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# Artificial Intelligence Applications and Innovations

Ilias Maglogiannis, John Macintyre, Lazaros Iliadis

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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.

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Ilias Maglogiannis · John Macintyre ·  
Lazaros Iliadis (Eds.)

# Artificial Intelligence Applications and Innovations

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Proceedings

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# Preface

Artificial Intelligence (AI) continues to advance, following extreme development rhythms in the new era of the 21st century. It has already made its way into our daily lives in various forms. It is estimated that more than 80 billion USD have been invested by car industries for the design and development of autonomous self-driving vehicles. AI technologies like *Google Duplex* are accomplishing real-world conversations and arrangements with humans, using *Deep Neural Networks* (e.g., Google voice search, Wavenet). It is estimated by the International Data Corporation, a global provider of market intelligence, that investments in AI business globally will reach up to 110 billion USD by 2024.

AI is a major part of the Fourth Industrial Revolution, together with other technologies like the *Internet of Things*, *Genetic Engineering*, *Quantum Computing*, and its impact in the evolution of our post-modern societies in various domains is huge and growing. On the other hand, there are major areas of ethical concern for our societies, namely privacy, surveillance, bias-discrimination, and elimination of entire job categories. Moreover, serious questions arise on the superiority and indispensability of human judgment on important aspect of life. In other words, “Can smart machines outthink our human judgment?”.

The *17th International Conference on Artificial Intelligence Applications and Innovations* (AIAI 2021) offered insight into all timely challenges related to technical, legal, and ethical aspects of intelligent systems and their applications. New algorithms and potential prototypes employed in diverse domains were introduced.

AIAI is a mature international scientific conference series that has been held all over the world and it is well established in the scientific area of AI. Its history is long and very successful, following and propagating the evolution of intelligent systems.

The first event was organized in Toulouse, France, in 2004. Since then, it has had a continuous and dynamic presence as a major global, but mainly European, scientific event. It has been organized in China, Greece, Cyprus, Australia, and France. It has always been technically supported by the International Federation for Information Processing (IFIP) and more specifically by Working Group 12.5, which is interested in AI applications.

Following a long-standing tradition, this Springer volume belongs to the IFIP AICT series and it contains the papers that were accepted to be presented orally at the AIAI 2021 conference. An additional volume comprises the papers that were accepted and presented at the workshops and were held as parallel events. The event was held during June 25–27, 2021, in Greece (virtually). The diverse nature of papers presented demonstrates the vitality of AI algorithms and approaches. It certainly proves the very wide range of AI applications as well.

The response of the international scientific community to the AIAI 2021 call for papers was more than satisfactory, with 113 papers initially submitted by authors in 21 different countries from all over the globe, namely Australia, Austria, Belgium, Czech

Republic, Egypt, France, Germany, Greece, Lebanon, Netherlands, India, Italy, China, Poland, Portugal, Romania, Sweden, Taiwan, Turkey, UK, and USA.

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 54 papers (47.79% of the submitted manuscripts) were accepted to be published as full papers (12 pages long) in the proceedings. Owing to the high quality of the submissions, the Program Committee decided that it should accept 7 more papers to be published as short papers (10 pages long).

The accepted papers cover the following thematic topics:

- Activity Recognition
- Adaptive Learning
- Adversarial Neural Networks
- AI for Media
- AI for Music Composition
- Anomaly Detection and AI
- Anxiety Recognition and AI
- Autoencoders
- Autonomous Driving
- Bioinformatics and AI
- Classification in Pattern Recognition
- Clustering
- Computer Vision
- Convolutional and Recurrent ANN
- Cybersecurity and AI
- Cyber Supply-Chain and AI
- Data Mining
- Deep Learning ANN
- Dialogue Act Recognition
- Embedded Machine Learning
- Fake News Detection and AI
- Feature Selection
- Financial Applications of AI
- Fuzzy Modeling
- Genetic Algorithms and Optimization
- Hybrid Intelligent Models
- Interoperability and AI
- Image Analysis for Face Recognition
- Machine Learning
- Meta-Learning and AutoML
- Multi Agent Systems
- Natural Language
- Recommendation Systems
- Robotics
- Social Media Intelligent Modeling
- SOM

Swarm Intelligence  
Text Mining and Machine Translation  
Time Series  
Emotion recognition

Eight keynote speakers were invited to give lectures on timely aspects of AI. We wish to thank all keynote speakers for enlightening our conference with their state-of-the-art lectures.

