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Engineering Applications of Neural Networks

20th International Conference, EANN 2019 Xersonisos, Crete, Greece, May 24–26, 2019 Proceedings

Springer

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EANN 2019 Preface

It is a fact that (according to Google) in September 2015 the search term "machine learning" (ML) became more popular than the term "artificial intelligence" (AI). According to the Economist, "data is the new oil of the 21st century." Today, we are living the revolution of deep learning (DEL), convolutional neural networks (CNN), and big data (BD). DEL, ML, and AI can be considered as a set of Russian dolls. DEL is a subset of ML, which is a subset of AI.

In the following years, AI will become more widely available owing to the explosion of cloud computing.

EANN is a mature international scientific conference held in Europe and well established in the scientific area of AI. Its history is long and very successful, following and spreading the evolution of intelligent systems.

The first event was organized in Otaniemi, Finland, in 1995. Since then, it has had a continuous and dynamic presence as a major global but mainly European scientific event. More specifically, it has been organized in Finland, UK, Sweden, Gibraltar, Poland, Italy, Spain, Bulgaria, and Greece. It has always been technically supported by the International Neural Network Society (INNS) and more specifically by the EANN Special Interest Group.

Following a long-standing tradition, this Springer volume belongs to the CCIS Springer series and it contains the papers that were accepted to be presented orally at the 20th EANN 2019 conference and to the First Workshop on Pervasive Intelligence (PEINT). The diverse nature of papers presented demonstrates the vitality of AI algorithms and approaches. It certainly proves the very wide range of neural networks and AI applications as well.

The event was held during May 24–26, 2019, in the Aldemar Knossos Royal five-star hotel in Crete, Greece.

The response of the international scientific community to the EANN 2019 call for papers was more than satisfactory, with 74 papers initially submitted. All papers were peer reviewed by at least two independent academic referees. Where needed, a third referee was consulted to resolve any potential conflicts. A total of 48.6% of the submitted manuscripts (36 papers) were accepted to be published as full papers (12 pages long) in the Springer CCIS proceedings. Owing to the high quality of the submissions, the Program Committee decided that it should additionally accept five more submissions to be published as short papers (10 pages long).

PEINT, which was organized under the framework of EANN 2019, also followed the same review and acceptance ratio rules. More specifically, the workshop accepted four full papers out of nine submissions (44.4%).

The following scientific workshop on timely AI and ANN subjects was organized under the framework of the EANN 2019:

The First Workshop on Pervasive Intelligence (PEINT).

We would like to thank Professor Dimitris Iakovidis and Professor Evaggelos Spyrou from the University of Thessaly Greece for their effort in organizing this interesting event.

Pervasive (ubiquitous) computing is a research area whose principle is to embed some kind of computational power (i.e., using microprocessors) into daily life objects, in an effort to make them able to communicate and perform tasks without the need for intense interaction with users. The concept of pervasive computing has recently emerged; a large number of applications such as wearable devices, smart/assistive homes and environments, smart cities, self-driving cars etc. are already part of everyday life. Pervasive computing devices are constantly available and networked, often interconnected with cloud services.

Among the plethora of the domains of application, several user groups such as people with disabilities or elderly persons may benefit the most. Disabled people may use smart devices so that difficulties within their daily life due their disabilities are surpassed. Moreover, elderly people may live in smart environments so that their activities of daily living may be monitored and they may be assisted to continue their lives independently, with minimal human intervention.

This workshop focused on methods and applications for data analysis in smart environments, enabled by AI, including (but not limited to) neural networks. It encouraged the submission of papers addressing concepts and methods related to the processing and analysis of data from multiple sensor modalities, especially high-throughput audio and video. Novel methods and algorithms in this context that cope with specific challenges and open research issues were presented. Experiments on publicly available datasets were also encouraged, to demonstrate the effectiveness of these methods. Application papers were sought that stress the societal impact of the proposed approach.

