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CHARACTER & HANDWRITING RECOGNITION

*Expanding
Frontiers*

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With Foreword by C Y Suen

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**CHARACTER AND HANDWRITING RECOGNITION:
EXPANDING FRONTIERS**

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PREFACE

Everytime we read a book, magazine, letter, check, newspaper, road sign or search for an address, we are in the process of recognizing alphanumeric characters and words. Such an amazing capability has been taken for granted for a very long time. But when one tries to use a computer to do it, such a seemingly trivial task becomes extremely difficult. How is it done? How can one learn, understand, memorize and recognize these characters and handwritings with so many different distortions and variations in so many different environments? What enables humans to do it? Furthermore, how can we make machines or computers do it? Such secrets remain largely unknown, but they are beginning to gradually unfold.

The study (research) of *character and handwriting recognition by computers* has attracted more and more attention recently not only because it is interesting and challenging but also because it is important for solving practical problems in many areas including office automation, industrial parts inspection, bank check processing, postal ZIP Codes and address recognition, signature verification, and document and text recognition. For example, in the USA alone, each day hundreds of millions of first-class mail pieces (about 15% have hand-printed or handwritten addresses on the envelopes, and 85% have machine-printed ones) are at present handled manually. Just imagine if such a tedious and time-consuming process could be automated using computers, to be more efficient and less expensive. What significant savings of time, manpower and cost there would be!

After more than 30 years of rigorous attacks, studies in the field remain as fresh as ever. There have been numerous papers, technical reports, theses, dissertations, and even patents and products, which resulted from intensive research and development. However, most of them were reported in different places, as a part of conference proceedings, journal articles or book chapters. Because of increasing interest in recent years, there is need for a coherent and integrated publication—a single volume in the literature dedicated solely to character and handwriting recognition. This book is perhaps one of the first of such efforts to publish new research results in the field, so that interested readers, researchers, scientists, engineers and industrialists can keep themselves abreast of the most recent developments in *character and handwriting recognition* methodologies and applications in a more convenient way.

This collection of 17 papers is authored or co-authored by dedicated professionals and researchers from industry as well as academia in nine countries: Canada, China (both Taiwan and mainland), France, Italy, Japan, Syria, UK, and USA. The vast geographical spectrum of authors is yet another evidence of the importance of this field and the ever-increasing attention and interest it attracts worldwide. The book is divided into four parts.

Part I is concerned with optical character recognition (OCR) and off-line character recognition. It contains three papers. S. Impedovo, L. Ottaviano, and S. Occhinegro present an excellent survey on OCR, highlighting the interesting problems and the

actual results on the state-of-the-art in OCR. Y. Y. Tang, H. D. Cheng, and C. Y. Suen introduce a new method called transformation-ring-projection (TRP) using parallel VLSI architecture for OCR that can achieve size-orientation-invariance characteristics. J. C. Simon and O. Baret revisit feature classification, defining it as 'regular' and 'singular', and apply the idea to line images, particularly handwritten words interpretation, and obtain 87% success.

The three papers of Part II deal with on-line character recognition. In his paper, C. C. Tappert reports that an on-line character recognizer was improved by making trade-offs among computation speed, recognition accuracy and flexibility, achieving a 97.3% accuracy rate with a speed of 85 characters/second on the IBM System 370/Model 3081. P. S. P. Wang and A. Gupta propose a new, improved structural technique for hand-printed character recognition, and showed it to be more natural than other methods in that it is less ambiguous and more consistent with human intuition and writing habits. T. Fujisaki, T. E. Chefalas, J. Kim, C. C. Tappert, and C. G. Wolf designed an on-line run-on character recognition system, which first recognizes English words, and then finds the best segmentation.

It is well known that Chinese and Japanese characters are unique and different from that of Western languages such as English, in that they are two-dimensional, non-alphabetic and have quite complicated stroke structures. Such properties make Chinese and Japanese character recognition by computers particularly difficult and challenging. In Part III, five papers explore such problems. F.-H. Cheng and W.-H. Hsu in their paper describe the typical research on Chinese OCR in Taiwan, focusing on several approaches to the recognition of handwritten Chinese characters by the analysis of a set of basic line segments called 'strokes'. J. S. Huang and P.-M. Huang present a machine-printed Chinese character recognition system with a higher than 99% recognition rate based on linear regression technique. S.-L. Chou and W.-H. Tsai propose a new method for handwritten Chinese character recognition by segment matching using an iteration scheme which gave an accuracy rate as high as 99.6%. J.-W. Tai briefly surveys some research methods and achievements on Chinese character recognition in mainland China which has a population of more than one billion with an increasing number of them using computers. H. Murase describes an on-line recognition system for a free-format handwritten Japanese character string, which may contain characters with separate constituents or overlapping characters. The system uses the candidate lattice method and can attain a segmentation rate of 98.8% and an overall recognition rate of 98.7% for 105 samples on specially designed hardware.

