Tingwen Huang
Zhigang Zeng
Chuandong Li
Chi Sing Leung (Eds.)

LNCS 7664

Neural Information Processing

19th International Conference, ICONIP 2012
Doha, Qatar, November 2012
Proceedings, Part II

2 Part II

Springer

Lecture Notes in Computer Science 7664

Tingwen Huang   Zhigang Zeng
Chuandong Li   Chi Sing Leung (Eds.)

Neural Information Processing

19th International Conference, ICONIP 2012
Doha, Qatar, November 12-15, 2012
Proceedings, Part II

Springer

Volume Editors

Tingwen Huang
Texas A&M University at Qatar, Education City
P.O. Box 23874, Doha, Qatar
E-mail: tingwen.huang@qatar.tamu.edu

Zhigang Zeng
Huazhong University of Science and Technology
Department of Control Science and Engineering
1037 Luoyu Road, Wuhan, Hubei 430074, China
E-mail: zgzeng@gmail.com

Chuandong Li
Chongqing University, College of Computer Science
174 Shazhengjie Street, Chongqing 400044, China
E-mail: licd@cqu.edu.cn

Chi Sing Leung
City University of Hong Kong, Department of Electronic Engineering
83 Tat Chee Avenue, Kowloon, Hong Kong, China
E-mail: eeleungc@cityu.edu.hk

ISSN 0302-9743 e-ISSN 1611-3349
ISBN 978-3-642-34480-0 e-ISBN 978-3-642-34481-7
DOI 10.1007/978-3-642-34481-7
Springer Heidelberg Dordrecht London New York

Library of Congress Control Number: 2012949896

CR Subject Classification (1998): F.1, I.2, I.4-5, H.3-4, G.3, J.3, C.1.3, C.3

LNCS Sublibrary: SL 1 – Theoretical Computer Science and General Issues

Typesetting: Camera-ready by author, data conversion by Scientific Publishing Services, Chennai, India

Printed on acid-free paper

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

Preface

This volume is part of the five-volume proceedings of the 19th International Conference on Neural Information Processing (ICONIP 2012), which was held in Doha, Qatar, during November 12–15, 2012. ICONIP is the annual conference of the Asia Pacific Neural Network Assembly (APNNA). This series of conferences has been held annually since 1994 and has become one of the premier international conferences in the areas of neural networks.

Over the past few decades, the neural information processing community has witnessed tremendous efforts and developments from all aspects of neural information processing research. These include theoretical foundations, architectures and network organizations, modeling and simulation, empirical study, as well as a wide range of applications across different domains. Recent developments in science and technology, including neuroscience, computer science, cognitive science, nano-technologies, and engineering design, among others, have provided significant new understandings and technological solutions to move neural information processing research toward the development of complex, large-scale, and networked brain-like intelligent systems. This long-term goal can only be achieved with continuous efforts from the community to seriously investigate different issues of the neural information processing and related fields. To this end, ICONIP 2012 provided a powerful platform for the community to share their latest research results, to discuss critical future research directions, to stimulate innovative research ideas, as well as to facilitate multidisciplinary collaborations worldwide.

ICONIP 2012 received tremendous submissions authored by scholars coming from 60 countries and regions across six continents. Based on a rigorous peer-review process, where each submission was evaluated by at least two reviewers, about 400 high-quality papers were selected for publication in the prestigious series of *Lecture Notes in Computer Science*. These papers cover all major topics of theoretical research, empirical study, and applications of neural information processing research. In addition to the contributed papers, the ICONIP 2012 technical program included 14 keynote and plenary speeches by Majid Ahmadi (University of Windsor, Canada), Shun-ichi Amari (RIKEN Brain Science Institute, Japan), Guanrong Chen (City University of Hong Kong, Hong Kong), Leon Chua (University of California at Berkeley, USA), Robert Desimone (Massachusetts Institute of Technology, USA), Stephen Grossberg (Boston University, USA), Michael I. Jordan (University of California at Berkeley, USA), Nikola Kasabov (Auckland University of Technology, New Zealand), Juergen Kurths (University of Potsdam, Germany), Erkki Oja (Aalto University, Finland), Marios M. Polycarpou (University of Cyprus, Cyprus), Leszek Rutkowski (Technical University of Czestochowa, Poland), Ron Sun (Rensselaer Polytechnic Institute, USA), and Jun Wang (Chinese University of Hong Kong, Hong Kong). The

ICONIP technical program included two panels. One was on "Challenges and Promises in Computational Intelligence" with panelists: Shun-ichi Amari, Leon Chua, Robert Desimone, Stephen Grossberg and Michael I. Jordan; the other one was on "How to Write Better Technical Papers for International Journals in Computational Intelligence" with panelists: Derong Liu (University of Illinois of Chicago, USA), Michel Verleysen (Université catholique de Louvain, Belgium), Deliang Wang (Ohio State University, USA), and Xin Yao (University of Birmingham, UK). The ICONIP 2012 technical program was enriched by 16 special sessions and "The 5th International Workshop on Data Mining and Cybersecurity." We highly appreciate all the organizers of special sessions and workshop for their tremendous efforts and strong support.

Our conference would not have been successful without the generous patronage of our sponsors. We are most grateful to our platinum sponsor: *United Development Company PSC (UDC)*; gold sponsors: *Qatar Petrochemical Company, ExxonMobil* and *Qatar Petroleum*; organizers/sponsors: *Texas A&M University at Qatar* and *Asia Pacific Neural Network Assembly.* We would also like to express our sincere thanks to the IEEE Computational Intelligence Society, International Neural Network Society, European Neural Network Society, and Japanese Neural Network Society for technical sponsorship.

We would also like to sincerely thank Honorary Conference Chair Mark Weichold, Honorary Chair of the Advisory Committee Shun-ichi Amari, the members of the Advisory Committee, the APNNA Governing Board and past presidents for their guidance, the Organizing Chairs Rudolph Lorentz and Khalid Qaraqe, the members of the Organizing Committee, Special Sessions Chairs, Publication Committee and Publicity Chairs, for all their great efforts and time in organizing such an event. We would also like to take this opportunity to express our deepest gratitude to the members of the Program Committee and all reviewers for their professional review of the papers. Their expertise guaranteed the high quality of the technical program of the ICONIP 2012!

We would like to express our special thanks to Web manager Wenwen Shen for her tremendous efforts in maintaining the conference website, the publication team including Gang Bao, Huanqiong Chen, Ling Chen, Dai Yu, Xing He, Junjian Huang, Chaobei Li, Cheng Lian, Jiangtao Qi, Wenwen Shen, Shiping Wen, Ailong Wu, Jian Xiao, Wei Yao, and Wei Zhang for spending much time to check the accepted papers, and the logistics team including Hala El-Dakak, Rob Hinton, Geeta Megchiani, Carol Nader, and Susan Rozario for their strong support in many aspects of the local logistics.

Furthermore, we would also like to thank Springer for publishing the proceedings in the prestigious series of *Lecture Notes in Computer Science.* We would, moreover, like to express our heartfelt appreciation to the keynote, plenary, panel, and invited speakers for their vision and discussions on the latest research developments in the field as well as critical future research directions, opportunities, and challenges. Finally, we would like to thank all the speakers, authors, and participants for their great contribution and support that made ICONIP 2012 a huge success.

November 2012

Tingwen Huang
Zhigang Zeng
Chuandong Li
Chi Sing Leung

Organization

Honorary Conference Chair

Mark Weichold	Texas A&M University at Qatar, Qatar

General Chair

Tingwen Huang	Texas A&M University at Qatar, Qatar

Program Chairs

Andrew Leung	City University of Hong Kong, Hong Kong
Chuandong Li	Chongqing University, China
Zhigang Zeng	Huazhong University of Science and Technology, China

Advisory Committee

Honorary Chair

Shun-ichi Amari	RIKEN Brain Science Institute, Japan

Members

Majid Ahmadi	University of Windsor, Canada
Sabri Arik	Istanbul University, Turkey
Salim Bouzerdoum	University of Wollongong, Australia
Jinde Cao	Southeast University, China
Jonathan H. Chan	King Mongkut's University of Technology, Thailand
Guanrong Chen	City University of Hong Kong, Hong Kong
Tianping Chen	Fudan University, China
Kenji Doya	Okinawa Institute of Science and Technology, Japan
Wlodzislaw Duch	Nicolaus Copernicus University, Poland
Ford Lumban Gaol	Bina Nusantara University, Indonesia
Tom Gedeon	Australian National University, Australia
Stephen Grossberg	Boston University, USA
Haibo He	University of Rhode Island, USA
Akira Hirose	University of Tokyo, Japan
Nikola Kasabov	Auckland University of Technology, New Zealand

Irwin King	The Chinese University of Hong Kong, Hong Kong
James Kwow	Hong Kong University of Science and Technology, Hong Kong
Soo-Young Lee	Advanced Institute of Science and Technology, Korea
Xiaofeng Liao	Chongqing University, China
Chee Peng Lim	Universiti Sains Malaysia, Malaysia
Derong Liu	University of Illinois at Chicago, USA
Bao-Liang Lu	Shanghai Jiao Tong University, China
John MacIntyre	University of Sunderland, UK
Erkki Oja	Helsinki University of Technology, Finland
Nikhil R. Pal	Indian Statistical Institute, India
Marios M. Polycarpou	University of Cyprus, Cyprus
Leszek Rutkowski	Czestochowa University of Technology, Poland
Noboru Ohnishi	Nagoya University, Japan
Ron Sun	Rensselaer Polytechnic Institute, USA
Ko Sakai	University of Tsukuba, Japan
Shiro Usui	RIKEN, Japan
Xin Yao	University of Birmingham, UK
DeLiang Wang	Ohio State University, USA
Jun Wang	Chinese University of Hong Kong, Hong Kong
Li-Po Wang	Nanyang Technological University, Singapore
Rubin Wang	East China University of Science and Technology, China
Zidong Wang	Brunel University, UK
Huaguang Zhang	Northeastern University, China

Organizing Committee

Chairs

Rudolph Lorentz	Texas A&M University at Qatar, Qatar
Khalid Qaraqe	Texas A&M University at Qatar,Qatar

Members

Hassan Bazzi	Texas A&M University at Qatar, Qatar
Hala El-Dakak	Texas A&M University at Qatar, Qatar
Mohamed Elgindi	Texas A&M University at Qatar, Qatar
Jihad Mohamad Jaam	Qatar University, Qatar
Samia Jones	Texas A&M University at Qatar, Qatar
Uvais Ahmed Qidwai	Qatar University, Qatar
Paul Schumacher	Texas A&M University at Qatar, Qatar

Special Sessions Chairs

Zijian Diao	Ohio University, USA
Hassab Elgawi Osman	The University of Tokyo, Japan
Paul Pang	Unitec Institute of Technology, New Zealand

Publicity Chairs

Mehdi Roopaei	Shiraz University, Iran
Enchin Serpedin	Texas A&M University,USA
Maolin Tang	Queensland University of Technology, Australia

