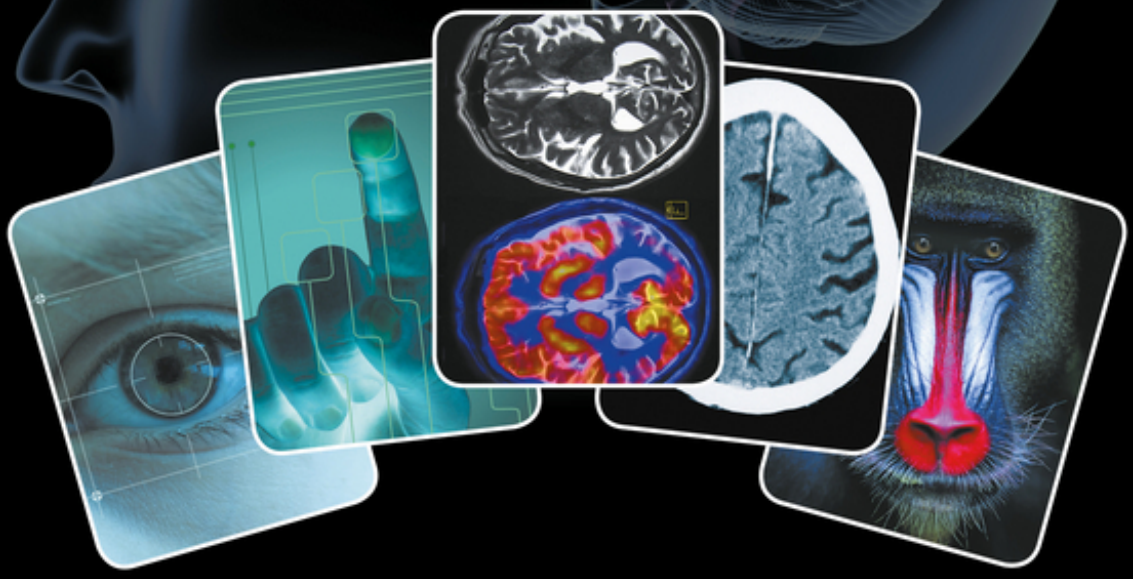
HYBRID INTELLIGENCE FOR IMAGE ANALYSIS AND UNDERSTANDING



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Hybrid Intelligence for Image Analysis and Understanding

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Dedication

Dedicated to my parents, the late Ajit Kumar Bhattacharyya and the late Hashi Bhattacharyya; my beloved wife, Rashni; my elder sisters, Tamali, Sheuli, and Barnali; my cousin sisters, Sutapa, Mousumi, and Soma; and all my students, who have made this journey enjoyable.

Dr. Siddhartha Bhattacharyya

Dedicated to all my students.

Dr. Indrajit Pan

Dedicated to my respected teachers.

Dr. Anirban Mukherjee

Dedicated to my parents, the late Arun Kanti Dutta and Mrs. Bandana Dutta.

Dr. Paramartha Dutta

Contents

Editor Biographies

Dr Siddhartha Bhattacharyya earned his bachelor's in Physics, bachelor's in Optics and Optoelectronics, and master's in Optics and Optoelectronics from University of Calcutta, India, in 1995, 1998, and 2000, respectively. He completed a PhD in computer science and engineering from Jadavpur University, India, in 2008. He is the recipient of the University Gold Medal from the University of Calcutta for his master's in 2012. He is also the recipient of the coveted **ADARSH VIDYA SARASWATI RASHTRIYA PURASKAR** for excellence in education and research in 2016. He is the recipient of the **Distinguished HoD Award** and **Distinguished Professor Award** conferred by Computer Society of India, Mumbai Chapter, India in 2017. He is also the recipient of the coveted **Bhartiya Shiksha Ratan Award** conferred by Economic Growth Foundation, New Delhi in 2017.

