IWANN INTERNATIONAL WORK CONFERENCE ON ARTIFICIAL NEURAL NETWORKS

PROGRAM AND ABSTRACTS

12-14 june, 2019
Gran Canaria (SPAIN)

IWANN 2019

International work-conference on Artificial Neural Networks

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12-14 june, 2019
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Preface

We are proud to present the abstract of final accepted papers for the 15th edition of the International Work-Conference on Artificial Neural Networks (IWANN) held in Gran Canaria, (Spain) during June 12-14, 2019.

IWANN is a biennial conference that seeks to provide a discussion forum for scientists, engineers, educators and students about the latest ideas and realizations in the foundations, theory, models and applications of hybrid systems inspired on nature (neural networks, fuzzy logic and evolutionary systems) as well as in emerging areas related to the above items. As in previous editions of IWANN, we also aim to create a friendly environment that could lead to the establishment of scientific collaborations and exchanges among attendees. The proceedings will include all the presented communications to the conference. It is also foreseen the publication of an extended version of selected papers in a special issue on several specialized journals (such as Neural Computing and Applications, PLOS One and Neural Proccesing Letters).

Since the first edition in Granada (LNCS 540, 1991), the conference has evolved and matured. The list of topics in the successive Call for Papers has also evolved, resulting in the following list for the present edition:

1. **Mathematical and theoretical methods in computational intelligence**. Mathematics for neural networks. RBF structures. Self-organizing networks and methods. Support vector machines and kernel methods. Fuzzy logic. Evolutionary and genetic algorithms.
2. **Neurocomputational formulations**. Single-neuron modelling. Perceptual modelling. System-level neural modelling. Spiking neurons. Models of biological learning.
3. **Learning and adaptation**. Adaptive systems. Imitation learning. Reconfigurable systems. Supervised, non-supervised, reinforcement and statistical algorithms.
4. **Emulation of cognitive functions**. Decision Making. Multi-agent systems. Sensor mesh. Natural language. Pattern recognition. Perceptual and motor functions (visual, auditory, tactile, virtual reality, etc.). Robotics. Planning motor control.
5. **Bio-inspired systems and neuro-engineering**. Embedded intelligent systems. Evolvable computing. Evolving hardware. Microelectronics for neural, fuzzy and bioinspired systems. Neural prostheses. Retinomorphic systems. Brain-computer interfaces (BCI) Nanosystems. Nanocognitive systems.
6. **Advanced topics in computational intelligence**. Intelligent networks. Knowledge-intensive problem solving techniques. Multi-sensor data fusion using computational intelligence. Search and meta-heuristics. Soft Computing. Neuro-fuzzy systems. Neuro-evolutionary systems. Neuro-swarm. Hybridization with novel computing paradigms.
7. **Applications**. Expert Systems. Image and Signal Processing. Ambient intelligence. Biomimetic applications. System identification, process control, and manufacturing. Computational Biology and Bioinformatics. Parallel and Distributed Computing. Human Computer Interaction, Internet Modeling, Communication and Networking. Intelligent Systems in Education. Human-Robot Interaction. Multi-Agent Systems. Time series analysis and prediction. Data mining and knowledge discovery.

At the end of the submission process, and after a careful peer review and evaluation process (each submission was reviewed by at least 2, and on the average 2.9, program committee members or additional reviewers), 150 papers were accepted for oral or poster presentation, according to the recommendations of reviewers and the authors' preferences.

In this edition of IWANN 2019, a Workshop, entitled: **"Artificial Intelligence in Nanophotonics"** will be presented, organized by Dr. Nikolay Zheludev, University of Southampton, UK and NTU Singapore and Dr. Cesare Soci NTU, Singapore.

During IWANN 2019 several Special Sessions will be carried out. Special Sessions will be a very useful tool in order to complement the regular program with new and emerging topics of particular

interest for the participating community. Special Sessions that emphasize on multi-disciplinary and transversal aspects, as well as cutting-edge topics are especially encouraged and welcome, and in this edition of IWANN 2019 are the following:

- **SS01: Artificial Neural Network for biomedical image processing.**
  Organized by: Dr. Yu-Dong Zhan
- **SS02: Deep learning models in healthcare and biomedicine.**
  Organized by: Dr. Leonardo Franco, Dr. Ruxandra Stoean and Dr. Francisco Veredas
- **SS03: Deep learning beyond convolution.**
  Organized by: Dr. Miguel Atencia
- **SS04: Machine learning in Vision and Robotics.**
  Organized by: Dr. Jos Garca-Rodrguez, Dr. Enrique Domnguez and Dr. Ramn Moreno
- **SS05: Data-driven Intelligent Transportation Systems.**
  Organized by: Dr. Ignacio J. Turas Domnguez, Dr. David Elizondo and Dr. Francisco Ortega Zamorano
- **SS06: Software Testing and Intelligent Systems.**
  Organized by: Dr. Juan Boubeta, Dr. Pablo C. Caizares and Dr. Gregorio Daz
- **SS07: Deep Learning and Natural Language Processing.**
  Organized by: Dr. Leonor Becerra-Bonache, Dr. M. Dolores Jimnez-Lpez and Dr. Benoit Favre
- **SS08: Random-Weights Neural Networks.**
  Organized by: Dr. Claudio Gallicchio
- **SS09: New and future tendencies in Brain-Computer Interface systems.**
  Organized by: Dr. Ricardo Ron and Dr. Ivan Volosyak
- **SS10: Human Activity Recognition.**
  Organized by: Dr.-Ing. habil. Matthias Ptzold
- **SS11: Computational Intelligence Methods for Time Series.**
  Organized by: Dr. Hctor Pomares
- **SS12: Advanced Methods for Personalized/Precision Medicine.**
  Organized by: Dr. Luis Javier Herrera and Dr. Fernando Rojas
- **SS13: Exploring document information to improve neural summarization models.**
  Organized by: Dr.Luigi Di Caro
- **SS15: Machine learning in weather observation and forecasting.**
  Organized by: Dr. Juan Luis Navarro-Mesa, Dr. Antonio Ravelo-Garca and Dr. Carmen Paz Surez Araujo

In this edition of IWANN, we were honored to have the presence of the following invited speakers:

1. Dr. Nuria Oliver, Director of Research in Data Science @ Vodafone Chief Data Scientist @ Data-Pop Alliance
2. Dr. Aureli Soria-Frisch, Director of Neuroscience, Starlab Consulting Division
3. Dr. Jose C. Principe, Distinguished Professor ECE, Eckis Professor of ECE, Director Computational NeuroEngineering Lab, University of Florida
4. Dr. Marin Soljacic is Professor of Physics at MIT.

This edition of the IWANN conference was organized by the University of Granada, University of Malaga and Polytechnical University of Catalonia. We wish to thank to the University of Gran Canaria for their support and grants.

We would also like to express our gratitude to the members of the different committees for their support, collaboration and good work. We specially thank to our Honorary Chairs (Prof. Joan Cabestany, Prof. Alberto Prieto and Prof. Francisco Sandoval), the Technical Program Chairs (Prof. Miguel Atencia, Prof. Francisco Garca-Lagos, Prof. Luis Javier Herrera and Prof. Fernando Rojas), Local Organizing Committee (Prof. Domingo J. Bentez Daz, Prof. Carmen Paz Surez Araujo and Prof. Juan Luis Navarro Mesa), Program Committe, the Reviewers, Invited Speaker,

Special Session Organizers and Workshop of AIN Organizers. Finally, we want to thank to Springer Computer Science Editorial, and especially Prof. Alfred Hofmann and Prof. Anna Kramer for their continuous support and cooperation.

June, 2019
Gran Canaria, Spain

Ignacio Rojas
Gonzalo Joya
Andreu Catala

IWANN 2019 Short Program

Wednesday, June 12th 2019		
8:30-9:00	**REGISTRATION DESK** *(start at 8:30h but it is opened during all the conference)*	
9:00-11:00	**Session A.1: Deep learning beyond convolution**	**Session B.1: Computational Intelligence Methods for Time Series (Part. I)**
11:00-11:30	**COFFEE BREAK**	
11:30-13:00	**Session A.2: Machine Learning in Vision and Robotics (Part.I)**	**Session B.2: Computational Intelligence Methods for Time Series (Part. II)**
13:00-14:00	**OPENING PLENARY LECTURE Prof. Jose C. Principe**	
14:00-16:00	**LUNCH**	
16:00-17:00	**Session A.3: Computational Biology and Bioinformatics**	**Session B.3: Advances in Computational Intelligence (Part. I)**
17:00-17:30	**COFFEE BREAK**	
17:30-18:30	**Session A.4: Evolutionary and genetic algorithms**	**Session B.4: Data-driven Intelligent Transportation Systems**
18:30-19:30	**Session A.5: Machine learning in weather observation and forecasting**	**Session B.5: Soft Computing**

NOTE:

1.- During the Thursday and Friday the **Workshop on Artificial Intelligence** in Nanophotonics will be held.

2.- Thursday will be held the Tutorial on **Transfer Learning for Deep Learning**. The tutorial will include a practical session with connection to the Barcelona Supercomputing Center (**BSC**).

For more details visit the IWANN website.

Thursday, June 13th, 2019		
9:00-11:00	Session A.6: Machine Learning in Vision and Robotics (Part.II)	Session B.6: Human Activity Recognition
11:00-11:30	COFFEE BREAK	
11:30-12:30	Tutorial on Transfer Learning for Deep Learning	Session B.7: New and future tendencies in Brain-Computer Interface systems
12:30-13:20	Session A.7: Machine Learning in Vision and Robotics (Part.III)	
13:20-14:20	PLENARY LECTURE. Prof. Marin Soljacic	
14:20-16:00	LUNCH	
16:00-17:20	Session A.8: Mathematics for neural networks	Session B.8: Application of Computational Intelligence
17:20-18:30	Session A.9: Deep learning models in healthcare and biomedicine	Session B.9: Random-Weights Neural Networks
18:30-19:00	COFFEE BREAK	
18:30-19:45	Session 10. Poster Session/ Demo Session	
20:30	Gala Dinner at Hotel Baobas	

Friday, June 14th, 2019		
9:00-11:00	Session A.11: Software Testing and Intelligent Systems	Session B.11: Deep Learning and Natural Language Processing
11:00-11:30	COFFEE BREAK	
11:30-12:30	PLENARY LECTURE Dr. Aureli Soria-Frisch	
12:30-13:10	Session A.12: Advances in Computational Intelligence (Part. II)	Session B.12: Image and Signal Processing
13:10-14:10	CLOSING PLENARY LECTURE Dr. Nuria Oliver (Video-Conference)	

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Session A.1: Deep learning beyond convolution

Session B.1: Computational Intelligence Methods for Time Series (Part. I)

Session A.2: Machine Learning in Vision and Robotics (Part. I)

Session A.4: Evolutionary and genetic algorithms

Session B.4: Data-driven Intelligent Transportation Systems

Session A.5: Machine learning in weather observation and forecasting

Session B.5: Soft Computing

Session A.7: Machine Learning in Vision and Robotics (Part. III)

Session B.7: New and future tendencies in Brain-Computer Interface systems

Session A.8: Mathematics for neural networks

Session B.8: Application of Computational Intelligence

Artificial Intellegence in nanophotonics (IWANN workshop)

Fuzzy preprocessing for semi-supervised image classification in modern industry

Petr Hurtik and Vojtěch Molek

Abstract: We are focusing on image classification in industrial processing taking into account the most problematic issue of the processing: the lack of labeled data. Here, we are considering three datasets: the first one is an unsorted collection of all types of manufactured products and includes 100 images per class. The second one consists of products sorted into particular classes due to their label assigned by a specialized employee and includes only ten images per class. The last one includes a massive volume of labeled images, but it is used only for the proposal verification. As the configuration is challenging for neural networks, we propose to use Image Represented by a Fuzzy Function in order to enrich original image information. We solve the task using various autoencoder architectures and prove that such the proposal increases the autoencoders success rate.

Interpretability of Recurrent Neural Networks Trained on Regular Languages

Christian Oliva and Luis F. Lago-Fernández

Abstract: We study the ability of recurrent neural networks to model and recognize simple regular languages. Training the networks under different levels of noise and regularization, we analyze their response in terms of accuracy and interpretability using a complete set of validation data. Our results show that a small noise level improves the generalization of the networks, while regularization provides a higher interpretability. Under proper levels of noise and regularization, the networks are able to obtain a high accuracy, and the hidden units display activation patterns that could be related to discrete states in a deterministic finite automaton.

Unsupervised learning as a complement to convolutional neural network classification in the analysis of saccadic eye movement in spino-cerebellar ataxia type 2

Catalin Stoean, Ruxandra Stoean, Roberto Antonia Becerra-Garcia, Rodolfo Garcia-Bermudez, Miguel Atencia, Francisco Garcia-Lagos, Luis Velazquez-Perez and Gonzalo Joya

Abstract: This paper aims at assessing spino-cerebellar type~2 ataxia by classifying electrooculography records into registers corresponding to healthy, presymptomatic and ill individuals. The primary used technique is the convolutional neural network applied to the time series of eye movements, called saccades. The problem is exceptionally hard, though, because the recorded saccadic movements for presymptomatic cases often do not substantially differ from those of healthy individuals. Precisely this distinction is of the utmost clinical importance, since early intervention on presymptomatic patients can ameliorate symptoms or at least slow their progression. Yet, each register contains a number of saccades that, although not consistent with the current label, have not been considered indicative of another class by the examining physicians. As a consequence, an unsupervised learning mechanism may be more suitable to handle this form of misclassification. Thus, our proposal introduces the k-means approach and the SOM method, as complementary techniques to analyse the time series. The three techniques operating in tandem lead to a well performing solution to this diagnosis problem.

Scale-Space Theory, F-transform kernels and CNN Realization

Vojtěch Molek and Irina Perfilieva

Abstract: We present scale-space and F-transform inspired modification to convolutional neural networks. The proposed modification improves network classification accuracy using multi-scale image representation and F-transform kernels pre-training. We evaluate our model on two databases and show better performance than networks without F-transform pre-training.

Numerosity representation in InfoGAN: an empirical study

Andrea Zanetti, Alberto Testolin, Marco Zorzi and Pawel Wawrzynski

Abstract: It has been shown that visual numerosity emerges as a statistical property of images in deep networks that learn a hierarchical generative model of the sensory input, through unsupervised deep learning [1]. The original deep generative model was based on stochastic neurons and, more importantly, on input (image) reconstruction. Statistical analysis highlighted a correlation between the numerosity present in the input and the population activity of some neurons in the second hidden layer of the network, whereas population activity of neurons in the first hidden layer correlated with total area (i.e., number of pixels) of the objects in the image. Here we further investigate whether numerosity information can be isolated as a disentangled factor of variation of the visual input. We train in unsupervised and semi-supervised fashion a latent-space generative model that has been shown capable of disentangling relevant semantic features in a variety of complex datasets, and we test its generative performance under different conditions. We then propose an approach to the problem based on the assumption that, in order to let numerosity emerge as disentangled factor of variation, we need to cancel out the sources of variation at graphical level.

Dynamic clustering of time series with Echo State Networks

Miguel Atencia, Catalin Stoean, Ruxandra Stoean, Roberto Rodríguez-Labrada and Gonzalo Joya

Abstract: Clustering with k-means and Echo State Networks

Using Artificial Neural Networks for recovering the Value-of-Travel-Time distribution

Sander Van Cranenburgh and Marco Kouwenhoven

Abstract: The Value-of-Travel-Time (VTT) expresses travel time gains into monetary benefits. In the field on transport, this measure plays a decisive role in the Cost-Benefit Analyses of transport policies and infrastructure projects as well as in travel demand modelling. Traditionally, theory-driven discrete choice models are used to infer the VTT distribution from choice data. This study proposes an alternative data–driven method to infer the VTT distribution based on Artificial Neural Networks (ANNs). The strength of the proposed method is that it is possible to uncover the VTT distribution (and its moments) without making strong assumptions about the shape of the distribution or the error terms, while being able to incorporate covariates and account for panel effects. We apply our method to data from the 2009 Norwegian VTT study. Finally, we cross-validate our method by comparing it with a series of state-of-the-art discrete choice models and other nonparametric methods used in the VTT literature. Based on the very encouraging results we have obtained, we believe that there is a place for ANN-based methods in future VTT studies.

Sparse, Interpretable and Transparent Predictive Model Identification for Healthcare Data Analysis

Leon Wei

Abstract: Data-driven modelling approaches play an indispensable role in analyzing and understanding complex processes. This study proposes a type of sparse, inter-pretable and transparent (SIT) model, which can be used to understand the de-pendent relationship of a response variable on a set of potential explanatory vari-ables. An ideal candidate for such a SIT representation is the well-known NARMAX (nonlinear autoregressive moving average with exogenous inputs) model, which can be established from measured input and output data of the sys-tem of interest, and the final refined model is usually simple, parsimonious and easy to interpret. The performance of the proposed SIT models is evaluated through two real healthcare datasets.

The Generalized Sleep Spindles Detector: A Generative Model Approach on Single-Channel EEGs

Carlos Loza and Jose Principe

Abstract: We propose a data-driven, unsupervised learning framework for one of the hallmarks of stage 2 sleep in the electroencephalogram (EEG)-sleep spindles. Neurophysiological principles and clustering of time series subsequences constitute the underpinnings of methods fully based on a generative latent variable model for single-channel EEG. Learning on the model results in representations that characterize families of sleep spindles. The discriminative embedding transform separates potential micro-events from ongoing background activity. Then, a hierarchical clustering framework exploits Minimum Description Length (MDL) encoding principles to effectively partition the time series into patterns belonging to clusters of different dimensions. The proposed algorithm has only one main hyperparameter due to online model selection and the flexibility provided by cross-correlation operators. Methods are validated on the DREAMS Sleep Spindles database with results that echo previous approaches and clinical findings. Moreover, the learned representations provide a rich parameter space for further applications such as sparse encoding, inference, detection, diagnosis, and modeling.

Anomaly detection for bivariate signals

Marie Cottrell, Cynthia Faure, Jérôme Lacaille and Madalina Olteanu

Abstract: The anomaly detection problem for univariate or multivariate time series is a critical question in many practical applications as industrial processes control, biological measures, engine monitoring, supervision of all kinds of behavior. In this paper we propose an empirical approach to detect anomalies in the behavior of multivariate time series. The approach is based on the empirical estimation of conditional quantiles. The method is tested on artificial data and its effectiveness is proven in the real framework of aircraft-engines monitoring.

A Scalable Long-Horizon Forecasting of Building Electricity Consumption

Naveen Kumar Thokala, Spoorthy Paresh and Girish Chandra M

Abstract: Load Forecasting plays a key role in the efficient operation of the building energy management systems. In this work, a framework is proposed for effective scalable implementation of long-term (month and quarter ahead) building load forecasting. It comprises of techniques to deal with outliers and missing values, dynamic input feature selection as well as a hybrid algorithm combining direct and recursive strategies for forecasting. The solution is successfully validated using the real consumption data of six office buildings and further the average accuracies of 92-95% and 88-92% for the month and the quarter ahead respectively, corroborates its usefulness

Long-Term Forecasting of Heterogenous Variables with Automatic Algorithm Selection

Naveen Kumar Thokala, Kriti Kumar, Girish Chandra M and Ravi Kumar Karumanchi

Abstract: An Enterprise System Bus (ESB) is a software which is used to communicate between various mutually interacting software applications in manufacturing plants. ESB performance is very important for the smooth functioning of the system. Any degradation or failure of the ESB results in huge revenue loss due to production discontinuity. There- fore, maintaining ESB in a healthy state is very essential and there are multiple factors related to resource utilization, workload and number of interfaces etc., which influences the performance of the ESB. Forecasting these variables at least a day ahead (24 hours ahead) is required to take appropriate actions by the business team to maintain the ESB performance under control. But, these variables are heterogeneous (continuous, discrete and percentages) in nature, highly non-linear and non-stationary. The challenges associated with the forecasting of these variables are (i) long horizon (24 hours ahead forecast at 5 minutes granularity requires to forecast 288 steps) (ii) data generated from these kinds of systems makes it very difficult to use any linear statistical methods like state-space models, ARIMA etc. To address these challenges, the paper presents a framework where a basket of learning algorithms based on Artificial Neural Network

(ANN), Support Vector Regression (SVR) and Random Forests (RF) were used to model the chaotic behavior of the time series with a real-time automatic algorithm selection mechanism which enables the appropriate forecasting algorithm to be chosen dynamically based on the performance over a time window, resulting in different algorithms being used for forecasting the same target variable on differ- ent days. Importance of the proposed strategy was demonstrated with suitable forecasting results for different variables/parameters impacting the performance of the critical Enterprise System Bus of an automotive manufacturing setup.

