

# PATTERN RECOGNITION

## The Journal of the Pattern Recognition Society

**Editor-in-Chief: ROBERT S. LEDLEY**  
National Biomedical Research Foundation,  
Georgetown University, Box 571479, Washington, DC  
20057-1479, USA

**Deputy Editor: CHING Y. SUEN**  
Department of Computer Science & Software Engineering  
CENPARMI, Concordia University, Building EV,  
Suite 3-105, 1455 de Maisonneuve Bld. West, Montreal,  
Quebec, H3G 1M6, Canada

### Associate Editors

#### General Articles

M. ABDEL-MOTTALEB, U.S.A.  
S. ABLAMEYKO, Belarus  
A. ADAN, Spain  
M. AHMADI, Canada  
M. G. ALBANESI, Italy  
VASSILIS ANASTASSOPOULOS,  
Greece  
I. ANDREADIS, Greece  
NIKOS ASIMOPOULOS, Greece  
RICHARD A. BALDOCK, U.K.  
J. BARRERA, Brazil  
M. BASU, U.S.A.  
E. BAYRO-CORROCHANO, Mexico  
GEORGE BEBIS, U.S.A.  
H. BEISNER, U.S.A.  
R. BERGEVIN, Canada  
BIR BHANU, U.S.A.  
PRABIR BHATTACHARYA, Canada  
HORST BISCHOF, Austria  
I. BLOCH, France  
RUUD M. BOLLE, U.S.A.  
D. BOUCHAFFRA, U.S.A.  
N. BOURBAKIS, U.S.A.  
ALAN C. BOVIK, U.S.A.  
ERNESTO BRIBIESCA, Mexico  
MICHAEL BUAS, U.S.A.  
TERRY CAELLI, Australia  
VIRGINIO CANTONI, Italy  
B. B. CHAUDHURI, India  
SU-SHING CHEN, U.S.A.  
H. D. CHENG, U.S.A.  
RAJ S. CHHIKARA, U.S.A.  
PAUL CHEW, U.S.A.  
LUIGI CINQUE, Italy  
KNUT CONRADSEN, Denmark  
ALBERTO DEL BIMBO, Italy  
C. H. DEBRUNNER, U.S.A.  
A. P. DHAWAN, U.S.A.  
MICHEL DHOME, France  
E. DOUGHERTY, U.S.A.  
STANLEY DUNN, U.S.A.  
ZORAN DURIC, U.S.A.  
T. ELTOFT, Norway  
MARTIN A. FISCHLER, U.S.A.  
HERBERT FREEMAN, U.S.A.  
HIROMICHI FUJISAWA, Japan  
C. GARCIA, France  
JOYDEEP GHOSH, U.S.A.  
MARK L. GILLENSON, U.S.A.  
LEV GOLDFARB, Canada  
YIFAN GONG, U.S.A.  
MARCO GORI, Italy

ARDESHIR GOSHTASBY, U.S.A.  
V. GOVINDARAJU, U.S.A.  
JAMES GRAHAM, U.K.  
WILLIAM I. GROSZKY, U.S.A.  
B. GUNSEL, Turkey  
LALIT GUPTA, U.S.A.  
ADOLFO GUZMAN, Mexico  
MADASU HANMANDLU, India  
EDWIN R. HANCOCK, U.K.  
J. P. HATON, France  
HAGIT Z. HEL-OR, Israel  
LAURENT HEUTTE, France  
WILLIAM E. HIGGINS, U.S.A.  
TIN KAM HO, U.S.A.  
WILLIAM A. HOFF, U.S.A.  
N. HONDA, Japan  
JAMES H. HOWARD, JR., U.S.A.  
JONATHAN J. HULL, U.S.A.  
J. ILLINGWORTH, U.K.  
ATSUSHI IMIYA, Japan  
HORACE H. S. IP, Hong Kong  
ANIL K. JAIN, U.S.A.  
JEAN-MICHEL JOLION, France  
C. KAMBHAMETTU, U.S.A.  
ABE KANDEL, U.S.A.  
BABACK MOGHADDAM, U.S.A.  
MOSHE KAM, U.S.A.  
SHUN'ICHI KANEKO, Japan  
T. KASPARIS, U.S.A.  
RANGACHAR KASTURI, U.S.A.  
KLARA KEDEM, Israel  
H. R. KESHAVAN, U.S.A.  
RAJIV KHOSLA, Australia  
A. KHOTANZAD, U.S.A.  
N. KIRYATI, Israel  
TADAHIRO KITAHASHI, Japan  
WALTER G. KROPATSCHE, Austria  
ADAM KRZYZAK, Canada  
MINEICHI KUDO, Japan  
S. KUMAR, U.S.A.  
L. J. LATECKI, U.S.A.  
JAMES S. J. LEE, U.S.A.  
GRAHAM LEEDHAM, Singapore  
SEONG-WHAN LEE, Korea  
ALES LEONARDIS, Slovenia  
REINER LENZ, Sweden  
JIA-GUU LEU, Taiwan  
S. LEVIALDI, Italy  
S. Z. LI, China  
XIAOBO LI, Canada  
C. LIEBERMAN, U.S.A.  
YUNCAI LIU, China