Program Committee Members

Sabri Arik
Emili Balaguer Ballester
Gang Bao
Matthew Casey
Li Chai
Jonathan Chan
Mou Chen
Yangquan Chen
Mingcong Deng
Ji-Xiang Du
El-Sayed El-Alfy
Osman Elgawi
Peter Erdi
Wai-Keung Fung
Yang Gao
Erol Gelenbe
Nistor Grozavu
Ping Guo
Fei Han
Hanlin He
Shan He
Bin He
Jinglu Hu
He Huang
Kaizhu Hunag
Jihad Mohamad Jaam
Minghui Jiang
Hu Junhao
John Keane
Sungshin Kim
Irwin King
Sid Kulkarni
H.K. Kwan
James Kwok
Wk Lai
James Lam
Soo-Young Lee
Chi Sing Leung
Tieshan Li
Bin Li
Yangmin Li
Bo Li
Ruihai Li
Hai Li
Xiaodi Li
Lizhi Liao
Chee-Peng Lim
Ju Liu
Honghai Liu
Jing Liu
C.K. Loo
Luis Martínez López
Wenlian Lu
Yanhong Luo
Jinwen Ma
Mufti Mahmud
Jacek Mańdziuk
Muhammad Naufal Bin Mansor
Yan Meng
Xiaobing Nie
Sid-Ali Ouadfeul
Seiichi Ozawa
Shaoning Paul Pang
Anhhuy Phan
Uvais Qidwai
Ruiyang Qiu
Hendrik Richter
Mehdi Roopaei
Thomas A. Runkler
Miguel Angel Fernández Sanjuán
Ruhul Sarker
Naoyuki Sato
Qiankun Song
Jochen Steil

John Sum
Bing-Yu Sun
Norikazu Takahashi
Kay Chen Tan
Ying Tan
Maolin Tang
Jinshan Tang
Huajin Tang
H. Tang
Ke Tang
Peter Tino
Haifeng Tou
Dat Tran
Michel Verleysen
Dan Wang
Yong Wang
Ning Wang
Zhanshan Wang
Xin Wang
Dianhui Wang
Ailong Wu
Bryant Wysocki
Bjingji Xu
Yingjie Yang
Shengxiang Yang
Wenwu Yu
Wen Yu
Xiao-Jun Zeng
Xiaoqin Zeng
Junping Zhang
Zhong Zhang
Wei Zhang
Jie Zhang
Dongbin Zhao
Hongyong Zhao
Huaqing Zhen

Publications Committee Members

Gang Bao
Guici Chen
Huangqiong Chen
Ling Chen
Shengle Fang
Lizhu Feng
Xing He
Junhao Hu
Junjian Huang
Feng Jiang
Bin Li
Chaobei Li
Yanling Li
Mingzhao Li
Lei Liu
Xiaoyang Liu
Jiangtao Qi
Wenwen Shen
Cheng Wang
Xiaohong Wang
Zhikun Wang
Shiping Wen
Ailong Wu
Yongbo Xia
Jian Xiao
Li Xiao
Weina Yang
Zhanying Yang
Wei Yao
Tianfeng Ye
Hongyan Yin
Dai Yu
Lingfa Zeng
Wei Zhang
Yongchang Zhang
Yongqing Zhao
Song Zhu

Platinum Sponsor

UDC
المتحدة للتنمية
UNITED DEVELOPMENT CO.

Gold Sponsors

QAPCO

ExxonMobil

Table of Contents – Part II

Session 2: Neural Modeling

On the Optimization of Multiclass Support Vector Machines Dedicated to Speech Recognition 1
Freha Mezzoudj and Assia Benyettou

Time Series Prediction Method Based on LS-SVR with Modified Gaussian RBF 9
Yangming Guo, Xiaolei Li, Guanghan Bai, and Jiezhong Ma

An Improved Method of Identification Based on Thermal Palm Vein Image 18
Ran Wang, Guoyou Wang, Zhong Chen, Jianguo Liu, and Yu Shi

Modelling Energy Use and Fuel Consumption in Wheat Production Using Indirect Factors and Artificial Neural Networks 25
Majeed Safa and Sandhya Samarasinghe

A Gaussian Mixture Model Based System for Detection of Macula in Fundus Images 33
Anam Tariq, Arslan Shaukat, and Shoab A. Khan

The Brain's Sequential Parallelism: Perceptual Decision-Making and Early Sensory Responses 41
Tobias Brosch and Heiko Neumann

Estimating Neural Firing Rates: An Empirical Bayes Approach 51
Shinsuke Koyama

Assessment of Financial Risk Prediction Models with Multi-criteria Decision Making Methods 60
Jose Salvador Sánchez, Vicente García, and Ana Isabel Marqués

Improving Risk Predictions by Preprocessing Imbalanced Credit Data 68
Vicente García, Ana Isabel Marqués, and Jose Salvador Sánchez

Hybrid Validation of Handwriting Process Modelling 76
Mohamed Aymen Slim, Maroua El Kastouri, Afef Abdelkrim, and Mohamed Benrejeb

Off-Line Handwritten Arabic Word Recognition Using SVMs with Normalized Poly Kernel 85
Abdulrahman Alalshekmubarak, Amir Hussain, and Qiu-Feng Wang

Bayesian Modeling of Visual Attention 92
Jinhua Xu

Classifier Ensemble Using a Heuristic Learning with Sparsity and Diversity 100
Xu-Cheng Yin, Kaizhu Huang, Hong-Wei Hao, Khalid Iqbal, and Zhi-Bin Wang

Optimization of SIRMs Fuzzy Model Using Łukasiewicz Logic 108
Takashi Mitsuishi, Takanori Terashima, and Yasunari Shidama

Synchronization of Hopfield Like Chaotic Neural Networks with Structure Based Learning 117
Nariman Mahdavi and Jürgen Kurths

Incremental Self-Organizing Map (iSOM) in Categorization of Visual Objects 125
Andrew P. Papliński

The Elastic Net as Visual Category Representation: Visualisation and Classification 133
Dror Cohen and Andrew P. Papliński

A Computational Model for Development of Post-Traumatic Stress Disorders by Hebbian Learning 141
Sebastien Naze and Jan Treur

Power-Law Scaling of Synchronization Robustly Reproduced in the Hippocampal CA3 Slice Culture Model with Small-World Topology 152
Toshikazu Samura, Yasuomi D. Sato, Yuji Ikegaya, Hatsuo Hayashi, and Takeshi Aihara

A Dynamic Bio-inspired Model of Categorization 160
Hamidreza Jamalabadi, Hossein Nasrollahi, Majid Nili Ahmadabadi, Babak Nadjar Araabi, AbdolHossein Vahabie, and Mohammadreza Abolghasemi

Improving Support Vector Machine Using a Stochastic Local Search for Classification in DataMining 168
Messaouda Nekkaa and Dalila Boughaci

Variety of Cortical Pathways Formed by Topographic Neural Projection: A Computational Study 176
Naoyuki Sato

Identification of Neural Network Structure from Multiple Spike Sequences 184
Kaori Kuroda, Kantaro Fujiwara, and Tohru Ikeguchi

Time Domain Parameters for Online Feedback fNIRS-Based Brain-Computer Interface Systems 192
Tuan Hoang, Dat Tran, Khoa Truong, Trung Le, Xu Huang, Dharmendra Sharma, and Toi Vo

Embedding Relevance Vector Machine in Fuzzy Inference System for Energy Consumption Forecasting 202
Hamid Aghaie Moghanjooghi, Babak Nadjar Araabi, and Majid Nili Ahmadabadi

GMM-ClusterForest: A Novel Indexing Approach for Multi-features Based Similarity Search in High-Dimensional Spaces 210
Yuchai Wan, Xiabi Liu, Kunqi Tong, Xue Wei, Yi Wu, Fei Guan, and Kunpeng Pang

A Regularized Linear Classifier for Effective Text Classification 218
Sharad Nandanwar and M. Narasimha Murty

A Real-Time, Event Driven Neuromorphic System for Goal-Directed Attentional Selection 226
Francesco Galluppi, Kevin Brohan, Simon Davidson, Teresa Serrano-Gotarredona, José-Antonio Pérez Carrasco, Bernabé Linares-Barranco, and Steve Furber

Analog Neural Network Approach for Source Localization Using Time-of-Arrival Measurements 234
Chi-Sing Leung, H.C. So, Frankie K.W. Chan, and A.G. Constantinides

Construction of Decision Trees by Using Feature Importance Value for Improved Learning Performance 242
Md. Ridwan Al Iqbal, Mohammad Saiedur Rahaman, and Syed Irfan Nabil

Wavelet Transform Based Consonant - Vowel (CV) Classification Using Support Vector Machines 250
T.M. Thasleema and N.K. Narayanan

Using Agent Based Modeling and Simulation for Data Mining 258
Emin Kugu, Levent Altay, and Ozgur Koray Sahingoz

Neurodynamical Top-Down Processing during Auditory Attention 266
Emili Balaguer-Ballester, Abdelhamid Bouchachia, Beibei Jiang, and Susan L. Denham

A Hybrid Visualization-Induced Self-Organizing Map for Multi Dimensional Reduction and Data Visualization 274
Chee Siong Teh, Ming Leong Yii, Chwen Jen Chen, and Zahan Tapan Sarwar

Human-Like Intuitive Playing in Board Games 282
Jacek Mańdziuk

Identification of Diffusion Coefficient in Nonhomogeneous Landscapes 290
Min A, John D. Reeve, Mingqing Xiao, and Dashun Xu

Data Discretization for Dynamic Bayesian Network Based Modeling of Genetic Networks 298
Nguyen Xuan Vinh, Madhu Chetty, Ross Coppel, and Pramod P. Wangikar

Generation of Environmental Representation of a Large Indoor Parking Lot 307
Jung-Ming Wang, Chih-Fan Hsu, Sei-Wang Chen, and Chiou-Shann Fuh

Survey on Simplified Olfactory Bionic Model to Generate Texture Images 316
Zhang Jin, Deng Yang, Li Yong-jun, Wang Ying, and Wang Ru-long

An Improved Method to Calculate Phase Locking Value Based on Hilbert-Huang Transform and Its Application 324
Zhang Jin, Wang Na, Kuang Huan, and Wang Ru-long

A Novel Hierarchical Statistical Model for Count Data Modeling and Its Application in Image Classification 332
Ali Shojaee Bakhtiari and Nizar Bouguila

Multitask Twin Support Vector Machines 341
Xijiong Xie and Shiliang Sun

Bandit-Based Structure Learning for Bayesian Network Classifiers 349
Sepehr Eghbali, Mohammad Hassan Zokaei Ashtiani, Majid Nili Ahmadabadi, and Babak Nadjar Araabi

Modeling the Mental Differentiation Task with EEG 357
Tan Vo, Tom Gedeon, and Dat Tran

Office-Space-Allocation Problem Using Harmony Search Algorithm 365
Mohammed A. Awadallah, Ahamad Tajudin Khader, Mohammed Azmi Al-Betar, and Phuah Chea Woon

A Unified Framework of Binary Classifiers Ensemble for Multi-class Classification 375
Takashi Takenouchi and Shin Ishii

An Orientation Detection Model Based on Fitting from Multiple Local Hypotheses 383
Hui Wei and Yuan Ren

Avoiding Catastrophic Forgetting by a Biologically Inspired Dual-Network Memory Model 392
Motonobu Hattori

Color Fractal Structure Model for Reduced-Reference Colorful Image Quality Assessment 401
Lihuo He, Dongxue Wang, Xuelong Li, Dacheng Tao, Xinbo Gao, and Fei Gao

Validation Based Sparse Gaussian Processes for Ordinal Regression 409
P.K. Srijith, Shirish Shevade, and S. Sundararajan

Cross-Subject Classification of Speaking Modes Using fNIRS 417
Christian Herff, Dominic Heger, Felix Putze, Cuntai Guan, and Tanja Schultz

Temporal Finite-State Machines: A Novel Framework for the General Class of Dynamic Networks 425
Karim El-Laithy and Martin Bogdan

A Novel Node Splitting Criteria for Decision Trees Based on Theil Index 435
Shina Sheen and R. Anitha

Modeling of Polycaprolactone Production from ε-Caprolactone Using Neural Network 444
Senthil Kumar Arumugasamy, Mohamad Hekarl Uzir, and Zainal Ahmad

