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IFIP is the global non-profit federation of societies of ICT professionals that aims at achieving a worldwide professional and socially responsible development and application of information and communication technologies.

IFIP is a non-profit-making organization, run almost solely by 2500 volunteers. It operates through a number of technical committees and working groups, which organize events and publications. IFIP's events range from large international open conferences to working conferences and local seminars.

The flagship event is the IFIP World Computer Congress, at which both invited and contributed papers are presented. Contributed papers are rigorously refereed and the rejection rate is high.

As with the Congress, participation in the open conferences is open to all and papers may be invited or submitted. Again, submitted papers are stringently refereed.

The working conferences are structured differently. They are usually run by a working group and attendance is generally smaller and occasionally by invitation only. Their purpose is to create an atmosphere conducive to innovation and development. Refereeing is also rigorous and papers are subjected to extensive group discussion.

Publications arising from IFIP events vary. The papers presented at the IFIP World Computer Congress and at open conferences are published as conference proceedings, while the results of the working conferences are often published as collections of selected and edited papers.

IFIP distinguishes three types of institutional membership: Country Representative Members, Members at Large, and Associate Members. The type of organization that can apply for membership is a wide variety and includes national or international societies of individual computer scientists/ICT professionals, associations or federations of such societies, government institutions/government related organizations, national or international research institutes or consortia, universities, academies of sciences, companies, national or international associations or federations of companies.

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Lazaros Iliadis · Ilias Maglogiannis (Eds.)

Artificial Intelligence Applications and Innovations

12th IFIP WG 12.5 International Conference
and Workshops, AIAI 2016
Thessaloniki, Greece, September 16–18, 2016
Proceedings

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Preface

Artificial Intelligence (AI) is a rapidly evolving and growing research area. During the last few decades it has expanded from a field of promise to one of actual delivery, with good practical application in almost every scientific domain. More specifically, during the last 5 years, AI algorithms have been applied more and more by Google in Facebook, by Microsoft (e.g., the CNTK that is an open source deep learning toolkit on GitHub) by Amazon, and by Baidu in China. The common core of all these recent research efforts is deep learning. Joaquin Candela, head of Facebook's Applied Machine Learning group, stated: "We're trying to build more than 1.5 billion AI agents, one for every person who uses Facebook or any of its products." Facebook is using a machine-learning platform known as the FBLeamer Flow. In fact, Facebook is already building AI that builds AI! Deep learning, deep neural networks, multi-agent systems and autonomous agents, image processing, biologically inspired neural networks (spiking ANN) are already a reality. Deep neural networks are changing the Internet.

The International Federation for Information Processing (IFIP) was founded in 1960 under the auspices of UNESCO, following the first historical World Computer Congress held in Paris in 1959. The First AIAI conference (Artificial Intelligence Applications and Innovations) was organized in Toulouse, France in 2004 by the IFIP. Since then, it has always been technically supported by the Working Group 12.5 "Artificial Intelligence Applications." After 12 years of continuous presence, it has become a well-known and recognized mature event, offering AI scientists from all over the globe the chance to present their research achievements and to cope with the AI research explosion that is taking place at a meteoric speed. The 12th AIAI was held in Thessaloniki, Greece, during September 16–18, 2016.

Following a long-standing tradition, this Springer volume belongs to the IFIP AICT series and it contains the accepted papers that were presented orally at the AIAI 2016 main conference and in the workshops that were held as parallel events. Three workshops were organized, by invitation to prominent and distinguished colleagues, namely:

- The Third MT4BD2016 (Workshop on New Methods and Tools for Big Data),
- The Fifth MHDW 2016 (Mining Humanistic Data Workshop), and
- The First 5G-PINE (Workshop on 5G-Putting Intelligence to the Network Edge).

It is interesting that two of these workshops have a continuous presence in the AIAI events, which means that they are well established in the AI community.

All papers went through a peer-review process by at least two independent academic referees. Where needed, a third and a fourth referee were consulted to resolve any potential conflicts. For the 12th AIAI conference, 65 papers were submitted. Out of these submissions, 30 papers (46.15 %) were accepted for oral presentation as full

ones, whereas another eight papers (12.3 %) were accepted as short ones. The authors of the accepted papers of the main event come from 12 different countries around the globe, namely: Brazil, Canada, China, Cyprus, Denmark, UK, Greece, India, Italy, Norway, Portugal, and USA.