ZHI-QIANG LIU, Hong Kong  
LUCA LOMBARDI, Italy  
HONG-QIAN LU, U.S.A.  
YI LU, U.S.A.  
JIEBO LU, U.S.A.  
MICHAEL MAGEE, U.S.A.  
ABHIJIT MAHALANOBIS, U.S.A.  
HENRI MAITRE, France  
D. MALTONI, Italy  
TAKASHI MATSUYAMA, Japan  
PETER MEER, U.S.A.  
R. MEHROTRA, U.S.A.  
B. M. MEHTRE, India  
ROBERT A. MELTER, U.S.A.  
MICHIO MINO, Japan  
JEAN-VINCENT MOREAU, France  
RANDY MOSS, U.S.A.  
DAVID MOUNT, U.S.A.  
VITTORIO MURINO, Italy  
YASUAKI NAKANO, Japan  
NATHAN S. NETANYAHU, Israel  
TIMOTHY NEWMANN, U.S.A.  
LAWRENCE O'GORMAN, U.S.A.  
B. J. OOMMEN, Canada  
Y.-H. PAO, U.S.A.  
D. W. PAGLIERONI, U.S.A.  
CHAN M. PARK, Korea  
L. PASTOR, Spain  
M.S. PATTICHIS, U.S.A.  
MARCELLO PELILLO, Italy  
YUN PENG, U.S.A.  
MICHAEL A. PENNA, U.S.A.  
JEROME K. PERCUS, U.S.A.  
A. PETROSINO, Italy  
T. PHAM, Australia  
K.N. PLATANOTIS, Canada  
REJEAN PLAMONDON, Canada  
RAVI P. RAMACHANDRAN,  
S. RANGANATH, Singapore  
N. RANGANATHAN, U.S.A.  
NALINI K. RATHA, U.S.A.  
A. RAVISHANKAR RAO, U.S.A.  
S. RAUDYS, Lithuania  
T. REED, U.S.A.  
E. RIVLIN, Israel  
MICHAEL ROBINSON, U.S.A.  
J. B. T. M. ROERDINK, Netherlands  
KARL ROHR, Germany  
FRANK H. RUDDLE, U.S.A.  
R. SABLATNIG, Austria  
PUNAM K. SAHA, U.S.A.  
A. SAMAL, U.S.A.

HANAN SAMET, U.S.A.  
SIMONE SANTINI, U.S.A.  
SUDEEP SARKAR, U.S.A.  
R. SCHETTINI, Italy  
SHOKRI Z. SELIM, Saudi Arabia  
ISHWAR K. SETHI, U.S.A.  
MUBARAK SHAH, U.S.A.  
LINDA G. SHAPIRO, U.S.A.  
FRANK Y. SHIH, U.S.A.  
M. SHRIDHAR, U.S.A.  
KALEEM SIDDIQI, Canada  
SAMEER SINGH, UK  
JACK SKLANSKY, U.S.A.  
ATHANASSIOS SKODRAS, Greece  
NIR A. SOCHEN, Israel  
MICHAEL SPANN, U.K.  
ROHINI SRIHARI, U.S.A.  
S. N. SRIHARI, U.S.A.  
M. D. SRINATH, U.S.A.  
LOUISE STARK, U.S.A.  
GEORGE STOCKMAN, U.S.A.  
CHING Y. SUEN, Canada  
P. N. SUGANTHAN, Singapore  
KOKICHI SUGIHARA, Japan  
B. J. SUPER, U.S.A.  
SHINICHI TAMURA, Japan  
T. N. TAN, China  
STEVEN L. TANIMOTO, U.S.A.  
JAMES C. TILTON, U.S.A.  
LEONID V. TSAP, U.S.A.  
JULIAN R. ULLMANN, U.K.  
SCOTT UMBACH, U.S.A.  
M. UNSER, Switzerland  
R. C. VELTKAMP, The Netherlands  
ANDREW M. WALLACE, U.K.  
T. WAKAHARA, Japan  
JASON T. L. WANG, U.S.A.  
HARRY WECHSLER, U.S.A.  
MICHAEL WERMAN, Israel  
ROLAND WILSON, U.K.  
R. C. WILSON, U.K.  
HONG YAN, Australia  
HERBERT YEE-HONG YANG, Canada  
N. YOKOYA, Japan  
MARSHALL YOVITS, U.S.A.  
BABACK MOGHADDAM, U.S.A.  
H. ZHA, U.S.A.  
CHANGSHUI ZHANG, China  
DAPENG ZHANG, Hong Kong  
ZHONGFEI ZHANG, U.S.A.  
SOTIRIOS G. ZIAVRAS, U.S.A.