The First Workshop on Emerging Trends in AI (ETAI) was sponsored by the *Neural Computing and Applications* Springer journal. This was an open workshop without submission of papers.

We are grateful to Professor John Macintyre from the University of Sunderland, UK, for organizing this workshop and for his continuous support of the EANN conference. We wish to thank Professors Lary Medsker and Andrew Starr for their contribution to this very interesting workshop.

AI is going through a new boom period, with exponential growth in the commercialization of research and development, products being introduced into the market with embedded AI, as well as "intelligent systems" of various types. Projections for commercial revenue from AI also show exponential growth; such is the ubiquitous nature of AI in the modern world that members of the public are interacting with intelligent systems or agents every day – even though they often are not aware of it!

This workshop, led by Professor John Macintyre, considered emerging themes in AI, covering not only the technical aspects of where AI is going, but the wider question of ethics, and the potential for future regulatory frameworks for the development, implementation, and operation of intelligent systems and their role in our society.

The workshop format included three short presentations by the keynote speakers, followed by an interactive Q&A session where the panel members and audience engaged in a lively debate on the topics discussed.

The subjects of their presentations were the following:

John Macintyre: "The Future of AI – Existential Threat or New Revolution?"
Andrew Starr: "Practical AI for Practical Problems"

Four keynote speakers were invited to give lectures on timely aspects of artificial neural networks and AI:

1. Professor Plamen Angelov, University of Lancaster, UK: "Empirical Approach: How to Get Fast, Interpretable Deep Learning"
2. Dr. Evangelos Eleftheriou, IBM Fellow, Cloud and Computing Infrastructure, Zurich Research Laboratory Switzerland: "In-memory Computing: Accelerating AI Applications"
3. Dr. John Oommen, Carleton University, Ottawa, Canada: "The Power of Pursuit." Learning Paradigm in the Partitioning of Data"
4. Professor Panagiotis Papapetrou, Stockholm University, Sweden: "Learning from Electronic Health Records: From temporal Abstraction to Timeseries Interpretability"

A three-hour tutorial on "Automated Machine Learning for Bioinformatics and Computational Biology" was given by Professor Ioannis Tsamardinos (Computer Science Department of University of Crete, co-founder of Gnosis Data Analysis PC, a university spin-off company, and Affiliated Faculty at IACM-FORTH) and Professor Vincenzo Lagani Ilia State University (Tbilisi, Georgia, and Gnosis Data Analysis PC co-founder).

Numerous bioinformaticians, computational biologists, and life scientists in general are applying supervised learning techniques and feature selection in their research work. The tutorial was addressed to this audience intending to shield them against methodological pitfalls, inform them about new methodologies and tools emerging in the field of Auto-ML, and increase their productivity.

The papers accepted for the 20th EANN conference are related to the following thematic topics:

- Deep learning ANN
- Genetic algorithms - optimization
- Constraints modeling
- ANN training algorithms
- Social media intelligent modeling
- Text mining/machine translation
- Fuzzy modeling
- Biomedical and bioinformatics algorithms and systems
- Feature selection
- Emotion recognition
- Hybrid intelligent models
- Classification-pattern recognition

- Intelligent security modeling
- Complex stochastic games
- Unsupervised machine learning
- ANN in industry
- Intelligent clustering
- Convolutional and recurrent ANN
- Recommender systems

The authors of submitted papers came from 19 different countries from all over the globe, namely: Australia, Austria, Brazil, Canada, Czech Republic, Germany, Greece, India, Italy, Japan, Malaysia, Norway, Romania, Russia, South Africa, Spain, Tunisia, the UK, and the USA.

May 2019

John Macintyre
Lazaros Iliadis
Ilias Maglogiannis
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Preface PEINT2019

Pervasive (ubiquitous) computing is a research area whose principle is to embed some kind of computational power, using microprocessors, into daily life objects, in an effort to make them able to communicate and perform tasks without the need for intense interaction with users. The concept of pervasive computing has recently emerged; a large number of applications such as wearable devices, smart/assistive homes and environments, smart cities, self-driving cars etc. are already part of everyday life. Pervasive computing devices are constantly available and networked, often interconnected with cloud services.

