Encyclopedia of Machine Learning

With 293 Figures and 78 Tables
The term “Machine Learning” came into wide-spread use following the first workshop by that name, held at Carnegie-Mellon University in 1980. The papers from that workshop were published as Machine Learning: An Artificial Intelligence Approach, edited by Ryszard Michalski, Jaime Carbonell and Tom Mitchell. Machine Learning came to be identified as a research field in its own right as the workshops evolved into international conferences and journals of machine learning appeared.

Although the field coalesced in the 1980s, research on what we now call machine learning has a long history. In his 1950 paper on “Computing Machinery and Intelligence”, Alan Turing introduced his imitation game as a means of determining if a machine could be considered intelligent. In the same paper he speculates that programming the computer to have adult level intelligence would be too difficult. “Instead of trying to produce a programme to simulate the adult mind, why not rather try to produce one which simulates the child’s? If this were then subjected to an appropriate course of education one would obtain the adult brain”. Investigations into induction, a fundamental operation in learning, go back much further to Francis Bacon and David Hume in the 17th and 18th centuries.

Early approaches followed the classical AI tradition of symbolic representation and logical inference. As machine learning began to be used in a wide variety of areas, the range of techniques expanded to incorporate ideas from psychology, information theory, statistics, neuroscience, genetics, operations research and more. Because of this diversity, it is not always easy for a new researcher to find his or her way around the machine learning landscape. The purpose of this encyclopedia is to guide enquiries into the field as a whole and to serve as an entry point to specific topics, providing overviews and, most importantly, references to source material. All the entries have been written by experts in their field and have been refereed and revised by an international editorial board consisting of leading machine learning researchers.

Putting together an encyclopedia for such a diverse field has been a major undertaking. We thank all the authors, without whom this would not have been possible. They have devoted their expertise and patience to the project because of their desire to contribute to this dynamic and still growing field. A project as large as this could only succeed with the help of the area editors whose specialised knowledge was essential in defining the range and structure of the entries.

The encyclopedia was started by the enthusiasm of Springer editors Jennifer Evans and Oona Schmidt and continued with the support of Melissa Fearon. Special thanks to Andrew Spencer, who oversaw production and kept everyone, including the editors on track.

Claude Sammut and Geoffrey I. Webb
Editors-in-Chief

Claude Sammut
School of Computer Science and Engineering
University of New South Wales
Sydney, Australia 2052
claude@cse.unsw.edu.au

Geoffrey I. Webb
Faculty of Information Technology
Clayton School of Information Technology
Monash University
P.O. Box 63
Victoria, Australia 3800
Geoff.Webb@monash.edu
Area Editors

Charu Aggarwal  
IBM T. J. Watson Research Center  
19 Skyline Drive  
Hawthorne  
NY 10532  
USA  
charu@us.ibm.com

Wray Buntine  
NICTA  
Locked Bag 8001  
Canberra ACT 2601  
Australia  
wray.buntine@nicta.com.au

James Cussens  
Department of Biology (Area 17)  
York Centre for Complex Systems Analysis  
University of York  
PO Box 373  
York YO10 5YW  
UK  
jc@cs.york.ac.uk

Luc De Raedt  
Dept. of Computer Science  
Katholieke Universiteit Leuven  
Celestijnenlaan 200A  
3001 Heverlee  
Belgium  
luc.deraedt@cs.kuleuven.be

Peter A. Flach  
Department of Computer Science  
University of Bristol  
Woodland Road  
Bristol BS8 1UB  
UK  
Peter.Flach@bristol.ac.uk

Russ Greiner  
Department of Computing Science  
University of Alberta  
Athabasca Hall 359  
Edmonton

Eamonn Keogh  
Computer Science & Engineering Department  
University of California  
Riverside  
California  
CA 92521  
USA  
eamonn@cs.ucr.edu

Michael L. Littman  
Department of Computer Science  
Rutgers, the State University of New Jersey  
110 Frelinghuysen Road  
Piscataway  
New Jersey 08854-8019  
USA  
mlittman@cs.rutgers.edu

Sridhar Mahadevan  
Department of Computer Science  
University of Massachusetts  
140 Governor’s Drive  
Amherst  
MA 01003  
USA  
mahadeva@cs.umass.edu

Stan Matwin  
School of Information Technology and Engineering  
University of Ottawa  
800 King Edward Ave., P.O. Box 450 Stn A  
Ottawa  
Ontario KIN 6N5  
Canada  
stan@site.uottawa.ca

Risto Miikkulainen  
Department of Computer Sciences  
The University of Texas at Austin  
1 University Station C0500
Austin
Texas
TX 78712-0233
USA
risto@cs.utexas.edu

Frank Stephan
Department of Mathematics
National University of Singapore
2 Science Drive 2
S14, Singapore 117543
Singapore
fstefan@comp.nus.edu.sg

Peter Stone
Department of Computer Sciences
The University of Texas at Austin
1 University Station C0500
Austin
Texas
TX 78712-0233
USA
pstone@cs.utexas.edu

