Patrick S.P. Wang
Editor

Pattern Recognition, Machine Intelligence and Biometrics

高等教育出版社
HIGHER EDUCATION PRESS

Springer

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With 605 figures, 4 of them in color

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Patrick S.P. Wang's Brief Vitae

Patrick S.P. Wang, ***Fellow of IAPR***, ***ISIBM and WASE***, is a professor of Computer and Information Science at Northeastern University, USA, Shanghai East China Normal University Zi-Jiang Visiting Chair Professor, research consultant at MIT Sloan School, and adjunct faculty of computer science at Harvard University. He received PhD in C.S. from Oregon State University, M.S. in I.C.S. from Georgia Institute of Technology, M.S.E.E. from Taiwan University (Taipei) and B.S.E.E. from Chiao Tung University (Hsin-chu).

As *IEEE* and *ISIBM Distinguished Achievement Awardee*, Dr. Wang was on the faculty at University of Oregon and Boston University, and senior researcher at Southern Bell, GTE Labs and Wang Labs prior to his present position. Dr. Wang was Otto-Von-Guericke Distinguished Guest Professor of Magdeburg University, Germany, and iCORE (Informatics Circle of Research Excellence) visiting professor of University of Calgary, Canada, Honorary Advisor Professor for China's Sichuan University, Xiamen University, and Guangxi Normal University. In addition to his research experience at MIT AI Lab, Dr. Wang has been a visiting professor and invited to give lectures, do research and present papers in a number of countries and areas, from Europe, Asia and many universities and industries in the U.S.A. and Canada. Dr. Wang has published over 160 technical papers and 26 books on Pattern Recognition, A.I. Biometrics and Imaging Technologies and has 3 OCR patents by US and Europe Patent Bureaus. One of his books is so important and widely cited that the USA Department of Homeland Security(DHS) uses it as reference for Call For Proposals 2010. For details please refer to DHS website: Image Pattern Recognition — Synthesis and Analysis of Biometrics (WSP): https://www.sbir.dhs.gov/PastSolicitationDownload.asp#101005.

As IEEE senior member, he has organized numerous international conferences and workshops including *conference co-chair of the 18th IAPR ICPR* (International Conference on Pattern Recognition) in 2006, Hong Kong, China, and served as reviewer for many journals and NSF grant proposals. Professor Wang is currently *founding Editor-in-Chief of IJPRAI* (Int. J. of Pattern Recognition and A.I.), and *Machine Perception and Artificial Intelligence Book* Series by World Scientific Publishing Co. and Imperial College Press, London, UK, and elected chair of IAPR-SSPR (Int. Assoc. for P.R.). Dr. Wang has been invited to give talks in many International Conferences including AIA2007, Innsbruck, Austria; IAS2007, Manchester, UK; IEEE-SMC2007, 2009, 2010, Montreal, San Antonio, Istanbul, respectively; WorldComp2010, Las Vegas, USA; CIS2007, Harbin, China, eForensics2008, Ade-

laide, Australia; ISI2008, Taipei, Taiwan, China; BroadCom2008, Pretoria, South Africa; VISAPP2009, Lisboa, Portugal; UKSim2011, Cambridge, UK, and IADIS2010, 2011, Freiburg, Germany, and Roma, Italy, respectively. Dr. Wang received IEEE Distinguished Achievement Award at IEEE-BIBE2007 at Harvard Medical, for Outstanding Contributions in Bioinformatics and Bioengineering.

In addition to his technical achievements and contributions, Professor Wang has been also very active in community services, and has written several articles on Du Fu, Li Bai's poems; Verdi, Puccini, Bizet, and Wagner's operas; and Mozart, Beethoven, Schubert and Tchaikovsky's symphonies. A collection of selected proses was published in his book *Harvard Meditation Melody* by Jian-Shing Pub. Co., Taipei, which won best publication award by Taiwan, China.

Lotfi A. Zadeh (left) and Patrick S.P. Wang (right)

Dear Patrick,

Many thanks for your message and the kind words.

I appreciate very much what you wrote. As you know, I am highly impressed by your achievements. With regard to the foreword, I have a problem. After my heart attack in December 2008 my vision and my hearing have experienced a decline. Today, to read printed matter I have to use a magnifying glass. Reading messages does not present a problem but reading a book does. This is why writing a foreword — even to a book dedicated to my admired friend, K.S.Fu, would be stressful. It is a source of great regret for me not to be able to respond affirmatively to your invitation. Please keep in touch.

With my warm regards.

Sincerely,

Lotfi

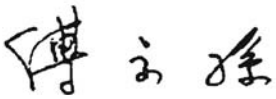
Lotfi A. Zadeh
Professor in the Graduate School
Director, Berkeley Initiative in Soft Computing (BISC)

King-Sun Fu (left) and Patrick S.P. Wang (right) in 1981 Int. Conf. Advanced Automation (ICAA1981), Taipei, China

Patrick S.P. Wang (left) and King-Sun Fu (right) in 1981 Int. Conf. Advanced Automation (ICAA1981), Taipei, China

In Honor and Memory of Late Professor King-Sun Fu

The late Professor King-Sun Fu is one of the founding fathers of pattern recognition, who, with visionary insight, founded the International Association for Pattern Recognition around 1980. In the almost 30 years since then, the world has witnessed the rapid growth and development of this field.



