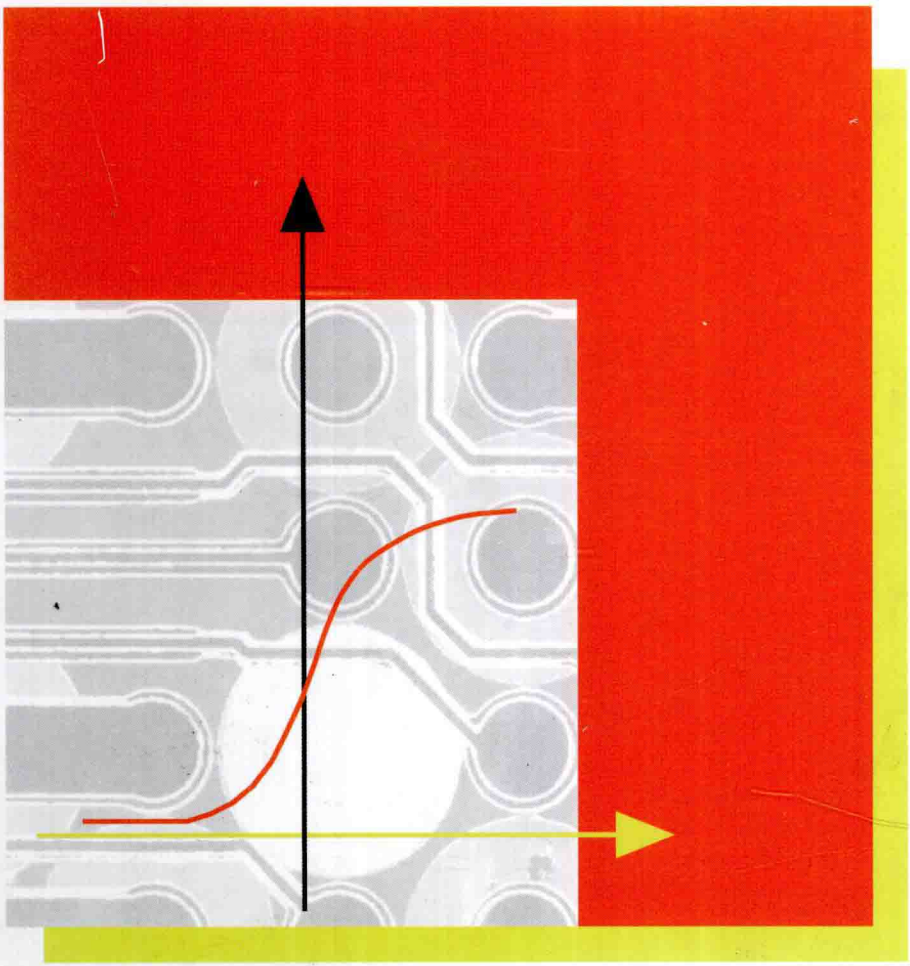
HANDBOOK OF PATTERN RECOGNITION AND COMPUTER VISION

4th Edition

editor

C H Chen



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A Brief Introduction to the Handbook Series, by C.H. Chen

The Handbook Series consisting of four sister volumes in four editions published in 1993, 1999, 2005 and 2010 respectively is dedicated to the late Professor King-Sun Fu (1930-1985). The fourth volume is published to celebrate his 80th birthday in 2010.