Dunja Mladenic
Department for Intelligent Systems
J. Stefan Institute
Jamova 39
1000 Ljubljana
Slovenia
Dunja.Mladenic@ijs.si

Prasad Tadepalli
School of Electrical Engineering and Computer Science
Oregon State University
1148 Kelley Engineering Center
Corvallis
Oregon
OR 97331-5501
USA
tadepall@eeecs.oregonstate.edu

Bernhard Pfahringer
Department of Computer Science
University of Waikato
Private Bag 3105
Hamilton
New Zealand
bernhard@cs.waikato.ac.nz

Takashi Washio
The Institute of Scientific and Industrial Research
Osaka University
8-1 Mihogaoka
Osaka
Ibaraki 567
Japan
washio@ar.sanken.osaka-u.ac.jp

C. David Page
Department of Biostatistics and Medical Informatics
University of Wisconsin Medical School
1300 University Avenue
Wisconsin
Madison WI 53706
USA
page@biostat.wisc.edu

Michail Prokopenko
CSIRO
Macquarie University
Building E6B,
Campus Herring Road
North Ryde
NSW
Australia 2113

Takashi Washio
The Institute of Scientific and Industrial Research
Osaka University
8-1 Mihogaoka
Osaka
Ibaraki 567
Japan
washio@ar.sanken.osaka-u.ac.jp
List of Contributors

Pieter Abbeel
Department of Electrical Engineering and Computer Sciences
University of California
746 Sutardja Dai Hall #1758
CA 94720-1758, Berkeley
California
USA
pabbeel@stanford.edu

Charu C. Aggarwal
IBM T. J. Watson Research Center
19 Skyline Drive
Hawthorne
NY 10532
USA
charu@us.ibm.com

Biliana Alexandrova-Kabadjova
General Directorate of Central Bank Operations
Central Banking Operations Division
Bank of Mexico
Av. S de Mayo No. 6
Col. Centro, C.P. 06059
Mexico, D.F
balexandrova@banxico.org.mx

Periklis Andritsos
Thoora Inc.
Toronto, ON
Canada
periklis@thoora.com

Peter Auer
Institute of Computer Science
University of Leoben
Franz-Josef-Strasse 18
8700 Leoben
Austria
auer@unileoben.ac.at

J. Andrew Bagnell
Robotics Institute
Carnegie Mellon University
5000 Forbes Avenue
Pittsburgh, PA 15213
USA
dbagnell@ri.cmu.edu

Michael Bain
University of New South Wales
Sydney
Australia
mike@cse.unsw.edu.au

Arindam Banerjee
Department of Computer Science and Engineering
University of Minnesota
Minneapolis, MN
USA
banerjee@cs.umn.edu

Andrew G. Barto
Department of Computer Science
University of Massachusetts Amherst
272 Computer Science Building
Amherst, MA 01003
USA
barto@cs.umass.edu

Rohan A. Baxter
Analytics, Intelligence and Risk
Australian Taxation Office
PO Box 900
Civic Square, ACT 2608
Australia
r.baxter@computer.org

Bettina Berendt
Katholieke Universiteit Leuven
Department of Computer Science
Celestijnenlaan 200A
3001 Heverlee
Belgium
Bettina.Berendt@cs.kuleuven.be
Indrajit Bhattacharya
IBM India Research Laboratory
New Delhi
India

Mustafa Bilgic
University of Maryland
AV Williams Bldg
Rm 3217
College Park, MD 20742
USA

Mauro Birattari
IRIDIA
Université Libre de Bruxelles
Brussels
Belgium
mbiro@ulb.ac.be

Hendrik Blockeel
Department of Computer Science
Katholieke Universiteit Leuven
Celestijnenlaan 200A
3001 Heverlee
Belgium
Hendrik.Blockeel@cs.kuleuven.be

Shawn Bohn
Pacific Northwest National Laboratory

Antal van den Bosch
Tilburg centre for Creative Computing
Tilburg University
P.O. Box 90153
5000 LE, Tilburg
The Netherlands
Antal.vdnBosch@uvt.nl

Jürgen Branke
Institut für Angewandte Informatik
und Formale Beschreibungsverfahren
Universität Karlsruhe (TH)
76128 Karlsruhe
Germany
branke@aifb.uni-karlsruhe.de

Pavel Brazdil
LIAAD-INESC Porto L.A./Faculdade de Economia
Laboratory of Artificial Intelligence and Computer Science
University of Porto
Rua de Ceuta n. 118
6.piso
Porto 4050-190
Portugal
pbrazdil@liaad.up.pt

Gavin Brown
The University of Manchester
School of Computer Science
Kilburn Building
Oxford Road
Manchester, M13 9PL
UK
Gavin.Brown@manchester.ac.uk

Ivan Bruha
Department of Computing & Software
McMaster University
Hamilton, ON
Canada
bruha@cas.mcmaster.ca

M.D. Buhmann
Numerische Mathematik
Justus-Liebig University
Mathematisches Institut
Heinrich-Buff-Ring 44
35392 Giessen
Germany
Martin.Buhmann@math.uni-giessen.de