King-Sun Fu

(10/2/1930 [Nanjing, China] – 4/29/1985 [D.C.,USA])

IEEE TRANSACTIONS ON
PATTERN ANALYSIS AND MACHINE INTELLIGENCE

K. S. FU, Senior Editor
School of Electrical Engineering
Purdue University
West Lafayette, Indiana 47907
Telephone (317) 494-8825

November 4, 1981

Dr. Patrick S. Wang
GTE Research Laboratories
40 Sylvan Road
Waltham, MA 02154

Dear Dr. Wang:

The enclosed manuscript has been submitted for possible publication in the IEEE Transactions on Pattern Analysis and Machine Intelligence. I should greatly appreciate it if you or one of your associates would review the manuscript for the Transactions. The paper is entitled: PAMI 81-8-5R, FUZZY TREE AUTOMATA AND SYNTACTIC PATTERN RECOGNITION.

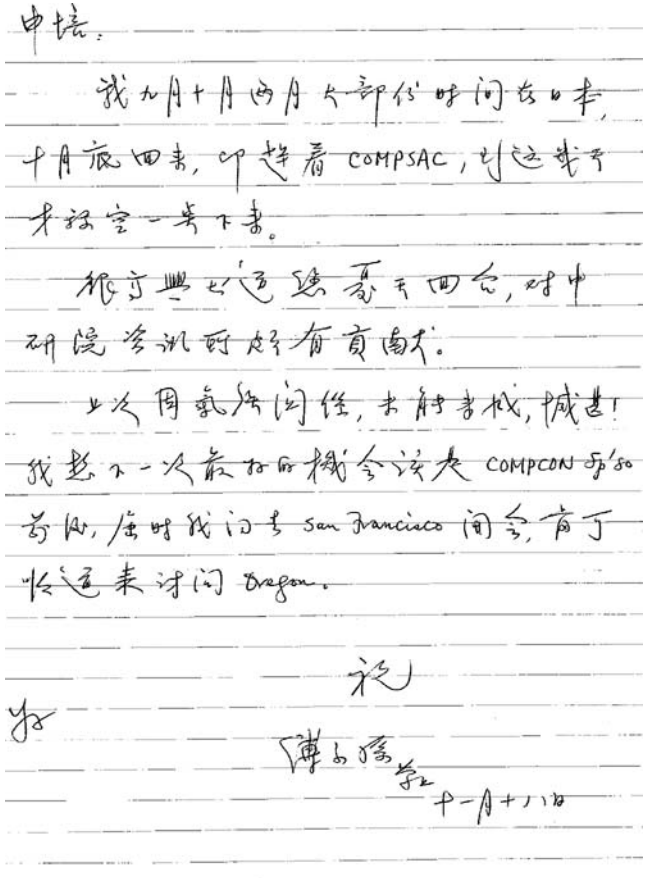
For your convenience, I enclose our standard referee form. Thank you very much for your assistance. This paper is for your re-review.

Sincerely,

K. S. Fu
Senior Editor, IEEETPAMI

KSF:mjb

Enclosure



中培：

我九月十月两月大部份时间在日本，十月底回来，印赶着 COMPSAC，到这我于才稍空一点下来。

很高兴长道德夏天回台，对中研院资讯所好有贡献。

上次因氣候阴怪，未能来找，憾甚！我想下一次最好的機会该是 COMPCON Sp'80 前後，屆时我们去 San Francisco 開会，有了收道来讨问 Oregon。

祝

好

傅永孫 敬

十一月十八日

PURDUE UNIVERSITY SCHOOL OF ELECTRICAL ENGINEERING

24 January 1980

Professor Patrick S. P. Wang
Department of Computer Science
University of Oregon
Eugene, OR 97403

Dear Patrick:

Thank you for your letter dated January 15, 1980. The following is my schedule to Eugene:

February 22, San Francisco - Eugene
8:25 a.m. 9:46 a.m. (UA 862)

February 23, Eugene - San Francisco
1:45 p.m. 2:55 p.m. (RW737)

The title of my talk is "Recent Developments in Syntactic Pattern Recognition." I will need an overhead projector and a 35mm slide projector for my talk.

Looking forward to seeing you in February.

Sincerely,

K. S. Fu
Goss Professor
of Engineering

KSF/msh

Electrical Engineering Building
West Lafayette, Indiana 47907

PURDUE UNIVERSITY SCHOOL OF ELECTRICAL ENGINEERING

January 19, 1981

Dear Dr. Wang:

We have proposed a NSF Workshop on Structural and Syntactic Pattern Recognition, which will be held on June 22-24, 1981, in Saratoga Springs, N.Y. General Electric is also a co-sponsor of the workshop. The purpose of this workshop is to assess the progress in structural and syntactic pattern recognition in terms of its contributions and limitations to practical applications and to project the future directions of this area. Knowing your interest and past contributions in this area, we would like to invite you to participate in this workshop. Your traveling expenses will be paid by the workshop pending the final approval of our proposal by NSF.†

The major emphasis of the workshop is on group discussions rather than many formal presentations of papers. We are planning to have a series of background papers and a small number of short presentations for new research results and applications. Please do not hesitate to let me know if you would like to give a paper at the workshop.