Global Reweighting and Weight Vector Based Strategy for Multiclass Boosting 452
M. Baig and Mian Muhammad Awais

Suppression of Functional System with Markovian Switching 460
Lizhu Feng, Yi Shen, and Zhuguo Li

P-Order Normal Cloud Model: Walking on the Way between Gaussian and Power Law Distributions 467
Yu Liu and Tianwei Zhang

A Novel Method of Sparse Least Squares Support Vector Machines in Class Empirical Feature Space 475
Takuya Kitamura and Takamasa Sekine

Semantic De-biased Associations (SDA) Model to Improve Ill-Structured Decision Support 483
Tasneem Memon, Jie Lu, and Farookh Khadeer Hussain

Echo State Networks and Extreme Learning Machines: A Comparative Study on Seasonal Streamflow Series Prediction 491
Hugo Siqueira, Levy Boccato, Romis Attux, and Christiano Lyra Filho

Delay-Dependent Stabilization of Uncertain Distributed Systems with Interval Time-Varying Delay 501
Lizhu Feng, Yi Shen, and Cheng Wang

GARF: Towards Self-optimised Random Forests 506
Mohamed Bader-El-Den and Mohamed Gaber

TaskRec: Probabilistic Matrix Factorization in Task Recommendation in Crowdsourcing Systems 516
Man-Ching Yuen, Irwin King, and Kwong-Sak Leung

Feature Selection for Electricity Load Prediction 526
Mashud Rana, Irena Koprinska, and Vassilios G. Agelidis

Statistical and Machine Learning Methods for Electricity Demand Prediction 535
Alexandra Kotillova, Irena Koprinska, and Mashud Rana

EnerPlan: Smart Energy Management Planning for Home Users 543
Usman Ali, Zeeshan Ali Rana, Fahad Javed, and Mian Muhammad Awais

Harnessing Chaotic Activation Functions in Training Neural Network ... 551
Md. Asaduzzaman, A.F.M. Nokib Uddin, Md. Shahjahan, and Kazuyuki Murase

Self-correcting Symmetry Detection Network 559
Wonil Chang, Hyun Ah Song, Sang-Hoon Oh, and Soo-Young Lee

Parallel Support Vector Configuration for Identification of Fast Independent Components in Morphological Patterns Derived by Cardiovasographic Analysis on the Radial Pulse 567
S.H. Karamchandani, M. Panju, S.N. Merchant, U.B. Desai, G.D. Jindal, and D.G. Khairnar

Energy-Based Temporal Neural Networks for Imputing Missing Values 575
Philemon Brakel and Benjamin Schrauwen

Emergence of Multi-step Discrete State Transition through Reinforcement Learning with a Recurrent Neural Network 583
Mohamad Faizal Samsudin, Yoshito Sawatsubashi, and Katsunari Shibata

Collaborative Generative Topographic Mapping 591
Mohamad Ghassany, Nistor Grozavu, and Younès Bennani

Rule Extraction from Ensemble Methods Using Aggregated Decision Trees 599
Md. Ridwan Al Iqbal

Classification of Power Quality Disturbances Using Artificial Neural Networks and a Logarithmically Compressed S-Transform 608
Emir Turajlic and Dzenan Softic

Multi-Threaded Support Vector Machines for Pattern Recognition 616
João Gonçalves, Noel Lopes, and Bernardete Ribeiro

A Malware Collection and Analysis Framework Based on Darknet Traffic 624
Jungsuk Song, Jang-Won Choi, and Sang-Soo Choi

Markovian Models for Electrical Load Prediction in Smart Buildings 632
Muhammad Kumail Haider, Asad Khalid Ismail, and Ihsan Ayyub Qazi

Extension of Incremental Linear Discriminant Analysis to Online Feature Extraction under Nonstationary Environments 640
Annie anak Joseph, Young-Min Jang, Seiichi Ozawa, and Minho Lee

Multivariate Isotonic Regression under Tree Semi-order Restrictions and Test in Multivariate Normal Distribution 648
Yuzhen Lu, Pu Dong, and Qing Li

Consonantal Recognition Using SVM and a Hierarchical Decision Structure Based in the Articulatory Phonetics 655
Adriano de Andrade Bresolin and Hermes Irineu Del Monego

SVM-Based Just-in-Time Adaptive Classifiers 664
Cesare Alippi, Li Bu, and Dongbin Zhao

Machine Learning Approach to Enhance the Design of Automated Theorem Provers 673
Mahdi Khalifa, Hazem Raafat, and Mohammed Almulla

Orthogonalized Partial Directed Coherence for Functional Connectivity Analysis of Newborn EEG 683
Amir H. Omidvarnia, Ghasem Azemi, Boualem Boashash, John M. O' Toole, Paul Colditz, and Sampsa Vanhatalo

Classification of Working Memory Load Using Wavelet Complexity Features of EEG Signals 692
Pega Zarjam, Julien Epps, Fang Chen, and Nigel H. Lovell

Author Index 701

Extension of Incremental Linear Discriminant Analysis to Online Feature Extraction under Nonstationary Environments

Annie anak Joseph[1], Young-Min Jang[2], Seiichi Ozawa[1], and Minho Lee[2]

[1] Graduate School of Engineering, Kobe University,
1-1 Rokko-dai, Nada-ku, Kobe 657-8501, Japan
`097t805t@stu.kobe-u.ac.jp`, `ozawasei@kobe-u.ac.jp`
[2] Electrical and Electronic Engineering, Kyungpook National University
1370 Sangyeok-dong, Buk-gu, Taegu 702-701, Korea
`ymjang@ee.knu.ac.kr`, `mholee@knu.ac.kr`

Abstract. In this paper, a new approach to an online feature extraction under nonstationary environments is proposed by extending Incremental Linear Discriminant Analysis (ILDA). The extended ILDA not only detect so-called "concept drifts" but also transfer the knowledge on discriminant feature spaces of the past concepts to construct good feature spaces. The performance of the extended ILDA is evaluated for the benchmark datasets including sudden changes and reoccurrence in concepts.

Keywords: incremental learning, concept drift, online feature extraction, linear discriminant analysis, knowledge transfer.

1 Introduction

Recently, online incremental learning becomes popular and increasingly important due to the wide range of online applications such as person identification and pattern recognition [1,2]. However, in the real world, the learning is often enforced under nonstationary environments where a target function or a class boundary changes over time, resulting in increasing loss of relevance between the current and the previous concepts. This leads to the need of model changes to adapt to the current concept promptly [3]. This dynamic nature in actual environments is called "concept drifts" [3]. And it is expected that the performance of the current model would be seriously dropped unless the model has ability to detect the concept drift and to update itself by adapting to changing environments.

Previous types of incremental feature extraction such as Incremental Principal Component Analysis (IPCA) [1] and Incremental Linear Discriminant Analysis (ILDA) [2,4] do not provide this ability. However, we believe that the detection of concept drifts for the feature extraction purposes also plays an important role to enhance the system performance. In order to extract good features under

T. Huang et al. (Eds.): ICONIP 2012, Part II, LNCS 7664, pp. 640–647, 2012.

nonstationary environments, this paper proposes an extended version of ILDA in which it can detect the changes in class boundaries as well as perform the knowledge transfer by utilizing useful discriminant vectors of the past concepts.

In order to find useful features autonomously in different concepts, we extend the Hisada et al.'s incremental linear discriminant analysis with knowledge transfer [2] which was developed for multi-task learning problems. In the proposed extension of ILDA, a discriminant feature space model is incrementally updated not only by learning the current concept data but also by combining effective discriminant vectors selected from the previous concepts based on the class separability. This selective augmentation of discriminant vectors is called *knowledge transfer of feature subspace.*

This paper is organized as follows. In Section 2, we extend the Hisada et al.'s ILDA with knowledge transfer model for the learning in nonstationary environments. Let us call the extended ILDA as ILDA-KT for the notational convenience. In Section 3, we evaluate the performance of ILDA-KT for the three benchmark datasets. Finally, Section 4 gives our conclusions and future work.

2 Extension of ILDA under Nonstationary Environments

2.1 Incremental Learning of Feature Space

First, let us assume that we have a set of N training data which belong to either of C classes. The set of class c samples is denoted as $\boldsymbol{X}_c = \{\boldsymbol{x}_{c1}, \cdots, \boldsymbol{x}_{cn_c}\}$ $(c = 1, \cdots, C)$, where $\boldsymbol{x}_{cj} \in \mathcal{R}^n$ is the jth data of class c and n_c is the number of class c data. The whole set of training data is denoted as $\boldsymbol{X} = \{\boldsymbol{X}_1, \cdots, \boldsymbol{X}_C\}$. For $\boldsymbol{X}$, we can define the following between-class scatter matrix $\boldsymbol{S}_B$ and within-class scatter matrix $\boldsymbol{S}_W$:

$$\boldsymbol{S}_B \overset{\text{def}}{=} \sum_{c=1}^{C} n_c(\bar{\boldsymbol{x}}_c - \bar{\boldsymbol{x}})(\bar{\boldsymbol{x}}_c - \bar{\boldsymbol{x}})^T \tag{1}$$

$$\boldsymbol{S}_W \overset{\text{def}}{=} \sum_{c=1}^{C} \boldsymbol{V}_c \tag{2}$$

where

$$\boldsymbol{V}_c = \sum_{j=1}^{n_c} (\boldsymbol{x}_{cj} - \bar{\boldsymbol{x}}_c)(\boldsymbol{x}_{cj} - \bar{\boldsymbol{x}}_c)^T. \tag{3}$$

Here, $\bar{\boldsymbol{x}}_c$ and $\bar{\boldsymbol{x}}$ are the mean vectors of the class c data and that of all data, respectively. In general, up to $(C-1)$ discriminant vectors are calculated for a C-class recognition problem due to the rank of $\boldsymbol{S}_B$. Let us define a set of such discriminant vectors as $\boldsymbol{W} = \{\boldsymbol{w}_1, \cdots, \boldsymbol{w}_{C-1}\}$ and call the feature space spanned by $\boldsymbol{W}$ a *discriminant feature space.* To obtain all the discriminant vectors $\boldsymbol{W}$, the following objective function has to be maximized:

$$J(\boldsymbol{W}) = \mathrm{tr}\left(\boldsymbol{W}^T \boldsymbol{S}_W^{-1} \boldsymbol{S}_B \boldsymbol{W}\right). \tag{4}$$

It is well known that $\boldsymbol{W}$ is obtained by solving the following generalized eigenvalue problem:

$$\boldsymbol{S}_B\boldsymbol{W} = \boldsymbol{S}_W\boldsymbol{W}\boldsymbol{\Lambda} \tag{5}$$

where $\boldsymbol{\Lambda}$ is a diagonal matrix whose diagonal element λ_i is the eigenvalue of the ith eigenvector $\boldsymbol{w}_i$.