Wray L. Buntine
NICTA
Locked Bag 8001
Canberra ACT 2601
Australia
wray.buntine@nicta.com.au
Tibério Caetano  
Research School of Information Sciences  
and Engineering  
Australian National University  
Canberra ACT 0200  
Australia  
tibério.caetano@nicta.com.au

Nicola Cancedda  
Xerox Research Centre Europe  
6, chemin de Maupertuis  
38240 Meylan  
France  
nicola.cancedda@xrce.xerox.com

Gail A. Carpenter  
Department of Cognitive and Neural Systems  
Center for Adaptive Systems  
Boston University  
Boston, MA  
USA

John Case  
Department of Computer and Information Sciences  
University of Delaware  Newark DE 19716-2586  USA  
case@cis.udel.edu

Tonatiuh Peña Centeno  
Economic Research Division  
Bank of Mexico  
Av. 5 de Mayo # 18  
Col. Centro, C.P. 06059  
Mexico, D.F.

Deepayan Chakrabarti  
Yahoo! Research  
701 1st Avenue  
Sunnyvale, CA 94089  
USA  
deepay@yahoo-inc.com

Philip K. Chan  
Department of Computer Sciences  
Florida Institute of Technology  
Melbourne, FL  
USA  
pkc@cs.fit.edu

Massimiliano Ciaramita  
Yahoo! Research Barcelona  
Ocata 1  
Barcelona 8003  
Spain  
massi@yahoo-inc.com

Adam Coates  
Department of Computer Science  
Stanford University  
Stanford, CA  
USA

David Cohn  
Google, Inc.  
1600 Amphitheatre Parkway  
Mountain View, CA 94043  
USA  
david.cohn@somewhere.com

David Corne  
Heriot-Watt University  
Earl Mountbatten Building  
Edinburgh EH14 4AS  
UK  
dwcorne@macs.hw.ac.uk

Susan Craw  
IDEAS Research Institute  
School of Computing  
The Robert Gordon University  
St. Andrew Street  
Aberdeen AB25 1HG  
Scotland  
UK  
s.crow@comp.rgu.ac.uk

Artur Czumaj  
Department of Computer Science  
University of Warwick  
Coventry CV4 7AL  
UK  
aczumaj@acm.org

Walter Daelemans  
Department of Linguistics  
CLIPS University of Antwerp  
Prinsstraat 13  
Antwerpen  
Belgium  
walter.daelemans@ua.ac.be
Sanjoy Dasgupta  
Department of Computer Science and Engineering  
University of California  
San Diego  
9500 Gilman Drive  
Mail Code 0404  
La Jolla, California 92093-0404  
USA  
dasgupta@cs.ucsd.edu

Gerald DeJong  
Department of Computer Science  
University of Illinois at Urbana  
Urbana, IL  
USA  
mrebl@uiuc.edu

Marco Dorigo  
IRIDIA  
Université Libre de Bruxelles  
Avenue Franklin Roosevelt 50  
1050 Brussels  
Belgium  
mdorigo@ulb.ac.be

Kurt Driessens  
Departement Computerwetenschappen  
Katholieke Universiteit Leuven  
Celestijnenlaan 200 A  
3001 Heverlee  
Belgium  
kurt.driessens@cs.kuleuven.be

Christopher Drummond  
Integrated Reasoning  
National Research Council Institute  
for Information Technology  
1200 Montreal Road  
Building M-50, Room 374  
Ottawa, ON K1A 0R6  
Canada  
Christopher.Drummond@nrc-cnrc.gc.ca

Yaakov Engel  
AICML, Department of Computing Science  
University of Alberta  
2-21 Athabasca Hall  
Edmonton  
Alberta T6G 2E8  
Canada  
yakiengel@gmail.com

Scott E. Fahlman  
Language Technologies Institute  
Carnegie Mellon University GHC 6417  
5000 Forbes Avenue  
Pittsburgh, PA 15213  
USA  
sef@cs.cmu.edu

Alan Fern  
School of Electrical Engineering and  
Computer Science  
Oregon State University  
2071 Kelley Engineering Center  
Corvallis, OR 97330-5501  
USA  
afern@eecs.orst.edu

Peter A. Flach  
Department of Computer Science  
University of Bristol  
Woodland Road  
Bristol, BS8 1UB  
UK  
Peter.Flach@bristol.ac.uk

Pierre Flener  
Department of Information Technology  
Uppsala University  
Box 337  
SE-751 05 Uppsala  
Sweden  
Pierre.Flener@it.uu.se

Johannes Fürnkranz  
TU Darmstadt  
Fachbereich Informatik  
Hochschulstraße 10  
64289 Darmstadt  
Germany  
juffi@ke.informatik.tu-darmstadt.de

Thomas Gärtner  
Knowledge Discovery  
Fraunhofer Institute for Intelligent Analysis and  
Information Systems  
Schloss Birlinghoven  
53754 Sankt Augustin  
Germany  
thomas.gaertner@iais.fraunhofer.de
João Gama  
Laboratory of Artificial Intelligence and Decision Support  
University of Porto  
Porto  
Portugal  
jgama@fep.up.pt