We hope that you will accept our invitation and we are looking forward to seeing you at the workshop.

Sincerely,

K. S. Fu,
Goss Professor of Engineering
on behalf of the Workshop
Organizing Committee
K.S. Fu (Co-Chairman)
T. Pavlidis (Co-Chairman)
J. L. Mundy
R. K. Aggarwal

† NSF rule may not allow us to pay participants from industry.

- -

Please return this form to K. S. Fu before February 15, 1981.

I will - / will not - accept the invitation to participate in the NSF Workshop on Structural and Syntactic Pattern Recognition (June 22-24).

I would like to present a paper with title: _____

_____. Please send an abstract if possible.)

_____
Name

Electrical Engineering Building
West Lafayette, Indiana 47907

申培：

这次讨论，承蒙招待，特此致谢！

COMPCON 完成，已於星期五下午回来。在 COMPCON 时，问到丘勤生有关今年 ICS 的事，据告由 Ramamoorthy 出任 Program Chairman，Call for Papers 即将於近期发出。

问候家中其他诸位先生。

祝

全家好

傅京孙上

三月二日

GTE Laboratories Incorporated
40 Sylvan Road
Waltham MA 02154
617 890 8460

GTE Telenet Technology Center

June 12, 1981

Dr. K. S. Fu
Goss Professor of Engineering
School of Electrical Engineering
Purdue University
West Lafayette, IN 47909

Dear Dr. Fu:

Enclosed please find a copy of the GTE Seminar Announcement about your visit.

Your hotel has been reserved and prepaied at the Hotel Sonesta, 5 Cambridge Parkway, Cambridge (617-491-3600) for June 25th and 26th.

I will be waiting for you at 5:25 PM (June 25th) at Logan International Airport.

On behalf of Dr. Joel Krugler, Manager of GTE Telenet Technology Center, and GTE Laboratories, let me extend our warmest welcome to you. We believe your visit will prove to be very enjoyable and mutually beneficial.

Sincerely yours,

Dr. Patrick Wang

PW:vs
cc: Dr. J. Krugler

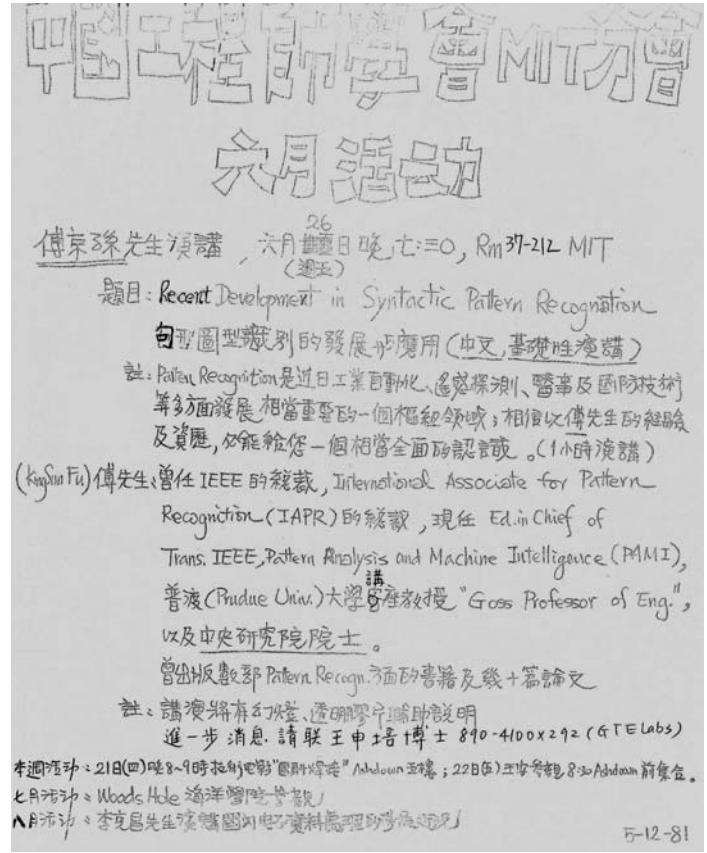
申培：

八日来信收到。很高兴知道你将回国参加今年的国建会。中研院资讯科学研究所，目前由郭法戚教授代理兼备处主任，所以開始基本日上，我想你回会北论了直接与郭法戚先生连络。（他目前也是会长收機会之主任，我想你也可在会长找到他）他去概要年期有两天是在中研院上班的。

上次因 United Airline 罷工，及此间由 Lafayette 去 Chicago 的那機班次被 Cancel，以正想组去西岸的 trip，被取消，秋天有機会，定當来讨贵校。祝