Real-time Logo Detection in Brand-related Social Media Images

Oscar Orti, Ruben Tous, Mauro Gomez, Jonatan Poveda, Leonel Cruz and Otto Wust

Abstract: This paper presents a work consisting in using deep convolutional neural networks (CNNs) for real-time logo detection in brand-related social media images. The final goal is to facilitate searching and discovering user-generated content (UGC) with potential value for digital marketing tasks. The images are captured in real time and automatically annotated with two CNNs designed for object detection, SSD InceptionV2 and Faster Atrous InceptionV4 (that provides better performance on small objects). We report experiments with 2 real brands, Estrella Damm and Futbol Club Barcelona. We examine the impact of different configurations and derive conclusions aiming to pave the way towards systematic and optimized methodologies for automatic logo detection in UGC.

Towards Automatic Crack Detection by Deep Learning and Active Thermography

Ramón Moreno and Ander Muniategui

Abstract: Metal joining processes are crucial in current technological devices. To grant the quality of the weldings is the key to ensure a long life cycle of a component. This work faces crack detection in EBW and TIG weldings using Inductive Thermography with the aim to substitute traditional NDT inspection techniques. The novel method presented in this work can be divided up into two main phases. The first one corresponds to the thermographic inspection, where the thermographic recordings are reconstructed and processed, whereas the second one deals with cracks detection. Last phase is a Convolutional Neural Network inspired in the well-known VGG model which segments the thermographic information, detecting accurately where the cracks are. The thermographic inspection has been complemented with measurements in an optical microscope, showing a good correlation between the experimental and the prediction of the this novel solution.

Optimization of Convolutional Neural Network ensemble classifiers by Genetic Algorithms

Miguel A. Molina-Cabello, Cristian Accino, Ezequiel López-Rubio and Karl Thurnhofer-Hemsi

Abstract: Breast cancer exhibits a high mortality rate and it is the most invasive cancer in women. An analysis from histopathological images could predict this disease. In this way, computational image processing might support this task. In this work a proposal which employes deep learning convolutional neural networks is presented. Then, an ensemble of networks is considered in order to obtain an enhanced recognition performance of the system by the consensus of the networks of the ensemble. Finally, a genetic algorithm is also considered to choose the networks that belong to the ensemble. The proposal has been tested by carrying out several experiments with a set of benchmark images.

One Dimensional Fourier Transform on Deep Learning for Industrial Welding Quality Control

Ander Muniategui, Jon Ander Del Barrio, Ramón Moreno, Xabier Angulo-Vinuesa, Manuel Masenlle and Aitor García de la Yedra

Abstract: This paper presents a method for an industrial welding qual- ity control. It focuses on the detection of Lack Of Fusions (LoF) in welded parts produced in a rotational welding process. The solutions are based on the LeNet and AlexNet networks that are extended with previous con- volutional layers based on 1D-pDFT and

Gabor filters. The new layers add to the network the ability to deal with the images using knowledge that arises from the physical process. In this paper the computer vision system as well as the procedure followed to obtain the defectives samples are described. In the industrial manufacturing use case under study the defective rate is less than %1.

Video categorisation mimicking text mining

Cristian Ortega-Leon, Pedro A. Marín-Reyes, Javier Lorenzo-Navarro, Modesto Castrillon-Santana and Elena Sanchez-Nielsen

Abstract: With the rapid growth of online videos on the Web, there is an increasing research interest in automatic categorisation of videos. It is essential for multimedia tasks in order to facilitate indexing, search and retrieval of available video files on the Web. In this paper, we propose a different technique for the video categorisation problem using only visual information. Entity labels extracted from each frame using a deep learning network, mimic words giving rise to manage the video classification task as a text mining problem. Experimental evaluation on two widely used datasets confirms that the proposing approach fits perfectly to video classification problems. Our approach achieves 64.30\% in terms of Mean Average Precision (mAP) in CCV dataset, above other approaches that make use of both visual and audio information

Improving Classification of Ultra-High Energy Cosmic Rays Using Spacial Locality by means of a Convolutional DNN

Francisco Carrillo-Perez, Alberto Guillén, Juan Miguel Carceller and Luis Javier Herrera

Abstract: Machine learning algorithms have shown their usefulness in a countless variety of fields. Specifically in the astrophysics field, these algorithms have helped the acceleration of our understanding of the Universe and the interaction between particles in recent years. Deep learning algorithms, enclosed in machine learning field, are showing outstanding performance in problems where spatial information is crucial, such as images or data with time dependency. Cosmic rays are high-energy radiation, mainly originated outside the Solar System and even from distant galaxies that constitute a fascinating problem in Physics today. When a Ultra-High Energy Cosmic Ray enters the Earth's atmosphere an extensive air shower is generated. An air shower is a cascade of particles and can be recorded with surface detectors. This work develops a supervised learning algorithm to classify the signals recorded by surface detectors with the aim of identifying the primary particle giving rise to the extensive air shower. Convolutional Neural Networks along with Feed Forward Neural Networks will be compared. Also, the aggregation of information from different surface detectors recording the same phenomenon will be studied against using the information of a single surface detector.

{Model and Feature Aggregation based Federated Learning for Multi-sensor Time Series Trend Following

Yao Hu, Xiaoyan Sun, Yang Chen and Zishuai Lu

Abstract: In the industrial field, especially the work or environment condition monitoring, it is crucial but difficult to follow the trend of the time series monitoring data (TSD) when the TSD come from different kinds of sensors and are collected by different companies. The privacy of the multi-sensor TSD must be carefully treated. Few studies, however, have been devoted to solving such problems. Federated learning (FL) is a good structure developed by Google for well keeping the personal privacy. Motivated by this, we here present an improved FL structure for not only keeping the data privacy but also extracting and fusing the trends features of the multi-sensor TSD. In our work, the client models of FL are first designed and optimized for getting the initial parameters and features w.r.t. the corresponding sensor's TSD, and then both the model parameters and the extracted features of all the activated clients (sensors) are sent to the central server and aggregated. The fused parameters and features are returned to the clients and used to update the optimization of the model with the newly coming TSD. Finally, the fused features of all multi-sensor TSD are put into an echo state network (ESN) to fulfill the trend following of the multi-sensor TSD. The proposed algorithm is applied to the multi-sensor electromagnetic radiation intensity TSD samples from an actual coal mine, and its superiority in promoting the accuracy on every sensor is demonstrated.

A Robust Echo State Network for Recursive System Identification

Renan Bessa and Guilherme Barreto

Abstract: The use of recurrent neural networks in online system identification is very limited in real-world applications, mainly due to the propagation of errors caused by the iterative nature of the prediction task over multiple steps ahead. Bearing this in mind, in this paper, we revisit design issues regarding the robustness of the ESN model in such online learning scenarios using a recursive estimation algorithm and an outlier robust-variant of it. By means of a comprehensive set of experiments, we show that the performance of the ESN is dependent on the adequate choice of the feedback pathways and that the prediction instability is amplified by the norm of the output weight vector, an often neglected issue in related studies.

Random Hyper-Parameter Search-Based Deep Neural Network for Power Consumption Forecasting

J. F. Torres, D. Gutiérrez-Avilés, A. Troncoso and F. Martínez-Álvarez

Abstract: In this paper, we introduce a deep learning approach, based on feed-forward neural networks, for big data time series forecasting with arbitrary prediction horizons. We firstly propose a random search to tune the multiple hyper-parameters involved in the method performance. There is a twofold objective for this search: firstly, to improve the forecasts and, secondly, to decrease the learning time. Next, we propose a procedure based on moving averages to smooth the predictions obtained by the different models considered for each value of the prediction horizon. We conduct a comprehensive evaluation using a real-world dataset composed of electricity consumption in Spain, evaluating accuracy and comparing the performance of the proposed deep learning with a grid search and a random search without applying smoothing. Reported results show that a random search produces competitive accuracy results generating a smaller number of models, and the smoothing process reduces the forecasting error.

A first approximation to the effects of classical time series preprocessing methods on LSTM accuracy

Daniel Trujillo Viedma, Antonio Jesús Rivera Rivas, Francisco Charte and Maria Jose Del Jesus

Abstract: A convenient data preprocessing has proven to be crucial in order to achieve high levels of accuracy, time series being no exception. For this kind of forecasting tasks, several specialized preprocessing methods have been described. Some of them being trend analysis and seasonal analysis. Several have been formally grouped around a methodology that is always applied to state of the art time series forecasting models, like the well known ARIMA. LSTM is a relatively novel architecture which has been specifically designed to get rid of the vanishing gradient problem. In these models, great results have been seen when applied for time series forecasting. Still, little is known about the impact of these traditional preprocessing methods on the accuracy of LSTM. In this work an empirical analysis on how classical time series preprocessing methods influence LSTM results is conducted. That all considered methods can potentially improve LSTM performance is concluded, being the seasonal component removal the method that achieves better, most robust accuracy gain.

Feature selection and assessment of lung cancer sub-types by applying predictive models

Sara Gonzalez, Daniel Secilla, Juan M. Gálvez, Ignacio Rojas and Luis Herrera

Abstract: The main goal of this study is the identification of a robust set of genes having the capability of discerning among the different sub-types of lung cancer: Small Cell Lung Carcinoma (SCLC), Adenocarcinoma (ACC), Squamous Cell Carcinoma (SCC) and Large Cell Lung Carcinoma (LCLC). To achieve this goal, an overall differentially expressed genes analysis was performed by using data from gene expression microarrays publicly stored at NCBI/GEO platform. Once the analysis was done, a total of 60 Differential Expressed Genes (DEGs) were selected and then used in the development of predictive models combining supervised machine

learning and feature selection algorithms. This provided a reduced and specific gene signature that allows identifying the sub-type of lung cancer of new samples. The predictive models designed are assessed in terms of accuracy, f1-score, sensitivity and specificity. Finally, a set of public web platforms having biological information on genes, were used in order to determine the relation that exists between the final subset of genes and the addressed sub-types of lung cancer.

Energy-time Analysis of Convolutional Neural Networks Distributed on Heterogeneous Clusters for EEG classification

Juan José Escobar Pérez, Julio Ortega, Miguel Damas, John Q. Gan and Rukiye Savran Kızıltepe

Abstract: Training a deep neural network usually requires a high computational cost. Nowadays, the most common way to carry out this task is through the use of GPUs due to their efficiency implementing complicated algorithms for this kind of tasks. However, training several neural networks, each with different hyperparameters, is still a very heavy task. Typically, clusters include one or more GPUs that could be used for deep learning. This paper proposes and analyzes a distributed parallel procedure to train multiple Convolutional Neural Networks (CNNs) for EEG classification, in a heterogeneous CPU-GPU cluster and in a Desktop PC. The procedure is implemented in C++ and with the MPI library to dynamically distribute the hyperparameters among the nodes, which are responsible for training the corresponding CNN by using Python, Keras, and TensorFlow. The proposed algorithm has been analyzed considering running times and energy measures, showing that when more nodes are used, the procedure scales linearly and the lowest running time is obtained. However, the desktop PC provides the best energy results.

The Frequent Complete Subgraphs in the Human Connectome

Mate Fellner, Balint Varga and Vince Grolmusz

Abstract: While it is still not possible to describe the neural-level connections of the human brain, we can map the human connectome with several hundred vertices, by the application of diffusion-MRI based techniques. In these graphs, the nodes correspond to anatomically identified gray matter areas of the brain, while the edges correspond to the axonal fibers, connecting these areas. In our previous contributions, we have described numerous graph-theoretical phenomena of the human connectomes. Here we map the frequent complete subgraphs of the human brain networks: in these subgraphs, every pair of vertices is connected by an edge. We also examine sex differences in the results. The mapping of the frequent subgraphs gives robust substructures in the graph: if a subgraph is present in the 80\% of the graphs, then, most probably, it could not be an artifact of the measurement or the data processing workflow. We list here the frequent complete subgraphs of the female and the male braingraphs of 414 subjects, each with 463 nodes, with a frequency threshold of 80\%, and identify complete subgraphs, which are more frequent in male and female connectomes, respectively. We hope that the deep structural analysis of the human connectome will motivate the construction of novel artificial neural networks in the near future.

Towards Applying River Formation Dynamics in Continuous Optimization Problems

Pablo Rabanal, Ismael Rodriguez and Fernando Rubio

Abstract: River Formation Dynamics (RFD) is a metaheuristic that has been successfully used by different research groups to deal with a wide variety of discrete combinatorial optimization problems. However, no attempt has been done to adapt it to continuous optimization domains. In this paper we propose a first approach to obtain such objective, and we evaluate its usefulness by comparing RFD results against those obtained by other more mature metaheuristics for continuous domains. In particular, we compare with the results obtained by Particle Swarm Optimization, Artificial Bee Colony, Firefly Algorithm, and Social Spider Optimization.

Go for Parallel Neural Networks

David Turner and Erich Schikuta

Abstract: Training artificial neural networks is a computationally intensive task. A common and reasonable approach to reduce the computation time of neural networks is parallelizing the training. Therefor, we presents a data parallel neural network implementation written in Go. The chosen programming language offers built-in concurrency support, allowing to focus on the neural network instead of the multi-threading. The multi-threaded performance of various networks was compared to the single-threaded performance in accuracy, execution time and speedup. Additionally, two alternative parallelization approaches were implemented for further comparisons. Summing up, all networks benefited from the parallelization in terms of execution time and speedup. While splitting the mini-batches for parallel gradient computation and merging the updates produced the same accuracy results as the single-threaded network. Averaging the parameters too infrequently in the alternative implementations had a negative impact on the accuracy.

Evolving Balancing Controllers for BipedCharacters in Games

George Palamas and Christopher Schinkel Carlsen

Abstract: This paper compares two approaches to physics based balancing controllers for 3D biped characters that can react to dynamic environments. The first approach, based on the concept of proprioception, use a Neuro-controller to define the position and orientation of the joints involved in the motion. The second approach use a self-adaptive Proportional Derivative (PD) controller along with a neural network. Both neural networks were trained using a Genetic Algorithm (GA). The study show that both approaches were capable of achieving balance and the GA proved to work well as a search strategy for both the Neuro-controller and the PD-controller. The results also show that the Neuro-controller performed better but the PD-controller was more flexible and capable to recover under external disturbances such as wind drag and momentary collisions with objects.

From Iterative Threshold Decoding to a Low-Power High-Speed Analog VLSI Decoder Implementation

Werner Teich, Heiko Teich and Giuseppe Oliveri

Abstract: Key capabilities of the fifth generation (5G) of cellular mobile communication systems are increased peak and network data rates and an energy efficient operation. Signal processing plays an important role to meet these goals. Recently, it has been shown that, for the problem of vector equalization, signal processing with analog electronic circuits has a large potential for a high-speed and low-power operation. In this paper we consider the problem of decoding for convolutional self-orthogonal codes. We report on a student project where we used standard off-the-shelf electronic components to realize an analog decoder circuit. The starting point is an iterative threshold decoder. Its structure corresponds to the one of a high-order recurrent neural network (HORNN). Structure as well as weights of the HORNN are given directly by the problem. The dynamics of the HORNN can be implemented in discrete-time, this corresponds to the iterative threshold decoder, or in continuous-time. Both implementations lead to the same asymptotic state, which represents the desired decoder output. The dynamical evolution of the continuous-time HORNN is governed by a system of coupled first-order nonlinear differential equations. Based on that, we design an analog electronic circuit, which solves this set of differential equations. Thus the analog circuit shows a similar dynamical behavior as the continuous-time HORNN, and especially also the same asymptotic state.

The problems of selecting problems

Alberto De La Encina, Natalia Lopez, Ismael Rodriguez and Fernando Rubio

Abstract: We face several teaching problems where a set of exercises has to be selected based on their capability to make students discover typical misconceptions or their capability to evaluate the knowledge of the students. We consider four different optimization problems, developed from two basic decision problems. The first two optimization problems consist in selecting a set of exercises reaching some required levels of coverage for each topic. In the first problem we minimize the total time required to present the selected exercises, whereas the

surplus coverage of topics is maximized in the second problem. The other two optimization problems consist in composing an exam in such a way that each student misconception reduces the overall mark of the exam to some specific required extent. In particular, we consider the problem of minimizing the size of the exam fulfilling these mark reduction constraints, and the problem of minimizing the differences between the required marks losses due to each misconception and the actual ones in the composed exam. For each optimization problem, we formally identify its approximation hardness and we heuristically solve it by using a genetic algorithm. We report experimental results for a case study based on a set of real exercises of Discrete Mathematics, a Computer Science degree subject.

Unsupervised learning Bee Swarm Optimization metaheuristic

Souhila Sadeg, Leila Hamdad, Haouas Mouloud, Abderrahmane Kouider, Karima Benatchba and Zineb Habbas

Abstract: In this work, we investigate the use of unsupervised data mining techniques to speed up Bee Swarm Optimization metaheuristic BSO. Knowledge is extracted dynamically during the search process in order to reduce the number of candidate solutions to be evaluated. One approach uses clustering (for grouping similar solutions) and evaluates only clusters centers considered as representatives. The second uses Frequent itemset mining for guiding the search process to promising solutions. The proposed hybrid algorithms are tested on MaxSAT instances and results show that a significant reduction in time execution can be obtained for large instances while maintaining equivalent quality compared to the original BSO.

QBSO-FS: a Reinforcement Learning based Bee Swarm Optimization metaheuristic for Feature Selection

Souhila Sadeg, Hamdad Leila, Amine Riad Remache, Mehdi Nedjmeddine Karech, Karima Benatchba and Zineb Habbas

Abstract: Feature selection is often used before a data mining or a machine learning task in order to build more accurate models. It is considered as a hard optimization problem and metaheuristics give very satisfactory results for such problems. In this work, we propose a hybrid metaheuristic that integrates a reinforcement learning algorithm with Bee Swarm Optimization metaheuristic (BSO) for solving feature selection problem. QBSO-FS follows the wrapper approach. It uses a hybrid version of BSO with Q-learning for generating feature subsets and a classifier to evaluate them. The goal of using Q-learning is to benefit from the advantage of reinforcement learning to make the search process more adaptive and more efficient. The performances of QBSO-FS are evaluated on 20 well-known datasets and the results are compared with those of original BSO and other recently published methods. The results shows that QBO-FS outperforms BSO-FS for large instances and gives very satisfactory results compared to other recently published algorithms.

A deep ensemble neural network approach to improve predictions of container inspection volume

Daniel Urda Muñoz, Juan Jesus Ruiz Aguilar, Javier Gonzalez Enrique and Ignacio Turias Dominguez

Abstract: The use of predictive models at the border inspection posts in a port may help to manage and plan operations processes in such a way that time delays and congestion issues are minimized. In this paper, an enriched time series database containing records of the number of inspec- tions carried out in the Port of Algeciras Bay between 2010 and 2018 is analyzed using two well-known statistical and computational intelligence methods such as linear regression (baseline model) and deep-fully con- nected neural networks. Additionally, a deep ensemble neural network approach is proposed in order to try to boost predictive performance even further. The results of the analysis show how deep fully-connected neural networks outperform a simple linear regression model, in par- ticular the ensemble approach obtains performances of $\sigma = 0.813$ and MSE = 330.160 in contrast to $\sigma = 0.804$ and MSE = 342.721 achieved by linear regression. A visual comparison of the original and predicted time series shows how the ensemble approach is able to model better high and low peaks than the time series predicted by linear regression.

Ro-Ro freight forecasting based on a ANN-SVR hybrid approach. Case of the Strait of Gibraltar

José Antonio Moscoso-Lopez, Juan Jesús Ruiz Aguilar, Daniel Urda Muñoz, Francisco Javier González-Enrique and Ignacio José Turias Dominguez

Abstract: The Ro-Ro (Roll-on Roll-off) freight forecasting plays an important role in ports management in the logistic node of the Strait of Gibraltar. International freight trips are subject to variable schedule or calendar. The use of the prediction in seven days in advance may be helpful as a decision-making tool in ports operations. This work addresses the forecasting problem on a daily time series by a novel ANN-SVR hybrid approach for 7 days ahead. The study compares the performance in the framework of several autoregressive windows and the improve of the performance through the stages of the hybrid model. The hybrid approach is based on Artificial Neural Networks, Support Vector Machines for regression and an ensemble approach in order to obtain an accurate forecasting. The results show that the presented models are an auspicious tool to predict Ro-Ro freight.