Alma Lilia García-Almanza  
General Directorate of Information Technology  
Bank of Mexico  
Av. 5 de Mayo No. 1  
Col. Centro, C.P. 06059  
Mexico, D.F.  
algarcia@banxico.org.mx

Marko Grobelnik  
Department for Intelligent Systems  
Jožef Stefan Institute  
Jamova 39  
1000, Ljubljana  
Slovenia  
Marko.Grobelnik@ijs.si

Gemma C. Garriga  
Laboratoire d'Informatique de Paris 6  
Universite Pierre et Marie Curie  
4 place Jussieu  
Paris 75005  
France  
gemma.garriga@hut.fi

Stephen Grossberg  
Department of Cognitive  
Boston University  
677 Beacon Street  
Boston, MA 02215  
USA  
steve@bu.edu

Wulfram Gerstner  
Laboratory of Computational Neuroscience  
Brain Mind Institute  
Ecole Polytechnique Fédérale de Lausanne  
Station 15  
1015 Lausanne EPFL  
Switzerland  
wulfram.gerstner@ep.ch

Jiawei Han  
Department of Computer Science  
University of Illinois at Urbana Champaign  
201 N. Goodwin Avenue  
Urbana, IL 61801  
USA  
hanj@cs.uiuc.edu

Lise Getoor  
Department of Computer Science  
University of Maryland  
AV Williams Bldg, Rm 3217  
College Park, MD 20742  
USA  
getoor@cs.umd.edu

Julia Handl  
Faculty of Life Sciences in Manchester  
University of Manchester  
UK  
j.handl@manchester.ac.uk

Michael Harries  
Technology Strategy Division  
Advanced Products Group, Citrix Labs  
North Ryde  
NSW 2113  
Australia

Christophe Giraud-Carrier  
Department of Computer Science  
Brigham Young University  
3361 TMCB Provo  
UT 84602  
USA

Jun He  
Department of Computer Science  
Aberystwyth University  
Aberystwyth SY23 3DB  
Wales  
UK  
j.he@cs.bham.ac.uk
Bernhard Hengst
School of Computer Science & Engineering
University of New South Wales
Sydney
NSW 2052
Australia
bernhardh@cse.unsw.edu.au

Tom Heskes
Radboud University Nijmegen
Toernooiveld
6525 ED
Nijmegen
The Netherlands
t.heskes@science.ru.nl

Geoffrey Hinton
Department of Computer Science Office PT 290 G
University of Toronto
6 King’s College Road
M5S 3G4, Toronto
Ontario
Canada
hinton@cs.toronto.edu

Lawrence Holder
School of Electrical Engineering and Computer Science
Box 642752
Washington State University
Pullman, WA 99164
USA
holder@wsu.edu

Tamás Horváth
Department of Computer Science III
University of Bonn and Fraunhofer IAIS
Fraunhofer Institute for Intelligent Analysis and Information Systems
Schloss Birlinghoven
53754 Sankt Augustin
Germany
tamas.horvath@ais.fraunhofer.de

Eyke Hüllermeier
Knowledge Engineering & Bioinformatics
Head of the KEBI Lab
Department of Mathematics and Computer Science
Philippus-Universität Marburg
Mehrzweckgebäude
Hans-Meerwein-Straße
35032 Marburg
Germany
eyke@informatik.uni-marburg.de

Phil Husbands
Department of Informatics
University of Sussex
Brighton BN19QH
UK
philh@sussex.ac.uk

Marcus Hutter
Australian National University
RSIS Room B259
Building 115
Corner of North and Daley Road
ACT 0200
Canberra
Australia
marcus.hutter@anu.edu.au

Christian Igel
Institut für Neuroinformatik
Ruhr-Universität Bochum
Universitässtr. 150
44780 Bochum
Germany
Christian.Igel@neuroinformatik.ruhr-uni-bochum.de

Sanjay Jain
Department of Computer Science
National University of Singapore
13 Computing Drive
Singapore 117417
Republic of Singapore
sanjay@comp.nus.edu.sg

Tommy R. Jensen
Institut für Mathematik
Alpen-Adria-Universität Klagenfurt
Universitätsstr. 65-67
9020 Klagenfurt
Austria
tjensen@uni-klu.ac.at