I recall when I entered the Ph.D. program at Purdue University in September 1962, I was the first graduate student to work under Prof. King-Sun Fu in the pattern recognition area. He just came back from a sabbatical at MIT at that time and gradually shifted his research from learning control to pattern recognition. Two influential papers we read at that time were Marvin Minsky's Steps toward artificial intelligence, 1959 and C.K. Chow's paper on An optimum character recognition system using decision functions, 1957. Another influential paper at that time was the one by T. Marill and D.M. Green, on the effectiveness of receptors in recognition systems, 1963, that generated a lot of interest on feature selection using divergence measures. Subsequently there were influential papers on nearest neighbor decision rule and Parzen density estimates. The 1960s and early 70s were the time of great progress in statistical pattern recognition in theory and applications. I remember Prof. Fu was very active in pattern recognition applications ranging from fingerprint recognition, handprinted character recognition, remote sensing, seismic signal classification, speech recognition, etc. In 1968 he published the book, Sequential Methods in Pattern Recognition I did not realize until later that he was also working on syntactic pattern recognition during 1970s This is an area much dear to his research interest that he had laid down a nearly complete foundation of syntactic pattern analysis with every possible application to pattern recognition and scene analysis that can be made. His effort led to the book on Syntactic Methods in Pattern Recognition 1982. Among many other research efforts by him are the contextual pattern recognition, combined syntactic and statistical approach to pattern recognition, etc. Prof. Fu, in his twenty-five years of distinguished professional career, indeed has contributed and influenced the enormous progress in pattern recognition and computer vision in the past half century. A well written

memorial to the late Prof. K.S. Fu was provided by Prof. C.C. Li in the second edition of the Handbook. I admire him not only on the academic achievements, but also on the inspirations he has provided to his Ph.D. students. He was always informal to his students who can see him whenever he was in office without prior appointments. He was very active and energetic in professional and lecture activities that required him to make almost one domestic trip each week and one overseas trip each month. Among his leadership activities is the establishment of IEEE Trans. on Pattern Analysis and Machine Intelligence, which has grown by page count from 1979 volume 1 of 417 pages to 2008 volume 30 of 2255 pages. Publication growth is only one measure of progress. The number and extent of pattern recognition and computer vision applications have grown far more than ten folds in the last 35 years and the impact of such applications to our daily lives is even more significant. It is indeed fortunate to see the continued and rapid progress in theory, methodologies, and applications of pattern recognition and computer vision.

The progress in pattern recognition since 1985 is particularly noted by the activities in combined and multiple classifiers, neural networks and support vector machines for pattern classifications, industrial applications of machine vision, and applications in biometrics, remote sensing, character recognition, etc. The dramatic and continued improvement in sensor and computation technologies plays a major role in the progress.

In the summer of 1990 I had a meeting with Dr. K.K. Phua, chairman of World Scientific Publishing in Singapore. He made an excellent suggestion for me to prepare a Handbook of Pattern Recognition and Computer Vision, which led to the publication of the first edition in 1993. The intent of the Handbook is not to serve as an encyclopedia or as a series of "Advances in PRCV" books. Unlike many engineering and software and hardware books, chapters in the handbook series have much longer lasting values. The basic problems and approaches to feature extraction, decision making, texture analysis, and clustering presented in the first edition remain to be the same. To a great extent each edition reflects some new emphasis in theory and applications. For examples: syntactic recognition was nicely presented in the first and second editions, human identification was well covered in the third edition, while life science areas and 3-D problems are more emphasized in the 4th edition. With enormous progress made even within a few years' time, just by looking at the large number of papers in ICPR08, a handbook like this can provide only a very small representative articles of the areas considered. It is hoped that such small but careful selection can offer readers many promising directions for further pursuit. As Prof. Anil K. Jain nicely put it in his lecture at ICPR08, there are

Preface to the 4th Edition, by C.H. Chen

Largely motivated by the rapid progress in pattern recognition and computer vision, as shown by a large number of journal and conference publications and the program of the latest ICPR (International Conference on Pattern Recognition), the 4th edition of the Handbook is published one year ahead of six year interval from the 3rd edition. The year 2010 also marks the 80th birthday of the late Prof. King-Sun Fu, for which this Handbook series is dedicated to.

As in the previous editions, the book consists of five parts, with all thirty-three chapters being new. Part 1 Basic Methods in Pattern Recognition Part 2 Basic Methods in Computer Vision and Image Processing, Part 3 Recognition Applications Part 4 Computer Vision and Pattern Recognition in Life Sciences and Human ID Part 5. System and Technology.

