

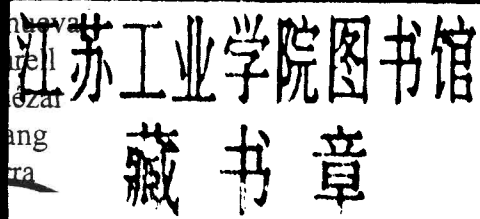
Proceedings
15th International Conference on
Pattern Recognition

Barcelona, Spain
September 3 – 7, 2000

Volume 3.
Image, Speech, and Signal Processing

Editors

A. Sanfeliu
J.J. Villanueva
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R. Alquézar
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Los Alamitos, California
Washington • Brussels • Tokyo

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Proceedings
15th International Conference on
Pattern Recognition

ICPR-2000

Volume 3
Image, Speech, and Signal Processing

Message from the ICPR2000

General Co-Chairs

Welcome to the 15th International Conference on Pattern Recognition and welcome to Barcelona!

Firstly, we would like to thank you all for participating in the ICPR2000. It has been an honour for us to have such a good reception. We never expected so many papers to be sent for submission. It has been a nice surprise.

We received 1438 papers and, we have finally accepted 973 (410 for Track 1; 251 for Track 2; 114 for Track 3; and, 198 for Track 4). From all those received we had to reject some very good papers for logistic reasons, and this large submission delayed the review process for different reasons. We therefore want to offer our apologies for all the changes we have made with the conference dates. We hope we have not caused too many inconveniences to the participants.

In this conference we have incorporated some new issues that we believe makes ICPR more attractive. As well as the combination of four parallel tracks of sessions with their respective Plenary Invited Speakers, we have included Invited Papers and Contests to increase the participation of the congress's people in this event. We have tried to put an Invited Paper for each oral session. We have specially invited 26 well known specialists in order for them to present the state of the art of a topic giving a personal review and outlook in a provocative, entertaining and meaningful way. We have also included several Contests to encourage the participation of research groups to solve specific issues.

We want to thank the help of many people. First of all the help of Edzard Gelsema Ex-president of IAPR, who's death surprised us during the organization of the Congress. We want to give special thanks to the Local Organization Co-Chairs, Maria Vanrell and René Alquézar for their dedication and devotion to ICPR2000, and to Mérida McCarthy for her administrative assistance. We would like to express our appreciation to all the referees for their excellent work and patience, specially considering the unexpected "avalanche" of papers. The work of the Track Chairs for their support at all times, and for maintaining the very high scientific quality of the conference, is also specially recognised. We also want to thank to members of the IAPR, the Centre de Visió per Computador, the Institut de Robòtica e Informàtica Industrial, the ESAI and the OTAC for their valuable help in the organization of the congress. Last but not least, we want to thank specially the collaboration in the organization of the Spanish Association for Pattern Recognition and Image Analysis (AERFAI), the Universitat Politècnica de Catalunya and the Universitat Autònoma de Barcelona.

We hope you all enjoy the conference and your stay in Barcelona!

Alberto Sanfeliu
Juan José Villanueva
ICPR2000 General Co-Chairs

Message from the Acting President of IAPR

It is my great pleasure to welcome you to the 15th International Conference on Pattern Recognition. This conference is the main event of the International Association for Pattern Recognition (IAPR). I hope you'll find it rewarding to attend the technical sessions, enjoy meeting colleagues and friends, and have some time for sightseeing in the beautiful city of Barcelona.

This ICPR is special for several reasons. First, it will be the last ICPR in this millenium. Secondly, it received the most papers ever submitted to an ICPR, and the organizers expect the largest number of people ever attending an ICPR. And thirdly, it marks 25 successful years of IAPR activities. Strictly speaking, IAPR was only founded at the 3rd International Conference on Pattern Recognition in Coronado, California, on November 8, 1976. But a significant portion of the work to set up the organization was actually done in the year 1975.

The large attendance to this conference is a clear indication of the growing importance of our field. But there are other indicators as well. Since the last ICPR held in Brisbane two years ago, the number of national member societies grew from 32 to 37, with New Zealand, Ireland, France, Turkey, and Cuba joining IAPR as new members. There seems to be even potential for a further increase in the number of member societies, particularly in South America and Africa. IAPR is a very active community. Looking at the previous issues of our Newsletter, I counted nearly 30 IAPR Workshops and Conferences held in 1999 and 2000, in addition to ICPR. All these developments and activities clearly show that our discipline is in very prosperous state.