Xin Jin
University of Illinois at Urbana-Champaign
Toernooiveld 1
6525 ED
Urbana, IL
USA
<table>
<thead>
<tr>
<th>Name</th>
<th>Institution</th>
<th>Address</th>
<th>Email</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antonis C. Kakas</td>
<td>Department of Computer Science</td>
<td>University of Cyprus</td>
<td><a href="mailto:antonis@ucy.ac.cy">antonis@ucy.ac.cy</a></td>
</tr>
<tr>
<td>Subbarao Kambhampati</td>
<td>Department of Computer Science and Engineering</td>
<td>Arizona State University</td>
<td><a href="mailto:rao@asu.edu">rao@asu.edu</a></td>
</tr>
<tr>
<td>Anne Kao</td>
<td>The Boeing Company</td>
<td>P.O. Box 3707 MC 7L-43, Seattle, WA 98124-2207</td>
<td><a href="mailto:akao@thumper.rt.cs.boeing.com">akao@thumper.rt.cs.boeing.com</a></td>
</tr>
<tr>
<td>George Karypis</td>
<td>Department of Computer Science and Engineering</td>
<td>University of Minnesota</td>
<td><a href="mailto:karypis@cs.umn.edu">karypis@cs.umn.edu</a></td>
</tr>
<tr>
<td>Samuel Kaski</td>
<td>Laboratory of Computer and Information Science</td>
<td>Helsinki University of Technology</td>
<td><a href="mailto:samuel.kaski@tkk.fi">samuel.kaski@tkk.fi</a></td>
</tr>
<tr>
<td>Carlos Kavka</td>
<td>Istituto Nazionale di Fisica Nucleare</td>
<td>University of Trieste</td>
<td><a href="mailto:Carlos.Kavka@ts.infn.it">Carlos.Kavka@ts.infn.it</a></td>
</tr>
<tr>
<td>Kristian Kersting</td>
<td>Knowledge Discovery</td>
<td>Fraunhofer IAIS</td>
<td><a href="mailto:kristian.kersting@iais.fraunhofer.de">kristian.kersting@iais.fraunhofer.de</a></td>
</tr>
<tr>
<td>Joshua Knowles</td>
<td>University of Manchester</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aleksander Kołcz</td>
<td>Microsoft One Microsoft Way</td>
<td>Redmond, WA 98052</td>
<td><a href="mailto:alek@ir.iit.edu">alek@ir.iit.edu</a></td>
</tr>
<tr>
<td>Kevin B. Korb</td>
<td>School of Information Technology</td>
<td>Monash University</td>
<td><a href="mailto:kbbkorb@gmail.com">kbbkorb@gmail.com</a></td>
</tr>
<tr>
<td>Stefan Kramer</td>
<td>Institut für Informatik/I12</td>
<td>Technische Universität München</td>
<td><a href="mailto:kramer@in.tum.de">kramer@in.tum.de</a></td>
</tr>
</tbody>
</table>
Krystof Krawiec
Institute of Computing Science
Poznan University of Technology
Piotrowo
60-695 Poznan
Poland
krawiec@cs.put.poznan.pl

Nicolas Lachiche
Image Sciences, Computer Sciences and Remote Sensing Laboratory
64, bld Brant
67400 Illkirch-Graffenstaden
France
Nicolas.Lachiche@urs.u-strasbg.fr

Michail G. Lagoudakis
Department of Electronic and Computer Engineering
Technical University of Crete
73100 Chania
Crete
Greece
lagoudakie@intelligence.tuc.gr

John Langford
Yahoo Research
New York, NY 10011
USA
jl@yahoo-inc.com

Pier Luca Lanzi
Dipartimento di Elettronica e Informazione
Politecnico di Milano
Milano 20133
Italy
lanzi@elet.polimi.it

Nada Lavrač
Department of Knowledge Technologies
Jožef Stefan Institute
Jamova 39
Ljubljana
Slovenia
Faculty of Information Technology
University of Nova Gorica
Vipavska 13
5000 Nova Gorica
Slovenia

Christina Leslie
Computational Biology Program
Sloan-Kettering Institute
Memorial Sloan-Kettering Cancer Center
1275 York Ave
Mail Box #460
New York, NY 10065
cleslie@cbio.mskcc.org

Shiau Hong Lim
University of Illinois
IL
USA
shonglim@uiuc.edu

Charles X. Ling
The University of Western Ontario
Canada
dr_charles_ling@yahoo.com

Huan Liu
Computer Science and Engineering
Ira Fulton School of Engineering
Arizona State University
Brickyard Suite 501
699 South Mill Avenue
Tempe, AZ 85287-8809
USA
huan.liu@asu.edu

Bin Liu
Faculty of Information Technology
Monash University
Melbourne 2052
Australia
bin.liu@infotech.monash.edu.au

John Lloyd
College of Engineering and Computer Science
The Australian National University
0200, Canberra ACT
Australia
jwl@mail.rise.anu.edu.au

Shie Mannor
Department of Electrical Engineering
Israel Institute of Technology
Technion
Technion City
32000 Haifa
Israel
shie@ee.technion.ac.il
Eric Martin
Department of Artificial Intelligence
School of Computer Science and Engineering
University of New South Wales
NSW 2052
Sydney
Australia
emartin@cse.unsw.edu.au

Serafín Martínez-Jaramillo
General Directorate of Financial System Analysis
Financial System Analysis Division
Bank of Mexico
Av. 5 de Mayo No. 1
Col. Centro, C.P. 06059
Mexico, D.F
smartin@banxico.org.mx

Stan Matwin
School of Information Technology and Engineering
University of Ottawa
Ottawa, ON
Canada
stan@site.uottawa.ca

Julian McAuley
Statistical Machine Learning Program
Department of Engineering and Computer Science
National University of Australia
NICTA, Locked Bag 8001
Canberra ACT 2601
Australia
julian.mcauley@nicta.com.au