He is currently the Principal of RCC Institute of Information Technology, Kolkata, India. In addition, he is serving as the Dean of Research and Development of the institute from November 2013. Prior to this, he was the Professor and Head of Information Technology of RCC Institute of Information Technology, Kolkata, India, from 2014 to 2017. Before this, he was an Associate Professor of Information Technology in the same institute, from 2011 to 2014. Before that, he served as an Assistant Professor in Computer Science and Information Technology of University Institute of Technology, The University of Burdwan, India, from 2005 to 2011. He was a Lecturer in Information Technology of Kalyani Government Engineering College, India, during 2001–2005. He is a coauthor of four books and the coeditor of eight books, and has more than 175 research publications in international journals and conference proceedings to his credit. He has got a patent on intelligent colorimeter technology. He was the convener of the AICTE-IEEE National Conference on Computing and Communication Systems (CoCoSys-09) in 2009. He was the member of the Young Researchers' Committee of the WSC 2008 Online World Conference on Soft Computing in Industrial Applications. He has been the member of the organizing and technical program committees of several national and international conferences. He served as the Editor-in-Chief of *International Journal of Ambient Computing and Intelligence* (IJACI) published by IGI Global (Hershey, PA, USA) from July 17, 2014, to November 6, 2014. He was the General Chair of the IEEE International Conference on Computational Intelligence and Communication Networks (ICCICN 2014) organized by the Department of Information Technology, RCC Institute of Information Technology, Kolkata, in association with Machine Intelligence Research Labs, Gwalior, and IEEE Young Professionals, Kolkata Section; it was held at Kolkata, India, in 2014. He is the Associate Editor of *International Journal*

of Pattern Recognition Research. He is the member of the editorial board of *International Journal of Engineering, Science and Technology* and *ACCENTS Transactions on Information Security* (ATIS). He is also the member of the editorial advisory board of HETC *Journal of Computer Engineering and Applications*. He has been the Associate Editor of the *International Journal of BioInfo Soft Computing* since 2013. He is the Lead Guest Editor of the Special Issue on *Hybrid Intelligent Techniques for Image Analysis and Understanding of Applied Soft Computing* (Elsevier, Amsterdam). He was the General Chair of the 2015 IEEE International Conference on Research in Computational Intelligence and Communication Networks (ICRCICN 2015) organized by the Department of Information Technology, RCC Institute of Information Technology, Kolkata, in association with IEEE Young Professionals, Kolkata Section and held at Kolkata, India, in 2015. He is the Lead Guest Editor of the Special Issue on Computational Intelligence and Communications in *International Journal of Computers and Applications* (IJCA) (Taylor & Francis, London) in 2016. He has been the Issue Editor of *International Journal of Pattern Recognition Research* since January 2016. He was the General Chair of the 2016 International Conference on Wireless Communications, Network Security and Signal Processing (WCNSSP2016) held during June 26–27, 2016, at Chiang Mai, Thailand. He is the member of the editorial board of *Applied Soft Computing* (Elsevier, Amsterdam).

He has visited several leading universities in several countries like China, Thailand, and Japan for delivering invited lectures. His research interests include soft computing, pattern recognition, multimedia data processing, hybrid intelligence, and quantum computing. Dr Bhattacharyya is a Fellow of Institute of Electronics and Telecommunication Engineers (IETE), India. He is a senior member of Institute of Electrical and Electronics Engineers (IEEE), USA; Association for Computing Machinery (ACM), USA; and International Engineering and Technology Institute (IETI), Hong Kong. He is a member of International Rough Set Society, International Association for Engineers (IAENG), Hong Kong; Computer Science Teachers Association (CSTA), USA; International Association of Academicians, Scholars, Scientists and Engineers (IAASSE), USA; Institution of Engineering and Technology (IET), UK; and Institute of Doctors Engineers and Scientists (IDES), India. He is a life member of Computer Society of India, Optical Society of India, Indian Society for Technical Education, and Center for Education Growth and Research, India.

Dr Indrajit Pan has done his BE in Computer Science and Engineering with Honors from The University of Burdwan in 2005; M.Tech. in Information Technology from Bengal Engineering and Science University, Shibpur, in 2009; and PhD (Engg.) from Indian Institute of Engineering Science and Technology, Shibpur, in 2015. He is the recipient of BESU, University Medal for securing first rank in M.Tech. (IT). He has a couple of national- and international-level research publications and book chapters to his credit. He has attended several international conferences, national-level faculty development programs, workshops, and symposiums.

In this Institute, his primary responsibility is teaching and project guidance at UG (B.Tech.) and PG (M.Tech. and MCA) levels as Assistant Professor of Information Technology (erstwhile Lecturer since joining in February 2006). Apart from this, he has carried out additional responsibility of Single Point of Contact (SPoC) for Infosys Campus Connect Initiative in 2009–2011, and Coordinator of Institute-level UG Project Committee in 2008–2010. At present, his additional responsibility includes Nodal Officer of Institutional Reforms for TEQIP–II Project since 2011 and Member Secretary of

Academic Council since 2013. Apart from these, he has actively served as an organizing member of several Faculty Development Programs and International Conferences (ICCICN 2014) for RCCIIT. He has also acted as the Session Chair in an International Conference (ICACCI 2013) and Member of Technical Committee for FICTA 2014. Before joining RCCIIT, Indrajit served Siliguri Institute of Technology, Darjeeling, as a Lecturer in CSE/IT from 2005 to 2006.