Assume that a new chunk of L training samples $\boldsymbol{Y}$ are given and the number of classes increases from C to C' $(C \leq C' \leq C + L)$. The new training samples are denoted as $\boldsymbol{Y} = \{\boldsymbol{Y}_1, \cdots, \boldsymbol{Y}_{C'}\}$ where $\boldsymbol{Y}_c = \{\boldsymbol{y}_{c1}, \cdots, \boldsymbol{y}_{cl_c}\}$ $(c = 1, \cdots, C')$. Here, $\boldsymbol{y}_{cj}$ is the jth training sample of class c and l_c is the number of class c samples. Note that $L = \sum_c l_c$. Then, the between-class scatter matrix $\boldsymbol{S}_B$ and the within-class scatter matrix $\boldsymbol{S}_W$ are updated by the following equations [4]:

$$\boldsymbol{S}'_B = \sum_{c=1}^{C'} n'_c(\bar{\boldsymbol{x}}'_c - \bar{\boldsymbol{x}}')(\bar{\boldsymbol{x}}'_c - \bar{\boldsymbol{x}}')^T \tag{6}$$

$$\boldsymbol{S}'_W = \sum_{c=1}^{C'} \boldsymbol{V}'_c \tag{7}$$

where

$$\begin{aligned}\boldsymbol{V}'_c = \boldsymbol{V}_c &+ \frac{l_c^2}{n_c'^2}(\bar{\boldsymbol{y}}_c - \bar{\boldsymbol{x}}_c)(\bar{\boldsymbol{y}}_c - \bar{\boldsymbol{x}}_c)^T + \frac{n_c^2}{n_c'^2}\sum_{j=1}^{l_c}(\boldsymbol{y}_{cj} - \bar{\boldsymbol{x}}_c)(\boldsymbol{y}_{cj} - \bar{\boldsymbol{x}}_c)^T \\ &+ \frac{l_c(l_c + 2n_c)}{n_c'^2}\sum_{j=1}^{l_c}(\boldsymbol{y}_{cj} - \bar{\boldsymbol{y}}_c)(\boldsymbol{y}_{cj} - \bar{\boldsymbol{y}}_c)^T\end{aligned} \tag{8}$$

$$\bar{\boldsymbol{x}}'_c = \frac{n_c}{n'_c}\bar{\boldsymbol{x}}_c + \frac{1}{n'_c}\sum_{j=1}^{l_c}\boldsymbol{y}_{cj} \tag{9}$$

$$\bar{\boldsymbol{x}}' = \frac{N}{N + L}\sum_{c=1}^{C'} n'_c\bar{\boldsymbol{x}}'_c \tag{10}$$

and $n'_c = n_c + l_c$ and $n_c = 0$ for $c = C + 1, \cdots, C'$.

In the proposed ILDA-KT, an individual discriminant space model for each concept is defined and the models are stored separately in the memory. When a known concept is given, the corresponding discriminant space model is retrieved from the memory and trained with new data incrementally. Let us assume that Z concepts were already trained and the discriminant space models $\Omega^{(z)} = \{\boldsymbol{S}_B^{(z)}, \boldsymbol{S}_W^{(z)}, \boldsymbol{\Lambda}^{(z)}, \boldsymbol{W}^{(z)}, \{\bar{x}_c^{(z)}\}_{c=1}^{C^{(z)}}, \{n_c^{(z)}\}_{c=1}^{C^{(z)}}\}$ $(z = 1, \cdots, Z)$ have been stored in the memory.

If a given chunk of data belongs to a new concept, the number of concept Z is incremented by one (i.e. $Z \leftarrow Z + 1$) and the index of the current concept z' is set to Z. Then, LDA is carried out for the given data $\boldsymbol{X} = \{\{\boldsymbol{x}_{cj}\}_{j=1}^{l_c}\}_{c=1}^{C^{(Z)}}$ where $\boldsymbol{x}_{cj}$ is jth data of class c, and the Zth discriminant space model $\Omega^{(Z)}$ is computed by solving the eigenvalue problem in Eq. (5). On the other hand, if a given chunk of data belongs to the z'th known concept, the discriminant space model $\Omega^{(z')}$ is retrieved from the memory, and ILDA [4] is performed for the given data $\boldsymbol{Y} = \{\{\boldsymbol{Y}_{cj}\}_{j=1}^{l_c}\}_{c=1}^{C^{(Z)}}$ to update $\Omega^{(z')}$ incrementally.

2.2 Detection of Concept Drifts

When a concept drift happens in a pattern recognition problem, class boundaries are changed and this will lead to the change in a discriminant space model. It implies that a between-class scatter matrix $\boldsymbol{S}_B$, a within-class scatter matrix $\boldsymbol{S}_W$, and the class c mean vector $\bar{\boldsymbol{x}}_c$ would be varied significantly by a concept drift. Therefore, to detect the changes in class boundaries, the temporal differences in $\boldsymbol{S}_B$, $\boldsymbol{S}_W$ and $\bar{\boldsymbol{x}}$ between the current and previous stages should be observed.

The proposed concept drift detection relies on a simple thought. Since at least one of the temporal changes in $\boldsymbol{S}_B$, $\boldsymbol{S}_W$ and $\bar{\boldsymbol{x}}$ are supposed to be large, an indicator to detect a concept drift is defined by the following time difference:

$$\Delta\Omega(t) = \|\Delta\boldsymbol{S}_B(t)\|_F + \|\Delta\boldsymbol{S}_W(t)\|_F + \|\Delta\bar{\boldsymbol{x}}(t)\|_2 \tag{11}$$

where

$$\Delta\boldsymbol{S}_B(t) = \boldsymbol{S}_B(t) - \boldsymbol{S}_B(t-1) \tag{12}$$

$$\Delta\boldsymbol{S}_W(t) = \boldsymbol{S}_W(t) - \boldsymbol{S}_W(t-1) \tag{13}$$

$$\Delta\bar{\boldsymbol{x}}(t) = \sum_{c=1}^{C} \left\{\bar{\boldsymbol{x}}_c(t) - \bar{\boldsymbol{x}}_c(t-1)\right\}. \tag{14}$$

Here, $\|\cdot\|_F$ and $\|\cdot\|_2$ mean the Frobenius norm and the L_2 norm, respectively.

While no concept drift happens, the time difference $\Delta\Omega(t)$ would be small. On the other hand, when a concept drift happens, it is expected that we observe a big jump in $\Delta\Omega(t)$ from the averaged time difference $\overline{\Delta\Omega}(t-1)$ for the previous time differences $\Delta\Omega(t')$ ($t' = t-1, t-2, \cdots$). Based on such a simple thought, we propose the following rule for detecting concept drifts:

[Detection of Concept Drifts]

If $\Delta\Omega(t) > \overline{\Delta\Omega}(t-1)$, suspect a concept drift and do the followings:

(1) Set $t' = t$.

(2) If $\Delta\Omega(t) > \overline{\Delta\Omega}(t'-1)$ is consecutively satisfied for $t = t'+1, t'+2, \cdots$, then a concept drift is detected.

Otherwise, perform ILDA and update the average time difference $\overline{\Delta\Omega}(t)$.

Note that there is no threshold value in the proposed concept drift detection algorithm.

2.3 Knowledge Transfer

In order to construct a high-performance discriminant space, useful discriminant vectors are searched for the complementary space of the current discriminant space, which is spanned by $\boldsymbol{W}^{(z')} = \{w_1^{(z')}, \cdots, w_{C^{(z')}-1}^{(z')}\}$. Here, z' is the index of the current concept. To evaluate the usefulness of discriminant vectors, we adopt the following class separability:

$$J(\boldsymbol{w}) = \frac{\boldsymbol{w}^T \boldsymbol{S}_B \boldsymbol{w}}{\boldsymbol{w}^T \boldsymbol{S}_W \boldsymbol{w}}. \tag{15}$$

The selection of useful discriminant vectors is conducted as follows. First, all the discriminant vectors $\boldsymbol{W}^{(z)}$ $(1 \leq z \leq Z)$ of the previous concepts are orthogonalized to the current discriminant space. This can be done by calculating the following residue vectors $\boldsymbol{W}^{(z)} = \{w_1^{(z)}, \cdots, w_{C^{(z)}-1}^{(z)}\}$:

$$\hat{\boldsymbol{w}}_i^{(z)} = \frac{\hat{\boldsymbol{w}}_i^{(z')}}{\|\hat{\boldsymbol{w}}_i^{(z')}\|} \quad (i = 1, \cdots, C^{(z)} - 1;\ z = 1, \cdots, Z;\ z \neq z') \tag{16}$$

where $\hat{\boldsymbol{w}}_i^{(z')} = \boldsymbol{w}_i^{(z)} - \boldsymbol{W}^{(z')}\boldsymbol{W}^{(z')T}\boldsymbol{w}_i^{(z)}$. Then, the usefulness of a discriminant vectors $\hat{\boldsymbol{w}}_i^{(z)}$ is evaluated based on the class separability $J(\hat{\boldsymbol{w}}_i^{(z)})$ in Eq. (15). If the following condition is satisfied, a discriminant vector $\hat{\boldsymbol{w}}^{(z)}$ of the zth concept is transferred:

$$J(\hat{\boldsymbol{w}}_i^{(z)}) > \eta \left\{ \min_k \{J(\boldsymbol{w}_k^{(z')})\} \right\} \tag{17}$$

where η is a positive constant.

A discriminant vector of the previous concept $\hat{\boldsymbol{w}}_i^{(z)}$ is transferred only if it increases the total class separability by a certain degree against the lowest class separability for the current discriminant vectors $\hat{\boldsymbol{w}}^{(z')}$. If the condition in Eq. (17) is satisfied, the ith discriminant vector $\hat{\boldsymbol{w}}_i^{(z)}$ is transferred to the current concept, and it is added to $\boldsymbol{W}^{(z')}$ as follows:

$$\boldsymbol{W}^{(z')'} = [\boldsymbol{W}^{(z')}, \hat{\boldsymbol{w}}_i^{(z)}]. \tag{18}$$

The knowledge transfer is applied to all discriminant vectors $\hat{\boldsymbol{w}}_i^{(z)}$ $(i = 1, \cdots, C^{(z)} - 1)$ of the zth concept, and the same computation is applied to other discriminant vectors of the current concept.

3 Performance Evaluation

To evaluate the performance of ILDA-KT under nonstationary environments, we adopt the SEA data [5], the checkerboard data with pulsing drift rate [6] and the contraceptive data [7]. The information on the three datasets is summarized in Table 1. For the SEA data, 250 training data are given to learn and independent 250 test data are used for evaluation at every learning stage. 50 learning stages are learned for each concept and the number of concepts is 4; thus, the total number of training and test data are 50,000, respectively. For the checkerboard data, 25 training data are given at every learning stage and independent 1,024

Table 1. Evaluated datasets

	#Attrib.	#Class	#Train	#Test
SEA [5]	3	2	50,000	50,000
Checkerboard [6]	2	2	10,000	409,600
Contraceptive [7]	9	3	3,315	1,020

Table 2. Accuracies of concept drift detection

	SEA	Checkerboard	Contraceptive
Accuracies	100% (3/3)	100% (3/3)	100%(2/2)

Table 3. Recognition accuracies [%] with standard deviation for SEA, checkerboard and contraceptive data

	SEA	Checkerboard	Contraceptive
ILDA	97.0±0.1	65.1±1.9	40.9±1.1
ILDA-CD	97.0±0.3	68.5±6.0	41.8±0.7
ILDA-KT	97.0±0.2	72.3±3.5	42.1±1.3

test data are used for evaluation. There are two concept to be learned and each concept consists of 200 learning stages; thus, the total number of training and test data are 10,000 and 409,600, respectively. Besides, for the contraceptive data, the use of the dataset is different from the explanation in [7]. 13 data are given as training data and evaluated with 4 data at every learning stage. There are 85 learning stages for each concept and the number of concepts is three; thus, the total number of training and test data are 3,315 and 1,020, respectively.

To see the effectiveness of ILDA-KT as feature extraction, we compare ILDA-KT with the following two models: ILDA and ILDA with concept drift detection function (ILDA-CD). ILDA does not have neither the concept drift detection function nor the knowledge transfer function, while ILDA-CD has only the concept drift detection function. In the experiment, the parameter η in Eq. (17) is set to 0.01.

