# WSOM+ 2017

## 12th International Workshop on Self-Organizing Maps and Learning Vector Quantization, Clustering and Data Visualization

**Loria, Nancy, France - *28-30 June 2017***

# Local Organizing Committee

- **Olivia Brenner**, communication manager, *olivia.brenner@loria.fr*
- **Marie Cottrell**, SAMM, Panthéon Sorbonne University, Paris,*marie.cottrell@univ-paris1.fr*
- **Jean-Charles Lamirel**, Synalp Project, LORIA &University of Strasbourg, *lamirel@loria.fr*
- **Madalina Olteanu**, SAMM, Panthéon Sorbonne University, Paris, *madalina.olteanu@univ-paris1.fr*
- **Virginie Priester**, research assistant, *virginie.priester@loria.fr*

Do not hesitate to contact any member of our local organizing committee, if you have any issues during the conference.

# Forewords

WSOM+2017 is the 12th in a series of biannual international conferences started with WSOM '97 in Helsinki. The series of WSOM meetings was initiated by Teuvo Kohonen, the creator of SOM and LVQ models. WSOM+2017 conference will be held in the city of Nancy, world famous for its group of architectural masterpieces inscribed on the UNESCO World Heritage and for the highly creative 20$^{th}$ century “Art Nouveau” movement.

The conference is co-organized by the research laboratories SAMM, Université Paris 1 Panthéon – Sorbonne, and LORIA, Nancy. SAMM (formerly named SAMOS) was the successful organizer of the WSOM 2005 edition and also played an important part in the development and the adaptations related to the SOM approach. LORIA, the host of the WSOM+2017 conference, is the main research center of the French Eastern region, gathering researchers that are concerned both by theoretical aspects of computer science and by applied research.

The new edition of the conference will extend its scope from the traditional domain on Self-Organizing Maps and Learning Vector Quantization to the general domain of Unsupervised Learning as well as to the promising and hot domain of Visualization. It will highlight key advances in these fields. The conference will guest 6 invited talks from renowned speakers: Pascal Massart (*Université Paris Sud*), Jean-Daniel Fekete (*INRIA* and *Université Paris Sud*), Etienne Côme (*IFSTTAR, Paris*), Nathalie Villa (*INRA Toulouse*), Alfredo Vellido (*Universidad Politécnica de Cataluña*) and Yann Guermeur (*LORIA, Nancy*).

The conference will include seven different sessions: three conference sessions are dedicated to theoretical aspects of SOM, LVQ, neural gas and learning models, three conference sessions are dedicated to applications of the models and one session mixes theoretical and practical aspects of learning for image and signal processing. Thirty-four papers will be presented, containing contributions of more than one hundred authors.

We wish a great conference to all our speakers and participants.

Marie Cottrell Jean-Charles Lamirel Madalina Olteanu

# Conference steering committee

Teuvo Kohonen (Finland) Honorary General Chairman

Marie Cottrell (France), Pablo Estevez (Chili), Timo Honkela (Finland), Thomas Martinetz (Germany), Erzsebet Merenyi (USA), Michel Verleysen (Belgium), Thomas Villmann (Germany), Takeshi Yamakawa (Japan), Hujun Yin (UK)

# Program committee

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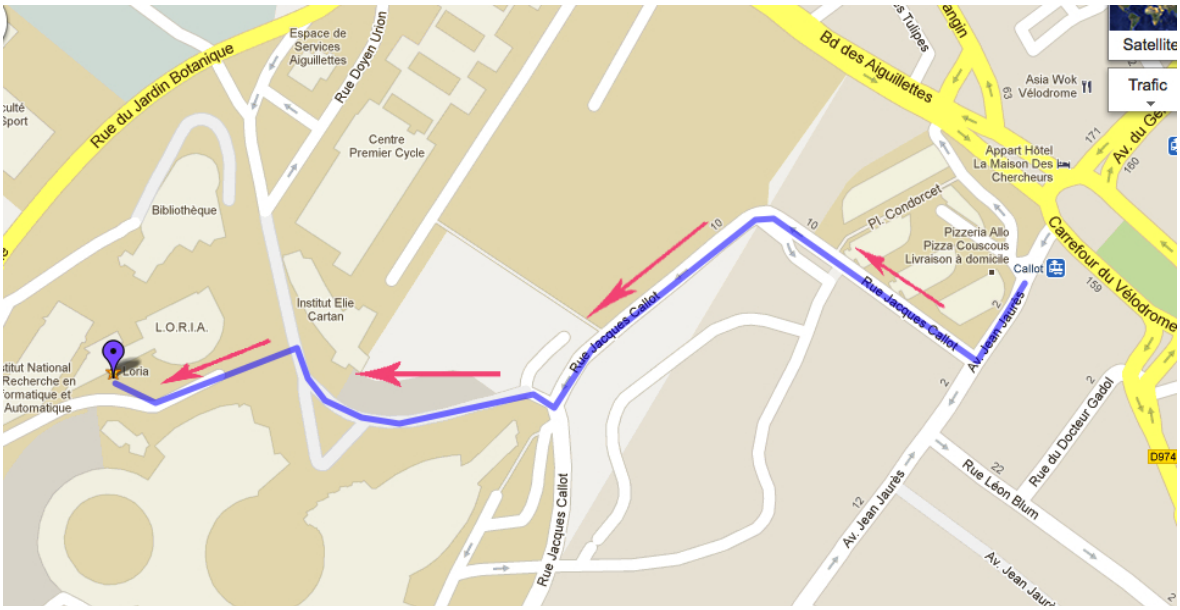
# Contents