In addition to the main conference, the following eight scientific workshops on timely AI subjects were organized under the framework of AIAI 2021:

- The *6th Workshop on 5G-Putting Intelligence to the Network Edge* (5G-PINE 2021)
- The *1st Workshop on Artificial Intelligence in Biomedical Engineering and Informatics* (AI-BIO 2021)
- The *1st Workshop on Defense Applications of AI* (DAAI 2021)
- The *1st Workshop on Distributed AI for REsource-Constrained Platforms* (DARE 2021)
- The *1st Workshop on Energy Efficiency and Artificial Intelligence* (EEAI 2021)
- The *10th Mining Humanistic Data Workshop* (MHDW 2021)
- The *1st Workshop on AI and Ethics* (AIETH 2021)
- Designing a Novel Adaptive Cybersecurity Solution for Internet-of-Vehicle Workshop (nIoVe)

We are grateful to everyone who made AIAI 2021 such a success, and we hope that we can meet again in person at the next event.

June 2021

Ilias Maglogiannis  
Lazaros Iliadis  
John MacIntyre





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# **Abstracts of Keynotes**

# Is “Big Tech” Becoming the “Big Tobacco” of Artificial Intelligence?

John Macintyre

Pro Vice Chancellor at the University of Sunderland, UK gave a Keynote Lecture on a very hot topic related to AI and Ethics.

**Abstract.** Recent developments in research, development, implementation and use of AI include worrying trends which ask big questions about the future direction of the whole field. As part of this, the role of “Big Tech” – the huge corporate entities who now dominate the development of AI technologies and products – is crucial, both in terms of the technology they develop, and the researchers they employ. Their dominance places them at the apex of the R&D and product development activity in AI, which in turn means they have a great responsibility to ensure that this activity leads to fair, transparent, accountable, and ethical AI systems and products. They also have a great responsibility to support and nurture their staff. This talk will examine recent developments in AI and the role of Big Tech, and ask whether they are stepping up to these responsibilities.

# Machine Learning: A Key Ubiquitous Technology in the 21st Century

Hojjat Adeli

Ohio State University, Columbus, USA, Fellow of the Institute of Electrical and Electronics Engineers (IEEE), Honorary Professor, Southeast University, Nanjing, China, Member, Polish and Lithuanian Academy of Sciences, Elected corresponding member of the Spanish Royal Academy of Engineering.

**Abstract.** Machine learning (ML) is a key and increasingly pervasive technology in the 21st century. It is going to impact the way people live and work in a significant way. In general, machine learning algorithms simulate the way brain learns and solves an estimation/recognition problem. They usually require a learning phase to discover the patterns among the available data, similar to the humans. An expanded definition of ML is advanced as algorithms that can learn from examples and data and solve seemingly intractable learning and unteachable problems, referred to as ingenious artificial intelligence (AI). Recent and innovative applications of ML in various fields and projects currently being pursued by leading high-tech and industrial companies such as Boeing, Google, IBM, Uber, Baidu, Facebook, and Tesla are reviewed. Then, machine learning algorithms developed by the author and his associates are briefly described. Finally, examples are presented in different areas from health monitoring of smart highrise building structures to automated EEG-based diagnosis of various neurological and psychiatric disorders such as epilepsy, the Alzheimer's disease, Parkinson's disease, and autism spectrum disorder.

