 years of experience in teaching, research, and academic administration. His primary areas of research are software testing, implementation of optimization algorithms, and machine learning techniques in software engineering. He has also published more than 40 publications in international journals and proceedings of international conferences of repute. He has served as a program committee member of several

conferences and edited Scopus and E-SCI-indexed journals. He has also organized several international conferences under the banner of IEEE and Springer. He is a Senior Member of IEEE, member of IEEE Computer Society and Executive Committee member of IEEE Uttar Pradesh section. He is a member of reviewer and editorial board of several international journals and conferences.

Dr. Vivek Kumar Singh is Assistant Professor at Department of Computer Science, Banaras Hindu University, India. His major research interest lies at the area of text analytics. Currently, he is working on scientometrics, sentiment analysis, social network analysis, altmetrics, which are the broader research area of text analytics. He has developed and coordinated a text analytics laboratory, which works in various text analytics tasks. He is an alumnus of Allahabad University, Allahabad, India. He has published more than 30 publications in international journals and in proceedings of international conferences of repute. He has also served in South Asian University, Delhi, India as Assistant Professor for more than 4 years. He has also associated with several research projects such as Indo-Mexican Joint Research Project funded jointly by the Department of Science and Technology, Government of India, along with the National Council for Science and Technology (CONACYT) of the United Mexican States.

Part I
Intelligent Hardware and Software Design

Biogeography-Based Optimization for Cluster Analysis

Xueyan Wu, Hainan Wang, Zhimin Chen, Zhihai Lu,
Preetha Phillips, Shuihua Wang and Yudong Zhang

Abstract With the aim of resolving the issue of cluster analysis more precisely and validly, a new approach was proposed based on biogeography-based optimization (abbreviated as BBO) algorithm. (Method) First, we reformulated the problem with an optimization model based on the variance ratio criterion (VARAC). Then, BBO was presented to search the optimal solution of the VARAC. There are 400 data of four groups in the experimental dataset, which have the degrees of overlapping of three distinct scales. The first one is nonoverlapping, the second one is partial overlapping, and the last is severely overlapping. BBO algorithm was compared with three different state-of-the-art approaches. We ran every algorithm 20 times. In this experiment, our results demonstrate the maximum VARAC values that can be found by BBO. The conclusion is that BBO is predominant which is extremely quick for the issue of clustering analysis.

Keywords Biogeography-based optimization • Genetic algorithm • Cluster analysis

X. Wu · H. Wang · Z. Lu · S. Wang (✉) · Y. Zhang (✉)
School of Computer Science and Technology, Nanjing Normal University,
Nanjing, Jiangsu 210023, China
e-mail: wangshuihua@njnu.edu.cn

Y. Zhang
e-mail: zhangyudong@njnu.edu.cn

X. Wu
Key Laboratory of Statistical Information Technology & Data Mining,
State Statistics Bureau, Chengdu, Sichuan 610225, China

X. Wu
School of Computer and Information Engineering, Henan Normal University,
Xinxiang, Henan 453000, China

Z. Chen
School of Electronic Information, Shanghai Dianji University, Shanghai 200240, China

Z. Chen
Key Laboratory of Symbolic Computation & Knowledge Engineering of Ministry
of Education, Jilin University, Changchun, Jilin 130012, China

1 Introduction

In the context of a group, cluster analysis is defined as a case of substance with the mode that a lot of targets in a large cluster which are closer to another side than others in the additional clusters [1]. Cluster analysis is a way of unsupervised studying, and in lots of areas, it is also used for statistical data analysis in a common technique, consisting of breeding value [2], food quality monitoring [3], gene engineering [4], pediatric immunization distress [5], chronic rhinosinusitis [6], community analysis [7], etc.

Currently, various algorithms were proposed for cluster analysis. They can be basically classified into the following four categories: centroid-based clustering, distribution-based clustering, density-based clustering, and connectivity-based clustering.

In the research, the most attractive to us is centroid-based methods. In this type, there are two representative algorithms, one is fuzzy c -means clustering (FCM) [8], the other is k -means clustering [9]. These are iterative methods and affected by a lot of factors, for example, if the initial partition is not determined properly, they may stop at local best instead of global optimal solution.