Infering Air Quality from Traffic Data using Transferable Neural Network Models

Miguel A. Molina-Cabello, Benjamin N. Passow, Enrique Dominguez, David Elizondo and Jolanta Obszynska

Abstract: This work presents a neural network based model for inferring air quality from traffic measurements. It is important to obtain information on air quality in urban environments in order to meet legislative and policy requirements. Measurement equipment tends to be expensive to purchase and maintain. Therefore, a model based approach capable of accurate determination of pollution levels is highly beneficial. The objective of this study was to develop a neural network model to accurately infer pollution levels from existing data sources in Leicester, UK. Neural Networks are models made of several highly interconnected processing elements. These elements process information by their dynamic state response to inputs. Problems which were not solvable by traditional algorithmic approaches frequently can be solved using neural networks. This paper shows that using a simple neural network with traffic and meteorological data as inputs, the air quality can be estimated with a good level of generalisation and in near real-time. By applying these models to links rather than nodes, this methodology can directly be used to inform traffic engineers and direct traffic management decisions towards enhancing local air quality and traffic management simultaneously.

A Deeper Look into 'Deep learning of aftershock patterns following large earthquakes': Illustrating First Principles in Neural Network Physical Interpretability

Arnaud Mignan and Marco Broccardo

Abstract: In the last years, deep learning has solved seemingly intractable problems, boosting the hope to find (approximate) solutions to problems that now are considered unsolvable. Earthquake prediction - a recognized moonshot challenge - is obviously worthwhile exploring with deep learning. Alt-hough encouraging results have been obtained recently, deep neural net-works (DNN) may sometimes create the illusion that patterns hidden in da-ta are complex when this is not necessarily the case. We investigate the results of De Vries et al. [Nature, vol. 560, 2018] who defined a DNN of 6 hidden layers with 50 nodes each, and with an input layer of 12 stress features, to predict aftershock patterns in space. The performance of their DNN was assessed using ROC with AUC = 0.85 obtained. We first show that a simple artificial neural network (ANN) of 1 hidden layer yields a similar performance, suggesting that aftershock patterns are not necessarily highly abstract objects. Following first principle guidance, we then bypass the elastic stress change tensor computation, making profit of the tensorial nature of neural networks. AUC = 0.85 is again reached with an ANN, now with only two geometric and kinematic features. Not only seems deep learn-ing to be "excessive" in the present case, the simpler ANN streamlines the process of aftershock forecasting, limits model bias, and provides better in-sights into aftershock physics and possible model improvement. Complexification is a controversial trend in all of

Science and first principles should be applied wherever possible to gain physical interpretations of neural networks.

Boosting Wavelet Neural Networks Using Evolutionary Algorithms for Short-Term Wind Speed Time Series Forecasting

Hua-Liang Wei

Abstract: This paper addresses nonlinear time series modelling and prediction problem using a type of wavelet neural networks. The basic building block of the neural network models is a ridge type function. The training of such a net-work is a nonlinear optimization problem. Evolutionary algorithms (EAs), including genetic algorithm (GA) and particle swarm optimization (PSO), together with a new gradient-free algorithm (called coordinate dictionary search optimization – CDSO), are used to train network models. An example for real speed wind data modelling and prediction is provided to show the performance of the proposed networks trained by these three optimization algorithms.

An Approach to Rain Detection using Sobel Image Preprocessing and Convolutional Neuronal Networks

José A. Godoy-Rosario, Antonio G. Ravelo-García, Pedro J. Quintana-Morales and Juan L. Navarro-Mesa

Abstract: Rain fall detection has been an important factor under study in a multitude of applications: estimation of floods in order to minimize damage before an environmental risk situation, rain removal from images, agriculture field, etc. Actually, there are numerous methods implemented in order to try to solve this issue. For example, some of them are based on the traditional weather station or in the use of the radar technology. In this work, we propose an approach to rain detection using image processing techniques and Convolutional Neuronal Networks (CNN). In order to improve the results of classification, images in rain and no rain conditions are pre-processed using the Sobel algorithm to detect edges. The architecture that defines the CNN is LeNet and it is carried out with three convolutional layers, three pooling layers and a soft max layer. With the proposed method, it is possible to detect the presence of rain in certain region of the image with an accuracy of 89%. The purpose of the proposed system is just to complete with a different added value, other traditional methods for detection of rain.

On the application of a recurrent neural network for rainfall quantification based on the received signal from microwave links

Iván Guerra-Moreno, Juan L. Navarro-Mesa, Antonio G. Ravelo-García and Carmen Paz Suarez-Araujo

Abstract: The detection and quantification of rainfall is of paramount importance in many application contexts. The research work we present here is intended to be part of a monitoring system in order to detect meteorological phenomena in situations of risk. Particularly, we extend the usage of systems intended for other specific purposes giving to them added value by incorporating weather observation as a new service. We investigate how techniques from machine learning can be used to design rain detection and quantification algorithms that learn directly from data, and become robust enough to perform detection under changing conditions over time. We show that Recurrent Neural Networks are well suited for rainfall quantification, and no precise knowledge of the underlying propagation model is necessary. In our approach, the quantification goes through an architecture with two layers. A first layer acts as a detector and it is trained using known precipitations from near rain gauges. A second layer plays the role of calibration that transforms detection levels into rainfall quantitation values. In this work, we pay much attention to the feature extraction module as it is of major importance in order to make reliable detection and accurate quantification, and study several options for extracting the most discriminative features associated to rain and no rain events. We show that our system can detect and quantify rain-no rain events with promising results in terms of sensibility (76,6%), specificity (97,0%) and accuracy (96,5%). The histograms of error and the accumulated rain rates show good performance, as well.

Ambient Temperature Estimation Using WSN Links and Gaussian Process Regression

Sofia Inácio and Joaquim Azevedo

Abstract: After several outdoor installations of wireless sensor networks (WSN) with low-cost, low-power and short-range radios, it was found that the quality of the connections between nodes was negatively influenced by the increase of temperature. Through several experiments with radios, it is believed that this is due to the degradation of electronic circuits with increasing temperature. However, this degradation can be used to monitor the ambient temperature when there are no temperature sensors. In this work, a Gaussian Process Regression (GPR) is applied for probabilistic temperature forecasting, having as predicted variables the signal level of the WSN connections. Using five links and one month of training data, the temperature prediction on one week of test data was very satisfactory.

Many-Objective Cooperative Co-Evolutionary Feature Selection: A Lexicographic Approach

Jesús González, Julio Ortega, Miguel Damas and Pedro Martín-Smith

Abstract: This paper presents a new wrapper method able to optimize simultaneously the parameters of the classifier while the size of the subset of features that better describe the input dataset is also being minimized. The search algorithm used for this purpose is based on a co-evolutionary algorithm optimizing several objectives related with different desirable properties for the final solutions, such as its accuracy, its final number of features, and the generalization ability of the classifier. Since these objectives can be sorted according to their priorities, a lexicographic approach has been applied to handle this many-objective problem, which allows the use of a simple evolutionary algorithm to evolve each one of the different sub-populations.

An Online Tool for Unfolding Symbolic Fuzzy Logic Programs

Gines Moreno and José Antonio Riaza Valverde

Abstract: In many declarative frameworks, unfolding is a very wellknown semantics-preserving transformation technique based on the application of computational steps on the bodies of program rules for improving efficiency. In this paper we describe an online tool which allows us to unfold a symbolic extension of a modern fuzzy logic language where program rules can embed concrete and/or symbolic fuzzy connectives and truth degrees on their bodies. The system offers a comfortable interactionwith users for unfolding symbolic programs and it also provides useful options to navigate along the sequence of unfolded programs. Finally, the symbolic unfolding transformation is connected with some fuzzy tuning techniques that we previously implemented on the same tool.

Ensemble of Attractor Networks for 2D Gesture Recognition

Carlos Davila, Mario Gonzalez, Jorge-Luis Perez-Medina, David Dominguez, Angel Sanchez and Francisco B. Rodriguez

Abstract: This work presents an Ensemble of Attractor Neural Net- works (EANN) model for gesture recognition. 2D single-stroke gestures were captured and tested offline by the ensemble. The ensemble was compared to a single attractor with the same complexity, i.e. with equal connectivity. We show that the ensemble of neural networks improves the gesture recognition in terms of capacity and quality of the gestures retrieval, regarding the single network. The ensemble was able to im- prove the retrieval of correlated patterns with a random assignment of pattern subsets to the ensemble modules. Thus, optimizing the ensemble input is a possibility for maximizing the patterns retrieval. The proposed EANN proved to be robust for gesture recognition with large initial noise promising to be robust for gesture invariants.

USING INFERRED GESTURES FROM SEMG SIGNAL TO TELEOPERATE A DOMESTIC ROBOT FOR THE DISABLED

Nadia Nasri, Francisco Gomez-Donoso, Sergio Orts-Escolano and Miguel Cazorla

Abstract: With the lightning speed of technological evolution, several methods have been proposed with the aim of controlling robots and using them to serve humanity. In this work, we present and evaluate a novel learning-based system to control Pepper, the humanoid robot. We leveraged an existing low-cost surface electromyography (sEMG) sensor, that is in the consumer market, Myo armband. To achieve our goal, we created a dataset including 6 hand gestures recorded from 35 intact people by the usage of the Myo Armband device, which has 8 non-intrusive sEMG sensors. Using raw signals extracted from Myo armband, we have been able to train a gated recurrent unit-based network to perform gesture classification. Afterwards, we integrated our system with a live hand gesture recognition application, transmitting the commands to the robot for implementing a live teleoperation method. In this way, we are able to evaluate in real-time the capabilities of our system. According to the experiments, the teleoperation of a Pepper robot achieved an average of 77.5\% accuracy during test.

3D Orientation Estimation of Pharmaceutical Minitablets with Convolutional Neural Network

Gregor Podrekar, Domen Kitak, Andraž Mehle, Domen Rački, Rok Dreu and Dejan Tomaževič

Abstract: We present a Convolutional Neural Network for 3D orientation estimation of pharmaceutical minitablets, i.e., round tablets with diameter less than 3 mm. The network inputs a single grayscale image with the minitablet positioned approximately in the center and predicts a 3D unit orientation vector that fully describes the 3D orientation of the imaged minitablet. We trained the network on synthetic images, generated by rendering CAD models of minitablets at realistic conditions by varying the orientation, scale, camera distance, position within the imaging plane and surface properties. No manual 3D orientation labeling of training images was therefore required. We evaluated the accuracy of the approach on both synthetic and real images. The real images were acquired during pharmaceutical film coating processes. Accuracies of 1.388◦ and 2.657◦ were achieved on synthetic and real image datasets, respectively. We tested two different minitablet shapes. Obtained results indicate that good performance can be obtained on a real image datasets despite training the network on synthetic data only. The estimated 3D orientations provide means for further automated analysis of the images, which we demonstrated by measuring an important coating process parameter (coating thickness) during the minitablet coating process. Although tested only for minitablets, the 3D orientation estimation approach should perform well also for other symmetrical shapes.

Flatness Defect Detection and Classification in Hot Rolled Steel Strips Using Convolutional Neural Networks

Marco Vannocci, Antonio Ritacco, Angelo Castellano, Filippo Galli, Marco Vannucci, Vincenzo Iannino and Valentina Colla

Abstract: This paper addresses the improvement of flatness defect detection and classification in the steel industry. Localization and classification of the defects is respectively taken care of by a detector and a classifier. The pipeline can start with either CSV or image files coming straight from the plant sensors. To probe the performance of the system, it was used to detect and classify flatness defects in hot steel strips. A total of about 513 strips produced in a real steelworks were used for this purpose for a total of about 4806 defect images. A comparison be- tween different traditional machine learning and deep learning models was carried out showing better performances with the latter approach.

Image Completion with Filtered Low-Rank Tensor Train Approximations

Rafal Zdunek, Krzysztof Fonal and Tomasz Sadowski

Abstract: The topic of image completion has received increasing attention in recent years, motivated by many important applications in computer vision, data mining and image processing. In this study, we consider the problem of recovering missing values of pixels in highly incomplete images with a random or irregular structure. The analyzed gray-scale or colour images are transformed to multi-way arrays which are then recursively approximated by low-rank tensor decomposition models. In our approach, the multi-way array is represented by the tensor train model, and in each iterative step, the low-rank approximation is filtered with the Gaussian low-pass filter. As a result, the proposed algorithms considerably outperform the state-of-the art methods for matrix and tensor completion problems, especially when an incompleteness degree is very high, e.g. with 90% of missing pixels.

Knowledge Construction Through Semantic Interpretation of Visual Information

Cristiano Russo, Kurosh Madani and Antonio Maria Rinaldi

Abstract: The skills required by machines in the last decade have grown exponentially. Recent efforts made by the scientific community have shown amazing results in the field of research related to artificial intelligence and robotics. Recent studies shows that machines may be superior to humans in carrying out certain tasks. However, in many approaches they still fail to achieve high-level skills required to support humans and interact with them. Furthermore, the "intelligence" exhibited is hardly ever the result of a real autonomous decision. In this article we propose a novel approach, with the aim of providing a machine with the ability to evolve and build its own knowledge by combining both semantic and visual information. The proposed concept, its implementation and experimental results are shown and discussed.

Ensemble Transfer Learning Framework for Vessel Size Estimation from 2D Images

Mario Miličević, Krunoslav Žubrinić, Ivan Grbavac and Ana Kešelj

Abstract: The term gross tonnage refers to the internal volume of a vessel and it has several legal, administrative and safety uses. Therefore, there is significant value in developing a mechanism for the automatic estimation of vessel size based on 2D images taken in uncontrolled conditions. However, this is a demanding task as vessels can be photographed from various angles and distances, a part of a vessel can be obstructed, or a vessel can blend with the background. We proposed an ensemble of fine-tuned transfer learning models, which we trained on 20,000 images in a training dataset consisting of randomly downloaded images from the Shipspotting website. Multiple deep learning methods were applied and modified for regression problems, together with two classical machine learning algorithms. A detailed analysis of model performances was given, based on which it can be concluded that such an approach results in a vessel size evaluation of the same quality as with the best human experts from the corresponding field.

Analyzing Digital Image by Deep Learning for Melanoma Diagnosis

Karl Thurnhofer-Hemsi and Enrique Dominguez

Abstract: Image classification is an important task in many medical applications, in order to achieve an adequate diagnostic of different lesions. Melanoma is a frequent kind of skin cancer, which most of them can be detected by visual exploration. Heterogeneity and database size are the most important difficulties to overcome in order to obtain a good classification performance. In this work, a deep learning based method for accurate classification of wound regions is proposed. Raw images are fed into a Convolutional Neural Network (CNN) producing a probability of being a melanoma or a non-melanoma. Alexnet and GoogLeNet were used due to their well-known effectiveness. Moreover, data augmentation was used to increase the number of input images. Experiments show that the compared models can achieve high performance in terms of mean accuracy with very few data and without any preprocessing.

Detecting Driver Drowsiness in Real Time through Deep Learning based Object Detection

Haroon-Ur-Rashid Khan, Nabit Bajwa, Muhammad Faique Shakeel and Ahmad Anwaar

Abstract: Vehicle accidents due to drowsiness in drivers take thousands of lives each year worldwide. This fact clearly exhibits a need for a drowsiness detection applica-tion that can help prevent such accidents and ultimately save lives. In this work, we propose a novel deep learning methodology based on Convolutional Neural Networks (CNN) to tackle this problem. The proposed methodology treats drowsiness detection as an object detection task, and from an incoming video stream of a driver, detects and localizes open and closed eyes. MobileNet CNN architecture with Single Shot Multibox Detector (SSD) is used for this task of object detection. A separate algorithm is then used to detect driver drowsiness based on the output from the MobileNet-SSD architecture. In order to train the MobileNet-SSD Network a custom dataset of about 6000 images was compiled and labeled with the objects face, eye open and eye closed. Out of these, 350 im-ages were randomly separated and used to test the trained model. The trained model was evaluated on the test dataset using the PASCAL VOC metric and achieved a Mean Average Precision (mAP) of 0.84 on these categories. The pro-posed methodology, while maintaining reasonable accuracy, is also computation-ally efficient and cost effective, as it can process an incoming video stream in real time on a standalone mobile device without the need of expensive hardware sup-port. It can easily be deployed on cheap embedded devices in vehicles, such as the Raspberry Pi 3 or a mobile smartphone.

The Influence of Human Walking Activities on the Doppler Characteristics of Non-Stationary Indoor Channel Models

Muhammad Muaaz, Ahmed Abdelmonem Abdelgawwad and Matthias Uwe Pätzold

Abstract: This paper analyzes the time-variant (TV) Doppler power spectral density of a 3D non-stationary fixed-to-fixed indoor channel simulator after feeding it with realistic trajectories of a walking person. The trajectories of the walking person are obtained by simulating a full body musculoskeletal model in Open- Sim. We provide expressions of the TV Doppler frequencies caused by these trajectories. Then, we present the complex channel gain consisting of fixed scatterers and a cluster of moving scatterers. After that, we use the concept of the spectrogram to analyze the TV Doppler power spectral density of the complex channel gain. Finally, we present expressions of the TV mean Doppler shift and Doppler spread. The work of this paper is important for human activity recognition systems using radio-frequency (non-wearable) sensors as the demand for such systems has increased nowadays.

A Neural Network for Stance Phase detection in smart cane users

Juan Rafael Caro-Romero, Joaquin Ballesteros, Francisco Garcia-Lagos, Cristina Urdiales and Francisco Sandoval

Abstract: Persons with disabilities often rely on assistive devices to carry on their Activities of Daily Living. Deploying sensors on these devices may provide continuous valuable knowledge on their state and condition. Canes are among the most frequently used assistive devices, regularly employed for ambulation by persons with pain on lower limbs and also for balance. Load on canes is reportedly a meaningful condition indicator. Ideally, it corresponds to the time cane users support weight on their lower limb (stance phase). However, in reality, this relationship is not straightforward. We present a Multilayer Perceptron to reliably predict the Stance Phase in cane users using a simple support detection module on commercial canes. The system has been successfully tested by cane users in care facilities in Spain. It has been optimized to run on a low cost microcontroller.

Closed-Eye Gaze Gestures: Detection and Recognition of Closed-Eye Movements with Cameras in Smart Glasses

Rainhard Dieter Findling, Le Ngu Nguyen and Stephan Sigg

Abstract: Gaze gestures bear potential for user input with mobile devices, especially smart glasses, due to being always available and hands-free. So far, gaze gesture recognition approaches have utilize open-eye movements only and disregarded closed-eye movements. This paper is a first investigation of the feasibility of detecting and recognizing closed-eye gaze gestures from close-up optical sources, e.g. eye-facing cameras embedded in smart glasses. We propose four different basic closed-eye gaze gesture protocols, which extend the alphabet of existing open-eye gaze gesture alphabets. We further propose a methodology for detecting and extracting the corresponding closed-eye movements with full optical flow, time series processing, and machine learning. In the evaluation of the four protocols we find closed-eye gaze gestures to be detected 82.8%-91.6% of the time, and extracted gestures to be recognized correctly with an accuracy of 92.9%-99.2%

RF-Based Human Activity Recognition: A Non-Stationary Channel Model Incorporating the Impact of Phase Distortion

Alireza Borhani and Matthias Paetzold

Abstract: This paper proposes a non-stationary channel model that captures the impact of the time-variant (TV) phase distortion caused by hardware imperfections. The model allows for studying the spectrogram of in-home radio channels influenced by walking activities of the home user under realistic non-stationary propagation conditions. The resolution of the spectrogram is investigated for the von-Mises distribution of the phase distortion. It is shown that high-entropy distributions considerably mask fingerprints of the user activity on the spectrogram of the channel. For an orthogonal frequency-division multiplexing (OFDM) system, a computationally simple method for mitigating the undesired phase rotation is proposed. Both theoretical and simulation results confirm that the proposed method significantly reduces the impact of the phase distortion, allowing us to retrieve the desired spectrogram imprinted by the activity of the home user. The results of this paper are useful for the development of software-based radio frequency (RF)-based activity recognition systems.

Workout Type Recognition and Repetition Counting with CNNs from 3D Acceleration Sensed on the Chest

Kacper Skawinski, Ferran Montraveta Roca, Rainhard Dieter Findling and Stephan Sigg

Abstract: Sports and workout activities have become important parts of modern life. Nowadays, many people track characteristics about their sport activities with their mobile devices, which feature inertial measurement unit (IMU) sensors. In this paper we present a methodology to detect and recognize workout, as well as count repetitions done in a recognized type of workout, from a single 3D accelerometer worn at the chest. We consider four different types of workout (pushups, situps, squats and jumping jacks). Our technical approach to workout type recognition and repetition counting is based on machine learning with a convolutional neural network. Our evaluation utilizes data of 10 subjects, which wear a Movesense sensors on their chest during their workout. We thereby find workout to be recognized correctly on average 89.9% of the time, and the workout repetition counting to yield an average detection accuracy of 97.9% over all types of workout.pet

BatchNorm Decomposition and Deep Neural Network Explanation

Lucas Hui and Alex Binder

Abstract: Layer-wise relevance propagation (LRP) has shown potential for explaining neural network classifier decisions. In this paper, we investigate how LRP is to be applied to deep neural network which makes use of batch normalization (BatchNorm), and show that despite the functional simplicity of BatchNorm, several intuitive choices of published LRP rules perform poorly for a number of frequently used state of the art networks. Also, we show that by using the ε-rule for BatchNorm layers we are able to detect

training artifacts for MobileNet and layer design artifacts for ResNet. The causes for such failures are analyzed deeply and thoroughly. We observe that some assumptions on the LRP decomposition rules are broken given specific networks, and propose a novel LRP rule tailored for BatchNorm layers. Our quantitatively evaluated results show advantage of our novel LRP rule for BatchNorm layers and its wide applicability to common deep neural network architectures. As an aside, we demonstrate that one observation made by LRP analysis serves to modify a ResNet for faster initial training convergence.

