

Encyclopedia of Machine Learning

Claude Sammut, Geoffrey I. Webb (Eds.)

Encyclopedia of Machine Learning

With 293 Figures and 78 Tables

Editors

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

ISBN 978-0-387-30768-8 e-ISBN 978-0-387-30164-8
Print and electronic bundle ISBN 978-0-387-34558-1
DOI 10.1007/978-0-387-30164-8
Springer New York

Library of Congress Control Number: 2010935441

© Springer Science+Business Media, LLC 2011

All rights reserved. This work may not be translated or copied in whole or in part without the written permission of the publisher (Springer Science+Business Media, LLC, 233 Spring Street, New York, NY 10013, USA), except for brief excerpts in connection with reviews or scholarly analysis. Use in connection with any form of information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed is forbidden.

The use in this publication of trade names, trademarks, service marks, and similar terms, even if they are not identified as such, is not to be taken as an expression of opinion as to whether or not they are subject to proprietary rights.

While the advice and information in this book are believed to be true and accurate at the date of going to press, neither the authors nor the editors nor the publisher can accept any legal responsibility for any errors or omissions that may be made. The publisher makes no warranty, express or implied, with respect to the material contained herein.

Printed on acid-free paper

Springer is part of Springer Science+Business Media (www.springer.com)

Preface

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

Alberta T6G 2E8
Canada
greiner@cs.ualberta.ca

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 K1N 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

Dunja Mladenic

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

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

Bernhard Pfahringer

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

Michail Prokopenko

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

Frank Stephan

Department of Mathematics
National University of Singapore
2 Science Drive 2
S14, Singapore 117543
Singapore
fstephan@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

Prasad Tadepalli

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

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. 5 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

Janez Brank

Department for Intelligent Systems
Jožef Stefan Institute
Jamova 39
1000 Ljubljana
Slovenia
janez.branc@ijs.si

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@somerandom.com

David Corne

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

Susan Crow

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. Fahman

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

Gemma C. Garriga

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

Wulfram Gerstner

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

Lise Getoor

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

Christophe Giraud-Carrier

Department of Computer Science
Brigham Young University
3361 TMCB Provo
UT 84602
USA

Marko Grobelnik

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

Stephen Grossberg

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

Jiawei Han

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

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 1
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
Philipps-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
Universitätsstr. 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

Antonis C. Kakas

Department of Computer Science
University of Cyprus
75 Kallipoleos Str., P.O. Box 537
Nicosia 1678
Cyprus
antonis@ucy.ac.cy

Subbarao Kambhampati

Department of Computer Science and Engineering
Arizona State University
Tempe, AZ
USA
rao@asu.edu

Anne Kao

The Boeing Company
P.O. Box 3707 MC 7L-43
Seattle, WA 98124-2207
USA
akao@thumper.rt.cs.boeing.com

George Karypis

Department of Computer Science and Engineering
Digital Technology Center
and Army HPC Research Center
University of Minnesota
Minneapolis, MN 55455
USA
karypis@cs.umn.edu

Samuel Kaski

Laboratory of Computer
and Information Science
Helsinki University of Technology
P.O. Box 5400
02015 TKK
Finland
samuel.kaski@tkk.fi

Carlos Kavka

Istituto Nazionale di Fisica Nucleare
University of Trieste
Trieste 34127
Italy
Carlos.Kavka@ts.infn.it

James Kennedy

U.S. Bureau of Labor Statistics
Postal Square Building
2 Massachusetts Ave., NE
Washington, DC 20212-0001
USA
Kennedy.Jim@bls.gov

Eamonn Keogh

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

Kristian Kersting

Knowledge Discovery
Fraunhofer IAIS
Schloß Birlinghoven
53754 Sankt Augustin
Germany
kristian.kersting@iais.fraunhofer.de

Joshua Knowles

University of Manchester

Aleksander Kotcz

Microsoft One Microsoft Way
Redmond, WA 98052
USA
alek@ir.iit.edu

Kevin B. Korb

School of Information Technology
Monash University
Room 205, Bldg 63, 3800
Clayton, Victoria
Australia
kbborb@gmail.com

Stefan Kramer

Institut für Informatik/I12
Technische Universität München
Boltzmannstr. 3
85748 Garching b. München
Germany
kramer@in.tum.de

Krzysztof 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

Serafin 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 Institute
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 K1N 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@eeecs.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
claudio@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, K1N 6N5
Ottawa, Ontario
Canada
jsayyad@site.uottawa.ca

Yoav Shoham

Computer Science Department
Stanford University
353 Serra Mall
Stanford, CA 94305
USA
shoham@stanford.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 YO10 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

Ljupčo 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

Luís 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
michaliso@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
ewiewior@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