好

傅京孫 上 五.廿八



中國工程師學會 MIT分會

六月活動

傅京孫先生演講，六月26日(週五)晚七:三0，Rm 37-212 MIT

題目：Recent Development in Syntactic Pattern Recognition

句型圖型識別的發展與應用（中文，基礎性演講）

註：Pattern Recognition是近日工業自動化、遙感探測、醫事及國防技術等多方面發展相當重要的一個樞紐領域；相信以傅先生的經驗及資歷，必能給您一個相當全面的認識。（1小時演講）

(KingSun Fu) 傅先生：曾任IEEE的總裁，International Associate for Pattern Recognition (IAPR)的總裁，現任Ed. in Chief of Trans. IEEE, Pattern Analysis and Machine Intelligence (PAMI)，普渡(Prudue Univ.)大學講座教授"Goss Professor of Eng."，以及中央研究院院士。

曾出版數部Pattern Recogn.方面的書籍及幾十篇論文

註：講演將有幻燈、透明膠片輔助說明

進一步消息請联王申培博士 890-4100x292 (GTE Labs)

本週活动：21日(四)晚8~9時在射电影"圓形焊接" Ashdown五樓；22日(五)五安參觀 8:30 Ashdown前集合。

七月活动：Woods Hole 海洋學院參觀

八月活动：李克昌先生演講圖形电子資料處理的多層遞歸

5-12-81

傅先生：

收到來信，及電話謝。

附上照片二張，望可用。

感謝您的好意，我本希望能寫一點的，但我希望您能諒解，我本希望能寫一點的，但我希望您能諒解。

感謝您的好意，我本希望能寫一點的，但我希望您能諒解。

何以克能作罷。這原諒。

勞過考慮，本不希望從幻燈起。

祝一家好

[illegible]

一月二日

敬愛的傅大嫂：您好！

我是王申培，傅教授身前好友，現在 Northeastern 及 Harvard U 任教。為了發揚傅教授身前志向，我和一羣中外朋友發起創辦了一个新的國際為報 "International Journal of Pattern Recognition and Artificial Intelligence" (IJPRAI) "國際模式識別和人工智能學報"。創刊号將於1987年春季(傅教授逝世二週年紀念時)出刊，並將獻給傅教授。闢除了科技性的文章外，我將着手寫一篇紀念文。不知可否麻煩您支持兩件事：

(1). 請提供一些傅教授身前生活照，(如室內独照，或合照，戶外亦可)

(2). 我寫的紀念文主要是把傅教授身前的交往着重在科技研究心得交換的經驗。可否請您寫一篇紀念文(懷念文)從您的观点来看？長短形式皆不拘。傅教授是位很有成就，有深遠影响力，並擅受大家愛戴的学者，相信您的文章一定会給大家帶来很大的啟發，尤其在教授逝世二週年紀念刊上發表，更是具有極其深遠的意義，不知您意見如何？

在您百忙之中，冒昧打扰您，實在过意不去。我在此谨代表所有 IJPRAI 的編輯委員會(包括 A. Rosenfeld, H. Freeman, H. Bunke, T. Ichikawa, J. Tou, S.K. Chang, C.H. Chen, Y.T. Chien 等)向您致十二萬分的敬意和謝意，並熱誠希望您能幫我們這个忙，使千千萬萬關心愛戴的讀者深受其惠。

專此祝您

時祺

王申培 12/1/86

GTE

Patrick Wang

GTE Laboratories Incorporated
40 Sylvan Road
Waltham, MA 02254
617 890 4100

Date 6.10

傅教授：

您好！

寄上 GTE 海報，MIT 中國工程師学会海報及邀請函。非常欢迎您来。旅館已訂好 Sonesta Hotel，在 S Cambridge Park, Cam. 六月25-26兩晚 (Guarantee late payment) 25日下午5:25 我会準时在机場迎接。再請祝

王申培 敬上

Foreword By J.K. Aggarwal

It is again a pleasure and an honor to introduce this collection of papers in memory of the late Professor King-Sun Fu. Professor Fu contributed significantly to the growth of pattern recognition through teaching, research, scholarship and supervision of Ph.D. students at Purdue University. It is sad that Professor Fu did not live to see the spectacular growth that we are witnessing today in the use of pattern recognition and computer vision in industry, military, and daily products. Professors Tzay Young and King-Sun Fu published a collection of papers entitled Handbook of Pattern Recognition and Image Processing. The book was published in 1986 after Professor Fu passed away in 1985.

Professor Patrick S.P. Wang has followed in the spirit of the collection published by Young and Fu.