# Conference location and venue

## By tram from Nancy

- Take tram T1 from “Nancy Gare” in the direction of Vandoeuvre-CHU (9 stops, 15 mins)
- **Get off at the “Callot” stop and 10 mins walk:**
  - Head in the direction of Lycée Jacques Callot
  - Head up towards the “Campus Sciences”
  - Go through the campus access barrier
  - Cross the car park and LORIA is in front of you

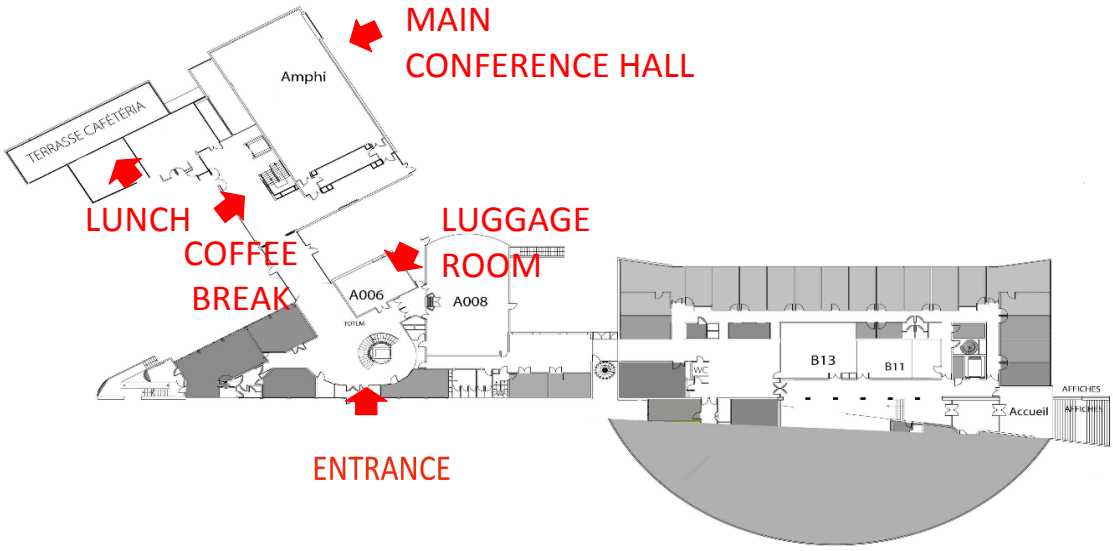



**More information (venue, hotels, restaurants) can be found on the [LORIA WEB site]**

**http://wsom2017.loria.fr/infos-pratiques/**

# Practical information

**WSOM+2017 –JUNE 28-30**




The conference takes place in the auditorium "Gilles Kahn".Coffee breaks are served in Hall C, near the auditorium.The luggage can be stored in room A006 "Jacques-Louis Lions". Lunches will be served in the cafeteria of the main building.

The departure by bus for the guided tour in Nancy and the Welcome Party at the “Université de Lorraine” (Wednesday, June 28, at 17:00) and for the Epinal Tour and Gala Dinner (Thursday, June 29, at 14:00) are fixed at the LORIA building entrance.

WIFI access will be available for each participant.