To solve above the problems, Cotta and Moscato [10] proposed that the best way to detect the global optimum clustering is branch and bound algorithm. But it requires too much calculating time. In the past few years, to solve the problem of clusters, evolutionary algorithm has been proposed, because it is insensitive to initial values. Jarboui et al. [11] put forward an original clustering approach on a foundation of the combinatorial particle swarm optimization (CPSO) algorithm. Gelbard et al. [12] proposed cross-cultural research to cluster analysis with the methodology named Multi-Algorithm Voting (MAV). Niknam and Amiri [13]

Z. Lu

Guangxi Key Laboratory of Manufacturing System & Advanced
Manufacturing Technology, Guilin, Guangxi 541004, China

P. Phillips

School of Natural Sciences and Mathematics, Shepherd University,
Shepherdstown, WV 25443, USA

P. Phillips

West Virginia School of Osteopathic Medicine, 400 N Lee St, Lewisburg,
WV 24901, USA

S. Wang

Department of Electrical Engineering, The City College of New York,
CUNY, New York, NY 10031, USA

Y. Zhang

State Key Lab of CAD & CG, Zhejiang University, Hangzhou, Zhejiang 310027, China

Y. Zhang

School of Computing, Mathematics and Digital Technology (SCMDT), Manchester
Metropolitan University, Manchester M156BH, UK

thought the k -means algorithm is extremely dependent on its initial state and integration of the local best solution. Hence, they put forward to a fresh hybrid evolutionary algorithm. Huo [14] raised chaotic artificial bee colony (CABC) as one method for the issue of cluster division. Abul Hasan and Ramakrishnan [15] underwent a survey on cluster analysis about hybrid evolutionary algorithms. They believed that optimization algorithms are required for cluster analysis to obtain better results. Zhang and Wu [16] proposed bacterial foraging optimization (BFO) for cluster analysis. Kuo et al. [17] put forward an original approach named dynamic clustering on the basis of PSO and GA (DCPG) algorithm. Firefly algorithm (FFA) was used by Zhang and Li [18]. They took 400 data and divided them into four groups for testing. Yang et al. [19] proposed and explored the idea of exemplar-based clustering analysis optimized by genetic algorithms (GA). Wan [20] made a full use of the assembling analysis and researched k -means with particle swarm optimization (KPSO). Palaparthi et al. [21] researched a multi-objective optimization (MOO) channel in relevance with cluster analysis to research the vocal folds' form-function connection. On the basis of the algorithms of improved genetic, Cao and Mu [22] put forward to a weighted k -means clustering algorithm. Ozturk et al. [23] proposed a modified binary artificial bee colony algorithm. Zhou and Zhang [24] proposed a very advanced algorithm called quantum-behaved particle swarm optimization (QPSO).

Nevertheless, those above approaches are vulnerable to several disadvantages: (1) They may converge to local optimal solutions, corresponding to suboptimal results. (2) They may cost too lengthy time and cost large memory. Hence, a new algorithm, viz., biogeography-based optimization (BBO) [25] was suggested in settling the issue with this research.

The remaining portion of this paper is as follows: In Sect. 2, we define the mathematical model of partitional clustering, as well as propose the clustering criterion and encoding strategy. In Sect. 3, we describe the novel BBO method. In Sect. 4, we describe the experiment, this section includes three types of artificial data which have different overlapping degrees. In Sect. 5, we discuss about the experiment results. Finally, in Sect. 6, we conclude this paper.

2 Model Definition

Hypothesis: there are n samples $\mathbf{Q} = (q_1, q_2, \dots, q_n)$ in a d -dimensional metric space. Every sample belongs to one of the m sets. Every $q_i \in R^d$ indicates a particular feature vector that is composed of d dimension. The clusters are denoted as $\mathbf{F} = \{f_1, f_2, \dots, f_k\}$, where k represents the number of clusters. They should submit three declarations as follows:

$$\begin{aligned}
f_i &\neq \phi \quad \text{for } i = 1, 2, \dots, m \\
f_i \cap f_j &= \phi \quad (i \neq j) \\
\cup f_i &= \{q_1, q_2, q_3, \dots, q_n\}
\end{aligned} \tag{1}$$

The aim of this study is to look for the most appropriate partition F^* that corresponds to the best sufficiency among all possible solutions [26].