The present book is fifth in the series published by Professor Patrick S.P. Wang and his co-editors. The earlier four collections are:

(i) Handbook of Pattern Recognition and Computer Vision
Editors: C.H. Chen, L.F. Pau and P.S.P. Wang
1993, World Scientific Publishing
32 papers, 984 pages

(ii) Handbook of Pattern Recognition and Computer Vision
Editors: C.H. Chen, L.F. Pau and P.S.P. Wang
1999, World Scientific Publishing
34 papers, 1019 pages

(iii) Handbook of Pattern Recognition and Computer Vision
Editors: C.H. Chen and P.S.P. Wang
2005, World Scientific Publishing
33 papers, 639 pages

(iv) Pattern Recognition and Computer Vision
Editor: P.S.P. Wang
2010, River Publishers
28 papers, 451 pages

The present volume again honors the contributions of Professor Fu. He was the founding editor of the IEEE Transaction on Pattern Analysis and Machine Intelligence. Today this transaction has the highest regard of researchers and developers. It is among the crown jewels of the publications of the IEEE. He also helped start the organization known as the International Association for Pattern Recognition (IAPR) in the early 1970s. Today IAPR has membership from 42 countries all over the globe. The family and friends of Professor Fu created the King-Sun Fu Prize in his memory under the auspices of the IAPR. IAPR awards this prize every two years at its International Conference on Pattern Recognition popularly known as ICPR. It is noteworthy that seven winners of the King-Sun Fu Prize (out of a total of

11 awarded so far) are among the authors in the book edited by Professors Young and Fu.

The present book consists of 30 papers clustered in five broad chapters. It consists of original contributions from a few coupled disciplines, including pattern recognition, machine intelligence, computer vision, image processing, and signal processing. Authors review existing methodologies, propose new approaches, and build systems on fairly diversified applications including face recognition, activity recognition, and biometric authentication. The book will appeal to researchers, students, and technologists.

It is a pleasure to be part of the tribute to Professor King-Sun Fu.

J.K. Aggarwal
Cullen Trust Professor
Department of Electrical and Computer Engineering
The University of Texas at Austin
May 2011

Foreword By Brian C. Lovell

This is the second in a series of books on pattern recognition to honour the memory of Professor King-Sun Fu. No one deserves more credit for the founding of the International Association for Pattern Recognition than King-Sun Fu. In 1971, King-Sun Fu invited several leading researchers to set up a committee for an international conference on pattern recognition[1]. This led directly to the First International Joint Conference on Pattern Recognition (IJCPR) which was held in Washington, D.C., from 30th October to 1st November, 1973. Discussions at the Lyngby IJCPR in 1974 recommended the formation of an entirely new international society which would be a kind of federation of national organizations in pattern recognition. The name of the organization would be "The International Association for Pattern Recognition" as suggested by Herbert Freeman.

The IAPR came into official existence in January, 1978 with King-Sun Fu as the inaugural President. Today the IAPR has 43 member organisations from all around the globe. It sponsors numerous pattern recognition conferences in many countries as well as organising the International Conference on Pattern Recognition (formerly IJCPR) conference series.

Thus it was a tremendous blow when King-Sun Fu died suddenly on 29 April 1985 aged just 55. His untimely death was a loss to the whole community and was keenly felt by his family, friends, students, and his IAPR colleagues. He, more than anyone, created the organization, serving as its inaugural president, and was a leading figure in the field of Pattern Recognition. In 1988 the IAPR awarded the first K.S. Fu Prize to commemorate his achievements. The prize was to be given no more often than biennially to a living person "in recognition of a technical contribution of far-reaching significance and impact on the field of pattern recognition or its closely allied fields made at any time in the past." The K.S. Fu prize serves as the "Nobel Prize" for pattern recognition.

It is appropriate to commemorate King-Sun Fu's achievements with this second edition of collected works representing emerging aspects of the exciting field of pattern recognition which he did so much to establish. These chapters cover diverse topics ranging from biometrics to image forensics and data mining. They give an insight into just how much the field of pattern recognition has advanced since the foundational works of King-Sun Fu in the 1970s.

Brian C. Lovell
President of the IAPR, 2008 – 2010
May 2011

1 Freeman, H., Detailed History of the IAPR, http://www.iapr.org/docs/IAPR-History.pdf, [last visited: March 2011]

Foreword By Sargur N. Srihari

My memories of King-Sun Fu date from the early 1970's when I was a graduate student beginning my studies in pattern recognition. At that time Fu's work at Purdue University was very influential for anyone interested in entering the field.

Fu was synonymous with a new area of pattern recognition called *syntactic pattern recognition*[1]. Statistical pattern recognition was already an established field with the appearance of the pre-print of Duda and Hart's textbook in 1972[2]. Syntactic pattern recognition was an alternative approach to recognizing visual patterns, such as handwritten characters, based on formal grammars. Fu was a vigorous advocate of the syntactic approach as an alternative to purely statistical models. The goal was to exploit knowledge of structure in designing pattern recognition algorithms. There existed a small body of work such as that of R. Narasimhan at the University of Illinois who proposed a full set of grammatical rules for the English alphabet[3]. Others included R. A. Kirsch of the National Bureau of Standards who proposed rules for shapes[4] and A. Joshi of the University of Pennsylvania who suggested tree grammars[5]. While Fu and Narasimhan, who both did their graduate work at the University of Illinois-Urbana/Champaign, were interested in syntactic pattern recognition , Fu took it to the next stage by proposing the use of probabilities with grammatical rules. The explanatory powers associated with such methods were attractive to the field of Artificial Intelligence which was just beginning to take off. Today pattern recognition and the associated field of machine learning have enormous applications in every field. It is quite common to see both syntactic and statistical pattern recognition being used in the same system, e.g., domain-specific rules written by linguists and maximum entropy Markov models are both used in a single commercially available information extraction system[6].