In Part IV, several applications of character and handwriting recognition are discussed. E. Cohen, J. J. Hull and S. N. Srihari describe an approach for reading a block of handwritten text when there are certain loose constraints placed on the spatial layout and syntax of the text. The system is applied to reading handwritten postal addresses in which the semantic representation is a digit string (ZIP Code). A. C. Downton, R. W. S. Tregidgo and E. Kabir present an algorithm architecture for a high-performance OCR system that can be used for recognition and verification of

handwritten and hand-printed British postal addresses. N. G. Bourbakis and A. T. Gumahad II introduce a non-conventional text character extraction method called the horizontal and vertical projections (HVP) method, and applied a knowledge-based Fourier transform technique to recognize typed text characters. F. Nouboud and R. Plamondon discuss a real-time constraint-free hand-printed character recognition system based on a structural approach with a high degree of accuracy (96%) for writer-dependent applications. M. Ammar investigated the reference pattern based features (RPBF) approach for verification of skillfully simulated handwritten signatures, which gave a testing accuracy rate of about 90%. Finally, I. Guyon discusses the importance of neural networks whose architecture is inspired by that of human brains, and introduces a time-delay neural network (TDNN) for handwritten character recognition and its application for designing the AT&T touch terminal.

Many people have contributed to the creation of this book, which was also published as a special issue of the *International Journal of Pattern Recognition and Artificial Intelligence* (Vol. 5, No. 1 & 2, June 1991). I would like to express my appreciation to Dr. K. K. Phua and Professor H. Bunke for their encouragement to publish it. I also want to thank all reviewers for their precious comments and criticisms, especially Professor C. Y. Suen for his invaluable suggestions, opinions, and his Foreword in which he presents an excellent overview of character and handwriting recognition by computers. Last but not least, I want to thank all authors for their dedicated effort and fine work, without which this book would be impossible.

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FOREWORD

Making computers see and recognize objects like humans has captured the attention of many scientists in different disciplines. One of the most fascinating areas of computer vision with practical applications is optical character recognition. Indeed, machine recognition of both printed and handwritten characters has been intensively and extensively researched by scientists in different countries around the world. Characters written in many different languages have been recognized, e.g. from numerals to alphanumeric characters, and from Roman languages to Oriental languages. See, for example, the proceedings of the international conferences on Pattern Recognition.¹ However, the infinite varieties of qualities and character shapes produced by handwriting and by modern printing machines continue to pose a major challenge to researchers in the field of pattern recognition. There is an urgent need to solve the problem, and it has become increasingly evident that satisfactory solutions would be very useful in applications where it is necessary to process large volumes of printed and handwritten data, e.g. automatic sorting of mail and checks, verification of signatures, and machine recognition and analysis of different kinds of forms and documents.

Many different methods to recognize characters have been explored during the past four decades by a large number of scientists. A variety of approaches have been proposed and tested by many researchers in the field, e.g. the use of structural and syntactic classifiers, statistical and Fourier descriptors, models matching, and neural networks.

With respect to automatic recognition of handwritten characters, the immense effort spent in this field proves that this is an even more challenging problem due to the geometric diversity of character shapes produced by writers who have different writing styles and habits. Also the complexities of oriental characters have added another dimension of difficulty to the problem. This is further compounded by our lack of understanding of the ways humans recognize characters.

How does the human brain recognize the different characters? Which parts of the characters does it look for? What kinds of features do we capture when we see a character? Is there some way we can extract character recognition knowledge from humans who have become such superb character recognizers? What will be the impact of the new idea of using multiple experts? These are some of the questions which remain unanswered so far. Obviously, a lot more research needs to be done in this field before we can make computers recognize characters and read documents reliably and intelligently.

Fortunately, research in computer recognition of characters has now entered a new era. Within the past ten months, several new international conferences and workshops

¹ Proceedings of the International Conferences on Pattern Recognition, 1973–1990.

have been established in handwriting recognition, document analysis and recognition, and advanced technology in mail sorting and recognition.²⁻⁵ Scientists now realize the shortcomings of current optical reading machines in the market place and the urgent need to conduct more research in this growing area. Hopefully the publication of this collection of papers and the above activities will not only shed light on some of the most difficult problems in optical character recognition, but will also bring further growth and progress to this challenging field.

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² *Proc. United States Postal Service Advanced Technology Conference*, Washington, D. C., Nov. 1990.

³ *Pre-proceedings Int. Workshop on Syntactic and Structural Pattern Recognition*, Murray Hill, June 1990.

⁴ C. Y. Suen, Ed., *Frontiers in Handwriting Recognition*, *Proc. Int. Workshop on Frontiers in Handwriting Recognition*, CENPARMI, Montreal, Apr. 1990.

⁵ First International Conference on Document Analysis and Recognition, Saint-Malo, France, Sept. 30–Oct. 2, 1991.

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