The year 2000 brought us not only good news. It was with great sadness that we had to accept the deaths of IAPR President E. Gelsema and former IAPR President J.C. Simon. They are missed by all of us. We will remember them always as leading scientists, active promoters of IAPR, and fine individuals.

I would like to take this opportunity to express my appreciation to all our colleagues who were engaged in the organization of this conference, especially to the General Co-Chairs and the Track Co-Chairs. Furthermore, many thanks go to the organizers of various IAPR events and the chairs and members of various committees, particularly the Executive Committee.

It has been very enjoyable and rewarding for me to cooperate with them.

**Horst Bunke
University of Bern
Bern, Switzerland
IAPR President**

Message from the ICPR2000 Local Organizing Committee Co-Chairs

Welcome to Barcelona and thanks for participating in the 15th International Conference on Pattern Recognition. We thank all the participants and all the people who expressed their interest or will to participate but for any reasons have not finally come.

First of all, we want to thank the opportunity we have had of organizing this event. The organization of a conference like ICPR2000 has been a source of valuable experiences and has given the opportunity to collaborate with many people of our scientific community. Most of the organization has been done using a web-based software which has kept all the data updated and allowed all the people involved in the organization to share all the information at any time. Even though this has brought slight problems, it has been very useful, simplifying all the communications in general. From here, we want to encourage the future organizers to go further in digitalisation and electronic communication in all the stages of the conference organization including the final publication of all the papers.

Due to the large amount of submitted papers, the review process was especially difficult and we would like to thank all the referees for their kind contribution and for their patience, the non-digital shipping of papers introduced the most important delay in the organization. In this respect, we want to express our gratitude to all the track chairs, Yiannis Aloimonos, Jan-Olof Eklundh, Anil K. Jain, Josef Kittler, Tom Huang, Jean Serra, James Crowley and Yoshiaki Shirai, who have been ready to do at any moment all the tasks concerning the technical program. They are responsible of the high technical level of this conference. In this sense, we also want to specially thank to Joan Climent for preparing an excellent tutorial program.

We also appreciate the help of the IAPR Executive Committee, as well as Brian Lovell and Walter Kropatsch as main organizers of previous ICPR conferences, for their guidelines, comments and suggestions, and of Susan and Michael Duff in the dissemination of news regarding this event.

Obviously, this kind of events are not strictly organised by two people, we have always been supported by our colleagues from the Centre de Visió per Computadora of the UAB and the Institut de Robòtica i Informàtica Industrial of the UPC, from them we want to specially thank to Ernest Valveny, Josep Lladós, Albert Pujol, Ramon Baldrich and Xavier Roca.

Finally, we want to thank the help of many people who have taken responsibilities for different parts of the organization. In particular, to Mérida McCarthy for her excellent administrative support and willingness, Pere Quintana for the multiple organization tasks, Imma Valls and Joan Masoliver for their full time assistance on the computer programs and Ernest Estruga for his excellent designs. We also, want to thank to Tom Baldwin, Bob Werner and Lorretta Palagi of the IEEE CS Press for all the facilities in the publication process.

Maria Vanrell
René Alquézar
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University of Maryland, USA

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Computer Science Department
KTH, Royal Institute of Technology, Sweden

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Computer Science & Engineering Department
Michigan State University, USA

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GRAVIR of the Institut IMAG
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Yoshiaki Shirai
Dept. of Computer-Controlled Mechanical Systems
Osaka University, Japan