Trainable Thresholds for Neural Network Quantization

Alexander Goncharenko, Andrey Denisov, Sergey Alyamkin and Evgeny Terentev

Abstract: Embedded computer vision applications for robotics, security cameras, and mobile phone applications require the usage of mobile neural network architectures like MobileNet-v2 or MNAS-Net in order to reduce RAM consumption and accelerate processing. An additional option for further resource consumption reduction is 8-bit neural network quantization. Unfortunately, the known methods for neural network quantization lead to significant accuracy reduction (more than 1.2%) for mobile architectures and require long training with quantization procedure. To overcome this limitation, we propose a method that allows to quantize mobile neural network without significant accuracy loss. Our approach is based on trainable quantization thresholds for each neural network filter, that allows to accelerate training with quantization procedure up to 10 times in comparison with the standard techniques. Using the proposed technique, we quantize the modern mobile architectures of neural networks with the accuracy loss not exceeding 0.1%. Ready-for-use models and code are available at: https://github.com/agoncharenko1992/FAT-fast-adjustable-threshold.

Tandem Modelling based Emotion Recognition in Videos

Salma Kasraoui, Zied Lachiri and Kurosh Madani

Abstract: The work presented in this paper introduces a new model for emotion recognition from videos, Tandem Modelling (TM). The core of the proposed system consists of a hybrid neural network model that joins two feed-forward neural net models with a bottle-neck connection layer (BNL). Specifically, appearance and motion of each video sequence are encoded using a hand-crafted spatio-temporal descriptor. The obtained features are propagated through a not fully-connected neural net (NFCN) and a new tandem features are generated and the dimensionality reduction is performed at the BNL. In a second level, a fully connected network (FCN) is trained to encode one of the six basic emotional states (anger, disgust, fear, happiness, sadness and surprise) with the neutral state. The classification results reached by the proposed TM show superiority over state-of-the-art approaches.

Preliminary results using a P300 brain-computer interface speller: A possible interaction effect between presentation paradigm and set of stimuli

Álvaro Fernández-Rodríguez, María Teresa Medina-Juliá, Francisco Velasco-Álvarez and Ricardo Ron-Angevin

Abstract: Several proposals to improve the performance controlling a P300-based BCI speller have been studied using the standard row-column presentation (RCP) par-adigm. However, this paradigm could not be suitable for those patients with lack of gaze control. To solve that, the rapid serial visual presentation (RSVP) para-digm, which presents the stimuli located in the same position, has been proposed in previous studies. Thus, the aim of the present work is to assess if a stimuli set of pictures that improves the performance in RCP, could also improve the per-formance in a RSVP paradigm. Six participants have controlled four conditions in a calibration task: letters in RCP, pictures in RCP, letters in RSVP and pictures in RSVP. The results showed that pictures in RCP obtained the best accuracy and information transfer rate. The improvement effect given by pictures was greater in the RCP paradigm than in RSVP. Therefore, the improvements reached under RCP may not be directly transferred to the RSVP.

A Comparison of cVEP-Based BCI-Performance between Different Age Groups

Felix Gembler, Piotr Stawicki, Aya Rezeika and Ivan Volosyak

Abstract: Persons who need assistive technologies to communicate with the relatives, for example ALS patients, could benefit from Brain-Computer Interface (BCI) technology if it is used alternatively or in addition to established communication tools. BCIs based on visual evoked potentials (VEPs) have shown high system speeds in many studies. However, some major issues need to be addressed: On the one hand, the strength of VEP responses varies across subjects. Especially age-related performance differences have been covered in several studies and need to be investigated further. On the other hand, the stimuli used to evoke the VEP response, are considered as annoying by many people. The paper investigates the subjective level of annoyance in different age groups for different flickering rates as well as age-related performance differences in cVEP based BCIs. In this regard, the cVEP-based eight target spelling interface was tested with two age groups (13 subjects each, ranging from 20 to 28 years and 62 to 83 years). Typically, 60 Hz monitor refresh rate is used to generate the cVEP stimuli. Here, three different flickering speeds were tested (m-sequences generated using refresh rates of 30, 60 and 120 Hz for stimuli presentation). The mean ITR of the elderly age group was 42.03, 45.32 and 45.75 bits per minute (bpm) while the young group achieved an ITR of 53.09, 64.01 and 72.92 bpm for the 30, 60 and 120 Hz setups. The difference was significant for the faster flickering setups (60 and 120 Hz). Hence, our results show that elderly people have slightly worse BCI performance in terms of information transfer rate (ITR). Regarding the level of annoyance, subjects from both age groups preferred the 120 Hz setup which offered a more subtle visual stimulation.

Remote Steering of a Mobile Robotic Car by means of VR-based SSVEP BCI

Piotr Stawicki, Felix Gembler, Roland Grichnik and Ivan Volosyak

Abstract: Brain-Computer Interface (BCI) technology, including applications based on the Steady-State Visual Evoked Potentials (SSVEPs) have proven to provide reliable and accurate control. In this paper we present and evaluate remote steering of a previously developed and successfully tested Mobile Robotic Car (MRC) utilizing the SSVEP paradigm. The visual stimulation was presented inside of head-mounted virtual reality (VR) glasses, here the Oculus Go. The live video feedback from the MRC perspective was displayed inside the custom made app of the VR environment. The 3-class visual stimulation was located on both sides and above the video stream of the MRC camera. The task of this study was to steer the MRC through a 8 meters long path (in real word) with 6 turns. Seven participants took part in the experiment reaching on average an accuracy of 97.07 (standard deviation: 5.31) %, an ITR of 10.32 (2.88) bits/min with an average command classification time of 3.95 (2.3) seconds. For classification, the minimum energy combination method (MEC) with 16 EEG electrodes as well as filter bank decomposing strategy were utilized. All participants successfully completed the task, almost all subjects stated that the presented VR-based SSVEP-BCI was an highly immersive experience.

A VR-Based Hybrid BCI Using SSVEP and Gesture Input

Roland Grichnik, Mihaly Benda and Ivan Volosyak

Abstract: Brain-Computer Interfaces (BCIs) using Steady State Visual Evoked Potentials have been proven to work with many different display technologies for visual stimulation. The recent advent of consumer grade Virtual Reality (VR) Head-Mounted Devices (VR-HMDs) has made research in the area of VR-based BCIs more accessible than ever - yet the possibilities of such systems still have to be tested. In this paper, we present a BCI using a well-studied 3-step spelling interface converted into a Virtual Environment (VE). The Oculus Rift CV1 VR-HMD used in this study also provides motion tracking capability, which was used to implement a novel hybrid BCI utilizing gesture input. The interface consisted of three flickering boxes on a virtual screen in the VE for typing letters. Head shake gestures were used to intuitively trigger "Delete/Back" commands. A g.tec g.USBamp amplifier was used to record and filter the signal of eight electrodes mounted in an electroencephalography cap. The Minimum Energy Combination (MEC) method was used to classify commands in real time. Eighteen participants successfully performed seven spelling tasks each, reaching an accuracy of 91.11±10.26% (mean±Standard Deviation, SD) and an Information Transfer Rate of 23.56±7.54 bit/minute (mean±SD). Questionnaires filled out before and after the experiment show that most participants

enjoyed the VR BCI experience and found the gesture input to feel very natural. Future studies could expand the input mechanism by adding more head gestures, e.g. pecking, nodding or circling to control intuitively related software tasks.

Word prediction support model for SSVEP-based BCI web speller

Abdul Saboor, Mihaly Benda, Felix Gembler and Ivan Volosyak

Abstract: Steady state visual evoked potential (SSVEP) based BCI-systems are dependent on the brain signals which are elicited in response to a visual stimuli presented to the user. The spelling systems are very popular applications for the SSVEP-based BCI. In this paper, we are presenting a web-based speller supported with word prediction. The emphasis of the study was on two main points: 1) provide a dictionary based web speller which could also be accessed through a widely available web browsers; 2) increase the accuracy and speed of the SSVEP-based BCI speller. Using the concept of three step speller, a web interface was developed which provided additional support of word predictions based on characters typed and the co-occurrence of the previously typed word. The architectural pattern for the word prediction support model was based on MVC (model-view-controller). The AJAX call was placed form the web speller interface to access the database using Java Servlet and Java Beans. The relational database for the word prediction was derived from the Leipzig corpora collection. The developed system was tested with eleven healthy subjects. An average accuracy of 92.5 % and ITR of 18.8 bits/min were achieved. The results showed that word suggestions can increase the typing speed and accuracy of the web speller.

Is stress state an important factor in the BCI-P300 Speller Performance?

Liliana Garcia, Maud Zak, Celestin Grenier, Solene Hanrio, Dorine Henry, Romain Randriamanantena, Catherine Semal, Jean Marc Andre, Veronique Lespinet-Najib and Ricardo Ron-Angevin

Abstract: Brain-Computer Interface (BCI) is an advanced human–machine interaction technology requiring higher-order cognitive functions for an efficient task execution. The relation between cognition, human performance and psychological state has been studied for many years. Nevertheless, the effect of acute stress on cognitive performance involving BCI systems has never been studied. Nowadays, people are more and more affected by stressful situations. Stress is an important human factor which can impact the ability to appropriately process cognitive information related to language, working memory, attention, or executive control. Individuals are continuously interacting with technology to execute daily actions. BCI represent an alternative way to allow any individual, even with motor disabilities, to interact with that technology. BCI-P300 Speller is driven by EEG signals and enables communication without physical intervention. It is used in both clinical investigations and fundamental research. In this work, we study the impact of acute stress effects on cognitive ability to control a BCI-P300 speller. Although we have observed a broad spectrum of response to stress, analyses show a correlation between BCI-speller performance and user's stress state. We have also noted that BCI performance seems to be improved if users have a good cognitive engagement in the task and if they showed an ability to develop efficient strategies, such as selective attention or increased effort, in order to cope with the stressful situations. In conclusion, these preliminary results show that BCI-P300 Speller is a robust and reliable tool and suggest that an optimal utilization of BCI systems could be assured despite the fluctuations of users' state. We assume that neural mechanisms involved in the BCI task, may set the brain in an adequate level of generalized arousal, which allows establishment of compensatory mechanisms in stressful states.

A neural network-based approach to sensor and actuator fault-tolerant control

Marcin Pazera, Marcin Mrugalski, Marcin Witczak and Mariusz Bucikowski

Abstract: The paper is devoted to the problem of design of robust estimator and controller on the basis of the neural-network model represented in a linear parameter-varying form. In particular the fault-tolerant controller for multiple sensor and actuator faults is developed. The proposed approach is able to minimize the influence of the multiple faults of sensor as well as actuator on the controlled system. The robust estimator and robust controller procedure boil down to solving a set of linear matrix inequalities. The illustrative part of the paper is devoted to the application of the proposed approach to fault tolerant control of the laboratory multi-tank system.

Estimating Supervisor Set using Machine Learning and Optimal Control

Konrad Kosmatka and Andrzej Nowakowski

Abstract: The paper deals with the problem of finding an estimation of supervisor set and content of machine learning block. We propose a construction of a probability distribution of the learning set using the empirical risk functional defined by Vapnik and applying a new dual dynamic programming ideas to formulate a new optimization problem. As a consequence we state and prove a verification theorem for an approximate probability distribution defining the approximation of the supervisor set.

A new Online Class-Weighting approach with Deep Neural Networks for image segmentation of Highly Unbalanced Glioblastoma Tumors

Mostefa Ben Naceur, Rostom Kachouri, Mohamed Akil and Rachida Saouli

Abstract: The most common problem among image segmentation methods is unbalanced data, where we find a class or a label of interest has the minority of data compared to other classes. This kind of problems makes, Artificial Neural Networks, including Convolutional Neural Networks (CNNs), bias toward the more frequent label. Thus, training a CNNs model with such kind of data, will make predictions with low sensitivity, where the most important part in medical applications is to make the model more sensitive toward the lesion-class, i.e. tumoral regions. In this work, we propose a new Online Class-Weighting loss layer based on the Weighted Cross-Entropy function to address the problem of class imbalance. Then, to evaluate the impact of the proposed loss function, a special case study is done, where we applied our method for the segmentation of Glioblastoma brain tumors with both high- and low-grade. In this context, an efficient CNNs model called OcmNet is used. Our results are reported on BRATS-2018 dataset where we achieved the average Dice scores 0.87, 0.75, 0.73 for whole tumor, tumor core, and enhancing tumor respectively compared to the Dice score of radiologist that is in the range 74% - 85%. Finally, the proposed Online Class-Weighting loss function with a CNNs model provides an accurate and reliable segmentation result for the whole brain in 22 seconds as inference time, and that make it suitable for adopting in research and as a part of different clinical settings.

Validation of unimodal non-Gaussian clusters

Luis Lago, Jesús Aragón and Manuel Sánchez-Montañés

Abstract: We analyze the influence of the cluster shape on the performance of four cluster validation criteria: AIC, BIC, ICL and NI. First we introduce a method to generate unimodal and radially symmetric clusters whose shape can be interpolated between peaky long-tailed and flat distributions using a single parameter. Normally distributed clusters are obtained as a special case. Then we systematically study the performance of AIC, BIC, ICL and NI when validating clusters of arbitrary shapes. Using problems with two clusters, different inter-cluster distances and different dimensions, we show that, while BIC provides the best results for normally distributed clusters, in a general context with high dimensional data and unknown cluster distributions the use of ICL or NI may be a better choice.

About Filter Criteria for Feature Selection in Regression

Alexandra Degeest, Michel Verleysen and Benoît Frénay

Abstract: Selecting the best group of features from high-dimensional datasets is an important challenge in machine learning. Indeed problems with hundreds of features have now become usual. In the context of filter methods, the selected relevance criterion used for filtering is the key factor of a feature selection method. To select an appropriate criterion among the numerous existing ones, this paper proposes a list of six necessary properties. This paper describes then three relevance criteria, the mutual information, the noise variance and the adjusted R-squared, and compares them in the view of the aforementioned properties. Any new, or popular, criterion could be analysed in the light of these properties.

A New Classification Method for Predicting the Output of Dye Process in Textile Industry by Using Artificial Neural Networks

Ahsen Noor Subhopoto, Mehmet Akar and Sencer Sultanoglu

Abstract: In this paper, a new approach is proposed which predicts the output of the dyeing process in textile industry by using input data consisting of the alarms and/or the interventions during the process. Back-propagation algorithms and radial basis functions are utilized to form the neural networks in predicting whether the process is carried out correctly or not before an operator checks it manually. Industrial data are used to test the efficiency of the proposed concept which demonstrates that the success rate is over 85%.

A Clinical Decision Support System to Help the Interpretation of Laboratory Results and to Elaborate a Clinical Diagnosis in Blood Coagulation Domain

Francois Lasson, Alban Delamarre, Pascal Redou and Cedric Buche

Abstract: Hemophilia is a rare hemorrhagic disorder caused by clotting factor deficiencies that leads to a less efficient coagulation system. Treatments of this pathology rely on a patient's subjective assessment which reflects a need for a laboratory assay able to predict the clinical patient phenotype. According to the literature, global assays such as thrombin generation (TG), are good predictors of bleeding episodes and therefore seem to be good candidates to fit this need. Nevertheless, the result of the TG assay, known as thrombogram, is difficult to interpret for non-expert clinicians. In this paper, we present a machine learning-based clinical decision support system which goal is to help clinical decision making. In doing so, we have adopted several approaches in order to evaluate well-known machine learning algorithms, in terms of accuracy and robustness, on a thrombogram database generated using numerical simulations. Obtained results, 95.57% of accuracy using a cascade of a SVM and MLPs to classify all categories and 98.10% of accuracy for the binary case hemophilia A/B, prove that our proposal can efficiently diagnose hemophilia.

Adversarial Examples are a Manifestation of the Fitting-Generalization Trade-off

Oscar Deniz Suarez, Noelia Vallez and Gloria Bueno

Abstract: In recent scientific literature, some studies have been published where recognition rates obtained with Deep Learning (DL) surpass those obtained by humans on the same task. In contrast to this, other studies have shown that DL networks have a somewhat strange behavior which is very different from human responses when confronted with the same task. The case of the so-called "adversarial examples" is perhaps the best example in this regard. Despite the biological plausibility of neural networks, the fact that they can produce such implausible misclassifications still points to a fundamental difference between human and machine learning. This paper delves into the possible causes of this intriguing phenomenon. We first contend that, if adversarial examples are pointing to an implausibility it is because our perception of them relies on our capability to recognise the classes of the images. For this reason we focus on what we call cognitively adversarial examples, which are those obtained from samples that the classifier can in fact recognise correctly. Additionally, in this paper we argue that the phenomenon of adversarial examples is rooted in the inescapable trade-off that exists in machine learning (including DL) between fitting and generalization. This hypothesis is supported by experiments carried out in which the robustness to adversarial examples is measured with respect to the degree of fitting to the training samples.

Machine Learning as a Means to Adapt Requirement Changes for SDN Deployment Process in SDN Migration

H.W. Siew, S.C. Tan, J.N. Binlun, and C.K. Lee

Abstract: The deployment of SDN in legacy network has gained popularity across network operators as next generation network architecture. However, full deployment of SDN faces challenges in economical, organizational, and technical aspects. Hence, the deployment of SDN should be incremental over months or even years, and limited numbers of the nodes are upgraded to SDNenabled one in each period. This forms a

hybrid SDN (H-SDN) network which legacy and SDN nodes co-exist in the same network. Importantly, which and when a node should be replaced to SDN node are the common question which impacts the performance of a hybrid SDN network. Efforts to date primarily focus on determining sequence for migration which maximize the performance of traffic engineering (TE) in H-SDN network. However, most works do not take into consideration of the changes that may happen over the periods of SDN deployment. The possibility of these changes requires adaptation techniques to ensure effective migration sequence to cater present and future needs. In this article, we aim to identify the gap and propose the opportunity in which techniques originated from machine learning (ML) may play an important role in solving problem of incremental SDN deployment by alleviating the issues the occur during SDN migration as well as to improve the H-SDN deployment.

Convolutional neural network learning versus traditional segmentation for the approximation of the degree of defective surface in titanium for implantable medical devices

Ruxandra Stoean, Catalin Stoean, Adriana Samide and Gonzalo Joya

Abstract: One prevalent option used in the manufacturing of dental and orthopedic medical implants is titanium, since it is a strong, yet light, biocompatible metal. Nevertheless, possible micro-defects due to earlier chemical treatment can alter its surface morphology and lead to less resistance of the material for implantation. The scope of the present paper is to give an estimate of the defectuous area in titanium laminas by analysing microscopic images of the surface. This is done comparatively between traditional segmentation with thresholding and a sliding window classifier based on convolutional neural networks. The results show the supportive role of the proposed means towards a timely recognition of defective titanium sheets in the fabrication process of medical implants.

Convolutional Neural Networks and Feature Selection for BCI with Multiresolution Analysis

Javier León, Julio Ortega and Andrés Ortiz

Abstract: Classification in high-dimensional feature spaces is a difficult task, often hindered by the curse of dimensionality. This is the case with motor imagery tasks involving brain-computer interfaces (BCI) through electroencephalography (EEG), where the number of available patterns is limited, making more noticeable the effect of the high dimensionality on the generalization capabilities of the models. This paper tackles classification in that particular setting, drawing a comparison between an explicit feature selection procedure using evolutionary computation and an implicit feature selection using Convolutional Neural Networks. These two alternatives are also compared to an SVM approach that serves as a baseline quality threshold. According to the experiments performed in this paper, CNNs are able to produce promising results when compared to the SVM models and, after a partial hyperparameter optimization stage, also to previous work on the same dataset. Furthermore, this raises the issue of the tradeoff between computational cost---and model complexity---and classification accuracy, which is briefly discussed when assessing the quality of the results in relation to existing work.