As the title of the conference denotes, there are two core orientations of interest, basic research AI approaches and also applications in real-world cases. The diverse nature of the papers presented demonstrates the vitality of AI computing methods and proves the wide range of AI applications as well. The accepted papers of the 12th AIAI conference are related to the following thematic topics:

- Artificial Neural Networks
- Classification
- Clustering
- Control Systems – Robotics
- Data Mining
- Engineering Applications of AI
- Environmental Applications of AI
- Feature Reduction
- Filtering
- Financial-Economics Modeling
- Fuzzy Logic
- Genetic Algorithms
- Hybrid Systems
- Image and Video Processing
- Medical AI Applications
- Multi-Agent Systems
- Ontology
- Optimization
- Pattern Recognition
- Support Vector Machines
- Text Mining
- Web-Social Media Data AI Modeling

Three distinguished keynote speakers were invited to deliver lectures at the 12th AIAI conference.

Professor Barbara Hammer (Bielefeld University, Germany) gave a talk entitled “Discriminative Dimensionality Reduction for Data Inspection and Classifier Visualization.” Barbara Hammer received her PhD in computer science in 1995 and her *venia legendi* in computer science in 2003, both from the University of Osnabrück, Germany. From 2000 to 2004, she was chair of the junior research group Learning with Neural Methods on Structured Data at University of Osnabrück before accepting the position of professor of theoretical computer science at Clausthal University of Technology, Germany, in 2004. Since 2010, she has held a professorship for theoretical computer science for cognitive systems at the CITEC cluster of excellence at Bielefeld University, Germany. Several research stays have taken her to Italy, UK, India, France, The Netherlands, and the USA. Her areas of expertise include hybrid systems, self-organizing maps, clustering, and recurrent networks as well as applications in bioinformatics, industrial process monitoring, or cognitive science. She chaired the IEEE CIS Technical Committee on Data Mining in 2013 and 2014, and she is chair of the Fachgruppe Neural Networks of the GI and vice-chair of the GNNS. She has been elected as IEEE CIS AdCom member for 2016–2018. Barbara has published more than 200 contributions to international conferences/journals, and she is coauthor/editor of four books.

Professor Aristidis Likas (University of Ioannina, Greece) delivered a talk entitled “Number of Clusters Estimation, Multi-view Clustering and Their Use for Video Summarization.” Aristidis Likas is a professor in the Department of Computer Science and Engineering of the University of Ioannina, Greece. He received his diploma in

electrical engineering from the National Technical University of Athens, Greece, in 1990 and his PhD degree in electrical and computer engineering from the same university in 1994. Since 1996, he has been with the Department of Computer Science and Engineering, University of Ioannina, Greece. He is interested in developing methods for machine learning/data mining problems (mainly classification, clustering, statistical and Bayesian learning) and in the application of these methods to video analysis, computer vision, medical diagnosis, bioinformatics, and text mining. His recent research focuses on techniques for estimating the number of clusters, kernel-based clustering, and multi-view clustering. He has published more than 80 journal papers and more than 80 conference papers attracting over 5,000 citations. Recently, he received a Best Paper Award at the ICPR 2014 conference. He has participated in several national and European research and development projects. He is a senior member of the IEEE. He served as an associate editor of the *IEEE Transactions on Neural Networks* journal and as general co-chair of the ECML PKDD 2011 and the SETN 2014 conferences.

Professor Jan Peters (Max Planck Institute for Intelligent Systems, TU Darmstadt, Germany) gave a talk on “Machine Learning of Motor Skills for Robots: From Simple Skills to Table Tennis and Manipulation.” Jan Peters is a full professor (W3) for intelligent autonomous systems at the Computer Science Department of the Technische Universität Darmstadt and at the same time a senior research scientist and group leader at the Max Planck Institute for Intelligent Systems, where he heads the interdepartmental Robot Learning Group. Jan Peters has received the Dick Volz Best 2007 US PhD Thesis Runner-Up Award, the Robotics: Science & Systems – Early Career Spotlight, the INNS Young Investigator Award, and the IEEE Robotics & Automation Society’s Early Career Award. Jan Peters has been honored for the development of new approaches to robot learning, robot architecture, and robotic methods and their applications for humanoid robots. In 2015, he was awarded an ERC Starting Grant. Jan Peters has studied computer science, electrical, mechanical, and control engineering at TU Munich and FernUni Hagen in Germany, and at the National University of Singapore (NUS) and the University of Southern California (USC). He has received four master’s degrees in these disciplines as well as a PhD in computer science from USC.