Prem Melville
Machine Learning
IBM T. J. Watson Research Center
Route 134/P.O. Box 218
1101 Kitchawan Rd
Yorktown Heights, NY 10598
USA
pmelvil@us.ibm.com

Pietro Michelucci
Strategic Analysis, Inc.
4075 Wilson Blvd
Suite 200
Arlington, VA 22203
USA
pmichelucci@sainc.com

Rada Mihalcea
Department of Computer Science and Engineering
University of North Texas
Denton, TX 76203-6886
USA
rada@cs.unt.edu

Risto Miikkulainen
Department of Computer Sciences
The University of Texas at Austin
1 University Station C0500
Austin, TX 78712-0233
USA
risto@cs.utexas.edu

Dunja Mladenić
Department of Knowledge Technologies
Jožef Stefan Insitute
Jamova 39
1000, Ljubljana
Slovenia
Dunja.Mladenic@ijs.si

Katharina Morik
Department of Computer Science
Technische Universität Dortmund
Dortmund
Germany
katharina.morik@tu-dortmund.de

Jun Morimoto
Advanced Telecommunication Research Institute International ATR
Kyoto
Japan

Abdullah Mueen
Department of Computer Science and Engineering
University California-Riverside
Riverside, CA 92521
USA

Paul Munro
School of Information Sciences
University of Pittsburgh
Pittsburgh, PA
USA
pmunro@mail.sis.pitt.edu
Ion Muslea
Language Weaver, Inc.
4640 Admiralty Way, Suite 1210
Marina del Rey, CA 90292
USA
imuslea@languageweaver.com

Galileo Namata
Department of Computer Science
University of Maryland
College Park, MD 20742
USA

Sriraam Natarajan
Department of Computer Sciences
University of Wisconsin Medical School
1300 University Avenue
Madison, WI 53706
USA
natarasr@biostat.wisc.edu

Andrew Y. Ng
Stanford AI Laboratory
Stanford University
353 Serra Mall, Gates Building 1A
Stanford, CA 94305-9010
USA
ang@cs.stanford.edu

Siegfried Nijssen
Institut für Informatik
Albert-Ludwigs-Universität Freiburg
Georges-Köhler-Allee, Gebäude 079
79110 Freiburg i. Br.
Germany
snijssen@informatik.uni-freiburg.de

William Stafford Noble
Department of Genome Sciences
University of Washington
Seattle, WA
USA
noble@gs.washington.edu

Petra Kralj Novak
Department of Knowledge Technologies
Jožef Stefan Institute
Jamova 39
Ljubljana
Slovenia
Petra.Kralj.Novak@ijs.si

Daniel Oblinger
DARPA/IPTO
3701 Fairfax Drive
Arlington, VA 22203
USA
oblinger@pobox.com

Peter Orbanz
Department of Engineering
Cambridge University
Trumpington Street
Cambridge, CB2 1PZ
UK

Miles Osborne
Institute for Communicating and Collaborative Systems
University of Edinburgh
2 Buccleuch Place
Edinburgh EH8 9LW
Scotland
UK
miles@inf.ed.ac.uk

C. David page
Department of Biostatistics and Medical Informatics
University of Wisconsin Medical School
1300 University Avenue
Madison, WI 53706
USA
page@biostat.wisc.edu

Jonathan Patrick
Telfer School of Management
University of Ottawa
55 Laurier avenue
Ottawa, ON KIN 6N5
Canada
patrick@telfer.uottawa.ca

Claudia Perlich
Data Analytics Research Group
IBM T.J. Watson Research Center
P.O. Box 218
Yorktown Heights, NY 10598
USA
perlich@us.ibm.com
Jan Peters
Department of Empirical Inference and Machine Learning
Max Planck Institute for Biological Cybernetics
Spemannstr. 38
72076 Tuebingen
Germany
mail@jan-peters.net

Bernhard Pfahringer
Department of Computer Science
University of Waikato
Private Bag 3105
Hamilton
New Zealand
bernhard@cs.waikato.ac.nz

Steve Poteet
Boeing Phantom Works
P.O. Box 3707 MC 7L-43
Seattle, WA
USA

Pascal Poupart
School of Computer Science
University of Waterloo
200 University Avenue West
Waterloo
ON N2L 3G1
Canada
pponpart@cs.uwaterloo.ca

Rob Powers
Computer Science Department
Stanford University
353 Serra Mall
Stanford, CA 94305
USA
powers@cs.stanford.edu

Cecilia M. Procopiuc
AT&T Labs
Florham Park, NJ
USA
magda@research.att.com

Martin L. Puterman
Centre for Health Care Management
Sauder School of Business
University of British Columbia
2053 Main Mall
Vancouver, BC V6T 1Z2
Canada
marty@chem.ubc.ca

Lesley Quach
Boeing Phantom Works
P.O. Box 3707 MC 7L-43
Seattle, WA
USA

Novi Quadrianto
Department of Engineering and Computer Science
Australian National University NICTA London Circuit
Canberra ACT 0200
Australia
novi.quadrianto@nicta.com.au