Fu also made important contributions to an area he named as *sequential pattern recognition*[7]. The goal here was to build pattern recognition algorithms which could take features as input one at a time and stop when a sufficient level of confidence was reached. He adapted Abraham Wald's se-

1 K.S. Fu, *Syntactic Methods in Pattern Recognition*, Academic Press, 1974.

2 R.O. Duda and P.E. Hart, *Pattern Recognition and Scene Analysis*, Wiley-Interscience, 1973.

3 R.A. Narasimhan, "Syntax-directed Interpretation of Classes of Pictures", Communications of the ACM, vol. 9, issue 6, 1966.

4 R.A. Kirsch, "Computer interpretation of English text and picture patterns", *IEEE Trans. Elect. Comp.*, EC-13 (Aug. 1964), pp. 363 – 376.

5 A. Joshi, S.R. Kosaraju, H. Yamada, "String Adjunct Grammars", *Proceedings Tenth Annual Symposium on Automata Theory*, Waterloo, Canada, 1969.

6 K.S. Fu, *Sequential Methods in Pattern Recognition and Machine Learning*, Academic Press, 1968.

7 R.K. Srihari, W. Li, C. Niu and T. Cornell, "InfoXtract: A Customizable Intermediate Level Information Extraction Engine", *Journal of Natural Language Engineering*, Cambridge U. Press , 14(1), 2008, pp.33 – 69.

quential probability ratio test, known primarily to statisticians, and brought it to the attention of the pattern recognition community. Today sequential models have developed much further and are at the heart of machine learning methods such as hidden Markov models, conditional random fields and linear dynamical systems.

Arguably, the biggest legacy of Fu was the establishment of the *IEEE Transactions on Pattern Analysis and Machine Intelligence* (IEEE-TPAMI) which began publication in 1981. It was an almost single-handed effort to build a community of researchers. Previously papers on pattern recognition would go to *IEEE Transactions on Computers* (IEEE-TC) which was dominated by digital circuits research. In fact the first I heard about IEEE-TPAMI was after I had submitted a paper to IEEE-TC, I received a call from King-Sun Fu asking whether it would be appropriate to transfer it to the newly established IEEE-TPAMI. I readily agreed and was pleased to have had a paper in the first issue of IEEE-TPAMI[8].

It was not surprising that Fu chose to use the phrase *Pattern Analysis* since that reflected both statistical methods and grammatical rules. The term *Machine Intelligence* reflected the inclusion of Artificial Intelligence (AI). At that time AI was thought of as consisting of algorithms based on logic, heuristics and expert rules. The phrase "machine intelligence" was less used but it had been the title of an influential series of volumes emerging from Edinburgh University[9]. The term "machine" avoided negative connotations of artificial intelligence such as whether natural intelligence was superior to artificial intelligence. Today IEEE-PAMI is the pre-eminent transactions of the IEEE. It has the highest impact factor of all Artificial Intelligence journals. Perhaps IEEE-PAMI itself is a tribute to King-Sun Fu's foresight.

Finally I had two other interactions with King-Sun Fu. As a graduate student I wrote to him about some fine points in the sequential models he espoused. I received a prompt response from him clarifying it and sending me a helpful pre-print. My only occasion to meet him in person was at a *Computer Vision and Pattern Recognition (CVPR)* conference in Chicago in 1979.

The present volume reflects many of the same themes and applications that were foreseen by King-Sun Fu in the early days of syntactic pattern recognition, sequential models and the pre-eminent journal that he founded.

Sargur N. Srihari
SUNY Distinguished Professor
University at Buffalo, The State University of New York
May 2011

8 S.N. Srihari, "Recursive Implementation of a Two-step Nonparametric Decision Rule," *IEEE Transactions on Pattern Analysis and Machine Intelligence*, IEEE-TPAMI, vol. 1, no. 1, 1981, pp. 90 – 94.

9 D. Michie, On Machine Intelligence, Edinburgh University Press, 1974.

Preface

In our time of rapidly changing Information Technology (IT) age, there is growing interest in Pattern Recognition and Machine Intelligence and its applications to Biometrics in academia and industries. Novel theories have been found, with new design of technology and systems, in hardware, software and mid-ware. They are extensively studied and widely used to our daily life to solve realistic problems, including science, engineering, agriculture, e-commerce, education, robotics, government, hospital, games and animation, medical imaging analysis and diagnosis, military, personal identification and verifications, and homeland security. The foundation of all these can be traced back to late Professor King-Sun Fu (10/2/1930—4/29/1985), one of the fathers of Pattern Recognition, who was visionary and founded the International Association for Pattern Recognition (IAPR) in 1978. Ever since then, after 33 years, the world has eye witnessed the rapid growth and development of this field, and most people can sense and be touched by its applications in our daily lives.