Attention-based Recurrent Neural Networks (RNNs) for Short Text Classification: An Application in Public Health Monitoring

Oduwa Edo-Osagie, Iain Lake, Obaghe Edeghere and Beatriz De La Iglesia

Abstract: In this paper, we propose an attention-based approach to short text classification, which we have created for the practical application of Twitter mining for public health monitoring. Our goal is to automatically filter Tweets which are relevant to the syndrome of asthma/difficulty breathing. We describe a bi-directional Recurrent Neural Network archi- tecture with an attention layer (termed ABRNN) which allows the network to weigh words in a Tweet differently based on their perceived importance. We further distinguish between two variants of the ABRNN based on the Long Short Term Memory and Gated Recurrent Unit architectures respectively, termed the ABLSTM and ABGRU. We apply the ABLSTM and ABGRU, along with popular

deep learning text classification models, to a Tweet relevance classification problem and compare their performances. We find that the ABLSTM outperforms the other models, achieving an accuracy of 0.906 and an F1-score of 0.710. The attention vectors computed as a by-product of our models were also found to be meaningful representations of the input Tweets. As such, the described models have the added utility of computing document embeddings which could be used for other tasks besides classification. To further validate the approach, we demonstrate the ABLSTM's performance in the real world application of public health surveillance and compare the results with real-world syndromic surveillance data provided by Public Health England (PHE). A strong positive correlation was observed between the ABLSTM surveillance signal and the real-world asthma/difficulty breathing syndromic surveillance data. The ABLSTM is a useful tool for the task of public health surveillance.

A transfer-learning approach to feature extraction from cancer transcriptomes with deep autoencoders

Guillermo López-García, José M. Jerez, Leonardo Franco and Francisco J. Veredas

Abstract: The diagnosis and prognosis of cancer are among the more challenging tasks that oncology medicine deals with. With the main aim of fitting the more appropriate treatments, current personalized medicine focuses on using data from heterogeneous sources to estimate the evolution of a given disease for the particular case of a certain patient. In recent years, next-generation sequencing data have boosted cancer prediction by supplying gene-expression information that has allowed diverse machine learning algorithms to supply valuable solutions to the problem of cancer subtype classification, which has surely contributed to better estimation of patient's response to diverse treatments. However, the efficacy of these models is seriously affected by the existing imbalance between the high dimensionality of the gene expression feature sets and the number of samples available for a particular cancer type, To counteract what is known as the curse of dimensionality, feature selection and extraction methods have been traditionally applied to reduce the number of input variables present in gene expression datasets. Although these techniques work by scaling down the input feature space, the prediction performance of traditional machine learning pipelines using these feature reduction strategies remains moderate. In this work, we propose the use of the Pan-Cancer dataset to pre-train deep autoencoder architectures on a subset composed of thousands of gene expression samples of very diverse tumor types. The resulting architectures are subsequently fine-tuned on a collection of specific breast cancer samples. This transfer-learning approach aims at combining supervised and unsupervised deep learning models with traditional machine learning classification algorithms to tackle the problem of breast tumor intrinsic-subtype classification. Our main goal is to investigate whether leveraging the information extracted from a large collection of gene expression data of diverse tumor types contributes to the extraction of useful latent features that ease solving a complex prediction task on a specific neoplasia.

Echo State Networks with Artificial Astrocytes and Hebbian Connections

Peter Gergeľ and Igor Farkaš

Abstract: For the last few decades, the neuroscientific research has highlighted the importance of astrocytes, a type of glial cells, in the information processing capabilities. By dynamic bidirectional communication with neurons, astrocytes regulate their excitability through a variety of mechanisms. Traditional artificial neural networks (ANNs) are connectionist models that describe how information passes throughout layer of neurons abstracting from low-level mechanisms. However, very little research has addressed artificial astrocytes and their incorporation into ANNs. In this paper, we present an echo state network (ESN) extended with astrocytes which influence the neurons by fixed or Hebbian connections. By systematic analysis we investigate their role on five classification tasks and show that they can outperform the standard ESN without astrocytes. Although the model with fixed astrocytic weights yields from none to little improvement, the model with Hebbian weights from astrocytes to neurons is significantly superior.

Richness of Deep Echo State Network Dynamics

Claudio Gallicchio and Alessio Micheli

Abstract: Reservoir Computing (RC) is a popular methodology for the efficient design of Recurrent Neural Networks (RNNs). Recently, the advantages of the RC approach have been extended to the context of multi-layered RNNs, with the introduction of the Deep Echo State Network (DeepESN) model. In this paper, we study the quality of state dynamics in progressively higher layers of DeepESNs, using tools from the areas of information theory and numerical analysis. Our experimental results on RC benchmark datasets reveal the fundamental role played by the strength of inter-reservoir connections to increasingly enrich the representations developed in higher layers. Our analysis also gives interesting insights into the possibility of effective exploitation of training algorithms based on stochastic gradient descent in the RC field.

Image classification and retrieval with random depthwise signed convolutional neural networks

Yunzhe Xue and Usman Roshan

Abstract: We propose a random convolutional neural network to generate a feature space in which we study image classification and retrieval performance. Put briefly we apply random convolutional blocks followed by global average pooling to generate a new feature, and we repeat this k times to produce a k-dimensional feature space. This can be interpreted as partitioning the space of image patches with random hyperplanes which we formalize as a random depthwise convolutional neural network. In the network's final layer we perform image classification and retrieval with the linear support vector machine and k-nearest neighbor classifiers and study other empirical properties. We show that the ratio of image pixel distribution similarity across classes to within classes is higher in our network's final layer compared to the input space. When we apply the linear support vector machine for image classification we see that the accuracy is higher than if we were to train just the final layer of VGG16, ResNet18, and DenseNet40 with random weights. In the same setting we compare it to a recent unsupervised feature learning method and find our accuracy to be comparable on CIFAR10 but higher on CIFAR100 and STL10. We see that the accuracy is not far behind that of trained networks, particularly in the top-k setting. For example the top-2 accuracy of our network is near 90\% on both CIFAR10 and a 10-class mini ImageNet, and 85\% on STL10. We find that k-nearest neighbor gives a comparable precision on the Corel Princeton Image Similarity Benchmark than if we were to use the final layer of trained networks. As with other networks we find that our network fails to a black box attack even though we lack a gradient and use the sign activation. We highlight sensitivity of our network to background as a potential pitfall and an advantage. Overall our work pushes the boundary of what can be achieved with random weights.

Improving Randomized Learning of Feedforward Neural Networks by Appropriate Generation of Random Parameters

Grzegorz Dudek

Abstract: In this work, a method of random parameters generation for randomized learning of a single-hidden-layer feedforward neural network is proposed. The method firstly, randomly selects the slope angles of the hidden neurons activation functions from an interval adjusted to the target function, then randomly rotates the activation functions, and finally distributes them across the input space. For complex target functions the proposed method gives incomparably better results than the approach commonly used in practice, where the random parameters are selected from the fixed interval. This is because it introduces the steepest fragments of the activation functions into the input hypercube, avoiding their saturation fragments.

Voice Command Recognition Using Statistical Signal Processing and SVM

Stanislaw Osowski and Alexandra Osowska

Abstract: The paper presents automatic system for recognition of voice commands. On the basis of smartphone voice recordings the neural based system for recognition of spoken commands is proposed. It applies the

statistical processing of data leading to diagnostic feature generation and application of support vector machine as the final classifier. The recognized words are typical commands that might be used in automatic controlling of the wheelchair or represent the passwords used in speaker identification. The results of numerical experiments will be presented and discussed.

Multiple sclerosis detection via wavelet entropy and feedforward neural network trained by adaptive genetic algorithm

Han Ji and Hou Shou Ming

Abstract: Multiple sclerosis is a disease that damages the central nervous system. Current medical treatments can only prevent or relieve symptoms. In order to improve the detection efficiency, we propose a method based on wavelet entropy and feedforward neural network trained by adaptive genetic algorithm that is implemented over 10 runs of 10-fold cross validation, and we also use Three-level decomposition of db2 wavelet. The experimental results show that the accuracy of our method detection is significantly higher than the HWT-LR method.

Computational intelligence approach for liquid-gas flow regime classification based on frequency domain analysis of signals from scintillation detectors

Robert Hanus, Marcin Zych, Marek Jaszczur and Leszek Petryka

Abstract: Liquid-gas flows frequently occur in the mining, energy, chemical, and oil industry. One of the well-known non-contact method applied for measurement of parameters for such flows is the gamma-ray absorption technique. An analysis of the signals from scintillation detectors allows us to determine the flow parameters and to identify the flow structure. In this work, four types of liquid-gas flow regimes known as a slug, plug, bubble, and transitional plug – bubble were evaluated using selected computational intelligence methods. The experiments were carried out for two-phase water-air flow in horizontal pipe with internal diameter equal to 30 mm using a sealed Am-241 gamma-ray sources and a NaI(Tl) scintillation detectors. Based on the signal analysis in the frequency domain, eight features for the fluid flow were extracted and then were used at the input of the classifier. Three computational intelligence methods: single decision tree, multilayer perceptron, and radial basis function neural network were used for the flow structure identification. It was found that all the methods give good classification results for the types of analysed liquid-gas flow.

Enterprise System Response Time Prediction Using Non-Stationary Function Approximations

Ravikumar Karumanchi, Kriti Kumar, Naveen Kumar Thokala and Girish Chandra

Abstract: We consider the problem of predicting response time of a large scale enterprise system using causal forecasting models. Specifically, the problem pertains to predicting potential system failure well in advance so that preventive actions can be initiated. Various influential factors are identified and their relationship with the system response time is estimated from data using non-stationary (time dependent) functional approximations. Experimental results on the prediction performance of different methods are presented and their discriminative characteristics with regard to error distribution are used to suggest a recommendation for practical implementation.

Bistable Sigmoid Networks

Stanislav Uschakow, Jörn Fischer and Thomas Ihme

Abstract: Abstract. It is commonly known that Hopfield Networks suffer from spurious states and from low storage capacity. To eliminate the spurious states Bistable Gradient Networks (BGN) introduce neurons with bistable behavior. The weights in BGN are calculated in analogy to those of Hopfield Networks, associated with Hebbian learning. Unfortunately, those networks still suffer from small storage capacity, resulting in high reconstruction errors when used to reconstruct noisy patterns. This paper proposes a new type of neural network

consisting of neurons with a sigmoid hyperbolic tangent transfer function and a direct feed- back. The feedback renders the neuron bistable. Furthermore, instead of using Hebbian learning which has some drawbacks when applied to 1overlapped patterns, we use the first order Contrastive Divergence (CD) learning rule. We call these Networks Bistable Sigmoid Networks (BSN). When recalling patterns from the MNIST database the reconstruction error is zero even for high load providing no noise is applied. For an in- creasing noise level or an increasing amount of patterns the error rises only moderate.

SGD-based Wiener Polynomial Approximation for Missing Data Recovery in Air Pollution Monitoring Dataset

Ivan Izonin, Michal Greguš, Roman Tkachenko, Mykola Logoida, Oleksandra Mishchuk and Yurii Kynash

Abstract: Paper describes the developed SGD-based Wiener polynomial approximation method for the missing data recovery of air pollution monitoring tasks. The main steps of algorithmic implementation of the method have been described and the necessity of a combination of both of these tools is substantiated. The basic parameters of the method (the degree of the polynomial, the loss function of the SGD algorithm) for design an optimal variant of it are experimentally investigated. One out of four studied loss functions was chosen for the practical implementation of the method for the design of the future applied air pollution monitoring system. It is founded that high degrees of the Wiener polynomial significantly increase the training time with a slight increase in accuracy. That's why a second-degree polynomial was chosen. The simulation of the method showed high as accuracy (based on MAPE, RMSE, MAE) as the speed of its work. Comparison of the developed method's results with the existing regression analysis methods (Adaptive Boosting, GRNN, SVR with different kernels) confirmed the high efficiency of its work. The proposed combination of the method allows obtaining an effective result from the point of view of accuracy-speed for the large volumes of data processing. The developed method will be useful when solving different tasks, for example, for a smart home or a smart city, medicine, economics, etc. That is, for those tasks where the problem of missing data does not allow conducting further effective intellectual analysis

Heavy duty vehicle fuel consumption modelling based on exploitation data by using artificial neural networks

Oskar Wysocki, Lipika Deka, David Elizondo, Jacek Kropiwnicki and Jacek Czyżewicz

Abstract: One of the ways to improve the fuel economy of heavy duty trucks is to op-erate the combustion engine in its most efficient operating points. To do that, a mathematical model of the engine is required, which shows the relations between engine speed, torque and fuel consumption in transient states. In this paper, easy accessible exploitation data collected via CAN bus of the heavy duty truck were used to obtain a model of a diesel engine. Various polynomial regression, K-Nearest Neighbor and Artificial Neural Network models were evaluated, and based on RMSE the most relevant sets of parameters for the given algorithm were selected. Finally, the models were compared by using RMSE and Absolute Relative Error scores for 5 test samples. These represent the whole engine's operating area. Apart from goodness of fit, the models were analyzed in terms of sensitivity to the size of the training samples. ANN and KNN proved to be good algorithms for modeling fuel consumption by using exploitation data. The ANN model was ranked best, as it required less observations to be trained in order to achieve an absolute relative error which was lower than 5%. A conventional method, i.e. polynomial regression, performed significantly worse than either the ANN or the KNN models. The approach presented in this study shows the potential for using easy accessible exploitation data to modeling fuel consumption of heavy duty trucks. This leads to the reduction of fuel consumption having a clear positive impact on the environment.

Use of complex networks for the automatic detection and the diagnosis of Alzheimer's disease

Aruane Pineda, Fernando Ramos, Luiz Betting and Andriana Campanharo

Abstract: Alzheimer's disease (AD) is classified as a chronic neurological disorder of the brain and affects approximately 25 million elderly individuals worldwide. This disorder leads to a reduction in people's productivity and imposes restrictions on their daily lives. Studies of AD often rely on electroencephalogram (EEG) signals to provide information on the behavior of the brain. Recently, a map from a time series to a network has been proposed and that is based on the concept of transition probabilities; the series results in a so-called ``quantile graph" (QG). Here, this map, which is also called the QG method, is applied for the automatic detection of healthy patients and patients with AD from recorded EEG signals. Our main goal is to illustrate how the differences in dynamics in the EEG signals are reflected in the topology of the corresponding QGs. Based on various network metrics, namely, the clustering coefficient, the mean jump length and the betweenness centrality, our results show that the QG method can be used as an effective tool for automated diagnosis of Alzheimer's disease.

Detection of Cancerous Lesions with Neural Networks

Hassan El-Khatib, Dan Popescu and Loretta Ichim

Abstract: The paper presents two methods for automatic identification of skin cancer in forms of melanoma. In the first method we design a Neural Network that help us to classify the skin lesions. The design of the Neural Network is discussed by analyzing the performance of the training process of the network and the number of target classes. The sensitivity, specificity and accuracy are then determined. The second method uses GoogleNet Convolutional Neural Network (CNN), which is pretrained with the large image database ImageNet. The CNN model is then fine-tuned to classify skin lesions using transfer learning. The classification accuracy is also calculated. The results obtained using the two methods were then compared. The experimental results on a free database demonstrates that the sec-ond method can provide high accuracy if some conditions are respected when de-signing the neural networks.

Digital Implementation of a Biological-Plausible Model For Astrocyte Ca2+ Oscillations

Majid Ahmadi, Moslem Heidarpur and Arash Ahmadi

Abstract: New findings show that astrocytes are important parts of the information processing in brain and believed to be responsible for some brain diseases such as Alzheimer and Epilepsy. Astrocytes generate Ca2+ waves and release neuro-transmitters over a large area. To study astrcoytes, one need to simulate large number of biologically realistic models of these cells alongside neuron models. Software simulation is flexible but slow. On the other hand, hardware simulation has advantage of running parallel, is more energy efficient and much faster. This work presents a digital hardware which can effectively implement nonlinear differential equations of astrocyte. As proof of concept, the design was simulated and implemented on the Field Programmable Gate Array (FPGA) device. As the results indicated, proposed hardware was capable of replicating the astrocyte in cellular level.

Custom-Made Monitor For Easy High-Frequency SSVEP Stimulation

Mihaly Benda, Felix Gembler, Piotr Stawicki, Sadok Ben-Salem, Zahidul Islam, Arne Vogelsang and Ivan Volosyak

Abstract: In this paper, we present and evaluate a special Custom-Made Computer Display (CMCD) with additional background light, which is separately controlled in order to create visual stimuli for Brain-Computer Interfaces (BCIs). While the monitor itself is working with a 60 Hz refresh rate, twelve strips of LED lights that are placed in between the backlight allow for a higher frequency flickering than any flickering object on a conventional screen. The goal of this study is to evaluate the effectiveness of this CMCD, which is mostly based on a change in intensity rather than in contrast. Therefore, we compared the responses to both types of flickering

at different frequency ranges, while also measuring the speed and accuracy of the BCI with short spelling tasks. The CMCD LED illumination yielded slightly superior performance in terms of offline ITR in comparison to the standard flickering.

Toward robust mispronunciation detection via audio-visual speech recognition

Mahdie Karbasi, Steffen Zeiler, Jan Freiwald and Dorothea Kolossa

Abstract: A recent trend in language learning is gamification, i.e.~the application of game-design elements and game principles in non-game contexts. A key component therein is the detection of mispronunciations by means of automatic speech recognition. Constraints like quiet environments and the use of close-talking microphones hinder the applicability for language learning games. In this work, we propose to use multi-modal---specifically audio-visual---speech recognition as an alternative for detecting mispronunciations in acoustically noisy or otherwise challenging environments. We examine a hybrid speech recognizer structure, using either feed-forward or bidirectional long-short term memory (BiLSTM) networks. There are several options to integrate both modalities. Here, we compare early fusion, i.e.~the use of one joint audio-visual network, with a turbo-decoding approach that combines contributions from acoustic and visual models. We evaluate the performance of these topologies in detecting some common phoneme mispronunciations, namely the errors in manner (MoA) and in place of articulation (PoA). It is shown that our novel architecture, using BiLSTM acoustic and visual submodels in conjunction with turbo-decoding, is very well suited for the task of mispronunciation detection, and that the visual modality contributes strongly to achieving noise-robust performance.

Multiple Linear Regression based on Coefficients Identification using Non-Iterative SGTM Neural-Like Structure

Ivan Izonin

Abstract: In the paper, a new method for solving the multiple linear regression task via a linear polynomial as a constructive formula is proposed. It is based on the use of high-speed SGTM Neural-Like Structure. This linear non-iterative computational intelligence tool is used for identification of polynomial coefficients. As a result of the implementation of the learning algorithm and applied the matrix of test signals to the trained SGTM, the identification of the linear polynomial coefficients is carried out. A further solution of the task occurs by searching a dependent variable using the obtained polynomial. The results of the method have been tested on the task of the output of the electric power prediction of the combined-type factory. The method ensures the identification of five polynomial's coefficients at the high speed, which ensures high accuracy of the solution. Based on the comparison with known regression analysis methods, the highest accuracy of the work has been established. The transition from neural-like structure to the solution of the task in the form of a linear polynomial provides the possibility for the simple interpretation of the result of the regression or classification tasks. That does not require high qualifications from the user. In addition, the developed method, based on the repetition of training outcomes and the lack of debugging and parameter selection procedures, allows synthesizing linear polynomial for complex models that use various non-linear extensions of SGTM inputs while preserving the accuracy of their operation. The proposed approach can be used in the fields of medicine, economics, materials science, service sciences etc., for fast and accurate solution of regression or classification tasks with the possibility of easy interpretation of the result

Detector of small objects with application to the license plate symbols

Alexey Alexeev, Yuriy Matveev, Georgy Kukharev, Sattam Almatarneh and Anton Matveev

Abstract: The paper discusses the neural network architecture of the detector groups of small and closely spaced objects, the distance between which may be only a few pixels. Today, the problem of detecting small objects using neural network methods is due to the architecture in which most of the spatial information is lost due to the pooling. To preserve spatial information, we suggest using a fully connected network based on convolutional neural networks such as Network in Network (NiN). The work aims to develop a new approach to the detection of small objects. The demonstration of the proposed solution is performed in the task of detecting symbols on

car license plates, images of which were obtained from video recording cameras of road violations. The proposed settlement does not use such specific operations as accurate localization of license plates, segmentation, and binarization of their symbols, preliminary identification of the type of license plate for subsequent filtering of false detections using license plates templates. In the proposed solution, the recognition of characters on the license plate is made on the input gray image of arbitrary size and regardless of the type (pattern) of license plates and its spatial orientation. The only image requirement is the character size range, the task of which can be provided by preliminary scaling of the image. In most systems, this requirement is met, since we know the location of the camera and video surveillance area. The mean Average Precision (mAP) as indicator of the separate license plates symbols detector was 90.25%, which can compete with the quality provided by modern automatic recognition systems for license plates.