# Human-Centered Computer Vision: Core Components and Applications

Antonis Argyros<sup>1,2</sup>

<sup>1</sup> Computer Science Department, University of Crete, Greece

<sup>2</sup> Researcher, Foundation for Research and Technology – Hellas (FORTH)

**Abstract.** Computer vision is an area of artificial intelligence aimed at developing technical systems capable of perceiving the environment through image and video processing and analysis. In this talk, we mainly focus on human-centered computer vision, that is, computer vision for capturing aspects of human presence such as the geometry and motion of the human body, as well as for recognizing human actions, behavior, intentions and emotional states. Such technologies may constitute a fundamental building block for the development of a variety of applications in almost all aspects of human life (health, security, work, education, transportation, entertainment, etc.). In this special area, we give specific examples of our research activity and highlight the significant boost achieved due to the exploitation of state-of-the-art machine learning techniques and deep neural networks. We also give examples of applications developed based on these technologies in the field of robotics and ambient intelligence environments.

# Unveiling Recurrent Neural Networks - What Do They Actually Learn and How?

Peter Tino

School of Computer Science, University of Birmingham, UK

**Abstract.** When learning from “dynamic” data where the order in which the data is presented does matter, the key issue is how such temporal structures get represented within the learning machine. In the case of artificial neural networks, an often-adopted strategy is to introduce feedback-connections with time delays. This enables the neurons to form their activation patterns based on the past, as well as the current neural activations. Neural networks of this kind became known as Recurrent Neural Networks (RNN). Many diverse architectures fall under this umbrella, with a wide variety of application domains. We will briefly review past attempts to understand the way RNNs learn to represent the past in order to perform the tasks they are trained on.

To that end, we will adopt the general view of RNNs as parameterized state space models and input driven non-autonomous dynamical systems. We will then present some new results connecting RNNs to a widely known class of models in machine learning - kernel machines. In particular, we will show that RNNs can be viewed as “temporal feature spaces”. This framework will enable us to understand how high-dimensional RNNs constructed with very few degrees of freedom in their parameterization can still achieve competitive performances. Such observations can be viewed as “dynamical analogs” to classical “static” kernel machines that often achieve excellent performance using rich feature spaces constructed with very few degrees of freedom (e.g. single scale parameter in Gaussian kernels).



# Deep Learning and Kernel Machines

Johan Suykens

KU Leuven, ESAT-Stadius and Leuven AI Institute, Belgium

**Abstract.** Over the last decades, with neural networks and deep learning, several powerful architectures have been proposed, including e.g., convolutional neural networks (CNN), stacked autoencoders, deep Boltzmann machines (DBM), deep generative models and generative adversarial networks (GAN). On the other hand, with support vector machines (SVM) and kernel machines, solid foundations in learning theory and optimization have been achieved. Within this talk, we outline a unifying picture and show several new synergies, for which model representations and duality principles play an important role. A recent example is restricted kernel machines (RKM), which connects least squares support vector machines (LS-SVM) to restricted Boltzmann machines (RBM). New developments on this will be shown for deep learning, generative models, multi-view and tensor-based models, latent space exploration, robustness and explainability.

# How Can Artificial Intelligence Efficiently Support Sustainable Development?

Eunika Mercier-Laurent

Université de Reims Champagne-Ardenne, CReSTIC/MODECO, France

**Abstract.** This talk considers the multiple role AI may play in sustainability. Actually, sustainable development is among the greatest challenges for humanity. Sustainability and development are apparently opposite. The current efforts to face the Planet Crisis by separate actions generate less impact than expected. Artificial Intelligence approaches and capacity of available technologies are underexplored. Eco-innovation actions focus mainly on smart transportation, smart use of energy and water and waste recycling but do not consider the necessary evolution of behaviors and focus. The trendy Digital transformation follows mostly traditional approaches. The concepts such as Smart, Intelligent, Innovative, Green or Wise City invented to promote existing technology transform the IT market. Most of offers consist in data processing with statistical/optimization methods. But AI can do better – the AI approaches and techniques combined with adequate thinking may help innovating the way of facing Planet Crisis.

# Backpropagation Free Deep Learning

Jose C. Principe

University of Florida, USA

**Abstract.** This talk presents recent results that show the feasibility of training deep networks classifiers without backpropagation. We will prove that it is possible to substitute error propagation in general conditions and practically achieve the same performance as conventional algorithms. This methodology allows modularization of the algorithmic pipeline and improves explainability. We will then address some of the benefits of this technology for applications.