Today at the eve of his 81th birthday and 26th anniversary of unfortunate and untimely passing of Prof. Fu, we are proud to produce this volume of collected works by the world renowned professionals and experts in Pattern Recognition, Machine Intelligence, and Biometrics (PRMIB) in honor and memory of the late Professor King-Sun Fu. We hope this book will help promote further its course of not only fundamental principles, systems and technologies, but also its vast applications to help solving our daily life problems.

There have been tons of complimentary remarks and praises about Professor Fu's extraordinary achievements on PRMIB, including hundreds of paper and book publications, numerous prestigious awards, founder of IEEE-PAMI and IAPR and an NSF Research centers and so on. Professor Fu is known as one of the greatest computer scientists and engineers. But actually more than that, he is also a great artist and music lover. He believes liberal arts education, and plays volleyball well. In his Lab at Purdue University, most, if not all his team, researchers and students' popular entertainment or exercise is to play volleyball. He also enjoys reading novels and poems. I remember when he came to Boston to give a seminar, we had some discussions on his most recent work then, on "towards a unification theory of statistical and syntactic pattern recognition". He noticed on my desk that there was a paper clip of my article "On Puccini's opera 'Turandot' and Chinese folk song 'Jasmine flower' ". It immediately attracted his attention and interest to request a copy. Everywhere we met or communicated in USA, Canada, Europe or Asia, he always showed strong concerns on not only progress of pattern recognition, but also world affairs, humanity and environment. Although, regrettably, he

did not finish his ambitious plan to establish a theory towards unification of statistical, syntactical and structural pattern recognition, pretty much like Einstein did not have time to finish his effort towards unification of forces, yet, Professor King-Sun Fu indeed was not only a distinguished professor, but also a great teacher from whom we do learn much. No wonder, as Professor Thomas Huang put it, in his King-Sun Fu Prize laureate speech at 2002 ICPR, Quebec City, Canada, that "There is no so-called last student of Professor Fu. We all are his students". Yes, indeed, Professor Fu, you live in our hearts forever.

This book of Pattern Recognition, Machine Intelligence and Biometrics in memory of Prof King-Sun Fu is divided into 4 parts as follows:

Part I: **Pattern Recognition and Machine Intelligence** begins with A Review of Applications of Evolutionary Algorithms in Pattern Recognition by Luis Gerardo de la Fraga and Carlos A. Coello Coello, which shows some of the most representative work regarding techniques and applications of volutionary algorithms in pattern recognition. K.C. Wong, Dennis Zhuang, Gary C.L. Li and En-Shiun Annie Lee introduce Pattern Discovery and Recognition in Sequences. In A Hybrid Method of Tone Assessment for Mandarin CALL System by Yang Qu, Xin He, Yue Lu and Patrick S.P. Wang, an approach based on forced alignment of Hidden Markov Model (HMM) is employed to train utterances for obtaining model of getting accurate syllable boundary of utterances. Zheng Liu and Wei Wu present a state-of-art review of the fusion techniques for infrared images in Fusion with Infrared Images for an Improved Performance and Perception. Janos Csirik and Horst Bunke introduce a general framework for pattern classification in wireless sensor networks that aims at increasing the lifetime of the underlying system by using a number of features as small as possible in Feature Selection and Ranking for Pattern Classification in Wireless Sensor Networks. In Principles and Applications of RIDED-2D — A Robust Edge Detection Method in Range Images, Jian Wang, et al. proposes a novel Rule-based Instantaneous Denoising and Edge Detection method (RIDED-2D) for preprocessing range images.

Part II: **Computer Vision and Image Processing** begins Lens Shading Correction for Dirt Detection by Chih-Wei Chen and Chiou-Shann Fuh, presents a novel inspection framework to detect dirt and blemish in production line of optical fabrication automatically. In Using Prototype-Based Classification for Automatic Knowledge Acquisition, Petra Perner and Anja Attig describe how prototype-based classification can be used for knowledge acquisition in image classification. Elena S'anchez-Nielsen and Mario Hern'andez-Tejera include experimental results with inside and outside video streams demonstrating the effectiveness and efficiency for real-time machine vision based tasks in unrestricted environments. In Human Extremity Detection for Action Recognition, Elden Yu and J.K. Aggarwal propose that the location of human extremities alone (including head, hands, and feet) provides an

excellent approximation to body motion. Brian C. Heflin, et al. review influential works along recent topics of ensemble learning approaches devised for recognizing and tracking objects in Tracking Learning for Object Recognition and Tracking. In Depth Image Based Rendering, Michael Schmeing and Xiaoyi Jiang give an introduction to Depth Image Based Rendering and discusses some challenges including proposed solutions.