Luc De Raedt
Department of Computer Science
Katholieke Universiteit Leuven
Celestijnenlaan 200A
BE - 3001 Heverlee
Belgium
luc.deraedt@cs.kuleuven.be

Dev Rajnarayan
NASA Ames Research Center
Mail Stop 269-1
Moffett Field, CA 94035
USA

Adwait Ratnaparkhi
Yahoo! Labs
Santa Clara
California
USA
adwait_ratnaparkhi@yahoo.com

Soumya Ray
School of EECS
Oregon State University
1148 Kelley Engineering Center
97331
Corvallis, OR
USA
sray@eecs.oregonstate.edu
Mark Reid
Research School of Information Sciences and Engineering
The Australian National University
Canberra, ACT 0200
Australia
mark.reid@anu.edu.au

Jean-Michel Renders
Xerox Research Centre Europe
6, chemin de Maupertuis
38240 Meylan
France

John Risch
Pacific Northwest National Laboratory

Jorma Rissanen
Complex Systems Computation Group
Department of Computer Science
Helsinki Institute of Information Technology
Helsinki 00014
Finland
Jorma.Rissanen@hiit.fi

Nicholas Roy
Massachusetts Institute of Technology
Cambridge, MA
USA

Lorenza Saitta
Università del Piemonte Orientale
Alessandria
Italy
Michele.Sebag@lri.fr

Yasubumi Sakakibara
Department of Biosciences and Informatics
Keio University
yasu@bio.keio.ac.jp
Hiyoshi
Kohoku-ku
Japan

Claude Sammut
School of Computer Science and Engineering
The University of New South Wales
Sydney
NSW 2052
Australia
claude@cse.unsw.edu.au

Joerg Sander
Department of Computing Science
University of Alberta
Edmonton, AB
Canada
joerg@cs.ualberta.ca

Scott Sanner
Statistical Machine Learning Group
NICTA, 7 London Circuit, Tower A
ACT 2601
Canberra
Australia
scott.sanner@nicta.com.au

Stefan Schaal
Department of Computer Science
University of Southern California
ATR Computational Neuroscience Labs
3641 Watt Way
Los Angeles, CA 90089-2520
USA
sschaal@usc.edu

Ute Schmid
Department of Information Systems and Applied Computer Science
University of Bamberg
Feldkirchenstr. 21
96045 Bamberg
Germany
ute.schmid@uni-bamberg.de

Stephen Scott
University of Nebraska
Lincoln, NE
USA

Michele Sebag
Laboratoire de Recherche en Informatique
Université Paris-Sud
Bât 490
91405 Orsay
France
Michele.Sebag@lri.fr

Prithviraj Sen
University of Maryland
AV Williams Bldg, Rm 3217
College Park, MD 20742
USA
Hanhuai Shan
Department of Computer Science and Engineering
University of Minnesota
Minneapolis, MN
USA
shan@cs.umn.edu

Hossam Sharara
Department of Computer Science
University of Maryland
College Park, MD 20742
Maryland
USA

Victor S. Sheng
The University of Western Ontario
Canada

Jelber Sayyad Shirabad
School of Information Technology and Engineering
University of Ottawa
800 King Edward
P.O. Box 450
Stn A, KIN 6N5
Ottawa, Ontario
Canada
jsayyad@site.uottawa.ca

Yoav Shoham
Computer Science Department
Stanford University
353 Serra Mall
Stanford, CA 94305
USA
shoham@standford.edu

Thomas R. Shultz
Department of Psychology and
School of Computer Science
McGill University
1205 Dr. Penfield Avenue
Montréal
QC H3A 1B1
Canada
thomas.shultz@mcgill.ca

Ricardo Silva
Gatsby Computational Neuroscience Unit
University College London
Alexandra House
17 Queen Square
London WC1N 3AR
UK
rbas@gatsby.ucl.ac.uk

Vikas Sindhwani
IBM T. J. Watson Research Center
Route 134/P.O. Box 218
1101 Kitchawan Rd
Yorktown Heights, NY 10598
USA

Moshe Sipper
Department of Computer Science
Ben-Gurion University
P.O. Box 653
Beer-Sheva 84105
Israel
sipper@cs.bgu.ac.il

William D. Smart
Associate Professor
Department of Computer Science and Engineering
Washington University in St. Louis
Campus Box 1045
One Brookings Drive
St. Louis, MO 63130
USA
wds@cse.wustl.edu

Carlos Soares
LIAAD-INESC Porto L.A./Faculdade de Economia
Laboratory of Artificial Intelligence and Computer Science
University of Porto
Rua de Ceuta n. 118
6.piso, 4050-190
Porto
Portugal

Christian Sohler
Heinz Nixdorf Institute & Computer Science Department
University of Paderborn
Fuerstenallee 11
33102 Paderborn
Germany
csohler@upb.de
Frank Stephan
Department of Computer Science
and Department of Mathematics
National University of Singapore
Singapore 119076
Republic of Singapore
fstephan@comp.nus.edu.sg

Peter Stone
Department of Computer Sciences
The University of Texas at Austin
Austin, TX
USA
pstone@cs.utexas.edu