We are grateful to Professors Spyros Sioutas, Katia Lida Kermanidis (Ionian University, Greece), Christos Makris (University of Patras Greece), and Phivos Mylonas (Ionian University, Greece). Thanks to their invaluable contribution and hard work, the 5th MHDW workshop was held successfully once more and it has already become a well-accepted event running in parallel with AIAI.

It was a great pleasure to host the Third MT4BD in the framework of the AIAI conference. We wish to sincerely thank its organizers for their great efforts and for their invaluable contribution. More specifically we wish to thank Spiros Likothanassis (University of Patras, Greece) and Dimitris Tzovaras (CERTH/ITI, Thessaloniki, Greece) for this well-established event.

The First 5G-PINE (Putting Intelligence to the Network Edge) workshop was an important part of the AIAI 2016 conference and it was driven by the hard work of Ioannis P. Chochliouros (Hellenic Telecommunications Organization - OTE, Greece), Leonardo Goratti (CREATE-NET, Italy), Oriol Sallent (UPC Spain), Haris Mouratidis

(University of Brighton, UK), Ioannis Neokosmidis (INCITES, Luxembourg), and Athanasios Dardamanis (SmartNet, Greece).

All workshops had a high attendance from scientists from all parts of Europe and some from Asia (e.g., UK, Greece, India, Italy, Spain, and Turkey) and we would like to thank all participants for this. The workshops received 33 submissions of which 17 were accepted as full papers, while seven were selected to be presented as short ones.

The 12th organization of AIAI is a real proof of the brand name that the conference has gained among the circles of the international scientific community. After so many years of hard effort, it is recorded as a mature event with loyal followers and it has plenty of new and qualitative research results to offer to the international scientific community. We hope that the readers of these proceedings will be highly motivated and stimulated for further research in the domain of AI in general.

September 2016

Lazaros Iliadis
Ilias Maglogiannis

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Invited Talks

Discriminative Dimensionality Reduction for Data Inspection and Classifier Visualization

Barbara Hammer

Bielefeld University, Germany

Abstract. The amount of electronic data available today increases rapidly; hence humans rely on automated tools which allow them to intuitively scan data volumes for valuable information. Dimensionality reducing data visualization, which displays high dimensional data in two or three dimensions, constitutes a popular tool to directly visualize data sets on the computer screen. Dimensionality reduction, however, is an inherently ill-posed problem, and the results vary depending on the chosen technology, the parameters, and even random aspects of the algorithms - there is a high risk to display noise instead of valuable information.

In the presentation, we discuss discriminative dimensionality reduction techniques, i.e. methods which enhance a dimensionality reduction method by auxiliary information such as class labels. This allows the practitioner to easily focus on those aspects he is interested in rather than noise. We will discuss two different approaches in this realm, which rely on a parametric resp. non-parametric metric-learning scheme, and display their effect in several benchmarks. We discuss how these methods can be extended to non-vectorial and big data, and how they open the door to a visualization of not only the given data but any given classifier.

Multimodality in Data Clustering: Application to Video Summarization

Aristidis Likas

University of Ioannina, Greece

Abstract. Clustering constitutes an essential problem in machine learning and data mining with important applications in science, technology and business. In this talk, multimodality is related to clustering in two different ways.

The first part of this talk focuses on the clustering of data that are multimodal in the sense that multiple representations (views) are available for each data instance, coming from different sources and/or feature spaces. Typical multi-view clustering approaches treat all available views as being equally important. We will present approaches that assign a weight to each view. Such weights are automatically tuned to reflect the quality of the views and lead to improved clustering solutions.