### Rapid and Brief Communications Section

KEIICHI ABE, Japan  
ARUN AGARWAL, India  
ABDEL BELAID, France  
KOICHIRO DEGUCHI, Japan

BRUCE DENBY, France  
A. GLEN HOUSTON, U.S.A.  
MARIE-PIERRE JOLLY, U.S.A.  
ROBERT M. KLEYLE, U.S.A.

JOSE L. MARROQUIN, Mexico  
SHARATH PANKANTI, U.S.A.  
MATTI PIETIKAINEN, Finland

DINGGANG SHEN, U.S.A.  
YUAN-FANG WANG, U.S.A.  
FRANCK XIA, U.S.A.

Published Monthly. © 2006 Pattern Recognition Society

**Publication information:** Pattern Recognition (ISSN 0031-3203). For 2006, Volume 39 is scheduled for publication. Subscription prices are available upon request from the Publisher or from the Regional Sales Office nearest you or from this journal's website: (<http://www.elsevier.com/locate/patcog>). Further information is available on this journal and other Elsevier products through Elsevier's website: (<http://www.elsevier.com>). Subscriptions are accepted on a prepaid basis only and are entered on a calendar year basis. Issues are sent by standard mail (surface within Europe, air delivery outside Europe). Priority rates are available upon request. Claims for missing issues should be made within six months of the date of dispatch.

**Advertising information:** Advertising orders and enquiries can be sent to: **USA, Canada and South America:** Mr Tino DeCarlo, The Advertising Department, Elsevier Inc., 360 Park Avenue South, New York, NY 10010-1710, USA; phone: (+1) (212) 633 3815; fax: (+1) (212) 633 3820; e-mail: [t.decarlo@elsevier.com](mailto:t.decarlo@elsevier.com). **Europe and ROW:** Katrina Barton, Print Operations Co-ordinator, Elsevier, 84 Theobalds Road, London, WC1X 8RR, UK; Tel: +44 (0) 20 7611 4117; Fax: +44 (0) 20 7611 4463; email to: [commercialsales@elsevier.com](mailto:commercialsales@elsevier.com)

**Author enquiries:** For enquiries relating to the submission of articles (including electronic submission where available) please visit Elsevier's Author Gateway at <http://authors.elsevier.com>. The Author Gateway also provides the facility to track accepted articles and set up e-mail alerts to inform you of when an article's status has changed, as well as detailed artwork guidelines, copyright information, frequently asked questions and more.

Contact details for questions arising after acceptance of an article, especially those relating to proofs, are provided after registration of an article for publication.

**Orders, claims, and journal enquiries:** please contact the Customer Service Department at the Regional Sales Office nearest you: **Orlando:** Elsevier, Customer Service Department, 6277 Sea Harbor Drive, Orlando, FL 32887-4800, USA; phone: (+1) (877) 839 7126 [toll free number for US customers], or (+1) (407) 345 4020 [customers outside US]; fax: (+1) (407) 363 1354; e-mail: [usjcs@elsevier.com](mailto:usjcs@elsevier.com). **Amsterdam:** Elsevier, Customer Service Department, PO Box 211, 1000 AE Amsterdam, The Netherlands; phone: (+31) (20) 4853757; fax: (+31) (20) 4853432; e-mail: [nlinfo-f@elsevier.com](mailto:nlinfo-f@elsevier.com). **Tokyo:** Elsevier, Customer Service Department, 4F Higashi-Azabu, 1-Chome Bldg, 1-9-15 Higashi-Azabu, Minato-ku, Tokyo 106-0044, Japan; phone: (+81) (3) 5561 5037; fax: (+81) (3) 5561 5047; e-mail: [jp.info@elsevier.com](mailto:jp.info@elsevier.com). **Singapore:** Elsevier, Customer Service Department, 3 Killiney Road, #08-01 Winsland House I, Singapore 239519; phone: (+65) 6349 0222; fax: (+65) 6733 1510; e-mail: [asiainfo@elsevier.com](mailto:asiainfo@elsevier.com).

**USA mailing notice:** Pattern Recognition (ISSN 0031-3203) is published monthly by Elsevier Ltd (The Boulevard, Langford Lane, Kidlington, Oxford OX5 1GB, UK). Annual subscription price in the USA US\$ 2,863.00 (valid in North, Central and South America), including air speed delivery. Periodical postage rate paid at Rahway NJ and additional mailing offices.

**USA POSTMASTER:** Send address changes to Pattern Recognition, Elsevier, 6277 Sea Harbor Drive, Orlando, FL.

**AIRFREIGHT AND MAILING** in USA by Mercury International Limited, 365, Blair Road, Avenel, NJ 07001.