Alexander L. Strehl
Department of Computer Science
Rutgers University
110 Frelinghuysen Road
Piscataway, NJ 08854
USA
strehl@cs.rutgers.edu

Prasad Tadepalli
School of Electrical Engineering and Computer Science
Oregon State University
1148 Kelley Engineering Center
Corvallis, OR 97331-5501
USA
tadepall@eecs.oregonstate.edu

Russ Tedrake
Department of Computer Science
Massachusetts Institute of Technology
32 Vassar Street
Cambridge, MA 02139
USA
russt@mit.edu

Yee Whye Teh
Gatsby Computational Neuroscience Unit
University College London
17 Queen Square
London WC1N 3AR
UK
yeewhye@gmail.com

Jon Timmis
Department of Computer Science
and Department of Electronics
University of York
Heslington
York 10 5DD
UK
jtimmis.cs.york.ac.uk

Jo-Anne Ting
University of Edinburgh

Kai Ming Ting
Gippsland School of Information Technology
Monash University
Gippsland Campus Churchill
3842, Victoria
Australia
kaiming.ting@infotech.monash.edu.au

Ljupco Todorovski
Faculty of Administration
University of Ljubljana
Gosarjeva 5
1000 Ljubljana
Slovenia
Ljupco.Todorovski@fu.uni-lj.si

Hannu Toivonen
Department of Computer Science
University of Helsinki
P.O. Box 68 (Gustaf Hällströmin katu 2b)
00014 Helsinki
Finland
hannu.toivonen@cs.helsinki.fi

Luis Torgo
Department of Computer Science
Faculty of Sciences
University of Porto
Rua Campo Alegre
1021/1055, 4169–007
Porto
Portugal
ltorgo@dcc.fc.up.pt

Panayiotis Tsaparas
Microsoft Research
Microsoft
Mountain View, CA
USA
panayiotis.tsaparas@microsoft.com
Paul E. Utgoff
Department of Computer Science
University of Massachusetts
140 Governor’s Drive
Amherst, MA 01003–4610
USA

William Uther
NICTA and the University of New South Wales
William.Uther@nicta.com.au

Sethu Vijayakumar
University of Edinburgh
University of Southern California

Ricardo Vilalta
Department of Computer Science
University of Houston
4800 Calhoun Rd
Houston, TX 77204-3010
USA

Michail Vlachos
IBM Zürich Research Laboratory
Säumerstrasse 4
8803 Rüschlikon
Switzerland
michalis@gmail.com

Kiri L. Wagstaff
Machine Learning Systems
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, CA
USA
kiri.wagstaff@jpl.nasa.gov

Geoffrey I. Webb
Faculty of Information Technology
Clayton School of Information Technology
Monash University
P.O. Box 63
Victoria 3800
Australia
Geoff.Webb@monash.edu

R. Paul Wiegand
Institute for Simulation and Training
University of Central Florida
Orlando, FL
USA
paul@tesseraet.org
wiegand@ist.ucf.edu

Eric Wiewiora
University of California
San Diego
eiwewior@cs.ucsd.edu

Anthony Wirth
Department of Computer Science
and Software Engineering
The University of Melbourne
Victoria 3010
Australia
awirth@csse.unimelb.edu.au

Michael Witbrock
Cycorp, Inc.
3721 Executive Center Drive
Austin, TX 78731
USA
witbrock@cyc.com

David Wolpert
NASA Ames Research Center
Moffett Field, CA
USA
dhw@ptolemy.arc.nasa.gov

Stefan Wrobel
Department of Computer Science
University of Bonn, and Fraunhofer IAIS
(Institute for Intelligent Analysis and Information Systems) Fraunhofer IAIS
Schloss Birlinghoven
53754 Sankt Augustin
Germany

Jason Wu
Boeing Phantom Works
P.O. Box 3707 MC 7L-43
Seattle, WA
USA

Zhao Xu
Knowledge Discovery
Fraunhofer IAIS
Schloß Birlinghoven
53754 Sankt Augustin
Germany
Ying Yang
Australian Taxation Office
990 White Horse Road
Box Hill
VIC 3128
Australia
Ying.Yang@ato.gov.au

Sungwook Yoon
PARC Labs
Coyote Hill Road
Palo Alto, CA
USA

Thomas Zeugmann
Division of Computer Science
Graduate School of
Information Science and Technology
Hokkaido University
Sapporo
Japan
thomas@ist.hokudai.ac.jp

Xinhua Zhang
School of Computer Science
Australian National University
NICTA London Circuit
Canberra
Australia
xinhua.zhang@anu.edu.au

Ying Zhao
Department of Computer Science and Technology
Tsinghua University
Beijing 100084
China

Fei Zheng
Faculty of Information Technology
Monash University
Clayton School of I.T.
Room 217, Bldg 63
Wellington Road
Clayton
Melbourne
Victoria 3800
Australia
fei.zheng@infotech.monash.edu.au

Xiaojin Zhu
Department of Computer Sciences
University of Wisconsin-Madison
1210 West Dayton Street, 53706
Madison, WI
USA
jerryzhu@cs.wisc.edu