Chapter 1.1 of **Part 1** by F. D. Torre presents a unified approach to component analysis for pattern recognition, making use of least-squares weighted kernel reduced rank regression (LS-WKRRR). Chapter 1.2 by V. Gunes, et al. introduces and explains several essential concepts and components for building multiple classifier systems. Chapter 1.3 by H. Bunke and K. Riesen deals with graph based object representation and introduces a novel approach for graph embedding in vector space. Chapter 1.4 by E. Granger, et al. shows that match tracking parameter of fuzzy ARTMAP neural networks with particle swarm optimization can produce a significantly lower generalization error than with other match tracking strategies. Chapter 1.5 by T.A. Duong, et al. presents a bio-inspired approach to object recognition by taking a global view of an object that considers the shape feature as the logical building block and the color feature, if available, as additional information. Though Part 1 covers disjoint methods in pattern recognition, it reflects the divergent approaches to pattern recognition as the present time.

Chapter 2.1 of **Part 2** by L. Zhang, et al. introduces the concepts and basic types of probabilistic graphical methods, which are shown to perform important computer vision tasks such as facial expression recognition and image segmentation. Chapter 2.2 by C. Lei and Y. H. Yang presents a region-tree based

framework for general image discrete labeling problems with application to stereo matching and optical estimation.

Chapter 2.3 by T. Bouwmans, et al. has a comprehensive survey of the statistical background modeling in the context of moving object (foreground) detection. Chapter 2.4 by K. Kanatani, et al. presents a rigorous mathematical treatment of algorithms for 3-D reconstruction from two views. Chapter 2.5 by E. Rahtu and J. Heikkila considers affine invariance in feature extraction using normalization and invariant approaches with particular reference to multiscale framework that offers systematic tool to alleviate some of the basic problems encountered with traditional invariant techniques. Chapter 2.6 by N. Ohmishi, et al. presents an algorithm for detecting the dominant plane by using Independent Component Analysis for robot navigation. Chapter 2.7 by S. Tari considers creating a field within the shape domain with emergent structures capturing the parts automatically and the field is computed by minimizing an energy which captures both local and global as well as both region and boundary based interactions among shape points.

Thus Part 2 has covered an expanded set of topics in computer vision.

Chapter 3.1 of **Part 3** by G. Moser, et al. presents for the combined optical and synthetic aperture radar remote sensing image data a novel region-based semiparametric classification technique. Chapter 3.2 by L. Bruzzone and C. Persello has a comprehensive presentation of support vector machine for remote sensing classification. Chapter 3.3 by M. I. Shah and C.Y. Suen provides a comprehensive survey of word searching techniques to detect and locate instances of the given template/query images in the document image databases. Chapter 3.4 by C. L. He, et al. presents a novel rejection criterion that employs linear discriminant analysis to optimize the criterion for rejection in handwriting recognition. Chapter 3.5 by M. Liwicki and H. Bunke evaluates recognition techniques for whiteboard notes written in Roman scripts including the hidden Markov model (HMM)-based recognizer and the bidirectional long short-term memory networks. Chapter 3.6 by J. Kim and E. Andre investigates the automatic emotion recognition using physiological signals with physiological features extracted from various analysis domains for classification of four musical emotions using an extended linear discriminant analysis. Chapter 3.7 by F. Shih considers automatic solar flare detection with solar images observed by a telescope in the Big Bear Solar Observatory. Though Part 3 covers only a limited number of application areas it certainly reflects the emergence of many potential pattern recognition applications.

Chapter 4.1 of **Part 4** by Y. Feng and P.C. Yuen discusses the threats to biometric authentication systems and security enhancing schemes for biometric