As seen in Table 2, the drift points are correctly detected for all datasets; thus, the detection of concept drifts works well in ILDA-KT. Table 3 shows the recognition accuracies which are averaged over 50 trials (i.e., the average performance for 50 different data sequences). Note that the recognition accuracy and the number of discriminant vectors are averaged over the entire learning stages. From Table 3, we can see that there is no significant difference in accuracy among three models for the SEA data. This is because no useful discriminant vector exists in other concepts and the knowledge transfer was not carried out in ILDA-KT. On the other hand, ILDA-KT outperforms both ILDA and ILDA-CD in terms of the recognition accuracy for the checkerboard and contraceptive data. Since the checkerboard data are generated under a cyclical environment, this result indicates that the proposed ILDA-KT works well even in the cyclical environments. For both datasets, the accuracy of ILDA-KT is significantly

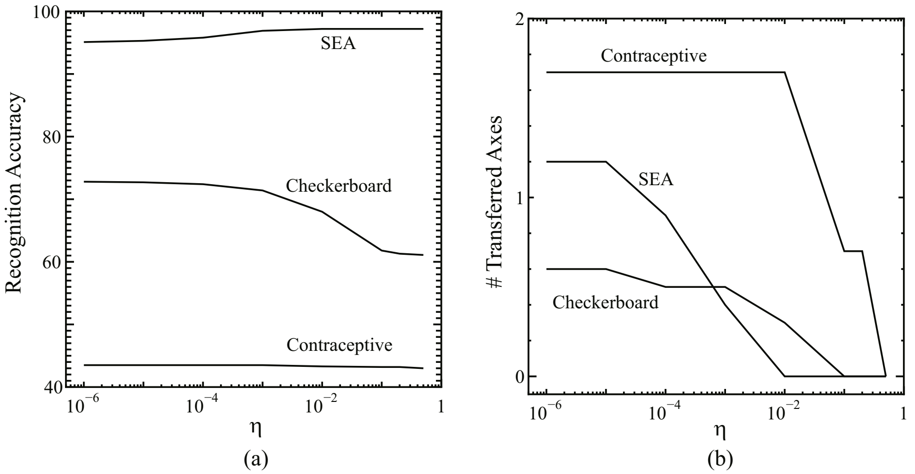

Fig. 1. Influence of η on **(a)** the recognition accuracy [%] and **(b)** the number of transferred axes for the SEA, checkerboard and contraceptive data

improved not only by detecting concept drifts correctly but also by transferring useful discriminant vectors as inductive bias. Therefore, we can say that the class separability in Eq. (15) works well as a criterion for knowledge transfer.

Apart from that, the performance of ILDA-CD is better than ILDA for both datasets. Since ILDA-CD does not have any knowledge transfer mechanism (i.e., no inductive bias is available), the discriminant space for a new concept should be learned from scratch after a concept drift is detected. On the other hand, ILDA has neither concept drift detection nor knowledge transfer. Therefore, the discriminant space model is always updated in ILDA without recognizing concepts themselves, but we can consider it as another type of knowledge transfer because the discriminant space model of the previous concept works as inductive bias when learning a new concept. However, there is no guarantee that such inductive bias contributes to the performance enhancement, instead it may lead to giving negative effects (i.e., negative bias). Therefore, we can say that the performance advantage in the proposed ILDA-KT comes from the selective knowledge transfer of useful discriminant vectors.

To see the effect of knowledge transfer in ILDA-KT, the recognition accuracies and the number of discriminant axes are evaluated for different ηs. As seen in Figure 1, although the number of transferred discriminant axes are increased, the accuracy for the SEA data is rather dropped if η is smaller than 0.001. This is because the discriminant vectors to be transferred serve as negative bias, leading to the degradation in accuracy.

For the checkerboard data, even if η becomes smaller than 0.001, the number of transferred axes does not change very much; thus, it leads to almost the same recognition accuracy. On the other hand, the accuracies for the contraceptive data are almost the same for any η. This implies that the relatedness among all the concepts are small and the transferred discriminant axes do not contribute to the performance enhancement. From Table 3, however, we can see that ILDA-KT outperforms ILDA in accuracy, in which only one discriminant space is incrementally updated. Therefore, it suggests that although the usefulness of the knowledge transfer depends on datasets, the performance is not degraded in ILDA-KT by transferring *non-negative bias*.

4 Conclusions and Future Work

In this paper, we propose an extended ILDA with the knowledge transfer function (noted as ILDA-KT). ILDA-KT learns discriminant space models incrementally under nonstationary environments. In addition, the proposed ILDA-KT can detect the changes in concepts to be learned as well as perform the knowledge transfer of effective discriminant vectors from different concepts in order to earn good generalization performance with less training data. From the experiment results, we conclude that the concept drift detection and the knowledge transfer in ILDA-KT work well. However, the usefulness of knowledge transfer depends on datasets.

There still remains future work for this research. The most problematic issue is how to select the parameter η under incremental learning settings. This can be done by using the cross validation if a sufficient number of initial training data are available [8]. However, it is not always ensured that sufficient data are available in real cases. This issue is left as our future work.

References

1. Zhao, H., Yuen, P.C., Kwok, J.T.: A Novel Incremental Principal Component Analysis and Its Application for Face Recognition. IEEE Trans. on SMC-Part B 36(4), 873–886 (2006)
2. Hisada, M., Ozawa, S., Kau, Z., Kasabov, N.: Incremental Linear Discriminant Analysis for Evolving Feature Spaces in Multitask Pattern Recognition Problems. Evolving System 1(1), 17–27 (2010)
3. Zliobaite, I.: Learning under Concept Drift: An Overview, `http://zliobaite.googlepages.com/Zliobaite_CDoverview.pdf`
4. Pang, S., Ozawa, S., Kasabov, N.: Incremental Linear Discriminant Analysis for Classification of Data Streams. IEEE Trans. on SMC-Part B 35(5), 905–914 (2005)
5. Street, W.N., Kim, Y.: A Streaming Ensemble Algorithm (SEA) for large-scale Classification. In: Proc. 7th ACM SIGKDD Int. Conf. Knowledge Discovery and Data Mining, pp. 377–382 (2001)
6. Polikar, R., Elwell, R.: Benchmark Datasets for Evaluating Concept Drift/NSE Algorithms, `http://users.rowan.edu/~polikar/research/NSE`
7. Leandro, L.M., Allan, P.W., Xin, Y.: The Impact of Diversity on Online Ensemble Learning in the Presence of Concept Drift. IEEE. Trans. on Knowledge and Data Engineering 22(5), 730–742 (2010)
8. Ozawa, S., Pang, S., Kasabov, N.: Incremental Learning of Chunk Data for On-line Pattern Classification Systems. IEEE. Trans. on Neural Networks 19(6), 430–445 (2008)

Author Index

Abbass, Hussein A. I-202, I-210, I-600, IV-132
Abdel-Aal, Radwan E. IV-593
Abdelhafidi, M.K. IV-330, IV-339
Abdelkrim, Afef II-76
Abdul-Rahman, Shuzlina IV-644
Abolghasemi, Mohammadreza II-160
Abu-Dayya, Adnan III-512, IV-508
Adhikary, Jyoti Ranjan III-382
Aedo, Ignacio IV-560
Agarwal, Mridul IV-172
Agelidis, Vassilios G. II-526
Aggoun, Amar I-56
Ahmad, Mudassar IV-396
Ahmad, Zahiruddin V-283
Ahmad, Zainal II-444
Ahmadabadi, Majid Nili II-160, II-202, II-349, III-133, III-244
Ahmed, Amr I-640
Ahsan, Mian Umair V-506
Aihara, Takeshi II-152
Akaho, Shotaro III-520
Akhtar, Mahmood IV-36
Akram, Muhammad Usman IV-36
Alahakoon, Damminda I-48
AlAjmi, Hessah H. IV-568
Alalshekmubarak, Abdulrahman II-85
Alanazi, Eisa III-653
Al-Ani, Ahmed I-92, III-141
Alani, Mohammed M. V-637
Al-Baity, Heyam III-456
Al-Betar, Mohammed Azmi II-365
Alghamdi, Mansour M. I-533
Ali, Rozniza IV-256
Ali, Usman II-543
Alimi, Adel M. III-17
Aliouane, Leila V-730, V-737
Alippi, Cesare II-664
Al-Jumaily, Adel IV-500
Al-Khalifa, Hend S. IV-568
Al-Khatib, Wasfi G. I-533
Almaadeed, Noor I-56
Al-Maadeed, Somaya IV-552, V-576, V-584
Al-Muhtaseb, Husni I-533
Almulla, Mohammed II-673
Al-Nashash, Hasan I-331
Alouini, Mohamed Slim III-512
Al-Razgan, Muna S. IV-568
Al-Shahrani, Mona D. IV-568
Al-Stouhi, Samir I-576
Altadmri, Amjad I-640
Altay, Levent II-258
Aly, Saleh V-479
Amar, Muhammad V-361
Amblard, Cecile III-612
Amir, Hussain I-524
Amira, Abbes I-56, V-576
Andras, Peter V-654
Anitha, R. II-435
Anjum, Samreen I-624
Anuar, Nur Fharah IV-644
Ao, Ping III-348
Aoki, Kenji IV-476
Aota, Yoshito I-251
Araabi, Babak Nadjar II-160, II-202, II-349, III-133
Araújo, Fabricio V-592
Ariffin, Junaidah III-678
Arora, Vipul I-25
Artières, Thierry V-116
Arumugasamy, Senthil Kumar II-444
Asadpour, Masoud III-244
Asaduzzaman, Md. II-551
Asgharian, Hassan I-243
Ashraf, Mohammad IV-272
Ashtiani, Mohammad Hassan Zokaei II-349
Assaleh, Khaled III-262
Atiya, Amir F. III-141
Attux, Romis II-491
Avraamides, Marios N. I-76
Awad, Ali III-9
Awadallah, Mohammed A. II-365
Awais, Mian Muhammad II-452, II-543
Azemi, Ghasem II-683
Azzag, Hanane III-364

Baba-Ali, Ahmed Riadh III-307
Babbar, Rohit III-612
Bader-El-Den, Mohamed II-506
Báez, Patricio García IV-584
Bai, Guanghan II-9
Baig, M. II-452
Baig, Zubair A. IV-593
Bakhtiari, Reyhaneh I-243
Balaguer-Ballester, Emili II-266
Ban, Tao I-260, I-375, IV-100, V-620
Banerji, Sugata III-299
Bantupalli, Srikanth I-681
Barbu, Tudor V-328
Barlow, Michael IV-132
Barzegar, Siamak III-252
Becerra-Alonso, David III-217
Behera, Laxmidhar I-25, III-568, IV-172
Belaton, Bahari IV-297, V-516
Belhaouari, Samir B. I-152
Ben Amar, Chokri I-234
Benkhider, Sadjia I-135
Bennani, Younès II-591
Benrejeb, Mohamed II-76
Bensmail, Halima I-624
Benyettou, Assia II-1
Bettayeb, Maamar IV-330, IV-339
BinMakhashen, Galal M. V-410
Bisson, Gilles I-184
Blanco, Ángel del IV-603
Blansché, Alexandre I-424
Blumer, Katy V-506
Boashash, Boualem II-683, IV-634
Boccato, Levy II-491
Bogdan, Martin II-425
Bonabi, Safa Yaghini I-243
Bosse, Tibor I-322, I-473
Bouaziz, Souhir III-17
Boubchir, Larbi IV-634
Bouchachia, Abdelhamid II-266
Boudella, Amar V-730
Boudet, Laurence IV-289
Boudjeloud-Assala, Lydia I-424
Boughaci, Dalila II-168, V-541
Bouguila, Nizar II-332, III-25
Bouhali, Othmane I-624
Boukhalfa, Kamel III-560
Bouneffouf, Djallel III-324
Bouridane, Ahmed V-584
Bousbahi, Fatiha IV-528
Bouzeghoub, Amel III-324
Bozorgtabar, Behzad V-662
Brakel, Philemon II-575
Bresolin, Adriano de Andrade II-655
Brohan, Kevin II-226
Bron, James E. IV-256
Brosch, Tobias II-41
Bruneau, Pierrick IV-289
Bu, Jiajun V-318
Bu, Li II-664