Users may benefit from the plethora of application domains of pervasive computing. Several user groups, such as people with disabilities, or elderly persons, may benefit the most. Disabled people may use smart devices so as to surpass difficulties in their daily life. Moreover, elderly people may live in smart environments so that their activities of daily living may be monitored and they may be assisted to continue their lives independently, with minimal human intervention.

The International Workshop on Pervasive Intelligence (PEINT) focuses on methods and applications for data analysis in smart environments, enabled by artificial intelligence, including (but not limited to) neural networks. It encourages research addressing concepts and methods related to the processing and analysis of data from multiple sensor modalities, especially high-throughput audio and video. Novel methods and algorithms in this context should cope with specific challenges and open research issues. Applications should highlight the societal impact of the proposed approaches. Experiments on publicly available datasets are highly encouraged to demonstrate the effectiveness of the proposed methods and applications.

Topics of interest of PEINT Workshop include but are not limited to human action/activity and object recognition; human emotion recognition from audio/visual data; audio/visual methods for affective modeling; natural language processing for behavioral analysis; intelligent optical measurement systems; deep learning for image, audio, and multimodal data analysis; multimodal image fusion; wearable technologies for the disabled; smart/assistive environments; sensor networks for smart environments; dialogue systems; telemedicine; virtual and augmented reality environments; measurements for pervasive systems; decision-making based on multimodal cues; cloud computing for efficient data communications and processing; video coding, processing, and analysis.

A total of four high-quality papers were accepted as full papers (acceptance rate 45%) for PEINT 2019, covering most of the aforementioned topics, with contributions beyond the state of the art, both in terms of methodologies and applications. These include deep learning approaches for recognition of human actions, object detection and fuzzy image fusion approaches in the context of smart pervasive technologies for the visually impaired. Also, a neural network-based parallel coding methodology for

efficient video communications is presented, with applicability to a variety of domains, such as audiovisual cloud services and telemedicine.

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Invited Papers

Learning from Electronic Health Records: From Temporal Abstractions to Time Series Interpretability

Panagiotis Papapetrou

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Abstract. The first part of the talk will focus on data mining methods for learning from Electronic Health Records (EHRs), which are typically perceived as big and complex patient data sources. On them, scientists strive to perform predictions on patients' progress, to understand and predict response to therapy, to detect adverse drug effects, and many other learning tasks. Medical researchers are also interested in learning from cohorts of population-based studies and of experiments. Learning tasks include the identification of disease predictors that can lead to new diagnostic tests and the acquisition of insights on interventions. The talk will elaborate on data sources, methods, and case studies in medical mining.

The second part of the talk will tackle the issue of interpretability and explainability of opaque machine learning models, with focus on time series classification. Time series classification has received great attention over the past decade with a wide range of methods focusing on predictive performance by exploiting various types of temporal features. Nonetheless, little emphasis has been placed on interpretability and explainability. This talk will formulate the novel problem of explainable time series tweaking, where, given a time series and an opaque classifier that provides a particular classification decision for the time series, the objective is to find the minimum number of changes to be performed to the given time series so that the classifier changes its decision to another class. Moreover, it will be shown that the problem is NP-hard. Two instantiations of the problem will be presented. The classifier under investigation will be the random shapelet forest classifier. Moreover, two algorithmic solutions for the two problem instantiations will be presented along with simple optimizations, as well as a baseline solution using the nearest neighbor classifier.

Empirical Approach: How to Get Fast, Interpretable Deep Learning

Plamen Angelov

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Abstract. We are witnessing an explosion of data (streams) being generated and growing exponentially. Nowadays we carry in our pockets Gigabytes of data in the form of USB flash memory sticks, smartphones, smartwatches etc. Extracting useful information and knowledge from these big data streams is of immense importance for the society, economy and science. Deep Learning quickly become a synonymous of a powerful method to enable items and processes with elements of AI in the sense that it makes possible human like performance in recognizing images and speech. However, the currently used methods for deep learning which are based on neural networks (recurrent, belief, etc.) is opaque (not transparent), requires huge amount of training data and computing power (hours of training using GPUs), is offline and its online versions based on reinforcement learning has no proven convergence, does not guarantee same result for the same input (lacks repeatability).