Indrajit is a Member of Institute of Electrical and Electronics Engineers (IEEE), USA; and Association for Computing Machinery (ACM), USA.

Dr Anirban Mukherjee did his bachelor's in Civil Engineering in 1994 from Jadavpur University, Kolkata. While in service, he achieved a professional Diploma in Operations Management (PGDOM) in 1998 and completed his PhD on *Automatic Diagram Drawing based on Natural Language Text Understanding* from Indian Institute of Engineering, Science and Technology (IIEST), Shibpur, in 2014. Serving RCC Institute of Information Technology (RCCIIT), Kolkata, since its inception (in 1999), he is currently an Associate Professor and Head of the Department of Engineering Science & Management at RCCIIT. Before joining RCCIIT, he served as an Engineer in the Scientific & Technical Application Group in erstwhile RCC, Calcutta, for six years. His research interest includes computer graphics, computational intelligence, optimization, and assistive technology. He has coauthored two UG engineering textbooks: one on *Computer Graphics and Multimedia* and another on *Engineering Mechanics*. He has also coauthored more than 18 books on Computer Graphics/Multimedia for distance learning courses He holds BBA/MBA/BCA/MCA/B.Sc (Comp.Sc.)/M.Sc (IT) of different universities of India. He has a few international journal articles, book chapters, and conference papers to his credit. He is in the editorial board of *International Journal of Ambient Computing and Intelligence* (IJACI).

Dr Paramartha Dutta, born 1966, did his bachelor's and master's in Statistics from the Indian Statistical Institute, Calcutta, in the years 1988 and 1990, respectively. He afterward completed his master's degree of technology in Computer Science from the same Institute in 1993, and PhD in engineering from the Bengal Engineering and Science University, Shibpur, in 2005, respectively. He has served in the capacity of research personnel in various projects funded by Government of India, which include DRDO, CSIR, Indian Statistical Institute, Calcutta, and others. Dr Dutta is now a Professor in the Department of Computer and System Sciences of the Visva Bharati University, West Bengal, India. Prior to this, he served Kalyani Government Engineering College and College of Engineering in West Bengal as a full-time faculty member. Dr Dutta remained associated as Visiting/Guest Faculty of several universities and institutes, such as West Bengal University of Technology, Kalyani University, and Tripura University. He has coauthored eight books and has also five edited books to his credit. He has published about 185 papers in various journals and conference proceedings, both international and national; as well as several book chapters in edited volumes of reputed international publishing houses like Elsevier, Springer-Verlag, CRC Press, and John Wiley, to name a few.

Dr Dutta has guided three scholars who already had been awarded their PhD. Presently, he is supervising six scholars for their PhD program. Dr Dutta has served as editor of special volumes of several international journals published by publishers of international repute such as Springer. Dr Dutta, as investigator, could implement successfully projects funded by AICTE, DST of the Government of India.

Prof. Dutta has served/serves in the capacity of external member of boards of studies of relevant departments of various universities encompassing West Bengal University of Technology, Kalyani University, Tripura University, Assam University, and Silchar, to name a few. He had the opportunity to serve as the expert of several interview boards conducted by West Bengal Public Service Commission, Assam University, Silchar, National Institute of Technology, Arunachal Pradesh, Sambalpur University, and so on.

Dr Dutta is a Life Fellow of the Optical Society of India (OSI); Computer Society of India (CSI); Indian Science Congress Association (ISCA); Indian Society for Technical Education (ISTE); Indian Unit of Pattern Recognition and Artificial Intelligence (IUPRAI) – the Indian affiliate of the International Association for Pattern Recognition (IAPR); and senior member of Associated Computing Machinery (ACM); IEEE Computer Society, USA; and IACSIT.

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Foreword

Image analysis and understanding have been daunting tasks in computer vision given the high level of uncertainty involved therein. At the same time, a proper analysis of images plays a key role in many real-life applications. Examples of applications include image processing, image mining, image inpainting, video surveillance, and intelligent transportation systems, to name a few. Albeit there exists a plethora of classical techniques for addressing the problem of image analysis, which include filtering, hierarchical morphologic algorithms, 2D histograms, mean shift clustering, and graph-based segmentation, most of these techniques often fall short owing to their incapability in handling inherent real-life uncertainties. In past decades, researchers have been able to address different types of uncertainties prevalent in real-world images, thanks to the evolving state of the art of intelligent tools and techniques such as convolutional neural networks (CNNs) and deep learning. In this direction, computational intelligence techniques deserve special mention owing to their flexibility, application-free usability, and adaptability. Of late, hybridization of different computational intelligence techniques has come up with promising avenues in that these are more robust and offer more efficient solutions in real time.