Cabral, George G. IV-535
Cambria, Erik I-656
Cancelliere, Rossella V-116
Carbonero-Ruz, Mariano III-217
Carneros, Juan Jesús IV-281
Carrasco, José-Antonio Pérez II-226
Chaibi, Amine III-364
Chakravarthy, Srinivasa IV-91
Chan, Frankie K.W. II-234
Chan, Jonathan H. V-697
Chandra, B. IV-619
Chang, Jyh-Yeong III-291
Chang, Wonil II-559
Chao, Guoqing III-340
Chaudhari, Sneha III-465
Chaudhry, Junaid Ahsenali I-432, IV-396, IV-404
Chelly, Zeineb III-480
Chen, Chun V-318
Chen, Chwen Jen II-274
Chen, Fang II-692
Chen, Gang I-260
Chen, Huangqiong IV-683
Chen, Huanhuan IV-356
Chen, Jian III-76
Chen, Junpeng V-300, V-386
Chen, Ning III-228
Chen, Sei-Wang II-307
Chen, Wei III-398
Chen, Yiran I-357
Chen, Zhong II-18
Cheng, Can I-447
Cheng, Jian I-447
Cheng, Jun III-269
Cheng, Shuping V-237
Chetty, Girija IV-272, IV-492, V-465
Chetty, Madhu I-689, II-298, V-369
Cheung, Ray C.C. V-134
Chevaleyre, Yann III-603

Chiewchanwattana, Sirapat I-465
Chinta, Punya Murthy I-366
Choi, Jang-Won II-624
Choi, Sang-Soo II-624
Chorfi, Henda Ouertani IV-528
Chowdhury, Ahsan Raja I-689
Chung, Paul W.H. V-557
Cichocki, Andrzej III-84, III-166
Coghill, George G. V-525
Coghill, George M. I-280
Cohen, Dror II-133
Colditz, Paul II-683
Cong, Fengyu III-166
Constantinides, A.G. II-234
Coppel, Ross II-298
Cotroneo, Rossana IV-222
Coyle, Damien IV-356

Dahmri, Oualid I-135
Dai, Yu V-647
Daoud, Jamal I. V-689
da Silva, Ivan Nunes III-637
Davidson, Simon II-226
Davoudpour, Maryam III-252
de Carvalho, Andre III-488
de Farias, Gilles Paiva M. IV-535
Deligiorgi, Despina IV-544
Del Monego, Hermes Irineu II-655
de Man, Jeroen I-322
Denham, Susan L. II-266
de Oliveira Jr., Walter Ribeiro I-632
Desai, U.B. II-567
de Souza, Renata Maria Cardoso R. III-504, IV-660, IV-691, V-592
Dewan, Sagar IV-91
Dhahri, Habib III-17
Díaz, Paloma IV-560
Dillon, Harvey I-92
Dinu, Liviu Petrisor I-117, V-722
Djarfour, Noureddine V-730
Djouadi, Yassine I-608
Dong, Haiwei I-142, V-506
Dong, Pu II-648
Dong, Xishuang I-176
Dornhöfer, Mareike V-205
Doush, Iyad Abu IV-108
Drias, Habiba I-135
Du, Jianguo III-68
Du, Ruo-Fei V-447
Duan, Fuqing V-221
Duan, Ruo-Nan IV-468
Duch, Włodzisław I-160, III-390, IV-180
Durrani, Tariq I-656
Dutta, Samrat III-568

Eghbali, Sepehr II-349, III-133
El-Alfy, El-Sayed M. IV-593, V-410
El Anbari, Mohammed I-624
Elek, Istvan V-703
Elhadj, Yahya O. Mohamed IV-164
El Kastouri, Maroua II-76
El-Laithy, Karim II-425
Elmir, Youssef V-576
Elouedi, Zied III-480
Elshafei, Mustafa I-533
Elwakil, Ahmed S. I-40
Engchuan, Worrawat V-697
Epps, Julien II-692
Eswaran, Chikkannan V-549

Falkmer, Torbjörn IV-347
Fan, Ming I-1, V-1
Fan, Wentao III-25
Fard, Saeed Panahian I-409
Farshidian, Farbod I-439
Fathi, Madjid V-205
Fauzi, Mohammad Faizal Ahmad V-549
Fayek, Magda III-141
Feng, Boqin V-610
Feng, Lizhu II-460, II-501
Feng, Xiang V-9, V-17
Fernández-Manjón, Baltasar IV-603
Feroz, Samreen I-8
Fiasché, Maurizio III-686
Francisco, Daniela Oliveira III-637
Franco, Leonardo IV-281
Fu, Xiao IV-123
Fuh, Chiou-Shann II-307
Fujiki, Jun III-520
Fujita, Ikki IV-305
Fujiwara, Kantaro II-184
Fung, Chun Che IV-52
Furber, Steve II-226
Furutani, Hiroshi IV-476

Gaber, Mohamed II-506
Gacem, Amina III-560
Gai, Mario V-116
Gallinari, Patrick V-116
Galluppi, Francesco II-226

Gançarski, Alda Lopes III-324
Ganiz, Murat Can I-551
Gao, David Yang III-50, III-702, IV-677
Gao, Fei II-401, V-337
Gao, Rui IV-123
Gao, Xinbo II-401, V-337
García, Vicente II-60, II-68
Garg, Priyanka III-694
Gaussier, Eric III-612
Gedeon, Tom II-357, IV-388
Gerrard, Claire E. I-280
Gerritsen, Charlotte I-322
Ghassany, Mohamad II-591
Ghazzai, Hakim III-512
Goecke, Roland V-662
Gómez, Iván IV-281
Gonçalves, João II-616
Gondal, Iqbal V-361, V-488
Gong, Dunwei III-76
Gong, Liangqi III-348
Gorse, Denise IV-450
Goyal, Madhu I-100
Graham, Bruce I-392
Grassi, Marco I-656
Grimal, Clément I-184
Grozavu, Nistor II-591
Grüning, André I-168
Gu, Rong I-305
Gu, Xiaodong V-100
Guan, Cuntai II-417
Guan, Fei II-210
Guan, Yi I-176
Guessoum, Abderrezak IV-330, IV-339
Guo, Bo V-300, V-386
Guo, Hong-Bo III-92
Guo, Jianming V-109
Guo, Li I-392
Guo, Ping V-75, V-142, V-221
Guo, Shanqing IV-100
Guo, Yangming II-9
Guo, Yi-nan I-447
Gupta, Ankush V-196
Gupta, Rohit IV-172

Habib, Amatal I-8
Haider, Muhammad Kumail II-632
Halaseh, Hala R. V-506
Hameed, Shihab A. V-689
Hammerla, Nils V-654
Han, Min V-681
Han, Ming-Feng III-291
Han, Peng III-157
Han, Yinghua III-157
Hao, Hong-Wei II-100, V-91
Hara, Satoshi III-108
Hashim, AishaHassan A. V-689
Hassaïne, Abdelâali IV-552, V-576, V-584
Hassan, Saima I-152
Hatori, Yasuhiro III-425
Hattori, Motonobu II-392
Hayashi, Hatsuo II-152
He, Junwei IV-83
He, Liang V-256
He, Lihuo II-401, V-337
He, Xiangjian V-151
Heger, Dominic II-417
Heinze, Theodor IV-415
Herff, Christian II-417
Hinde, Chris J. IV-518
Hino, Hideitsu III-520
Hirose, Akira V-229, V-353
Hoang, Tuan II-192, III-191
Hokari, Haruhide IV-423
Homma, Kazuhiro III-545
Hong, Jer Lang I-339, V-283, V-292
Hou, Xinwen III-116
Hou, Zeng-Guang IV-652
Hruschka, Eduardo III-488
Hsu, Chih-Fan II-307
Hu, Bo V-498
Hu, Xiaolin III-373
Hu, Zhongyi V-159
Hua, Xueliang V-488
Huan, Kuang II-324
Huang, Hui V-83
Huang, Junjian I-315
Huang, Kaizhu II-100, III-116, III-528
Huang, Mingjing V-159
Huang, Qingcheng III-58
Huang, Tingwen I-357
Huang, Weicheng V-50
Huang, Xu II-192
Huang, Yuzhu I-218
Humayun, Ahmad IV-575
Humenberger, Martin IV-18
Hunt, Doug IV-626
Hunt, Simon IV-518

Hussain, Amir I-584, I-656, II-85, III-629, IV-256
Hussain, Farookh Khadeer II-483

Ikeda, Kazushi I-501
Ikegaya, Yuji II-152
Ikeguchi, Tohru II-184
Imai, Takahiro I-401
Inagaki, Naoyuki I-501
Inoue, Daisuke I-260, I-375, V-620
Ionescu, Radu-Tudor I-117, V-722
Iqbal, Khalid II-100
Iqbal, Md. Ridwan Al II-242, II-599
Ishii, Shin II-375
Ismail, Asad Khalid II-632
Ismail, Mohamed A. III-577
Isokawa, Teijiro IV-148
Issam, Bendib IV-196
Ito, Yoshifusa V-25
Izumi, Hiroyuki V-25
Izzidien, Ahmed I-681

Jaafar, Jafreezal I-152
Jadhao, Vinod I-516
Jafri, Ali Raza I-8
Jamalabadi, Hamidreza II-160
Jang, Young-Min II-640
Jankovic, Marko V. III-552
Jarndal, Anwar IV-231
Jaruskulchai, Chuleerat III-34
Javed, Fahad II-543
Javed, M. Younus IV-36
Jerez, José M. IV-281
Jia, Yangyang V-9
Jiang, Beibei II-266
Jiang, Hengyong V-9, V-17
Jiang, Yuanyuan V-109
Jin, Zhang II-316, II-324
Jindal, G.D. II-567
Jo, Liza IV-9
Joseph, Annie anak II-640
Jung, Eun-Soo I-560
Justino, Edson J.R. I-632

Kaban, Ata III-456
Kacalak, Wojciech IV-115, IV-248
Kada, Meriem V-541
Kadi, Mohamed Djamel Eddine V-541
Kadobayashi, Youki I-375
Kadri, Abdullah IV-508
Kajornrit, Jesada IV-52
Kamel, Mohamed S. III-577
Kamiura, Naotake IV-148
Kanamori, Takafumi I-109
Kanda, Jorge III-488
Kang, Xiaoxu I-68
Karamchandani, S.H. II-567
Kasabov, Nikola III-670
Kaur, Preetinder I-100
Kawahara, Yoshinobu III-594
Kawakita, Masanori V-400
Ken, Choy Chee IV-297
Khader, Ahamad Tajudin II-365, IV-297
Khairnar, D.G. II-567
Khalifa, Mahdi II-673
Khan, Adnan Mujahid IV-575
Khan, Imran M. V-525
Khan, Michael IV-575
Khan, Shoab A. II-33
Khosravi, Abbas I-152
Khoury, Pascal IV-450
Kim, Bo-Kyeong I-560
Kim, Bumhwi V-188
Kim, Chang-hyun IV-140
Kim, Dae-Shik I-484
Kim, Geon-min IV-140
Kim, Sangwook I-194
King, Irwin II-516, III-694
Kitamura, Takuya II-475
Kiuchi, Mai V-275
Klahold, André V-205
Kobayashi, Kunikazu III-537
Komori, Kazuki III-545
Kondo, Naoshi IV-156
Kong, Jianyi IV-431
Konno, Yuuya V-353
Koprinska, Irena II-526, II-535
Kotillova, Alexandra II-535
Koyama, Shinsuke II-51
Kozawa, Satoshi I-501
Kudo, Hiroaki V-42
Kugu, Emin II-258, V-213
Kume, Takuya V-42
Kurano, Tadashi III-537
Kuremoto, Takashi III-537
Kuroda, Kaori II-184
Kurogi, Shuichi V-50, V-59, V-247
Kurths, Jürgen II-117