A deep learning approach to anomaly detection in the Gaia space mission data

Alessandro Druetto, Marco Roberti, Rossella Cancelliere, Davide Cavagnino and Mario Gai

Abstract: The data reduction system of the Gaia space mission generates a large amount of intermediate data and plots for diagnostics, beyond practical possibility of full human evaluation. We investigate the feasibility of adoption of deep learning tools for automatic detection of data anomalies, focusing on convolutional neural networks and comparing with a multilayer perceptron. The results evidence very good accuracy (~99.7%) in the classification of the selected anomalies.

A Fixed-Size Pruning Approach for Optimum-Path Forest

Leonardo Costa, Gabriel Barbosa and Ajalmar Rêgo Da Rocha Neto

Abstract: Optimum-Path Forest (OPF) is a recently proposed graphbased classifier that has achieved remarkable results in various applications. OPF has many advantages when compared to other supervised classifiers, since it is free of parameters, achieves zero classification errors on the training set without overfitting, handles multiple classes without modifications or extensions, and does not make assumptions about the shape and separability of the classes. Despite these advantages, it still suffers with a high computational cost required to execute its classification process, which grows proportionally to the size of the training set. In order to overcome this drawback, we propose a new approach based on genetic algorithms to prune irrelevant training samples and still preserve accuracy in OPF classification. In our proposal, named FSGAP-OPF, the standard reproduction and mutation operators are modified so as to maintain the number of the pruned patterns with a fixed-size. To evaluate the performance of our method, we tested its generalization capabilities on datasets obtained from the UCI repository. On the basis of our experiments, we can say that FSGAP-OPF is a good alternative for classification tasks and can also be used in problems where the memory consuming is crucial.

Constraint Exploration of Convolutional Network Architectures with Neuroevolution

Jonas Dominik Homburg, Michael Adams, Michael Thies, Timo Korthals, Marc Hesse and Ulrich Rückert

Abstract: The effort spend on adapting existing networks to new applications has motivated the automated architecture search. Even though network structures, discovered with evolutionary or other search algorithms, are able to surpass hand-crafted image classifiers in terms of accuracy, further network characteristics have been neglected. Thus we show that generational, evolutionary algorithms can be used for a constraint exploration of convolutional network architectures to create various networks which represent a trade-off in the applied constraints.

Impact of genetic algorithms operators on association rules extraction

Leila Hamdad, Karima Benatchba, Ahcene Bendjoudi and Ournani Zakaria

Abstract: The first goal of this paper is to study the impact of Genetic Algorithms (GA's) components such as encoding, different crossover and replacement strategies on the number and quality of extracted association rules. Moreover, we propose a strategy to manage the population. The later is organized in sub-populations where each one encloses same size rules. Each sub-population can be seen as a population on which a GA is applied. Hence, we propose two GAs, a sequential one and a parallel one. All tests are conducted on two types of benchmarks: synthetic and real ones of different sizes.

Failure Diagnosis of Wind Turbine Bearing Using Feature Extraction and a Neuro-Fuzzy Inference System (ANFIS)

Mojtaba Kordestani, Milad Rezamand, Rupp Carriveau, David Ting and Mehrdad Saif

Abstract: Bearing failures are the most common type of malfunction in wind turbines. As such, isolating these defects enables maintenance scheduling in advance; hence, preventing further damage to turbines. This paper introduces a new fault detection and diagnosis (FDD) method to isolate two types of bearing failure in Wind turbines (WTs). The pro- posed FDD method consists of a feature extraction/feature selection and an adaptive neuro-fuzzy inference system (ANFIS) method. The feature extraction and selection phase identifies proper features to capture the nonlinear dynamics of the failure. Then, the ANFIS classifier diagnoses the failure type using the extracted features. Several experimental test studies with the historical data of wind farms in South-western On- tario are performed to evaluate the performance of the FDD system. Test results indicate that the proposed monitoring system is accurate and effective.

Automatic Identification of Interictal Epileptiform Discharges with the Use of Complex Networks

Gustavo Tomanik, Luiz Betting and Andriana Campanharo

Abstract: The identification of Interictal Epileptiform Discharges (IEDs), which are characterized by spikes and waves in electroencephalographic (EEG) data, is highly beneficial to the automated detection and prediction of epileptic seizures. In this paper, a novel single-step approach for IEDs detection based on the complex network theory is proposed. Our main goal is to illustrate how the differences in dynamics in EEG signals from patients diagnosed with idiopathic generalized epilepsy are reflected in the topology of the corresponding networks. Based on various network metrics, namely, the strongly connected component, the shortest path length and the mean jump length, our results show that this method enables the discrimination between IEDs and free IEDs events. A decision about the presence of epileptiform activity in EEG signals was made based on the confusion matrix. An overall detection accuracy of 98.2% was achieved.

Red-Black Tree based NeuroEvolution of Augmenting Topologies

William R. Arellano, Paul A. Silva, Maria F. Molina, Saulo Ronquillo and Francisco Ortega Zamorano

Abstract: In Evolutionary Artificial Neural Networks (EANNs), evolutionary algorithms are used to give an additional alternative to adapt besides learning, specially for connection weights training and architecture design, among others. A type of EANNs known as \textit{Topology and Weight Evolving Artificial Neural Networks} (\textbf{TWEANNs}) are used to evolve topology and weights. In this work we introduce a new encoding on an implementation of NeuroEvolution of Augmenting Topologies (NEAT), a type of TWEANNs, by adopting the Red-Black Tree (RBT) as the main data structure to represent the connection genes instead of using a list. The new encoding gives a similar accuracy to the one obtained by a feed-forward network with back-propagation and in some cases is even better. Also, as the number of patterns increase, the average number of generations increase exponentially. Finally, there is no relationship between the number of attributes and the number of generations.

On possibilities of human head detection for person flow monitoring system

Petr Dolezel, Dominik Stursa and Pavel Škrabánek

Abstract: Along with a development of human society, economy, industry and engineering, as well as with a growing populations in world's biggest cities, various approaches to person detection become subject of a great interest. One approach to a person detection system development is proposed in this paper. A high-angle video sequence is considered as the input to the system. Then, three classification algorithms are considered: support vector machines, pattern recognition neural networks and convolutional neural networks. The results showed a very little difference between the classifiers, with the overall accuracy more than 95 \% over a testing set.

Automatic time series forecasting with GRNN: a comparison with other models

Francisco Martínez, Francisco Charte, Antonio Jesús Rivera Rivas and María Pilar Frías Bustamante

Abstract: In this paper a methodology based on general regression neural networks for orecasting time series in an automatic way is presented. The methodology is aimed at achieving an efficient and fast tool so that a large amount of time series can be automatically predicted. In this sense, general regression neural networks present some interesting features, they have a fast single-pass learning and produce deterministic results. The methodology has been implemented in the R environment. A study of packages in R for automatic time series forecasting, including well-known statistical and computational intelligence models such as exponential smoothing, ARIMA or multilayer perceptron, is also done, together with an experimentation on running time and forecast accuracy based on data from the NN3 forecasting competition.

Improving online handwriting text/non text classification accuracy under condition of stroke context absence

Serhii Polotskyi, Ivan Deriuga, Tetiana Ignatova, Volodymyr Melnyk and Hennadii Azarov

Abstract: In this paper an approach for text/non text stroke classification for on-line handwriting recognition is proposed. This approach allows to improve classification accuracy when the stroke's context is absent. Having a label for the input stroke, we set this label for a feature vector which corresponds to each timestamp of the given input stroke. A trained neural network classifies each timestamp for the given input sequence. Finally, a decoder assigns a class label to the whole stroke. This approach was tested on the online handwritten dataset IAMonDO in on-line mode and has shown 98.5% accuracy. This approach could be used for other time-series classification tasks when the context information is not available.

An efficient framework to detect and avoid driver sleepiness based on YOLO with Haar cascades and an intelligent agent

Belmekki Ghizlene, Mekkakia Zoulikha and Hector Pomares

Abstract: In this paper we present a new approach to discern and handle driver's drowsi-ness. This task is usually based only on its detection, without providing any intel-ligent feedback appropriated to the situation of the driver, and focusing only on the eyes. The response is usually a simple beep alarm which is not enough to wake up or keep the driver awake all along the road. The innovation in our meth-od resides first in the use of a combination of Haar cascades and deep convolu-tional neural networks for fast detection of the state of the driver and second, the use of an intelligent assistant agent who will follow up the driver by the front camera of his phone, and tries to take care of his security, and the security of the others.

Sparse Least Squares Support Vector Machines based on Genetic Algorithms: a Feature Selection Approach

Pedro Araujo and Ajalmar Rocha Neto

Abstract: This paper presents a new approach for pruning dataset features (i.e., feature selection) based on genetic algorithms (GAs) and sparse least squares support vector machines (LSSVM) for classification tasks.

LSSVM is a modified version of standard Support Vector Machine (SVM), which is in general faster to train than SVM since the training process of SVM requires the solution of a quadratic programming problem while the LSSVM demands only the solution of a linear equation system. GAs are applied to solve optimization problems without the assumption of linearity, differentiability, continuity or convexity of the objective function. There are some works where GAs and LSSVM work together, however, mostly to find the LSSVM kernel and/or classifier parameters. Nevertheless, our new proposal combines LSSVM and GAs for achieving sparse models, in which each support vector has just a few features in a feature selection sense. The idea behind our proposal is to remove non-relevant features from the patterns by using GAs. Removing a pattern has less impact than removing a feature since the training dataset has in general more patterns than features. On the basis of the results, our proposal leaves non-relevant features out of the set of features and still maintains or even improves the classification accuracy.

Performance of Different Classifiers on Noisy-Labeled Training Data

Irfan Ahmad

Abstract: Machine learning is an important area of Artificial Intelligence. It has applications in almost all the fields of science. Supervised machine learning, for classification problems, involves training the classifiers with labeled data. There are many classifiers, each having its own strengths and weaknesses in terms of classification accuracy and the ability of dealing with noisy class labels in the training data. There is limited work reported in the literature on investigating the performance of classifiers under different levels of class noise in the training data. The current work aims to presents a thorough investigation on the effects of class mislabeling on the performance of different classifiers. Five commonly used classifiers; SVM, random forest, ANN, naïve Bayes, and KNN were investigated on a benchmark database of handwritten digit images. Classifiers were trained with different levels of labeling noise, ranging from low, to medium, to very high, and their recognition performances were evaluated and compared. The study led to some interesting observations which are presented in this paper.

Application of Artificial Neural Network Model for Cost Optimization in a Single-Source, Multi-Destination System

Modestus Okwu and Oguoma Onyewuchi

Abstract: Technology, innovation and information are shifting, hence decision-making especially at strategic level in manufacturing, and business milieu is becomimg extremely complex. Decision-makers cannot afford to make thought-out decisions based on intuition or guesswork as a result of risk, uncertainty and costly consequences which may cause serious financial problems for organizations. Hence an understanding of the use of creative algorithms in decision making is desirable for decision makers. This article proposes an imaginative approach for solving a linear programming problem (LPP) for multi-product distribution by creating a transshipment system and analysis using artificial neural network (ANN) technique for effective product allocation and cost prediction. Data obtained from a bottling company in Nigeria was used for the analysis and several parameters like the nature of transfer function, number of neurons in the hidden layers were taken into consideration for effecive cost optimization. From the analysis of the study, it was observed that the company spent a total sum of ₦6,332,304.00 (17,590.00USD) on product distribution within the period of survey. From the established creative model, the total cost of distribution of product to available depots equaled ₦4,170,500.00 (11585.00.USD). The current operational cost was saved by roughly 34% using the ANN model. The study therefore concludes that ANN model provides a good prediction response in solving transportation/transshipment problems. The creative technique will help decision makers in manufacturing and bottling companies in the adoption of appropriate distribution strategies for cost optimization.

Waste classification system with use image processing and convolutional neural networks

Janusz Bobulski and Mariusz Kubanek

Abstract: Image segmentation and classification is more and more being of interest for computer vision and machine learning researchers. Many systems on the rise need accurate and efficient segmentation and

recognition mechanisms. This demand coincides with the increase of computational capabilities of modern computer architectures and more effective algorithms for image recognition. The use of convolutional neural networks for the image classification and recognition allows building systems that enable automation in many industries. This article presents a system for classifying plastic waste, using convolutional neural networks. The problem of segregation of renewable waste is a big challenge for many countries around the world. Apart from segregating waste using human hands, there are several methods for automatic segregation. The article proposes a system for classifying waste with the following classes: polyethylene terephthalate, high-density polyethylene, polypropylene and polystyrene. The obtained results show that automatic waste classification, using image processing and artificial intelligence methods, allows building effective systems that operate in the real world.

Exploring classification and clustering and its limits in a compressed hidden space of a single layer neural network with random weights

Meiyan Xie and Usman Roshan

Abstract: Classification in the hidden layer of a single layer neural network with random weights has shown high accuracy in recent experimental studies. We further explore its classification and clustering performance in a compressed hidden space on a large cohort of datasets from the UCI machine learning archive. We compress the hidden layer with a simple bit-encoding that yields a comparable accuracy to the original hidden layer thus reducing memory requirements and allowing to study up to a million random nodes. In comparison to the uncompressed hidden space we find classification accuracy with the linear support vector machine to be statistically indistinguishable from that of the network's compressed layer. We see that that test error of the linear support vector machine in the compressed hidden layer improves marginally after 10,000 nodes and even rises when we reach 1 million nodes. We show that k-means clustering has an improved adjusted rand index and purity in the compressed hidden space compared to the original input space but only the latter by a statistically significant margin. We also see that semi-supervised k-nearest neighbor improves by a statistically significant margin when only 10\% of labels are available. Finally we see that classification of different classifiers has lower error in the compressed hidden layer than the original space and with the linear support vector machine has the lowest error of all methods. Our experiments show that while the compressed hidden layer can achieve a high accuracy competitive to other classifiers it has a saturation point beyond which the accuracy does not improve, and that clustering and semi-supervised is better in the compressed hidden layer by a small yet statistically significant margin.

Fingerprint Recognition using a Specialized Ensemble of Attractor Networks

Mario Gonzalez, Carlos Davila, David Dominguez, Angel Sanchez and Francisco B. Rodriguez

Abstract: We tested the performance of the Ensemble of Attractor Neural Networks (EANN) model for fingerprint recognition. The EANN model has proved to increase the random patterns storage capacity, when compared to a single attractor of equal connectivity. In this work, we tested the EANN with real patterns, i.e. fingerprints dataset. The EANN improved the retrieval performance for real patterns more than tripling the capacity of the single attractor with the same number of connections. The EANN modules can also be specialized for different patterns sets according to their characteristics, i.e. pattern/network sparseness (activity). Three EANN modules were assigned with skeletonized fingerprints (low activity), binarized (original) fingerprints (medium activity), and dilated/thickened fingerprint (high activity), and their retrieval was checked. The more sparse the code the larger the storage capacity of the module. The EANN demonstrated to improve the retrieval capacity of the single network, and it can be very helpful for module specialization for different types of real patterns.

Multi-mother wavelet neural network training using ge-netic algorithm-based approach to optimize and improves the robustness of gradient-descent algorithms: 3d mesh deformation application

Naziha Dhibi and Chokri Ben Amar

Abstract: This paper presents the implementation of genetic algorithm which aims at searching for an optimal or near optimal solution to the deformation 3D objects problem based on multi-mother wavelet network training. First, we introduce the problem of 3D high mesh deformation using Multi-Mother Wavelet Network architecture (MMWN). Furthermore, gradient training limits of wavelet networks are characterized by their inability to evade local optima. The idea is integrated the genetic algorithm into the wavelet network to avoid both insufficiency and local minima in the 3D mesh deformation technique. Simulation results are demonstrated to validate the generalization ability and efficiency of the proposed Multi Mother Wavelet Neural Network based on genetic algorithms (MMWN-GA). Thus the significant improvement of the performances in terms of quality of 3D meshes deformation.

Deep learning based ship movement prediction system architecture

Alberto Alvarellos, Andrés Figuero, José Sande, Enrique Peña and Juan Rabuñal

Abstract: In this work we present the software architecture used to implement a ship movement prediction system based on a deep learning model. In previous works of the group we recorded the movement of several cargo vessels in the Outer Port of Punta Langosteira (Spain) and created a deep neural network that classifies the vessel movement given the vessel dimensions, the sea state and weather conditions. In this work we present the architectural design of a soft- ware system that allows to deploy machine learning models and publish the re- sults it provides in a web application. We later use this architecture to deploy the deep neural network we have mentioned, creating a tool that is able to pre- dict the behavior of a moored vessel 72 hours in advance. Monitoring the movement of a moored vessel is a difficult and expensive task and port opera- tors do not have a tool that predicts whether a moored vessel is going to exceed the recommended movements limits. With this work we provide that tool, be- lieving that it could help to coordinate the vessel operations, minimizing the economic impact that waves, tides and wind have when cargo vessels are una- ble to operate or suffer damages. Although we use the proposed system archi- tecture for solving a particular problem, it is general enough that it could be used for solving other problems by deploying any machine learning model compatible with the system.

Using Boolean- and Self-Enforcing-Networks for Mathematical E-Tutorial Systems

Christina Kluever and Juergen Kluever

Abstract: Mathematical thinking as an important instrument in science is a stumbling block for many students in the first years. A lot of investigations occur to help the students understanding the principles of mathematics. The proposed tutorial system for the basics focuses on the analysis and visualizations of the solution algorithms and solution processes with Boolean Networks and Self-Enforcing Networks. The students can check not only the correctness of their results, but also if the solution steps are complete. In addition, in case of wrong results the students can check in which step of the solution they made a mistake and what kind of mistake. The goal is to promote the explorative learning and to help understanding the problems through self-recognition.

MorphoGen: Unsupervised Inflection Generation Using Recurrent Neural Network Language Modelling

Octavia-Maria Șulea, Steve Young and Liviu P. Dinu

Abstract: Sub-word level alternations during inflection (apophonies) are a common linguistic phenomenon present in morphologically-rich languages, like Romanian. Inflection learning, or predicting the inflection class of a partially regular or fully irregular verb or noun in such a language has been a widely studied task in NLP,

but generative models are limited to capturing the most common ending patterns and apophonies. In this paper, we show how to train a character-level Recurrent Neural Network language model to be able to accurately generate the full inflection of Romanian verbs and model stem-level phonological alternations triggered by inflection in an unsupervised way. We also introduce a method to evaluate the accuracy of the generated inflections.

Dementia detection and classification from MRI images using Deep Machine Learning with Transfer Learning

Amen Bidani, Mohamed Salah Gouider and Carlos M. Travieso-González

Abstract: In this paper, we present new approach of T-DCNN (Transfer Learning for Deep Convolutional Neural Network) model and SVM (Support Vector Machine) model to detect and classify the dementia disease using MRI (Magnetic Resonance Imaging) brain scans from OASIS dataset. In addition, the neurodegenerative disease that is described by a decline in memory, language, and other problems of cognitive skills to make daily activities. These MRI brain scans are better to normalize before the image extraction with Bag of the features and the classification methods into no-demented, very mild demented, and mild demented. Results showed that Transfer Learning method for Deep Machine-Learning model achieved significant accuracy for better Dementia diagnosis.

Classification with Rejection Option Using the Fuzzy ARTMAP neural network

Fancisco Felipe Sousa, Alan Lucas Silva Matias and Ajalmar Rego Da Rocha Neto

Abstract: The ARTMAP networks are machine learning techniques focused on supervised learning, being known mainly for their ability to learn fast, stable, incremental and online. Despite these advantages, the Fuzzy ARTMAP (FAM) suffers from the categories proliferation problem, leading to a reduction in its performance for unknowm samples. Such disadvantage is mainly caused by the overlapping region (noise) between classes. The vast majority of work on this issue has been concerned with alleviating the problem. A technique used to improve the performance of a classifier is the rejection option, which is used to retain the classification of a sample if the decision is not considered to be reliable. Therefore, in this paper we introduce a variant of the Fuzzy ARTMAP to behave as a classifier with rejection option. The main idea is to create the region of rejection by looking at the place where the categories proliferates since it occurs precisely in the overlapping region. The proposal was validated by conducting experiments with real datasets, as well as by comparing them with other models (MLP, SVM, and SOM) applied with the same rejection option technique.

Deep Residual Learning for Human Identification Based on Facial Landmarks

Abdelgader Abdelwhab and Serestina Viriri

Abstract: The face detection and recognition are still challenging research areas, since up to date there is no accurate integral model that works in every situation. As a result, the focus has been shifted to Convolutional Neural Networks (CNNs) and fusion techniques with the hope of better solution. The CNNs have enhanced the state-of-the-art of the human facial identification. However, the CNNs are not easy to train due to degradation problem called (gradient vanishing) when the network depth increased, so there is a need of residual network to solve this problem by going deeper without losing the gradient. In this paper, a pre-trained deep residual network for features extraction and ensembles of classifiers are implemented and facial landmarks are extracted and passed to the pre-trained model. Support Vector Machine (SVM) and random forest classifiers are fused at decision level using weighted and majority voting techniques. The experimental results conducted on ORL database show an excellent mean accuracy rate of about 100%. The accuracy rate of about 100% was achieved on LFW dataset with a minimum 70 facial images per person, and 99% with a minimum 10 facial images per person.