The speaker recently introduced a new concept of empirical approach to machine learning and fuzzy sets and systems, had proven convergence for a class of such models and used the link between neural networks and fuzzy systems (neuro-fuzzy systems are known to have a duality from the radial basis functions (RBF) networks and fuzzy rule based models and having the key property of universal approximation proven for both).

In this talk he will present in a systematic way the basics of the newly introduced Empirical Approach to Machine Learning, Fuzzy Sets and Systems and its applications to problems like anomaly detection, clustering, classification, prediction and control. The major advantages of this new paradigm are the liberation from the restrictive and often unrealistic assumptions and requirements concerning the nature of the data (random, deterministic, fuzzy), the need to formulate and assume a priori the type of distribution models, membership functions, the independence of the individual data observations, their large (theoretically infinite) number, etc.

From a pragmatic point of view, this direct approach from data (streams) to complex, layered model representation is automated fully and leads to very efficient model structures. In addition, the proposed new concept learns in a way similar to the way people learn – it can start from a single example. The reason why the proposed new approach makes this possible is because it is prototype based and non-parametric.

“In-memory Computing”: Accelerating AI Applications

Evangelos Eleftheriou

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Abstract. In today’s computing systems based on the conventional von Neumann architecture, there are distinct memory and processing units. Performing computations results in a significant amount of data being moved back and forth between the physically separated memory and processing units. This costs time and energy, and constitutes an inherent performance bottleneck. It is becoming increasingly clear that for application areas such as AI (and indeed cognitive computing in general), we need to transition to computing architectures in which memory and logic coexist in some form. Brain-inspired neuromorphic computing and the fascinating new area of in-memory computing or computational memory are two key non-von Neumann approaches being researched. A critical requirement in these novel computing paradigms is a very-high-density, low-power, variable-state, programmable and non-volatile nanoscale memory device. There are many examples of such nanoscale memory devices in which the information is stored either as charge or as resistance. However, one particular example is phase-change-memory (PCM) devices, which are very well suited to address this need, owing to their multi-level storage capability and potential scalability.

In in-memory computing, the physics of the nanoscale memory devices, as well as the organization of such devices in cross-bar arrays, are exploited to perform certain computational tasks within the memory unit. I will present how computational memories accelerate AI applications and will show small- and large-scale experimental demonstrations that perform high-level computational primitives, such as ultra-low-power inference engines, optimization solvers including compressed sensing and sparse coding, linear solvers and temporal correlation detection. Moreover, I will discuss the efficacy of this approach to efficiently address not only inferencing but also training of deep neural networks. The results show that this co-existence of computation and storage at the nanometer scale could be the enabler for new, ultra-dense, low-power, and massively parallel computing systems. Thus, by augmenting conventional computing systems, in-memory computing could help achieve orders of magnitude improvement in performance and efficiency.

Contents

Invited Paper

The Power of the "Pursuit" Learning Paradigm in the Partitioning of Data . . . 3
Abdolreza Shirvani and B. John Oommen

AI in Energy Management - Industrial Applications

A Benchmark Framework to Evaluate Energy Disaggregation Solutions 19
Nikolaos Symeonidis, Christoforos Nalmpantis, and Dimitris Vrakas

Application of Deep Learning Long Short-Term Memory in Energy Demand Forecasting 31
Nameer Al Khafaf, Mahdi Jalili, and Peter Sokolowski

Modelling of Compressors in an Industrial CO_2-Based Operational Cooling System Using ANN for Energy Management Purposes 43
Sven Myrdahl Opalic, Morten Goodwin, Lei Jiao, Henrik Kofoed Nielsen, and Mohan Lal Kolhe