Referees

Track 1: Computer Vision and Image Analysis

Anand, M.N.	Johansen, Peter	Pun, Thierry
Angelopoulou, Elli	Jyrkinen, Lasse	Qiu, Maolin
Antani, Sameer	Kaminski, Jeremie	Radeva, Petia
Baldrich, Ramon	Kanatani, Kenichi	Rao, Cen
Basu, Anup	Kanungo, Tapas	Rasheed, Zeeshan
Bhanu, Bir	Kasturi, Rangachar	Reid, Ian
Bhattacharya, Prabir	Khan, Sohaib	Rigoutsos, Isidore
Binefa, Xavi	Lavest, Jean-Marc	Roca, Xavi
Bischof, Horst	Leberl, Franz	Röning, Juha
Bobick, Aaron	Lee, Sang	Sakurai, Shigeaki
Bolle, Ruud	Little, Jim	Saludes, Jordi
Boult, Terry	Lladós, Josep	Sánchez, Xavier
Branca, Antonella	Lopez, Antonio	Scherer, Stephan
Burkhardt, Hans	Lopez-Krahe, Jaime	Se, Stephen
Buxton, Bernard	Lourakis, Manolis	Segal, Dana
Caelli, Terry	Lowe, David	Serrat, Joan
Charou, Eleni	Maachi, Waren	Shah, Mubarak
Chellappa, Rama	Madsen, Claus B.	Sharma, Rajeev
Christensen, Henrik	Marchand-Maillet, Stéphane	Shavit, Adi
Connell, Jonathan	Mariano, Vladimir	Shirai, Yoshiaki
Coombs, Dave	Martí, Enric	Shizawa, Masahiko
Cootes, Terry	Martínez, Judith	Siddiqi, Kaleem
Crandall, David	Matsuyama, Takashi	Silven, Olli
Crowley, James	Mau-Tsuen, Yang	Smeulders, Arnold
da Fontoura Costa, Luciano	Maybank, Stephen	Soini, Antti
Daniilidis, Kostas	Medioni, Gerard	Sommer, Gerald
Del Bimbo, Alberto	Milios, Evangelos	Spetsakis, Minas
DeMenthon, Daniel	Minoh, Michihiko	Sporring, Jon
Deriche, Rachid	Mori, Yasuhide	Stark, Louise
Dhome, Michel	Myles, Zarina	Stevkovska, Jasmina
Doermann, David	Nayar, Shree	Sturm, Peter
Draper, Bruce	Nelson, Randal	Tistarelli, Massimo
Drew, Mark	Neumann, Bernd	Toledo, Ricardo
Escolano Ruiz, Francisco	Neumann, Jan	Triggs, Bill
Fermueller, Cornelia	Nishimura, Takuichi	Valveny, Ernest
Finlayson, Graham	Oikarinen, Jarkko	Vanrell, Maria
Fisher, Robert	Ojala, Timo	Varona, Xavi
Gandhi, Tarak	Okun, Oleg	Vemuri, Baba
Garcia-Sevilla, Pedro	Oliensis, John	Venkatesh, S.
Gargi, Ullas	Oren, Michael	Verri, Alessandro
Haar Romeny, B. M. Ter	Orphanoudakis, Stelios	von Seelen, Werner
Hancock, Edwin	Pankanti, Sharath	Walker, Ellen
Haralick, Bob	Park, J.H.	Weiss, Isaac
Hassan, Khuram	Peleg, Shmuel	Yabe, Hiroaki
Heikkilä, Janne	Perales, Francisco	Yachida, Masahiko
Hlavac, Vaclav	Petkovic, Dragutin	Yeshurun, Hezy
Hoe, Jesse	Pietikäinen, Matti	Yilmaz, Alper
Hogg, David	Pla, Filiberto	Zomet, Assaf
Hordley, Steven	Plamondon, Re'jean	
Javeed, Omer	Pujol, Albert	

Track 2: Pattern Recognition and Neural Networks

Abdel-Mottaleb, Mohammed
Abdulghafour, Muhamad
Aladjem, Mayer
Alquezar, Rene
Amin, Adnan
Baldrich, Ramon
Buhmann, Joachim
Chen, Sei-Wang
Climent, Joan
Dawoud, Amer
De Ridder, Dick
Duin, Robert
Farshad, Ramin
Feiguth, Paul
Ferri, Francesc
Flusser, J.
Ghosh, Joydeep
Giles, C. Lee
Grau, Antoni
Grim, J.
Gunsel, Bilge
Gyouten, Keiji
Haindl, M.
Hamamoto, Yoshihiko
Hancock, Edwin
Ho, Tin Kam
Hodge, Lovell
Imaya, Atsushi
Jain, Anil
Jelinek, J.
Jolion, Jean-Michel

Kamel, Mohamed
Kimura, Humitaka
Kropatsch, Walter
Kumazawa, Itsuo
Li, Stan
Llados, Josep
Lopez, Antonio
Lovell, Brian
Lumbreras, Felipe
Marszalec, Elzbieta
Martí, Enric
Martínez, Judit
Matas, Jiri
Mayer, H.
Michalek, J.
Mitani, Yoshihiro
Mizukami, Yoshiki
Murni, Aniat
Murshed, Nabeel
Murty, M. Narasimha
Novovicova, J.
Ogawa, Hidemitsu
Ohmachi, Shinichiro
Oommen, B. John
Paclik, P.
Pekalska, Elzbieta
Pelillo, Marcello
Petrrou, Maria
Pudil, Pavel
Pujol, Albert
Roca, Xavi