A genetic algorithm and neural network stacking ensemble approach to improve NO2 level estimations

Javier González-Enrique, Juan Jesús Ruiz-Aguilar, José Antonio Moscoso-López, Steffanie Van Roode Fuentes, Daniel Urda and Ignacio Turias

Abstract: This work investigates the possible improvements that a stacked ensemble can provide to NO2 estimations in a monitoring network located in the Bay of Algeciras (Spain). In the proposed ensemble, ANNs, linear and nonlinear genetic algorithms models have been used as the individual learners in the first stage. The non-linear GA models produce better results than linear GA models as they are able to detect useful relationships between variables that are ignored in the linear case. The outputs of the individual learners have been employed as the inputs of the ANN models of the second stage. The most accurate of these models produced the final NO2 estimation. The obtained results are promising as this final stage-2 model is able to outperform all the other estimation models considered in this work. This can be explained due to its ability to exploit the advantages offered by each individual model from stage-1 and then find an optimal combination of their outputs in order to increase the global estimation performance. The improvement of these NO2 estimations can be very useful to improve the autonomous capacities for monitoring networks.

A New Graph Based Brain Connectivity Measure

Addisson Salazar, Gonzalo Safont and Luis Vergara

Abstract: This paper presents a new measure of brain connectivity based on graphs. The method to estimate connectivity is derived from the set of transition matrices ob-tained by multichannel hidden Markov modeling (MHHM) and graph connectivi-ty theory. Analysis of electroencephalographic (EEG) signals from epileptic pa-tients performing neuropsychological tests with visual stimuli was approached. Those tests were performed as clinical procedures to evaluate the learning and short-term memory capabilities of the patients. The proposed method was applied to classify the stages (stimulus display and subject response) of the Barcelona and the Wechsler Memory Scale (WMS) - Figural Memory tests. To evaluate the capabilities of the proposed method, commonly used brain connectivity measures: correlation, partial correlation, and coherence were implemented for comparison. Results show the proposed method clearly outperforms the other ones in terms of classification accuracy and brain connectivity structures.

Combination of multiple classification results based on K-class alpha integration

Gonzalo Safont, Addisson Salazar and Luis Vergara

Abstract: Alpha integration methods have been previously used for integrating stochastic models and fusion in the context of detection (binary classification). This work proposes a new method based on alpha integration to perform soft fusion of scores in multi class classification problems that we have called vector score inte-gration. Equations are presented to optimize the parameters of the method to achieve the least mean squared error. The proposed alpha integration based meth-od was tested on several sets of real electroencephalographic signals. We per-formed automatic classification of two sets of polysomnographic data from sub-jects with sleep disorders in three classes: wake, rapid eye movement (REM) sleep, and non-REM sleep. In all cases, the proposed methods performed better than the considered single classifiers (linear discriminant analysis, naïve Bayes, classification trees, and random forests) and a classical fusion technique (majority voting).

Integration of CNN into a Robotic Architecture to build Semantic Maps of Indoor Environments

David Fernandez Chaves, Jose Raul Ruiz Sarmiento, Nicolai Petkov and Javier Gonzalez Jimenez

Abstract: In robotics, semantic mapping refers to the construction of a rich representation of the environment that includes high level information needed by the robot to accomplish its tasks. Building a semantic map requires algorithms to process sensor data at different levels: geometric, topological and object detections/categories, which must be integrated into an unified model. This paper describes a robotic architecture that successfully builds such semantic maps for indoor environments. For that, within a ROS-based

ecosystem, we apply a state-of-the-art Convolutional Neural Network (CNN), concretely YOLOv3, for detecting objects in images. These detections are placed within a geometric map of the environment making use of a number of modules of the architecture: robot localization, camera extrinsic calibration, data form a depth camera, etc. We demonstrate the suitability of the proposed framework by building semantic maps of several home environments from the Robot@Home dataset, using Unity 3D as a tool to visualize the maps as well as to provide future robotic developments.

Improving wearable activity recognition via fusion of multiple equally-sized data subwindows

Oresti Banos, Juan Manuel Galvez, Miguel Damas, Alberto Guillen, Luis Herrera, Hector Pomares, Ignacio Rojas and Claudia Villalonga

Abstract: The automatic recognition of physical activities typically involves various signal processing and machine learning steps used to transform raw sensor data into activity labels. One crucial step has to do with the segmentation or windowing of the sensor data stream, as it has clear implications on the eventual accuracy level of the activity recogniser. While prior studies have proposed specific window sizes to generally achieve good recognition results, in this work we explore the potential of fusing multiple equally-sized subwindows to improve such recognition capabilities. We tested our approach for eight different subwindow sizes on a widely-used activity recognition dataset. The results show that the recognition performance can be increased up to 15% when using the fusion of equally-sized subwindows compared to using a classical single window.

GPTSG: A Genetic Programming test suite generator using Information Theory measures

Alfredo Ibias Martínez, David Griñán and Manuel Núñez

Abstract: The automatic generation of test suites that get the best score with respect to a given measure is costly in terms of computational power. In this paper we present a genetic programming approach for generating test suites that get a good enough score for a given measure. We consider a black-box scenario and include different Information Theory measures. Our approach is supported by a tool that will actually generate test suites according to different parameters. We present the results of a small experiment where we used our tool to compare the goodness of different measures.

An Intelligent System Integrating CEP and Colored Petri Nets for Helping in Decision Making about Pollution Scenarios

Gregorio Díaz, Enrique Brazález, Hermenegilda Macia, Juan Boubeta-Puig and Valentín Valero

Abstract: Air pollution is currently a great concern especially in large cities. To reduce pollution levels, governments are imposing traffic restrictions. However, the decision about which grade of traffic restriction must be applied in a particular city zone is a cumbersome task. This decision depends on the pollution scenario occurred at a time period. To face this issue, we propose an analyzable and flexible intelligent system integrating Complex Event Processing (CEP) technology and Colored Petri Net (CPN) formalism to help domain experts to conduct such a decision-making process. This system uses a CEP engine to automatically analyze and correlate real air sensing data to detect pollutant averages at a particular sensor station. This produced information is then consumed in runtime by a CPN model in charge of obtaining the pollution scenarios, which are the basis to make decisions on the traffic regulations.

Using genetic algorithms to generate test suites for FSMs

Miguel Benito, Manuel Núñez and Mercedes Merayo

Abstract: It is unaffordable to apply all the possible tests to an implementation in order to assess its correctness. Therefore, it is necessary to select relatively small subsets of tests that can detect many errors. In this paper we use different approaches to select these test suites. In order to decide how good a test suite is, we confront it

with a set of {\it mutants}, that is, small variations of the specification of the system to be developed. The goal is that our algorithms builds test suites that {\it kill} as many mutants as possible. We compare the different approaches (consider all the possible subsets up to a given number of inputs, intelligent greedy algorithm and different genetic algorithms) and discuss the obtained results. The whole framework has been fully implemented and the tool is freely available.

Conformance relations for fuzzy automata

Iván Calvo, Mercedes Merayo and Manuel Núñez

Abstract: The use of formal methods improves the reliability of computer systems. In this context, fuzzy logic provides a tool to formally specify systems where uncertainty and imprecision play an important role. In this paper, we propose an extension of the fuzzy automata formalism and establish different conformance relations. The main goal of these relations is to formally capture the idea of a system behaving as specified by a specification. We sketch how our conformance relations can be alternatively characterized as a testing process by producing sound and complete sets of tests.

Investigating the Effectiveness of Mutation Testing Tools in the Context of Deep Neural Networks

Nour Chetouane, Lorenz Klampfl and Franz Wotawa

Abstract: Verifying the correctness of the implementation of machine learning algorithms like neural networks has become a major topic be- cause – for example – its increasing use in the context of safety critical systems like automated or autonomous vehicles. In contrast to evalu- ating the learning capabilities of such machine learning algorithms, in verification and in particular in testing we are interested in finding crit- ical scenarios and in giving some sort of guarantees with respect to the underlying used tests. In this paper, we contribute to the area of testing machine learning algorithms and investigate the effectiveness of tradi- tional mutation tools in the context of testing Deep Neural Networks. In particular, we try to answer the question whether mutated neural networks can be identified considering their learning capabilities when compared to the original network. To answer this question, we performed an empirical study using Java code implementations of such networks and a mutation tool to create mutated neural networks models. As an outcome, we are able to identify some mutations to be more likely to be detected than others.

Multi-input CNN for text classification in commercial scenarios.

Zuzanna Parcheta, Germán Sanchis-Trilles, Francisco Casacuberta and Robin Redahl

Abstract: In this work we describe a multi-input Convolutional Neural Network for text classification which allows for combining text preprocessed at word level, byte pair encoding level and character level. We conduct experiments on different datasets and we compare the results obtained with other classifiers. We apply the developed model to two different practical use cases: 1) classifying ingredients into their corresponding classes by means of a corpus provided by Northfork; and 2) classifying texts according to the English level of their corresponding writers by means of a corpus provided by ProvenWord. Additionally, we perform experiments on a standard classification task using Yahoo! Answers and ermEval2017 task A datasets. We show that the developed architecture obtains satisfactory results with these corpora, and we compare results obtained for each dataset with different state-of-the-art approaches, obtaining very promising results.

Applying Sentiment Analysis with cross-domain models to evaluate User eXperience in Virtual Learning Environments

Rosario Sanchis-Font, Maria Jose Castro-Bleda and José Ángel González

Abstract: Virtual Learning Environments are growing in importance as fast as e-learning is becoming highly demanded by universities and students all over the world. This paper investigates how to automatically evaluate User eXperience in this domain. Two Learning Management Systems have been evaluated, one system is an

ad-hoc system called "Conecto" (in Spanish and English languages), and the other one is an open-source Moodle personalized system (in Spanish). We have applied machine learning tools to all the comments given by a total of 133 users (37 English speakers and 96 Spanish speakers) to obtain their polarity (positive, negative, or neutral) using cross-domain models trained with a corpus of a different domain (tweets for each language) and general models for the language. The obtained results are very promising and they give an insight to keep going the research of applying sentiment analysis tools on User eXperience evaluation. This is a pioneering idea to provide a better and accurate understanding on human needs in the interaction with Virtual Learning Environments. The ultimate goal is to develop further tools of automatic feed-back of user perception for designing Virtual Learning Environments centered in user's emotions, beliefs, preferences, perceptions, responses, behaviors and accomplishments that occur before, during and after the interaction.

Visual disambiguation of PP-attachments: multimodal machine learning for syntactic analysis correction

Sebastien Delecraz, Leonor Becerra-Bonache, Frederic Bechet, Alexis Nasr and Benoit Favre

Abstract: Prepositional phrase attachments are known to be an important source of errors in parsing natural language. In some cases, pure syntactic features cannot be used for prepositional phrase attachment disambiguation while visual features could help. In this work, we are interested in the impact of the integration of such features in a parsing system. We propose a correction strategy pipeline for prepositional attachments using visual information, trained on a multimodal corpus of images and captions. The evaluation of the system shows us that using visual features allows, in certain cases, to correct the errors of a parser. It also helps to identify the most difficult aspects of such integration.

Meeting Summarization, a Challenge for Deep Learning

Francois Jacquenet, Marc Bernard and Christine Largeron

Abstract: Text summarization is one of the numerous challenges of Natural Language Processing. Given the volume of texts produced daily on the Internet managers can no longer have an exhaustive reading of current events, or progress reports from their employees, etc. They urgently need tools to automatically produce a summary of this flow of information. As a first approach, extractive summarization tools have been produced and there are now commercial tools available. However, this family of systems is not well suited to certain types of texts such as written transcriptions of dialogues or meetings. In that case, abstractive summarization tools are needed. Research in that field is very old but has been particularly stimulated since the mid-2010s by the recent successes of deep learning. This paper presents a short survey of deep learning approaches to abstractive text summarization and then highlights the various challenges that will have to be solved in the coming years to deal with meeting summaries in order to be able to provide a text summarization tool that generates good quality summaries.

Semantic Fake News Detection: A Machine Learning Perspective

Adrian M.P. Brasoveanu and Razvan Andonie

Abstract: Fake news detection is a difficult problem due to the nuancesof language. Understanding the reasoning behind certain fake items implies inferring a lot of details about the various actors involved. We believe that the solution to this problem should be a hybrid one, combining machine learning, semantics and natural language processing. We introduce a new semantic fake news detection method built around relational features like sentiment, entities or facts extracted directly from text. Our experiments show that by adding semantic features the accuracy of fake news classification improves significantly.

On Transfer Learning for Detecting Abusive Language Online

Ana Sabina Uban and Liviu P. Dinu

Abstract: Abusive language online has become a growing social issue in our age of social media. Given the massive amounts of data being generated daily on social platforms, manually detecting and regulating such

behavior has become unfeasible, so automatic solutions are necessary, and tasks related to identifying abusive language, in its various forms, from hate speech to bullying, have come into the focus of the natural language processing research community. In this paper, we focus on two subtypes of abusive language: aggressive language and offensive language, for which we implement a deep learning model based on convolutional neural networks. We further propose a new approach using transfer learning to boost performance of abusive language detection by leveraging data annotated with a different type of label, related to sentiment. We show how transferring knowledge between these tasks affects performance of detecting abusive language, offering insights into how these tasks are related, and how the more traditional task of sentiment analysis can be leveraged to help with solving the newer and less data rich task of abusive language detection.

Device-free passive human counting with Bluetooth Low Energy beacons

Maximilian Münch and Frank-Michael Schleif

Abstract: The increasing availability of wireless networks inside build- ings has opened up numerous opportunities for new innovative smart systems. For a lot of these systems, acquisition of context-sensitive information about attendant people has evolved to a key challenge. Espe- cially the position and distribution of attendants significantly influence the system's service quality. To meet this challenge, several types of sen- sor systems have been presented over the last two decades. Most of these systems rely on an active mobile device that has to be carried by the tracked entity. Contrary to the so-called device-based active systems, device-free passive sensing systems are grounded on the idea of detect- ing, tracking, and identifying attendant people without carrying any ac- tive device or to actively taking part in a localization process. In order to obtain information about the position or the distribution of present people, these systems quantify the impact of the physical attendants on radio-frequency signals. Most of device-free systems rely on the existing WiFi infrastructure and device-based active concepts, but here we want to focus on a different approach. In line with our previous research on presence detection with Bluetooth Low Energy beacons, in this paper, we introduce a strategy of using those beacons for a device-free passive human counting system.

Combining Very Deep Convolutional Neural Networks and Recurrent Neural Networks for Video Classification

Rukiye Savran Kızıltepe, John Q. Gan and Juan José Escobar

Abstract: Convolutional Neural Networks (CNNs) have been demonstrated to be able to produce the best performance in image classification problems. Recurrent Neural Networks (RNNs) have been utilized to make use of temporal information for time series classification. The main goal of this paper is to examine how temporal information between frame sequences can be used to improve the performance of video classification using RNNs. Using transfer learning, this paper presents a comparative study of seven video classification network architectures, which utilize either global or local features extracted by VGG-16, a very deep CNN pre-trained for image classification. Hold-out validation has been used to optimize the ratio of dropout and the number of units in the fully-connected layers in the proposed architectures. Each network architecture for video classification has been executed a number of times using different data splits, with the best architecture identified using the independent T-test. Experimental results show that the network architecture using local features extracted by the pre-trained CNN and ConvLSTM for making use of temporal information can achieve the best accuracy in video classification

Acceleration of Online Recognition of 2D Sequences using Deep Bidirectional LSTM and Dynamic Programming

Dmytro Zhelezniakov, Viktor Zaytsev and Olga Radyvonenko

Abstract: In this work, the approach for online recognition of 2D sequences using deep bidirectional LSTM was proposed. One of the complex cases of online sequence recognition is handwritten mathematical expressions (HME). In spite of many achievements in this area, it is a still challenging task as, in addition to character segmentation and recognition, the tasks of structure, relations, and grammar analysis should be resolved. Such a combination of recognizers could lead to an increase in computational complexity for large

expressions, which is unacceptable for on-device recognition in mobile applications. As end-to-end neural systems do not achieve plausible recognition speed for on-device calculations so far, to overcome this problem we proposed a deep-learning solution that employs recurrent neural networks (RNNs) for structure and character recognition in combination with re-ordering and modified CYK algorithm for expression building. Also, we explored a variety of structural and optimization enhancements to CYK algorithm that significantly improved the performance in terms of the recognition speed while the recognition accuracy remained at the same level. The proposed solution was evaluated using open source CROHME dataset and showed promising results after tests on a set of large expressions.

Link Prediction Regression for Weighted Co-authorship Networks

Ilya Makarov and Olga Gerasimova

Abstract: In this paper, we study the problem of predicting quantity of collaborations in co-authorship network. We formulated our task in terms of link prediction problem on weighted co-authorship network, formed by authors writing papers in co-authorship represented by edges between authors in the network. Our task is formulated as regression for edge weights , for which we use node2vec network embedding and new family of edge embedding operators. We evaluate our model on AMiner co-authorship network and showed that our model of network edge representation has better performance for stated regression link prediction task.

A Novel framework for Fine Grained Action Recognition in Soccer

Ganesh Yaparla, Sri Teja Allaparthi, Sai Krishna Munnangi and Garimella Rama Murthy

Abstract: Sports analytics have become a topic of interest in the field of Artificial intelligence. With the availability of huge volumes of high level data, significant progress has been made in the domain of action recognition in the past. Though video based action recognition has progressed well using state of the art deep learning techniques, its applications are limited to some higher level actions like throwing, jumping, running etc. There has been some work in fine-grained action recognition technique, such as, identification of type of throws in Basketball, and the type of a player's shots in Tennis. However with larger play field and with many players on field, multi player sports such as Soccer, Rugby, Hockey and etc. pose bigger challenges and remain unexplored. These games in general are live fed through field view cameras or skycams which aren't stationary. For these reasons, we chose to recognize player's actions in the game of Soccer and thereby, explore the capabilities of existing architectures and deep neural networks for these kind of games. Our main contributions are the proposed framework that can automatically recognize actions of players in live football game which will be helpful for text query based video search, for extracting stats in a football game and to generate textual commentary; and the Soccer-8k dataset which consists of different action clips in the soccer play.

A Serious Game to build a Database for ErrP Signal Recognition

Adam Pinto, Guilherme Nardari, Marco Mijam, Edgard Morya and Roseli Romero

Abstract: Brain wave signals allow communication between user and computer in a system called Brain-Computer Interface. Signal processing can detect attention, engagement, and errors in a task. Error-Related Potentials (ErrP) can be extracted from brain signals with noise, however, it is quite complicated to be recognized and accurate. This paper presents a new database, using gaming and a humanoid robot to induce the occurrence of user errors and methods to extract signal features. Both wavelets and Fourier transform are used to feature extraction, and a MultiLayer Perceptron (MLP) and a Convolutional Neural Network (CNN) to signal classification. Several experiments are presented demonstrating that wavelet extraction outperformed Fourier transform to extract the error and MLP performed a consistent accuracy.

Security Testing

Damas Gruska and M.Carmen Ruiz

Abstract: Security testing for multi-agent systems is proposed and studied. We start with security property called bisimulation process opacity. Unfortunately, this property is undecidable in general so we propose its more realistic variant based on tests and testing. A test represents an attacker's (i.e. possibly one of the agents) scenario to obtain some confidential information on systems. Here we consider system to be secure if it cannot be compromised by a given test or set of tests. By test we can express also capabilities of an attacker related to time properties such as time measurement accuracy, duration of tests (attacks), complete lack of attacker's time information and so on.

Some insights and observations on depth issues in deep learning networks

Arindam Chaudhuri

Abstract: In deep neural networks the depth of network is specified by number of layers and neurons in each layer. These parameters are basically set through trial and er-ror methods. During past few years deep networks have provided successful re-sults for various categories of constrained optimization problems at the cost of high memory and computation. The number of parameters in these networks are redundant in nature and are often replaced through subtle architectures. The num-ber of neurons in each layer of a deep network can be determined automatically through various complex functions. The different parameters of network can be determined through various regularizers by certain operations on network neu-rons. This provides a single coherent framework which optimizes memory and computation time thereby generalizing network architectures. The process reduces the number of parameters upto an appreciable amount while improving network accuracy. This has provided superior results for several regression and optimiza-tion computational scenarios.