Kuusik, Alar IV-364
Kwon, Mingu III-236

Lai, Anthony V-309
Lai, Weng Kin V-525
Lang, Bo V-378
Lange, Sascha V-126
Lavangnananda, Kittichai IV-313
Le, Trung II-192, III-183, III-191
Lebbah, Mustapha III-364
Lee, Giyoung IV-188
Lee, Juhyeon I-484
Lee, Malrey IV-404
Lee, Minho I-194, II-640, III-236, IV-188, V-188
Lee, Soo-Young I-560, II-559
Lee, Soo-young IV-140
Lee, Wee Lih IV-347
Lee, Yun-Jung V-188
Le Thanh, Nhan I-234
Létocart, Lucas III-585
Leung, Chi-Sing II-234
Leung, Chi Sing III-208, IV-204
Leung, Kwong-Sak II-516
Leung, Yee Hong IV-347
Li, Chaojie III-50, IV-677
Li, Chuandong I-315, V-647
Li, Guannan I-648
Li, Hongyu I-543, V-498, V-533
Li, J.F. V-83
Li, Jie I-305
Li, Juan I-33
Li, Jun I-492
Li, Qing II-648
Li, Tieshan V-418, V-428
Li, Wei III-315, V-418
Li, Wenye I-455, V-437
Li, Xi IV-431
Li, Xiaolei II-9
Li, Xiaolin III-474
Li, Xuelong II-401, V-337
Li, Yan V-91
Li, Yourong IV-431
Li, Zhen III-68
Li, Zhuguo II-460
Lian, Cheng IV-240
Liang, Bo IV-100
Liang, Haoran I-142
Liao, Iman Yi V-516
Lin, Chen I-543
Lin, Chin-Teng III-291
Lin, Lei III-42
Linares-Barranco, Bernabé II-226
Liu, Beiye I-357
Liu, Benben V-134
Liu, Changming IV-431
Liu, Chao III-50
Liu, Chengjun III-299
Liu, Cheng-Lin III-116, III-528
Liu, Derong I-127, I-218
Liu, Fan I-375
Liu, Jiafeng III-58
Liu, Jianguo II-18
Liu, Jin IV-123
Liu, Juan V-300, V-386
Liu, Jun III-356, V-610
Liu, Lixiong V-142
Liu, Ming III-42
Liu, Qing V-109, V-159
Liu, Ren-Jie V-447
Liu, Songbo III-58
Liu, Xiabi II-210
Liu, Xiaohua I-142
Liu, Yinglu III-116
Liu, Yu II-467
Liu, Zhengjiang V-418
Lo, Alan W.Y. V-134
Long, Fei V-713
Long, Ran III-348
Loo, Chu-Kiong IV-75
Lopes, Noel II-616
Lovell, Nigel H. II-692
Löwis, Martin von IV-415
Lu, Bao-Liang IV-468, IV-484, V-447
Lu, Guoyu III-670
Lu, Jie I-100, II-483
Lu, Xiaoming V-237
Lu, Yuzhen II-648
Lu, Zhenwei III-100
Lv, Feng IV-652
Lyra Filho, Christiano II-491
Lyu, Michael R. III-694

Ma, Jian V-610
Ma, Jiezhong II-9
Ma, Jin V-221
Ma, Peijun III-100
Ma, Wanli III-183
Maali, Yashar IV-500
Macleod, Christopher I-280

Maejima, Masaya V-267
Maghari, Ashraf Y.A. V-516
Mahdavi, Nariman II-117
Mahloojifar, Ali IV-356
Mahmud, Mufti I-584
Majewski, Maciej IV-115, IV-248
Malik, Aamir Saeed I-84
Mallipeddi, Rammohan I-194, IV-188
Mallipudi, Sony I-681
Malmberg, Ines IV-364
Malrey, Lee I-432
Mańdziuk, Jacek II-282
Mannem, Prashanth V-196
Manso-Martínez, Esperanza III-174
Marinazzo, Daniele I-226
Marqués, Ana Isabel II-60, II-68
Martínez-Estudillo, Alfonso Carlos III-217
Martínez-Estudillo, Francisco José III-217
Martínez-García, José Manuel IV-584
Maszczyk, Tomasz III-390
Mathews, Jayamol IV-9
Matos, Fabrízia Medeiros de S. IV-691
Matsui, Nobuyuki IV-148
Matsuyama, Yasuo V-267
Mattner, Jan V-126
Mavridis, Nikolaos I-142, V-506
Mazzocco, Thomas I-656
McCall, John I-280
Meftah, Imen Tayari I-234
Melo, Cristiano G. de IV-660
Memariani, Ali IV-75
Memon, Nasrullah IV-322
Memon, Tasneem II-483
Meng, Qingfeng III-68
Meng, Qinggang III-620, IV-518, V-557
Merchant, S.N. II-567
Merk, Robbert-Jan I-473
Meshoul, Souham III-456
Mezzoudj, Freha II-1
Miloud-Aouidate, Amal III-307
Min, A II-290
Minamidani, Takanari V-177
Minowa, Tadashi V-566
Mir, Hasan S. I-331
Mirian, Maryam III-133, III-244
Mitsuishi, Takashi II-108
Miura, Keiji V-629
Miyake, Yoshihiro I-251
Miyamoto, Daisuke V-599
Miyauchi, Arata IV-305
Mizobe, Yuta V-247
Moghanjooghi, Hamid Aghaie II-202
Moghbelli, Hassan V-455
Mohamed, Azlinah I-673, III-678, IV-644
Mohammadi, Raheleh IV-356
Mohemmed, Ammar III-670
Mohtasseb, Haytham I-640
Mokhtar, Sahar A. III-141
Morad, Ameer H. IV-60
Moreno-Ger, Pablo IV-603
Morioka, Shuhei IV-423
Morita, Satoru V-67
Moriyama, Eimatsu V-599
Morshed, Nizamul V-369
Mouhoub, Malek III-653
Mouhoubi, Karima III-585
Mount, William M. I-202, I-210, I-600
Mumtaz, Wajid I-84
Muniz, Patrícia V-592
Murase, Kazuyuki II-551
Murata, Noboru III-520
Murty, M. Narasimha I-366, I-516, II-218, IV-66
Musigawan, Pakarat I-465
Mutalib, Sofianita I-673, IV-644
Mwitondi, Kassim S. I-296

Na, Wang II-324
Nabil, Syed Irfan II-242
Nagao, Soichi III-417
Nagesh, Karthik IV-66
Nahar, Khalid M. O I-533
Nair, Madhu S. IV-9
Nakada, Kazuki V-629
Nakamura, Osamu V-177
Nakano, Hidehiro IV-305
Nakao, Koji V-620
Nakata, Yusuke I-383
Nambu, Isao I-401, IV-423
Nandanwar, Sharad II-218
Narasimha Murty, M. III-382
Narayanan, N.K. II-250
Naresh Babu, K.V. IV-619
Nasrollahi, Hossein II-160
Nawachi, Takuya V-169
Naze, Sebastien II-141
Nekkaa, Messaouda II-168

Neocleous, Costas K. I-76
Neokleous, Kleanthis C. I-76
Neumann, Heiko II-41
Ng, Kai-Tat III-208, IV-204
Nguyen, Hung V-151
Nguyen, Thai Binh V-703
Niasar, Abolfazl Halvaei V-455
Nili Ahmadabadi, Majid I-243, I-439
Ning, Jun V-418
Nishida, Takeshi V-50, V-59, V-247
Niu, Junyu I-543, V-498, V-533
Nizamani, Sarwat IV-322
Nõmm, Sven IV-364
Nomm, Sven I-592

Obayashi, Masanao III-537
Ogawa, Yuichi IV-156
Ogirala, Sri Krishna Chaitanya I-681
Oh, Sang-Hoon II-559
Ohnishi, Noboru V-42
Oja, Erkki III-277, III-285
Oliveira, Adriano L.I. de IV-535
Oliveira, Luiz S. I-632
Omidvarnia, Amir H. II-683
Ono, Kohei V-59
Onoda, Takashi V-275
Onojima, Shogo V-229
Ortega, Antonio Vanderlei IV-611
Orunurm, L. IV-364
Othman, Ahmed A. V-672
Ouadfeul, Sid-Ali V-730, V-737
Ovsjanski, Sergei IV-364
Ozawa, Seiichi II-640

Pamponet, Aydano Machado III-603
Pan, Hongxia I-568
Pan, Mingzhi I-568
Pandya, Abhilash I-576
Pang, Kunpeng II-210
Pang, Shaoning I-260, I-375, V-309, V-620
Panju, M. II-567
Paokanta, Patcharaporn IV-264
Papliński, Andrew P. II-125, II-133
Paradowski, Mariusz V-34
Park, Dong-Chul III-1
Park, Jun-Cheol I-484
Parkkinen, Jussi I-543
Partalas, Ioannis III-612
Parve, Marko IV-364
Pascual-Gaspar, Juan M. III-174
Patchaikani, Prem Kumar IV-172
Patnaik, Awhan III-568
Pelliccioni, Armando IV-222
Peng, Yiming V-309
Petlenkov, Eduard I-592
Pham, Trung Duy V-394
Phan, Anh Huy III-166
Philippopoulos, Kostas IV-544
Płoński, Piotr III-149
Polze, Andreas IV-415
Popescu, Marius I-117
Popescu, Theodor Dan IV-1
Prakash, Kolla Bhanu V-473
Putze, Felix II-417

Qazi, Ihsan Ayyub II-632
Qi, Peng III-373
Qidwai, Uvais A. I-432, IV-372, IV-380, IV-396, IV-404, IV-458

Raafat, Hazem II-673
Rabie, Alaleh I-92
Rabiee, Azam IV-441
Radwan, A.G. I-40
Rahaman, Mohammad Saiedur II-242
Rahman, Shuzlina Abdul I-673
Rai, Akshara IV-172
Rajapakse, Jayantha I-48
Raja Raman, Arun V-473
Rajpoot, Nasir I-648
Rajpoot, Nasir M. IV-575
Ramachandran, Ravi P. V-345
Rana, Mashud II-526, II-535
Rana, Zeeshan Ali II-543
Rangaswamy, M.A. Dorai V-473
Rashwan, Samaa III-663
Rassem, Aliaa III-645
Raval, Kalpesh V-345
Raza, Shan-e-Ahmad IV-575
Reeve, John D. II-290
Ren, Haifeng I-568
Ren, Qingsheng III-348
Ren, Shen IV-132
Ren, Yuan II-383
Reshmy, Krishnan I-524
Ribeiro, Bernardete II-616, III-228
Ridda, Laouar Mohamed IV-196
Riedmiller, Martin I-347, V-126
Ristaniemi, Tapani III-166

Rittenhouse, Robert G. IV-404
Roden, Janos V-703
Roula, Mohammed Ali I-681
Rouveirol, Céline III-585
Ruan, Ning III-702
Rubens, Neil III-552
Ru-long, Wang II-316, II-324