Part III: **Face Recognition and Forensics** begins with Usman Tariq, Yuxiao Hu, and Thomas S. Huang's Gender and Race Identification by Man and Machine, and details a comprehensive study on gender and race identification from different facial representations. In Common Vector Based Face Recognition, Ying Wen, Yue Lu, Pengfei Shi, and Patrick S.P. Wang study an approach for face recognition based on the difference vector plus the kernel PCA (Principal component analysis). In A Look at Eye Detection for Unconstrained Environments, Brian C. Heflin, et al. take a look at eye detection for the latter, which encompasses problems of flexible authentication, surveillance, and intelligence collection. Weishi Zheng et al. introduce recent advanced developments of using KPCA for nonlinear image preprocessing in Kernel Methods for Facial Image Preprocessing. Sangita Bharkad and Manesh Kokare give a brief survey of current fingerprint matching methods and technical achievement in this area in Fingerprint Identification — Ideas, Influences, and Trends of New Age. Hong Huang gives a Comparative Study of Face Recogition — Subspaces versus submanifolds. In Linear and Nonlinear Feature Extraction Approaches for Face Recognition, Wensheng Chen, Pong C. Yuen, Bin Fang and Patrick S.P. Wang introduce recent progress and existing challenges in the area of face recognition (FR). In Facial Occlusion Reconstruction Using Direct Combined Model, Chingting Tu and Jenn-Jier James Lien develop means to recover the occluded region(s) of the facial image such that the performance of these applications can be improved. Sargur N. Srihari and Chang Su consider generative models for forensic evidence where the goal is to describe the distributions using graphical models and to use such models to compute probabilistic metrics for measuring the degree of individuality of a forensic modality or of a piece of evidence in Generative Models and Probability Evaluation for Forensic Evidence. In Feature Mining and Pattern Recognition in Digital Image Forensics, Qingzhong Liu et al. present some recent results on detecting JPEG steganograms, doubly compressed JPEG images, and resized JPEG images based on a unified framework of feature mining and pattern recognition approaches.

Part Ⅳ: **Biometrics Authentication** begins with Biometric Authentication by Jiunn-Liang Lin, Ho-Ling Hsu, Tai-Lang Jong and Wen-Hsing Hsu, which introduces several biometric recognition technologies, including person's face, eye pupil, sound, etc., the standardization development of biometrics technology, and recent projects in all countries for various applications. In Radical-Based Hybrid Statistical-Structural Approach for Online Hand-

written Chinese Character Recognition, Chenglin Liu and Longlong Ma describe a new radical-based online handwritten Chinese character recognition approach which combines the advantages of statistical methods and radical-based structural methods. In Current Trends in Multimodal Biometric System — Rank Level Fusion, Marina Gavrilova and Maruf Monwar provide an in-depth overview of traditional multimodal biometric systems and current trends in multimodal biometric fusion. In Off-line Signature Verification by Matching With a 3D Reference Knowledge Image — From Research to Actual Application, Maan Ammar introduces a method for off-line verification of signatures, which can verify signatures and detect skilled forgeries with outstanding performance. In Unified Entropy Theory on Pattern Recognition and Maximum MI Discrimination based Subspace Pattern Recognition, a unified entropy theory on Pattern Recognition is presented by Ding Xiaoqing. In Fundamentals of Biometrics — Hand Written Signature and Iris by Radhika K R and Sheela S V, they introduced a new method combining hand written signature characteristics and iris texture variations to form an occurrence vector to provide biohashing. In Recent Trends in Iris Recognition, Lenina Birgale and Manesh Kokare discusse recent trends of Iris Recognition by means of Knowledge, Possession and Reality. In Using Multisets of Features and Interactive Feature Selection to Get Best Qualitative Performance for Automatic Signature Verification, Maan Ammar reports the results obtained by using the MSF technique in case of using large number of feature sets. Last but not least, in Fourier Transform in Numeral Recognition and Signature Verification, Giovanni Dimauro presents the fundamentals of digital transforms and their use in handwriting recognition.

A short description of each chapter evidently is not adequate to present the excellent contributions by all authors. The high-quality Publication of Higher Education Press (HEP) and Springer-Verlag, however, provides a ample opportunity to let each chapter to speak for itself, and therefore readers are strongly encouraged to peruse individual chapters in detail. This monumental and milestone book is indeed very rich and stimulating of vibrating activities in theory, applications, and system technologies in Pattern Recognition, Machine Intelligence and Biometrics (PRMIB).

Working out this book cannot be done by a single individual alone. It is the result of dedicated team work. I would like to take this opportunity to show my deepest appreciations to all contributors, without whom this book can never come out. I also want to thank all foreword writers (in alphabetic order): Professors Jake Aggarwal, Brian Lovell, and Sargur Srihari, who are either current or past President, Fellows, or King-Sun Fu Prize Laureates of IAPR, the largest and most prestigious organization of its kind. I also want to show my appreciation to Mrs. Meihua Wu Fu, who kindly provides some photos of late Professor King-Sun Fu. Thanks also go to HEP and Springer, for their strong support of this book project. Jake and his student Elden

Yu's suggestion to preface is also appreciated. Finally, I like to thank my parents, sons George Da-Yuan and David Da-Wen, for their understanding, encouragement and prayer. Above all, thank God for granting me life and soul, without which I can never have today.

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