The search space is set to be n -dimension, which is consistent with n -objects. Every dimension not only expresses a sample but also expresses the i -th individual $Y_i = \{y_{i1}, y_{i2}, \dots, y_{in}\}$ that conforms with the affection of n samples, such as $y_{ij} \in \{1, 2, \dots, m\}$, in which j indicates the j -th sample [27].

Suppose $n = 6$ and $k = 2$. Suppose the first cluster A contains the first, second, and third object, and the second cluster B contains the fourth, fifth, and sixth object.

Figure 1 illustrates the encoded representation of the cluster solution.

Some criteria have been put forward to estimate the sufficient where a predefined dataset could be assembled. Among the partitional clustering strategies, ‘‘Variance Ratio Criterion (VARAC) [28]’’ is one of the most popular used, which is defined as

$$\text{VARAC} = \frac{E}{R} \times \frac{n-d}{d-1}, \tag{2}$$

where R and E , respectively, represents the transformation between intra-cluster and inter-cluster. Their definitions are as follows:

$$R = \sum_{j=1}^d \sum_{i=1}^{n_j} (q_j^i - \bar{q}_j)^T (q_j^i - \bar{q}_j) \tag{3}$$

$$E = \sum_{j=1}^d n_j (\bar{q}_j - \bar{q})^T (\bar{q}_j - \bar{q}), \tag{4}$$

where $(.)^T$ represents the transpose operation, n_j stands for the cardinal of the cluster f_j , q_j^i represents the i -th target allotted to f_j , which is one of the clusters, \bar{q}_j represents the center of the j -th cluster, and \bar{q} represents the center of the whole data, $(d-1)$ denotes the between-cluster variation freedom degree, while $(n-d)$ represents the within-cluster variation freedom degree.

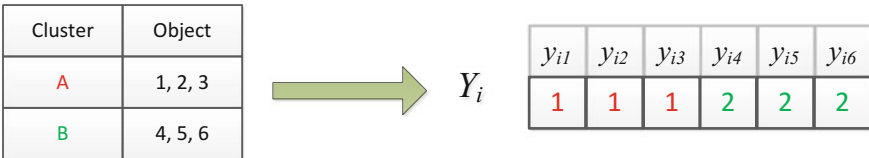


Fig. 1 Encoded representation

Generally speaking, it is expected that tight and divided clusters have important value of small R and large E . Therefore, if data partition result is much better, the value of VARAC is much larger. In order to avoid the rate to increase monotonically as the quantity of the clusters, the term $(n - d)/(d - 1)$ is normalized, which make VARAC by means of an optimization of the clusters, it can achieve maximize criterion.

3 Biogeography-Based Optimization

We gave an analogy in Fig. 2 with the well-known GA as a counterpart for making it easy to understand. As is shown in Fig. 2, the population of candidate solutions is represented as habitats in BBO [29–31]. The solution vector components are considered to be suitability index variables (SIVs). Those good solutions are considered habitat with high habitat suitability index (HSI), and vice versa [32–34]. BBO has been proven to give better performance than genetic algorithm (shorted as GA) [35], artificial bee colony (shorted as ABC) [36], firefly algorithm [37], bacterial chemotaxis optimization [38], particle swarm optimization (shorted as PSO) [39], and ant colony optimization [40]. Table 1 demonstrates the pseudocodes of BBO.

4 Experiments

The experiments were performed on a computer with i7 processor and 16 GB memory, under Windows 7 operating system.

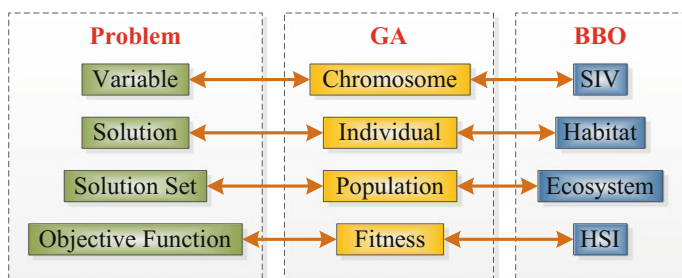


Fig. 2 The connection of optimization problem, GA, and BBO