In the second part of this talk the term ‘multimodality’ is used to express dataset inhomogeneity given some similarity or distance measure. We will present criteria for estimating the homogeneity of a group of data instances based on statistical tests of unimodality. Then we will describe the use of such criteria for developing incremental and agglomerative clustering methods that automatically estimate the number of clusters. We will also discuss methods for sequence segmentation that use the above criteria for deciding on segment boundaries.

Finally we will present results from the application of the above clustering and segmentation methods for video summarization, and, more specifically, for video sequence segmentation and extraction of representative key-frames.

Machine Learning of Motor Skills for Robots: From Simple Skills to Table Tennis and Manipulation

Jan Peters

Max Planck Institute for Intelligent Systems, Germany
TU Darmstadt, Germany

Abstract. Autonomous robots that can assist humans in situations of daily life have been a long standing vision of robotics, artificial intelligence, and cognitive sciences. A first step towards this goal is to create robots that can learn tasks triggered by environmental context or higher level instruction. However, learning techniques have yet to live up to this promise as only few methods manage to scale to high-dimensional manipulator or humanoid robots. In this talk, we investigate a general framework suitable for learning motor skills in robotics which is based on the principles behind many analytical robotics approaches. It involves generating a representation of motor skills by parameterized motor primitive policies acting as building blocks of movement generation, and a learned task execution module that transforms these movements into motor commands. We discuss learning on three different levels of abstraction, i.e., learning for accurate control is needed to execute, learning of motor primitives is needed to acquire simple movements, and learning of the task-dependent “hyperparameters” of these motor primitives allows learning complex tasks. We discuss task-appropriate learning approaches for imitation learning, model learning and reinforcement learning for robots with many degrees of freedom. Empirical evaluations on a several robot systems illustrate the effectiveness and applicability to learning control on an anthropomorphic robot arm. These robot motor skills range from toy examples (e.g., paddling a ball, ball-in-a-cup) to playing robot table tennis against a human being and manipulation of various objects.

Machine Learning Based Bioinformatics as a Tool for Big-Bata Analytics on Molecular Biology Datasets

Seferina Mavroudi

Technological Institute of Western Greece, Greece

Abstract. Deciphering the underlying biological mechanisms that lead to disease could pave the way for personalized medicine hopefully leading to early prevention of disease and drugs with minimal side-effects. Fulfilling this premise however is very demanding since Biology is complex, with thousands of key players interacting with each other in systems at various scales. In the light of the curse of dimensionality it is obvious that only the advent of big data in modern molecular biology provides the ground for building meaningful models that could formulate novel hypothesis. Moreover, extracting valuable biological knowledge in such environments is usually not feasible with simple statistical methods and sophisticated machine learning paradigms have to be encountered.

In the present talk we will briefly introduce the systems biology perspective according to which all essential biological molecules from genes, proteins, metabolites to cells and organs form “a network of networks”. We will mention the genomic, proteomic and other heterogeneous medical data sources of big data production and we will ultimately elaborate on the analysis of these kinds of data with modern machine learning techniques. The challenges, pitfalls and perspectives of the analysis will be discussed.

Specific case studies concerning proteomic and transcriptomic data analysis aiming at biomarker discovery will be presented. The first case study is related to big data proteomics analysis and specifically to the case of analyzing TMT based Mass Spectrometry datasets which is not only a big data problem but is also related to complex analysis steps. Due to the huge amount of the processing data, standard approaches and serial implementations fail to deliver high quality biomarkers while being extremely time consuming. For this task machine learning and more specifically meta-heuristic methods were deployed combined with high performance parallel computing techniques to provide biomarkers of increased predictive accuracy with feasible and realistic time requirements.

The second case study which will be presented includes big data analytics on transcriptomics data related to the diagnosis of early stage Parkinson disease. Specifically, a unique network medicine pipeline has been used to combine multiple gene expression datasets created from both microarrays and RNA-sequencing experiments. The proposed methodology not only uncovered significantly fewer biomarkers than the standard approach but also came out with a set of biomarkers which present higher predictive performance and are highly relevant to the underlying mechanisms of Parkinson disease. Cloud computing technology has been used to ease the application of the proposed pipeline in multiple datasets.

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