Outlier Detection in Temporal Spatial Log Data Using Autoencoder for Industry 4.0. 55
Lukas Kaupp, Ulrich Beez, Jens Hülsmann, and Bernhard G. Humm

Reservoir Computing Approaches Applied to Energy Management in Industry 66
Valentina Colla, Ismael Matino, Stefano Dettori, Silvia Cateni, and Ruben Matino

Signal2Vec: Time Series Embedding Representation 80
Christoforos Nalmpantis and Dimitris Vrakas

Biomedical - Bioinformatics Modeling

Classification of Sounds Indicative of Respiratory Diseases 93
Stavros Ntalampiras and Ilyas Potamitis

Eye Disease Prediction from Optical Coherence Tomography Images with Transfer Learning 104
Arka Bhowmik, Sanjay Kumar, and Neeraj Bhat

Severe Asthma Exacerbations Prediction Using Neural Networks 115
Arthur Silveira, Cristian Muñoz, and Leonardo Mendoza

A New Generalized Neuron Model Applied to DNA Microarray Classification 125
Beatriz A. Garro and Roberto A. Vazquez

Classification - Learning

A Hybrid Approach for the Fighting Game AI Challenge: Balancing Case Analysis and Monte Carlo Tree Search for the Ultimate Performance in Unknown Environment 139
Lam Gia Thuan, Doina Logofătu, and Costin Badică

A Probabilistic Graph-Based Method to Improve Recommender System Accuracy 151
Nima Joorabloo, Mahdi Jalili, and Yongli Ren

A Robust Deep Ensemble Classifier for Figurative Language Detection 164
Rolandos-Alexandros Potamias, Georgios Siolas, and Andreas Stafylopatis

Enhanced Feature Selection for Facial Expression Recognition Systems with Genetic Algorithms 176
Kennedy Chengeta

Imaging Time-Series for NILM. 188
Lamprini Kyrkou, Christoforos Nalmpantis, and Dimitris Vrakas

Learning Meaningful Sentence Embedding Based on Recursive Auto-encoders 197
Amal Bouraoui, Salma Jamoussi, and Abdelmajid Ben Hamadou

Pruning Extreme Wavelets Learning Machine by Automatic Relevance Determination 208
Paulo V. de Campos Souza, Vinicius J. Silva Araujo, Vanessa S. Araujo, Lucas O. Batista, and Augusto J. Guimaraes

Students' Performance Prediction Model Using Meta-classifier Approach. . . . 221
Hasniza Hassan, Syahid Anuar, and Nor Bahiah Ahmad

Deep Learning

A Deep Network System for Simulated Autonomous Driving Using Behavioral Cloning 235
Andreea-Iulia Patachi, Florin Leon, and Doina Logofătu

A Machine Hearing Framework for Real-Time Streaming Analytics Using Lambda Architecture 246
Konstantinos Demertzis, Lazaros Iliadis, and Vardis-Dimitris Anezakis

Deep Learning and Change Detection for Fall Recognition 262
Sotiris K. Tasoulis, Georgios I. Mallis, Spiros V. Georgakopoulos, Aristidis G. Vrahatis, Vassilis P. Plagianakos, and Ilias G. Maglogiannis

Image Classification Using Deep Neural Networks: Transfer Learning and the Handling of Unknown Images 274
Vedang Chauhan, Keyur D. Joshi, and Brian Surgenor

LEARNAE: Distributed and Resilient Deep Neural Network Training for Heterogeneous Peer to Peer Topologies 286
Spyridon Nikolaidis and Ioannis Refanidis

Predicting Customer Churn Using Artificial Neural Network 299
Sanjay Kumar and Manish Kumar

Virtual Sensor Based on a Deep Learning Approach for Estimating Efficiency in Chillers 307
Serafín Alonso, Antonio Morán, Daniel Pérez, Perfecto Reguera, Ignacio Díaz, and Manuel Domínguez