DeepTrace: A Generic Framework for Time Series Forecasting

Nithish Moudhgalya, Siddharth Divi, Adithya Ganesan, Sharan Sundar Sankaran and Vineeth Vijayaraghavan

Abstract: We propose a generic framework for time-series forecasting called DeepTrace, which comprises of 5 model variants. These variants are constructed using two or more of three task specific components, namely, Convolutional Block, Recurrent Block and Linear Block, combined in a specific order. We also introduce a novel training methodology by using future contextual frames. However, these frames are dropped during the testing phase to verify the robustness of DeepTrace in real-world scenarios. We use an optimizer to offset the loss incurred due to the non-provision of future contextual frames. The genericness of the framework is tested by evaluating the performance on real-world time series datasets across diverse domains. We conducted substantial experiments that show the proposed framework outperforms the existing state-of-art methods.

OnMLM: An Online Formulation for The Minimal Learning Machine

Alan Matias, Cesar Mattos, Tommi Kärkkäinen, João Gomes and Ajalmar Rocha Neto

Abstract: Minimal Learning Machine (MLM) is a nonlinear learning algorithm designed to work on both classification and regression tasks. In its original formulation, MLM builds a linear mapping between distance matrices in the input and output spaces using the Ordinary Least Squares (OLS) algorithm. Although the OLS algorithm is a very efficient choice, when it comes to applications in big data and streams of data, online learning is more scalable and thus applicable. In that regard, our objective of this work is to propose an online version of the MLM. The Online Minimal Learning Machine (OnMLM), a new MLM-based formulation capable of online and incremental learning. The achievements of OnMLM in our experiments, in both classification and regression scenarios, indicate its feasibility for applications that require an online learning framework.

AL4LA: Active Learning for Text Labeling Based on Paragraph Vectors

Damian Nimo-Jarquez, Elisa Guerrero and Rivas-Sanchez Mario

Abstract: Nowadays, despite the huge amount of digitized information, the biggest drawback to use machine learning in text mining is the lack of availability of a set of tagged data due to mainly, that it requires a great user effort that it is not always viable. In this paper, with the aim of reducing the great workload required to manually processing the contents of large volumes of documents, we present a methodology based on probabilistic inference and active learning to label documents in Spanish using a semi-supervised approach. First, a vector representation of the documents is generated, and then an interactive learning process to apply both, automatic and manual labeling is proposed. To evaluate the accuracy of the predictions and the efficiency of the methodology, different configurations regarding the automatic and manual labeling processes have been studied. The proposed methodology reduces the need for a large corpus of manually labeled texts by introducing a self-labeling process during training. We have shown that both tagging approaches can be combined maintaining accuracy and reducing user intervention.

Searching the shortest pair of edge-disjoint paths in a Communication Network. A Fuzzy approach.

Lissette Valdés Valdés, Sira María Allende Alonso, Alfonso Ariza Quintana and Gonzalo Joya Caparrós

Abstract: In this paper, we address the problem of finding the shortest pair of edge-disjoint paths between two nodes in a communication network. We use a new cost function named modified fuzzy normalized used bandwidth, which is described as a fuzzy triangular number, thus incorporating the uncertainty generated in calculating this magnitude in a real network. The proposed algorithm uses as a sub-algorithm an adaptation of a Modified Dijkstra algorithm applied in a mixed graph with arcs whose costs are negative triangular fuzzy numbers. We prove its effectivity by simulating traffic close to overload with two types of communication sources: regular and priority sending of information. The addressed problem presents a considerable interest in contexts such as finance entities or government services, where privacy and security against external attacks have to be considered, as well as in networks with high transmission speed such as the optical ones.

Artificial neural networks for bottled water demand forecasting: a small business case study

Israel D. Herrera-Granda, Joselyn A. Chicaiza-Ipiales, Erick P. Herrera-Granda, Leandro L. Lorente-Leyva, Jorge A. Caraguay-Procel, Iván D. García-Santillan and Diego H. Peluffo-Ordóñez

Abstract: This paper shows a neural networks-based demand forecasting model designed for a small manufacturer of bottled water in Ecuador, which currently doesn't have adequate demand forecast methodologies, causing problems of cus-tomer orders non-compliance, inventory excess and economic losses. However, by working with accurate predictions, the manufacturer will have an anticipated vision of future needs in order to satisfy the demand for manufactured products, in other words, to guarantee on time and reasonable use of the resources. To solve the problems that this small manufacturer has to face a historic demand data acquisition process was done through the last 36 months costumer order records. In the construction of the historical time series, that was analyzed, demand dates and volumes were established as input variables. Then the design of forecast models was done, based on classical methods and multi-layer neural networks, which were evaluated by means of quantitative error indicators. The application of these methods was done through the R programming language. After this, a stage of training and improvement of the network is included, it was evaluated against the results of the classic forecasting methods, and the next 12 months were predicted by means of the best obtained model. Finally, the feasibility, of the use of neural networks in the forecast of demand for purified water bottles, is demonstrated.

Document model with attention bidirectional recurrent network for gender identification

Bassem Bsir and Mounir Zrigui

Abstract: Author profiling is an important statistical and semantic processing task Author profiling is an important statistical and semantic processing task in the field of natural language processing (NLP). It refers to the extraction of information from author's texts such as gender, age and other kinds of personality traits. Author profiling can be applied in various fields like marketing, security and forensics. In this work, we explore how bi-directional deep learning ar-chitectures can be used to learn the abstract and higher-level features of the document, which could be employed to identify the author's age author. To deal with this, we extend Bidirectional Long Short-Term Memory Networks Lan-guage Models with an attention mechanism. The originality of our approach lays in its ability to capture the most important semantic information in a sen-tence. The experimental results on Facebook and twitter corpus show that our method outperformed the majority of the existing methods

Artificial Intellegence in nanophotonics (IWANN workshop)

Self-configuring optical mesh networks

David Miller

Abstract: Integrated photonic platforms such as silicon photonics can now make very com-plex circuits. Such complexity could be very useful, allowing sophisticated linear processing at high speeds and with very low powers, as in arbitrary matrix multiplication, for example, using meshes of waveguide interferometers. Historically, though, it was difficult to exploit such complexity because the resulting interference of coherent light requires very precise fabrication and configuration. Recently, however, architectures have been invented together with algorithms that allow simple progressive setup, without prior calibration. Furthermore, some architectures support "self-configuration" – they can be trained directly with the beams they are supposed to "recognize" – and extensions allow the elements in the mesh to "perfect" themselves automatically, compensating for fabrication variations. Such networks may offer a broad range of possible applications, including linear processing, such as arbitrary matrix multipliers for neural networks, quantum processing, spatial mode multiplexing in communications, and sensor preprocessing.

Deep Learning for Design and Retrieval of Nano-photonic Structures

Itzik Malkiel, Michael Mrejen, Achiya Nagler, Uri Arieli, Lior Wolf and Haim Suchowski

Abstract: We harness the power of Deep Learning and show its ability to predict the ge-ometry of nanostructures based solely on their far-field response. This ap-proach addresses in a direct way the currently inaccessible inverse problem breaking the ground for on-demand design of optical response with applica-tions such as sensing, imaging and also for plasmon's mediated cancer thermo-therapy.

Greedy reinforcement learning in large photonic neural networks: empirical findings of convexity and scaling

Daniel Brunner

Abstract: We have recently succeeded in the implementation of a large scale recurrent photonic neural network hosting up to 2025 photonic neurons. All network internal and readout connections are physically implemented with fully parallel technology. Based on a digital micro-mirror array, we can train the Boolean readout weights using a greedy version of reinforcement learning. We find that the learning excellently converges. Furthermore, it appears to possess a conveniently convex-like cost-function and demonstrates exceptional scalability of the learning effort with system size.

Machine learning metamaterials with 98% experimental efficiency and 50 nm thickness for broadband vectorial light control

Fedor Getman, Maksim Makarenko, Andrea Fratalocchi and Arturo Burguete Lopez

Abstract: In this invited talk we review our recent research on machine learning met-amaterials for broadband control of vectorial light beams. These metastruc-tures are designed by a proprietary machine learning approach based on swarm intelligence, which runs on high performance supercomputers. The theoretical design approach exploits a formulation of Maxwell's equations based on a specific form of Fano-Feshback projection, which allows to ob-tain compact representation of the dynamics in terms of a set of fully exact time dependent equations, which describes a large networks of interacting modes. By using an artificial intelligence search in

the complex phase space of such large network of interacting resonances, we designed a new class of ultra-thin (50 nm) dielectric metasurfaces that are capable of controlling broadband light with experimentally reported efficiencies exceeding 90% in the whole visible window.

Designing nanophotonic structures using conditional- deep convolutional generative adversarial network

Junsuk Rho

Abstract: A data driven design approach based on deep learning have been introduced in nanophotonics to reduce time-consuming iterative simulations, which have been a main challenge. Here, we report the first use of conditional deep convolutional generative adversarial networks to design nanophotonic antennae that are not constrained to a predefined shape. For given input reflection spectra, the network generates desirable designs in the form of images; this form allows suggestions of new structures that cannot be represented by structural parameters. Simulation results obtained from the generated designs agreed well with the input reflection spectrum. The network is not limited to suggest predefined structures, but can also generate new designs. This method opens new avenues towards the development of nanophotonics by providing a fast and convenient approach to design complex nanophotonic structures that have desired optical properties. If time allows, I will discuss further topics of other applications using more advanced deep-learning techniques.

Machine-Learning-Assisted Topology Optimization for Refractory Photonics

Zhaxylyk Kudyshev, Alexander Kildishev, Vlad Shalaev and Alexandra Boltasseva

Abstract: In our work, we expand and streamline a conventional meta-device design methodology to a global optimization space by advancing topology optimi-zation via artificial-intelligence-assisted algorithms and tailorable materials platforms. We apply the developed optimization approach to design effi-cient refractory photonic components for thermophotovoltaic applications.

Metamaterial Computing Machines

Nader Engheta

Abstract: We explore how metamaterials and metastructures can perform analog computation with waves and how they can solve equations.

From inverse design to implementation of practical photonics

Logan Su and Jelena Vuckovic

Abstract: Nanophotonic inverse design has demonstrated devices that are more compact, more efficient, more robust, and have novel functionalities as compared to traditional photonic devices. We present SPINS, an inverse design software library developed in our lab over the past decade, and describe its capabilities, with particular emphasis on robustness and fabricability. We show designs and experimental demonstrations of a wide variety of devices, including ultra-compact wavelength splitters, on-chip particle accelerator, slow-light waveguides, and photonic devices for the diamond platform. Last, we present methods for accelerating the optimization process with machine learning.

Advances in Neuromorphic Photonics

Paul R. Prucnal, Alexander Tait, Mitchell Nahmias, Thomas Ferreira de Lima, Hsuan-Tung Peng and Bhavin Shastri

Abstract: Neuromorphic photonics is an emerging field at the nexus of photonics and neuroscience, which combines the advantages of optics and electronics. We will look at challenges of photonic information processing, describe photonic neural-network approaches, and offer a glimpse at this field's future.

Artificial-Intelligence-Assisted Approach for Speeding Up Quantum Optical Measurements

Zhaxylyk Kudyshev, Simeon Bogdanov, Theodor Isacsson, Alexander Kildishev, Alexandra Boltasseva and Vladimir Shalaev

Abstract: Single quantum emitters offer useful functionalities for quantum optics and sensing, but the characterization of their properties is time consuming due to low photodetection rates. We have demonstrated that machine learning assisted data analysis can dramatically reduce data collection time and increase accuracy for measurements of second-order fluorescence autocorrelation and optical spin readout in diamond nitrogen-vacancy centers.

Quantum Solids in Ultrafast Strong Laser Fields: Topological Nanophotonic Phenomena

Mark Stockman

Abstract: We present the latest theoretical predictions and recent experiments on behavior of novel quantum materials – two dimensional solids, topological insulators, and Weyl semimetals – in ultrafast, strong, chiral laser fields. This behavior is determined by the topology of the solids' reciprocal space. It opens new avenues in quantum physics and quantum information.

Smart Predictive Laser Materials Processing via Deep Learning

Ben Mills, Daniel Heath, James Grant-Jacob, Yunhui Xie, Benita Mackay, Michael McDonnell, Matthew Praeger and Robert W. Eason

Abstract: Femtosecond pulses enable materials processing at an extremely high-resolution, as multiphoton absorption can be leveraged to ablate single structures that are considerably smaller than the laser focus. However, repeatable fabrication at this resolution is challenging since the multiphoton processes are highly nonlinear and hence susceptible to experimental noise, such as variations in laser power or unpredictable debris. Here, we demonstrate the application of neural networks for the real-time monitoring and correction of parameters during laser machining.

Building a Materials and Device Data-Bases for the Development of Photonic Nano-Structures through Machine Learning

Brian Hayden

Abstract: The development of AI and Machine Learning tools for the dis-covery and development of materials relies of the generation of reliable da-ta-bases of the compositional, chemical and structural dependence of as wide a range of materials functions as possible. These data-bases have main-ly been generated from ab-initio calculation, with fewer produced experi-mentally trough combinatorial synthesis and high-throughput screening. Data-bases are relatively small, and latent variables governing performance obscure. A metric learning based methodology emphasizing similarity measures rather than fixed similarity measures, and the imposition of con-tinuity in the composition, can provide a way forward with such experi-mental data sets. An example of this will be provided for a high-throughput catalyst data-base. Also presented will be an example of a experimental photonic materials multi-functional data-base with the potential, through machine learning, of providing the basis of photonic nano-structure design.

Cognitive Photonic Networks

Cesare Soci

Abstract: Using different optical fiber and waveguide platforms, we give examples of natural computing in linear optical networks, like solving polynomial and nondeterministic polynomial problems, and in nonlinear optical networks, like metaheuristic optimization and neuromorphic computing.
Keywords: Optical fibre networks, Laser-written waveguides, Solitonic waveguides.
Summary
With the following examples we bring about a discussion on the potential of optical photonic networks to implement natural computing:
1. Matrix inversion computation with a telecom fibre network
2. Solution of the Hamiltonian path combinatorial problem with optical fibre and laser-written waveguide oracles
3. Neuromorphic all-optical synapses in amorphous metal-sulphide microfibers and laser-written chalcogenide waveguides
4. All-optical implementation of the ant colony optimization algorithm in Er-doped fibre networks and solitonic lithium niobate waveguides
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Topological photonic phases through artificial neural networks

Laura Pilozzi, Francis A. Farrelly, Giulia Marcucci and Claudio Conti

Abstract: We propose the use of artificial neural networks to design and characterize photonic topological insulators. As a hallmark, the band structures of these systems show the key feature of the emergence of edge states, with energies lying within the energy gap of the bulk materials and localized at the boundary between regions of distinct topological invariants. Our machine learning application can identify the parameters of a complex topological insulator to obtain protected edge states at target frequencies. The rapidly growing interest in the field of topological photonics [1] is leading to the study of more and more complex structures to explore the properties of topological insulators. This growth asks for novel computational techniques for the design of non-trivial photonic functionalities. Very challenging is to achieve an effective design methodology capable of solving the inverse problem and obtain desired optical properties from topological features [2]. Various methodologies are available, but these tend to be very specific for the task at hand. Artificial intelligence techniques can give new design tools, and their recent growth in sophistication offers exciting perspectives for the field of topological photonics. Artificial neural networks can be trained to solve the inverse problem of designing photonic topological insulators, modeling the multidimensional nonlinear relationships among the many structure parameters, whose custom tailoring can enable enhanced innovative applications. In the neural network architecture, an appropriate label's choice makes it possible to handle multivalued branches of the direct problem. The edge state frequency is indeed a multi-mode function that can be unfolded by introducing

additional categorical labels. A feature of this approach is the introduction of a self-consistent cycle in which a tentative solution, obtained from the inverse problem, and run through the direct problem, ensure that the solution obtained is indeed viable.

Nanophotonic Architecture for Machine Learning Hardware

Marina Radulaski, Ranojoy Bose, Tho Tran, Thomas Van Vaerenbergh and Raymond Beausoleil

Abstract: We develop a thermally tunable hybrid photonic architecture for applications in machine learning. The architecture comprises GaAs photonic crystal cavities, SiNx grating couplers and waveguides, and chromium microheaters and is designed for implementation of nonlinear optical circuits.

Analog computing with optical excitations in the near field

Javier García de Abajo

Abstract: We will discuss the potential of near-field interactions between optical excitations for the implementation of analog problem solvers with applications in graph optimization and other complex functions. Challenges and possible solutions to dynamically implement specific solvers will be also discussed based upon intensity and phase spatial imprinting based upon external stimuli such as focused light beams, electron beams, and the interactions between them.

Introduction to Office of Naval Research Global - Naval Science and Technology International Office

Predrag Milojkovic

Abstract: I will present basic facts about history, structure, mission, and objectives of Office of Naval Research Global – US Naval Science and Technology International Office. ONR Global provides worldwide outreach to the various international science and technology communities, providing funding for the cutting edge research and science of relevance to the US Navy. ONR Global funds international research with grants, and can also fund visits of foreign scientists to the US, as well as support conferences and workshops throughout the world. We are strictly funding fundamental research only. I will also talk about my portfolio and interests as a Science Director in London office of ONR Global.

Coherent Ising Machine - Optical Neural Network operating at the Quantum Limit

Satoshi Kako and Yoshihisa Yamamoto

Abstract: We will present the basic concept, operational principle and implementation of a coherent Ising machine based on network of degenerate optical parametric oscillators. The machine with 2048 spins with all-to-all connections demonstrated competitive performance against modern digital computers.
There are at least three quantum computational models proposed today: unitary quantum computation [1,2], adiabatic quantum computation [3,4] and dissipative quantum computation [5,6]. A gate model quantum computer implements the unitary quantum computational model and is expected to solve efficiently problems with hidden periodicity or specific structure, while a coherent Ising machine (CIM) implements the dissipative quantum computational model and is expected to solve efficiently unstructured combinatorial optimization problems. There are two types of CIMs, optical delay line coupling machine [7-9] and measurement feedback coupling machine [10,11]. We will discuss the performance comparison against modern digital computers and algorithms [12] (Figure 1). Figure 1: Energy vs. time for coherent Ising machine and supercomputer against N = 2000 Sherrington-Kirkpatrick spin glass problem.
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Deep reservoir computing in tumor cells and Ising machines by spatial light modulators

Claudio Conti

Abstract: We review our recent work on the realization of optical computing machines by spatial light modulation. First, we show how to realize large-scale spatial Ising machines by a simple feedback mechanism. We simulate mean-field Ising and Mattis spin glasses. We then discuss the equivalence between light transmission through random media and deep reservoir com-puting. We report experiments by three-dimensional living tumor models embedded in an optical neural network able to calculate the metabolism and other quantities of interest for the tumor morphodynamics, also in the pres-ence of chemotherapy.
Keywords: Reservoir Computing, Random Neural Networks, Ising machines

1 Spatial Ising Machines by a simple spatial light modulator

The number of internal states in models for complex systems grows exponentially with the size. Optimization problems involving these models are classified as NP-hard and cannot be tackled efficiently by standard computing architectures. The search of the ground state of an ensemble of interacting spins, i.e., the minimization of an Ising Hamiltonian is a paradigmatic model, as recently considered by many authors (see references in [1]). Novel photonic platforms with many accessible spin-like variables are particularly interesting, as optical computing machines offer high-speed and scalability.

However, using spatial optical modulation to solve Ising spin dynamics has re-mained unexplored. Here, we propose and experimentally demonstrate the use of spatial light modulation for calculating the ground state of an Ising Hamiltonian. The phase matrix on a spatial light modulator (SLM) acts as a lattice of spins whose interaction is ruled by the constrained optical intensity in the far-field. Feedback from the detection plane allows the spatial phase distribution to evolve towards the minimum of the selected spin model. We find ferromagnetic-like ground-states in agreement with mean-field predictions. Our spatial Ising machine hosts thousands of parallelly-processed spins and represents a scalable and efficient approach for pho-tonic computing.

2 Deep reservoir computing by living tumor cells

The new era of artificial intelligence demands large-scale ultrafast hardware for machine learning. Optical artificial neural networks process classical and quantum information at the speed of light, and are compatible with silicon technology, but need expensive manufacturing of many computational layers (see references in [2]). New paradigms, as reservoir computing and the extreme learning machine, suggest that disordered and biological materials may realize artificial neural networks with thousands of computational nodes trained only at the input and at the readout. Here we employ biological complex systems, i.e., living three-dimensional tumor brain models, and demonstrate a random optical machine trained to detect tumor morpho-dynamics via image transmission. The tumor spheroid, as a three-dimensional deep computational reservoir, performs programmed optical functions, measures the me-tabolism, and detects cancer morphodynamics from laser-induced hyperthermia. Moreover, the random optical machine quantifies the effect of chemotherapy inhib-iting tumor growth. Our random and hybrid photonic/living system is a novel artifi-cial machine for computing and the real-time investigation of tumor dynamics. References:

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