# Brain-Inspired Data Analytics for Incremental and Transfer Learning of Cognitive Spatio-Temporal Data and for Knowledge Transfer

Nikola Kasabov

Fellow IEEE, Fellow RSNZ, Fellow INNS College of Fellows  
Professor of Knowledge Engineering and Founding Director KEDRI  
Auckland University of Technology, Auckland, New Zealand  
George Moore Chair/Professor, University of Ulster, UK  
Honorary Professor Teesside University UK and the University of Auckland, NZ

**Abstract.** The talk argues and demonstrates that brain-inspired spiking neural network (SNN) architectures can be used for incremental and transfer learning, i.e. to learn new data and new classes/tasks/categories incrementally utilising some previously learned knowledge. Similarly to how the brain manifests transfer learning, these SNN models do not need to be restricted in number of layers, neurons in each layer, etc. as they adopt self-organising learning principles. The new learned knowledge can be extracted in forms of graphs and symbolic fuzzy rules and its evolution traced over time. The presented approach is illustrated on an exemplar brain-inspired SNN architecture NeuCube (free software and open source available from [www.kedri.aut.ac.nz/neucube](http://www.kedri.aut.ac.nz/neucube) and from [www.neucube.io](http://www.neucube.io)). The extraction of symbolic rules from NeuCube at each learning tasks and each subject allows for knowledge transfer between humans and machines in an adaptive, evolving, interactive way. This opens the field to build new types of open and transparent BCI and AI systems.

More details can be found in: N.Kasabov, Time-Space, Spiking Neural Networks and Brain-Inspired Artificial Intelligence, Springer, 2019, <https://www.springer.com/gp/book/9783662577134>.

# **Abstracts of Tutorials**

# Modern Methods and Tools for Human Biosignal Analysis

Vangelis Metsis

Texas State University, USA

**Abstract.** The term biosignal refers to any signal that can be measured from living organisms. Biosignals have been used in medicine, sports science, and psychology for diagnoses, and there have been impressive advancements in these areas. Recently, the fields of human-computer interaction and affective computing have found an interest in using biosignals as a means of understanding the human state and intention. This interest has been reinforced by the fact that acquiring information with sensors and interfacing electrically with the human body has become much easier in the past few years. Moving from large analog technologies to digital ones has led to the miniaturization of sensing devices. Wireless transmission technologies (e.g., Bluetooth low energy), which can be easily integrated with the acquisition hardware, have removed the need for bulky wiring. This tutorial will present an overview of modern applications of human biosignals and will provide practical examples of machine learning-based methods and tools for biosignal analysis. Traditional machine learning algorithms for feature extraction and classification will be compared with recent developments in deep learning and its applications to biosignal and time-series data processing in general.

# **Anomaly Detection in Images**

Giacomo Boracchi

Politecnico di Milano, Italy

Anomaly detection problems are ubiquitous in engineering: the prompt detection of anomalies is often a primary concern, since these might provide precious information for understanding the dynamics of a monitored process and for activating suitable countermeasures. In fact, anomalies are typically the most informative regions in an image (e.g., defects in images used for quality control). Not surprisingly, anomaly detection problems have been widely investigated in the image processing and pattern recognition communities and are key in application scenarios ranging from quality inspection to health monitoring. The tutorial presents a rigorous formulation of the anomaly-detection problem that fits with many imaging scenarios and applications. The tutorial describes, by means of illustrative examples, the most important anomaly-detection approaches in the literature, and their connection with the machine-learning perspective of semi-supervised and unsupervised learning/monitoring. Special emphasis will be given to anomaly-detection methods based on learned models, which are often adopted to handle images and signals. In particular, these will be divided into traditional models (including dictionaries yielding sparse representations) and deep learning models. The tutorial is accompanied by various examples from our research projects where we applied anomaly-detection algorithms to solve real world problems: visual quality inspection for monitoring chip and nanofiber production.

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