recognition systems. Chapter 4.2 by S. Sarker, et al. presents a framework of the problem of recognition of continuous sign language, i.e. signs in sentences and not isolated signs or finger-spelled signs, by using combined manual and non-manual information. Chapter 4.3 by P. Manandhar, et al. considers the automated intra-vascular ultrasound image segmentation (IVUS) for diagnosis of coronary heart disease by using active contour model algorithm with special reference to tracking the change in guidewire position such that its effect on IVUS can be minimized. Chapter 4.4 by V. Gervasio and J.A. Jorge employs the interactive technique to improve the capability of active contour model in the segmentation of medical images. Chapter 4.5 by V. Meas-Yedid, et al. addresses the issues of both cell segmentation and spot detection for the images of biological objects. Chapter 4.6 by E. Zaharia and D. Maroulis presents the evolutionary genetic algorithms to automate the procedures of gridding microarray images and segmenting microarray spots, which are both challenging problems normally requiring human intervention. Chapter 4.7 deals with the multi-class protein folds recognition by using error-correcting output coding and ensemble classifier (support vector machine or flexible neural nets). Part 4 thus presents largely chapters that employ pattern recognition and computer vision techniques in life science problems.

Chapter 5.1 of **Part 5** by M.D. Levine and Y. Yu describes a 3D facial reconstruction system with the ability to recover a 3D human face from a single 2D frontal natural or standard image by using separately computed stages of shape reconstruction and texture recovery. Chapter 5.2 by J. Zhou and H. Peng formulates the automatic annotation as a pattern recognition problem with special focus on annotating fruitfly gene expression pattern images during embryogenesis and considering applications for multi-objective vs. mutual-exclusive annotation, and ROI vs. entire image annotation. Chapter 5.3 by Z. Ying and R. Naidu presents the dual energy computed tomography technology and associated Automated Threat Detection techniques in the context of checked baggage screening. Chapter 5.4 by M. Sun, et al. deals with assessment of food intake and physical activity by addressing the issue in food dimension measurement using spectral sensors and image processing models and algorithms, and presenting an effective computational method to characterize walking and jogging, Chapter 5.5 by E. Vallasques, et al. has a very detailed survey of watermarking systems employing evolutionary computation techniques that automatically set user-defined parameters of watermarking tasks and a case study is also presented. Chapter 5.6 by B. Lu and X. Wang presents a framework of large scale classification problems, such as a large scale Japanese patent classification problem, that has three independent components: decomposing

training data sets, training component or modular classifiers in parallel and combining trained component classifiers. Chapter 5.7 by G.B. Garibotto presents the main algorithms for human tracking around the 3D model based framework in an effort to implement an intelligent visual surveillance system. The topics covered in Part 5 again reflect the diversified activities in systems and technology.

The one sentence description of each chapter clearly is highly inadequate to present the excellent contributions by all authors We should let each chapter to speak for itself and thus the readers are strongly encouraged to go over individual chapters in detail. The handbook is indeed very rich in information about the vibrant activities in theory, applications and technology in pattern recognition and computer vision.

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thousands of approaches but no silver bullet. Indeed in pattern recognition area alone, we are still looking for better features and feature space. There is endless progress in sight in pattern recognition until perhaps when machines can be designed to automatically look for the best features and feature space. In related areas, it is noted that signal processing can define new feature space and provide mathematical features and artificial intelligence can exploit higher level knowledge and they both will have continued impact on pattern recognition. On the application front, both patter recognition and computer vision should look beyond automation with accuracy and speed and seek for more useful solutions to environment, life sciences, energy and related problems.

In going over the Handbook series, I like to point out that Prof. Ching Y. Suen has provided the most consistent as well as important contributions to all four volumes of the handbook series. His long and pioneering research and education in pattern recognition and document understanding parallels to those of Prof. K.S. Fu. In addition to the special recognition of Prof. Suen's contribution, I like to take this opportunity to thank all contributors of the handbook series, and the past co-editors Profs. L.F. Pau and P.S.P. Wang, as well as the World Scientific Publishing, without whose effort and encouragement, this series would not become a reality. Finally I like to thank my wife, Wanda, for her continued support and understanding in over four decades of my publication and research activities.

The following is a list of table of contents for the third, second and first editions of the handbook series.

Handbook of Pattern Recognition and Computer Vision, vol. 3, World Scientific Publishing 2005

Handbook of Pattern Recognition and Computer Vision, vol. 2, World Scientific Publishing 1999

Handbook of Pattern Recognition and Computer Vision, vol. 1, World Scientific Publishing 1993

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