Roli, Fabio
Saludes, Jordi
Sánchez, Xavier
Serrat, Joan
Sethi, Ishwar
Shihab, Khalil
Shimodaira, Hiroshi
Singh, Samir
Skano, Hitoshi
Skurichina, Marina
Stork, David
Subrahmonia, Jayashree
Tax, David
Taxt, Torfinn
Thomas, Federico
Tombre, Karl
Torras, Carme
Ueda, Naonori
Vanrell, Maria
Varona, Xavi
Vernazza, Gianni
Vidal, Enrique
Visa, Ari
Vitrià, Jordi
Wakabayashi, Tetsuya
Wanas, Nayer
Wilson, Richard
Xu, Lei
Yamashita, Yukihiro
Yeung, Dit-Yan
Ypma, Alexander

Track 3: Image, Speech and Signal Processing

Ablameyko, Sergey	Howitt, Andrew	Schlesinger, M.
Acton, Scott	Hu, Yu Hen	Sekimoto, Nobuhiro
Ahuja, Narendra	Kaveh, Mos	Sezan, Ibrahim
Albiol, Antonio	Kunt, Murat	Sheynin, Stanislav
Aranda, Joan	Lopez, Antonio	Siggelkow, Sven
Arnold, John	Maitre, Henri	Skodras, Athanassios
Ayala Gallego, Guillermo	Marqués, Ferran	Stamon, Georges
Behara, Sagar	Memon, Nasir	Stevenson, Robert L.
Bertrand, Gilles	Mersereau, Russell	Strope, Brian
Binefa, Xavi	Montes, Francisco	Tanaka, Naoki
Cetin, A. Enis	Namazi, Nader	Terol, Ivan
Chen, Chang Wen	Oehler, Karen	Torres, Luis
Chen, Tsuhan	Pan, Xiaochuan	Tuzikov, Alexander
Chin, Roland	Pardàs, Montse	Vallmitjana, Santiago
Cox, Ingemar	Pavlovic, Vladimir	Van Den Boomgaard, Rein
Dubois, Eric	Pearlman, William	Vannier, Michael
Duncan, James	Radeva, Petia	Venetsanopoulos, A.N.
Efstratiadis, Serafim	Ramponi, Giovanni	Viergever, Max
Fisher, Bob	Ramstad, Tor	Weng, John
Gu, chuang	Rodriguez, Jeffrey J.	Wu, Xiaolin
Hasegawa-Johnson, Mark	Ronse, Christian	Yang, Yongyi
Hazen, Timothy	Safranek, Robert	Yzuel, Maria
Heijmans, Henk	Salembier, Philippe	Zerubia, Josiane

Track 4: Applications, Robotics, Systems and Architectures

Abe, Keiichi	Kato, Nei	Sato, Kosuke
Al-Ohali, Y.	Kim, Jinho	Schiele, Bernt
Andersen, Claus	Kim, K.K.	Schomaker, Lambert
Araujo, Helder	Kimura, Fumitaka	Shimada, Yasuhiro
Asada, Minoru	Kise, Koichi	Soriano, Maricor
Aso, Hirotomo	Koerich, A.	Srihari, Sargur
Ayat, N. E.	Konolige, Kurt	Stamon, Georges
Babaguchi, Noboru	Koshimizu, Hiroyasu	Suen, Ching
Baird, Henry	Kuno, Yoshinori	Sugiyama, Takahiro
Belaid, Abdel	Lacey, Gerard	Tamura, Shinichi
Blake, Andrew	Lam, L.	Thomas, Federico
Bremond, Francois	Lee, Hsi-Jian	Thonnat, Monique
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Chen, X.	Mao, Jianchang	Tsuruoka, Shinji
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Etoh, Minoru	Nayar, Shree	Xu, Q.
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Grandidier, F.	Ohno, Hiroshi	Yamada, J
Hasegawa, Jun-ichi	Ohsawa, Yutaka	Yamamoto, Kazuhiko
Hata, Seiji	Ohta, Yuichi	Yamamoto, Masanobu
Hebert, Martial	Oka, Ryuichi	Yamamoto, Shinji
Henri, Maitre	Omachi, Shin'ichiro	Yardimci, Yasemin
Hoshino, Jun'ichi	Oshima, Masaki	Ye, X.
Hung, Yi-Ping	Quian, Y.	Yokoya, Naokazu
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Ishii, Akira	Santos-Victor, José	
Jarvis, Ray	Sasaki, Shigeru	

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Track 3: Image, Speech and Signal Processing

Oral Presentations

Session O3.1A. Image Enhancement, Restoration and Reconstruction I

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