This book aims to introduce the readers with the basics of image analysis and understanding, with recourse to image thresholding, image segmentation, and image and multimedia data analysis. The book also focuses on the foundations of hybrid intelligence as it applies to image analysis and understanding. As a sequel to this, different state-of-the-art hybrid intelligent techniques for addressing the problem of image analysis will be illustrated to enlighten the readers of upcoming research trends.

As an example of the recent trends in image analysis and understanding, albeit aging mitigates the glamor in human beings, wrinkles in face images can often be used for estimation of age progression in human beings. This can be further utilized for tracing unknown or missing persons. Images exhibit varied uncertainty and ambiguity of information, and hence understanding an image scene is far from being a general procedure. The situation becomes even graver when the images become corrupt with noise artifacts.

In this book, the editors have attempted to deliver some of the recent trends in hybrid intelligence as it applies to image analysis and understanding. The book contains 17 well-versed chapters illustrating diversified areas of application of image analysis using hybrid intelligence. These include multilevel image segmentation, character recognition, image analysis, video image processing, hyperspectral image analysis, and medical image analysis.

The first chapter deals with multilevel image segmentation. The authors propose a modified genetic algorithm (MfGA) to generate the optimized class levels of the multilevel images, and those class levels are employed as the initial input in the fuzzy c-means (FCM) algorithm. A performance comparison is depicted between the MfGA-based FCM algorithm, the conventional genetic algorithm (GA)-based FCM algorithm, and the well-known FCM algorithm with the help of three real-life multilevel grayscale images. The comparison revealed the superiority of the proposed method over the other two image segmentation algorithms.

Chapters 2 to 5 address the issue of character recognition and soft biometrics. Chapter 2 shows pros and cons of an entropy-based FCM clustering technique to classify huge training data for English character recognition. In chapter 3, the authors propose a two-stage word-level script identification technique for eight handwritten popular scripts, namely, Bangla, Devanagari, Gurumukhi, Oriya, Malayalam, Telugu, Urdu, and Roman. Firstly, discrete wavelet transform (DWT) is applied on the input word images to extract the most representative information, whereas in the second stage, radon transform (RT) is applied to the output of the first stage to compute a set of 48 statistical features from each word image. Chapter 4 presents a skin color region segmentation method based on K-means clustering and Mahalanobis distance for static hand gesture recognition. The final chapter in this group deals with soft-biometrics prediction. There, three prediction systems are developed using a support vector machine (SVM) classifier associated to various gradient and textural features. Since different features yield different aspects of characterization, the authors investigate classifier combination in order to improve the prediction accuracy. As a matter of fact, the fuzzy integral is used to produce a robust soft-biometrics prediction.

Chapters 6 and 7 focus on image analysis applications. More specifically, in chapter 6, the authors draw an analogy and comparison between the working principle of CNNs and the human brain. In chapter 7, the authors propose a framework for human action recognition that is trained using evolutionary algorithms and deep learning. A CNN classifier designed to recognize human actions from action bank features is initialized by evolutionary algorithms and trained using back-propagation algorithms.

Chapter 8 is targeted to video image processing applications. The authors propose a technique using Haar-like simple features to describe object models in chapter 8. This technique is applied with Adaboost classifier for object detection on the video records. The tracking method is described and illustrated by fusing global and local features.

Chapter 9 deals with a GIS-based application. The proposed GIS-anchored system extends a helping hand toward common and innocent people and exposes the trails for releasing themselves from the clutches of criminals. The chief intent of the proposed work is to not only check out the hot-spot areas (the crime-prone areas), but also give a glance to the flourishing of criminal activities in future. The process of determination of hot-spots is carried out by associating rank (an integer value) to each ward/block on the digitized map. The process of hooking up rank to a specific region is carried out on the basis of criminal activity at that particular region.

Chapters 10 and 11 deal with hyperspectral image analysis. Chapter 10 covers the hyperspectral data analysis and processing algorithms organized into three topics: spectral unmixing, classification, and target identification. In chapter 11, the authors deal with the band selection problem. They use the fuzzy *k*-nearest neighbors (KNN)