Deep Learning - Convolutional ANN

Canonical Correlation Analysis Framework for the Reduction of Test Time in Industrial Manufacturing Quality Tests 323
Paul Alexandru Bucur and Philipp Hungerländer

Convolutional Neural Network for Detection of Building Contours Using Multisource Spatial Data 335
George Papadopoulos, Nikolaos Vassilas, and Anastasios Kesidis

Fuzzy - Vulnerability - Navigation Modeling

A Meta-multicriteria Approach to Estimate Drought Vulnerability Based on Fuzzy Pattern Recognition 349
M. Spiliotis, A. Iglesias, and L. Garrote

Bioinspired Early Prediction of Earthquakes Inferred by an Evolving Fuzzy Neural Network Paradigm 361
Mario Malcangi and Marco Malcangi

Enhancing Disaster Response for Hazardous Materials Using Emerging Technologies: The Role of AI and a Research Agenda 368
Jaziar Radianti, Ioannis Dokas, Kees Boersma, Nadia Saad Noori, Nabil Belbachir, and Stefan Stieglitz

Machine Learning Modeling - Optimization

Evolutionary Optimization on Artificial Neural Networks for Predicting the User's Future Semantic Location 379
Antonios Karatzoglou

Global Minimum Depth in Edwards-Anderson Model 391
Iakov Karandashev and Boris Kryzhanovsky

Imbalanced Datasets Resampling Through Self Organizing Maps and Genetic Algorithms 399
Marco Vannucci and Valentina Colla

Improvement of Routing in Opportunistic Communication Networks of Vehicles by Unsupervised Machine Learning 412
Ladislava Smítková Janků and Kateřina Hyniová

Machine Learning Approach for Drone Perception and Control. 424
Yograj S. Mandloi and Yoshinobu Inada

ML - DL Financial Modeling

A Deep Dense Neural Network for Bankruptcy Prediction 435
Stamatios-Aggelos N. Alexandropoulos, Christos K. Aridas, Sotiris B. Kotsiantis, and Michael N. Vrahatis

Stock Price Movements Classification Using Machine and Deep Learning Techniques-The Case Study of Indian Stock Market 445
Nagaraj Naik and Biju R. Mohan

Study of Stock Return Predictions Using Recurrent Neural Networks with LSTM 453
Nagaraj Naik and Biju R. Mohan

Security - Anomaly Detection

Comparison of Network Intrusion Detection Performance Using Feature Representation 463
Daniel Pérez, Serafín Alonso, Antonio Morán, Miguel A. Prada, Juan José Fuertes, and Manuel Domínguez

Cyber Security Incident Handling, Warning and Response System for the European Critical Information Infrastructures (CyberSANE) 476
Spyridon Papastergiou, Haralambos Mouratidis, and Eleni-Maria Kalogeraki

Fault Diagnosis in Direct Current Electric Motors via an Artificial Neural Network 488
Theofanis I. Aravanis, Tryfon-Chrysovalantis I. Aravanis, and Polydoros N. Papadopoulos

1st PEINT Workshop

On Predicting Bottlenecks in Wavefront Parallel Video Coding Using Deep Neural Networks 501
Natalia Panagou, Panagiotis Oikonomou, Panos K. Papadopoulos, Maria Koziri, Thanasis Loukopoulos, and Dimitris Iakovidis

Recognizing Human Actions Using 3D Skeletal Information and CNNs. 511
Antonios Papadakis, Eirini Mathe, Ioannis Vernikos, Apostolos Maniatis, Evaggelos Spyrou, and Phivos Mylonas

Staircase Detection Using a Lightweight Look-Behind Fully Convolutional Neural Network 522
Dimitrios E. Diamantis, Dimitra-Christina C. Koutsiou, and Dimitris K. Iakovidis

Obstacle Detection Based on Generative Adversarial Networks and Fuzzy Sets for Computer-Assisted Navigation 533
George Dimas, Charis Ntakolia, and Dimitris K. Iakovidis

Author Index 545