Saada, Mohamad III-620
Saadi, Slami IV-330, IV-339
Sadeghian, Alireza III-252
Saeed, Rashid A. V-689
Safa, Majeed II-25
Safari, Saeed I-243
Sagheer, Alaa V-479
Sahingoz, Ozgur Koray II-258, V-213
Şahinli, Çağla I-551
Sai, Hideyasu V-177
Said, Raeed T. I-296
Saitoh, Ayumu IV-148
Sakai, Katsuhiro V-177
Sakai, Ko I-383, III-425
Sakamoto, Makoto IV-476
Sakumura, Yuichi I-501
Saleem, Sobia I-8
Saleh, Doaa A. III-663
Salgado, Liliane R.B. IV-660
Samarasinghe, Sandhya II-25
Samsudin, Mohamad Faizal II-583
Samura, Toshikazu II-152
Sánchez, Jose Salvador II-60, II-68
Sang, Do-Thanh III-1
Santana, Anderson V-592
Sarrafzadeh, Abdolhossein I-260
Sarwar, Zahan Tapan II-274
Sato, Naoyuki II-176
Sato, Takanori I-401
Sato, Yasuomi D. II-152
Sawasdimongkol, Pantharee IV-313
Sawatsubashi, Yoshito II-583
Schieber, Marc I-68
Schizas, Christos N. I-76
Schliebs, Stefan IV-626
Schrauwen, Benjamin II-575
Schultz, Tanja II-417
See, John V-549
Sekine, Takamasa II-475
Senan, Shayma V-689
Serrano-Gotarredona, Teresa II-226
Setayeshi, Saeed IV-441
Sevkli, Aise Zülal IV-528
Shaban, Khaled Bashir IV-508
Shahjahan, Md. II-551
Shakir, Mohamed IV-458
Shams, Wafaa Khazaal IV-372, IV-380
Shan, Lili III-42
Shanableh, Tamer III-262
Shar, Nisar Ahmed I-8
Sharma, Anurag I-269, III-406, III-434, III-445
Sharma, Dharmendra I-269, II-192, III-183, III-191, III-406, III-434, III-445, IV-272, IV-492, V-465
Sharma, Nandita IV-388
Shaukat, Arslan II-33
Sheen, Shina II-435
Shen, Yi II-460, II-501
Sherimon, P.C. I-524
Shetty, Sachin S. V-345
Shevade, Shirish II-409, III-125, III-465
Shi, Yu II-18
Shibata, Katsunari II-583
Shidama, Yasunari II-108
Shiigi, Tomoo IV-156
Shimamura, Junpei V-620
Shinn, Andrew P. IV-256
Shojaee Bakhtiari, Ali II-332
Siddiqua, Maryam I-8
Silva, Ivan Nunes da IV-611
Silva, Jackson V-592
Silva Filho, Telmo M. III-504
Sima, Haifeng V-142
Simon-Hurtado, Arancha III-174
Singh, Lavneet IV-492, V-465
Sinha, Atreyee III-299
Siqueira, Hugo II-491
Situ, W.C. IV-204
Slim, Mohamed Aymen II-76
Śluzek, Andrzej V-34
Smolenski, Brett Y. V-345
So, H.C. II-234
Soares, Carlos III-488
Softic, Dzenan II-608
Sogawa, Yasuhiro III-594
Sokolovska, Nataliya IV-212
Soliman, Omar S. III-645, III-663
Son, Hyung-Min V-188
Song, Gangbing IV-431
Song, Hyun Ah II-559
Song, Jungsuk II-624

Song, Lei V-309
Song, Mingli V-318
Springenberg, Jost Tobias I-347
Srijith, P.K. II-409, III-125
Srinivasan, Cidambi V-25
Srp, Ágoston IV-18
Stramaglia, Sebastiano I-226
Su, Xiaohong III-100
Suárez-Araujo, Carmen Paz IV-584
Sulzbachner, Christoph IV-18
Sum, Pui Fai III-208
Sun, Chang-yin IV-44
Sun, Chengjie III-42
Sun, Hui IV-484
Sun, Shiliang II-341, III-332, III-340
Sun, Xiaoyan III-76
Sunat, Khamron I-465
Sundararajan, S. II-409
Susheela Devi, V. I-509, III-496
Swetha, K.P. I-509, III-496
Szymański, Julian I-160, IV-180

Tabuchi, Hitoshi IV-148
Takahashi, Takeshi V-566, V-599
Takeda, Akiko I-109
Takenouchi, Takashi II-375
Takeuchi, Jun'ichi V-400
Talaat, Amira Samy III-141
Talebpour, Zeinab I-439
Tan, Ee Xion I-339
Tan, Kye Lok I-339
Tan, Min IV-652
Tan, Tele IV-347
Tang, Huiming IV-240, IV-683
Tang, Maolin III-92, III-315
Tang, Xianglong III-58
Tao, Dacheng I-492, II-401, III-269, V-318, V-337
Tao, Ye V-428
Tariq, Anam II-33
Tavakol, Maryam III-244
Teh, Chee Siong II-274
Teng, Fei V-159
Terashima, Takanori II-108
Thakor, Nitish V. I-68
Than, Naing Min IV-156
Thasleema, T.M. II-250
Tholley, Ibrahim V-557
Thomas, J. Joshua IV-297
Tian, Qichong III-398
Tian, Shu V-91
Tian, Yu-Chu III-92, III-315
Tong, Kunqi II-210
Toole, John M. O' II-683
Toriyama, Michinori I-501
Torrente, Javier IV-603
Tran, Dat II-192, II-357, III-183, III-191, IV-272, V-394
Travalin, Davide I-584
Treerattanapitak, Kiatichai III-34
Treur, Jan I-322, I-473, II-141
Truong, Khoa II-192
Tsubone, Tadashi III-199, III-545
Tsukazaki, Tomohiro V-247
Tu, Yan IV-27
Tuček, Deborah C. I-202, I-210, I-600
Turajlic, Emir II-608

Uddin, A.F.M. Nokib II-551
Ueno, Tsuyoshi III-594
Usman, Asima III-629
Uykan, Zekeriya I-416, I-551
Uzir, Mohamad Hekarl II-444

Vahabie, AbdolHossein II-160
Vajda, Ferenc IV-18
Van Dun, Bram I-92
Vanhatalo, Sampsa II-683
Vassiljeva, Kristina I-592
Vinh, Nguyen Xuan II-298, V-369
Vinh, Xuan Nguyen I-689
Vivaracho-Pascual, Carlos III-174
Vo, Tan II-357
Vo, Toi II-192

Wada, Yasuhiro I-401, IV-423
Wahab, Abdul IV-372, IV-380
Wai-Ming Tsang, Peter IV-204
Wakitani, Shin V-169
Wan, Yuchai II-210
Wang, Bin I-664
Wang, Cheng II-501
Wang, Dongxue II-401
Wang, Guoyou II-18
Wang, Haopeng IV-123
Wang, Hu I-288
Wang, Jianmin III-269
Wang, Jinkuan III-157
Wang, Jung-Ming II-307
Wang, Liming IV-100

Wang, Minrui III-474
Wang, Qili V-309
Wang, Qiu-Feng I-656, II-85
Wang, Ran II-18
Wang, Senlin V-318
Wang, Sha I-288
Wang, Xiao-Wei IV-468
Wang, Xiuqing IV-652
Wang, Xuzhi V-9, V-17
Wang, Yongji IV-652
Wang, Zhi-Bin II-100, V-91
Wang, Zhigang IV-431
Wangikar, Pramod P. II-298
Washio, Takashi III-108, III-594
Watabe, Daishi V-177
Wei, Bifan V-610
Wei, Hui II-383, V-378
Wei, Pengcheng I-315
Wei, Qinglai I-127, I-218
Wei, Xue II-210
Wen, Hao III-398
Wickramasinghe, Manjusri I-48
Widodo, Slamet IV-156
Wilson, Campbell V-361
Wong, Derren V-292
Wong, Kok Wai IV-52
Wong, Man To V-151
Woo, Dong-Min III-1
Woon, Phuah Chea II-365
Wu, Benbin V-256
Wu, Grant III-315
Wu, Guorong I-226
Wu, Qiang III-166
Wu, Tian-Xiang V-447
Wu, Xia I-33
Wu, Xin-kun IV-44
Wu, Yi II-210
Wysocki, Bryant I-357

Xia, Bin I-305
Xia, Likun I-84
Xiao, Lu I-1, V-1
Xiao, Mingqing II-290, III-356
Xiao, Yang V-713
Xie, Gang III-92
Xie, Xijiong II-341
Xin, Xin V-75
Xiong, Wei V-17
Xu, Dashun II-290
Xu, Jinhua II-92
Xu, Meiling V-681
Xu, Zhijie III-332
Xu, Zhuo I-305

Yaacoub, Elias III-512, IV-508
Yamamori, Kunihito IV-476
Yamamoto, Toru V-169
Yamanaka, Yoshikazu III-199
Yamashita, Yukihiko III-84
Yamauchi, Sayaka V-400
Yamazaki, Tadashi III-417
Yan, Jeff V-654
Yan, P.M. V-83
Yan, Xiaoyan IV-100
Yang, Deng II-316
Yang, Duanduan V-34
Yang, Jing V-256
Yang, Meng V-83
Yang, Peipei III-528
Yang, Wenlian V-428
Yang, Zhijun I-392
Yang, Zhirong III-277, III-285
Yang, Zijiang IV-27
Yano, Shohei IV-423
Yao, Li I-33
Yao, Wei IV-240
Yao, Yao V-75
Yaqub, Muhammad Farrukh V-488
Yasin, Mohd Azhar Mohd I-84
Yavari, Mojtaba V-455
Yeh, Wei-Chang V-151
Yii, Ming Leong II-274
Yin, Xu-Cheng II-100, V-91
Ying, Wang II-316
Yokota, Tatsuya III-84
Yokote, Ryota V-267
Yong-jun, Li II-316
Yoo, Jae Hyeon I-484
Yousif, Adil E. I-296
Yousri, Noha A. III-577
Yu, Jun III-269
Yu, Junzhi I-288
Yu, Shuai V-9, V-17
Yu, Su-Yang V-654
Yu, Xiaoqing IV-83
Yu, Yongguang I-288
Yuan, Bo III-348
Yuan, Liming III-58

Yuen, Man-Ching II-516
Yusoff, Marina III-678, IV-644
Yusoff, Nooraini I-168

Zainuddin, Zarita I-409
Zakir, Usman III-629
Zaremba, Krzysztof III-149
Zarghami, Tahereh I-331
Zarjam, Pega II-692
Zarraonandia, Telmo IV-560
Zdunek, Rafał I-616
Zeki, Akram M. V-689
Zeng, Zhigang IV-240, IV-683, V-713
Zerarga, Loutfi I-608
Zhang, Bin IV-123
Zhang, Bo III-373
Zhang, Daohai IV-668
Zhang, Daqiang I-392
Zhang, Dehua I-127
Zhang, He III-277, III-285
Zhang, Lin I-543, V-498, V-533
Zhang, Peter V-309
Zhang, Tianwei II-467
Zhang, Wei I-315, V-610
Zhang, Wen-bin IV-44
Zhang, Xu-Yao III-116, III-528
Zhang, Yong III-76
Zhao, Dongbin I-664, II-664
Zhao, Lingling III-100
Zhao, Qi V-318
Zhao, Qiang III-157
Zhao, Qibin III-166
Zhao, Runpeng I-568
Zhao, Ya V-100
Zheng, Jia IV-83
Zheng, Qinghua V-610
Zhou, Chenhui III-398
Zhou, Shenghui V-109, V-159
Zhou, Xianzhong V-237
Zhu, Lei V-620
Zhu, Mengyao IV-83
Zhu, Qiuyu I-16
Zou, Qibo I-176
Zou, Yun-zhi IV-44
Zourob, Mohammed III-262
Zuo, Qing-Song V-378