# WSOM+2017

# Program

***Wednesday, June 28th2017***

| | |
|---|---|
| **8H00-8H30** | **Registration** |
| **8H30-9H00** | **Welcome speech** |
| **9H00-10H00** | **Invited talk 1: Pascal MASSART** |
| **10H00-10H20** | **Coffee break** |
| **10h20-11h20** | **Invited talk 2: Jean-Daniel FEKETE** |
| **11H20-13H00** | **Session 1:Theoretical Aspects 1** |
| **13H00-14H00** | **Lunch** |
| **14H00-15H00** | **Invited talk 3: Etienne COME** |
| **15H00-15H20** | **Poster spotlights** |
| **15H20-16H00** | **Poster session and coffee break** |
| **16H00-17H00** | **Session 2: Image and Signal** |
| | |
| **17H30-19h00** | **Guided tour in Nancy** |
| **19H00** | **Welcome Party at the Lorraine University** |

***Thursday June 29th 2017***

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|---|---|
| **9H00-10H00** | **Invited talk 4: Nathalie VILLA-VIALANEIX** |
| **10H00-11H00** | **Session 3: Applications to real world problems** |
| **11h00-11h20** | **Coffee Break** |
| **11H20-13H** | **Session 4: Theoretical Aspects 2** |
| **13h00-14H00** | **Lunch** |
| **14H00** | **Departure for Epinal** |
| | **Visits** |
| | **Gala dinner** |

***Friday June 30th 2017***

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|---|---|
| **9H00-10H00** | **Invited talk 5: Alfredo VELLIDO** |
| **10H00-11H20** | **Session 5: Applications in Social Sciences** |
| **11H20-11H40** | **Coffee break** |
| **11H40-13H00** | **Session 6 :LVQ** |
| **13H00-14H00** | **Lunch** |
| **14H00-15H20** | **Session 7: Relational Networks and Neural Gas** |
| **15H20-16H20** | **Invited talk 6: Yann GUERMEUR** |
| **16H20-...** | **Closing, Posters, Coffee break** |

*20 minutes for each contribution, including answers to questions (15 +5).*

# Conference Schedule

**Wednesday, June 28**

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**8:00** **Registration**

**8:30** **Welcome speech**

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**9:00** **Invited talk**

**Estimator selection: the calibration issue**

Pascal Massart, *Université Paris Sud*

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**10:00** **Coffee break**

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**10:20** **Invited talk**

**Visualization of Complex Networks**

Jean-Daniel Fekete, *INRIA, Université Paris Sud*

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**Session 1** **Theoretical Aspects 1**

**11:20** **Motivated Self-Organization**

Nicolas Rougier[1] and Yann Boniface[2]

*[1]Inria Bordeaux Sud-Ouest, Talence, France,*

*[2]Loria - Vandoeuvre-lès-Nancy, France*

**11:40** **Fault Tolerance of Self Organizing Maps**

Cesar Torres-Huitzil[1], Oleksandr Popovych[2,3] and Bernard Girau[3]

*[1]Cinvestav Tamaulipas, Mexico,*

*[2]Igor Sikorsky KPI, Ukraine,*

*[3]University of Lorraine / LORIA, France*

**12:00** **An evolutionary building algorithm for Deep Neural Network**

Ryad Zemouri

*Conservatoire National des Arts et Métiers, Cedric-Lab, France*

**12:20** **Visualizing Data Sets on the Grassmannian Using Self-Organizing Mappings**

Michael Kirby and Chris Peterson

*Department of Mathematics, Colorado State University, USA*

**12:40 SOM-empowered Graph Segmentation for Fast Automatic Clustering of Large and Complex Data**

Erzsébet Merényi[1] and Joshua Taylor[2]

[1]*Department of Statistics and Department of Electrical and Computer Engineering, Rice University, Houston, Texas, USA,*

[2]*Department of Statistics, Rice University, Houston, Texas, USA*

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**13:00 Lunch**

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**14:00 Invited talk**

**Generative models for urban mobility analysis**

Etienne Côme, *IFSTTAR, France*

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**Poster Spotlights**

**Poster 1 Self-Organizing Maps as A Tool for Segmentation of Magnetic Resonance Imaging (MRI) of Relapsing-Remitting Multiple Sclerosis**

Paulo Afonso Mei[1], Cleyton De Carvalho Carneiro[2], Michelle Chaves Kuroda[3], Li Li Min[4], Stephen Fraser[1] and Fabiano Reis[1]

[1]*Faculty of Medicine, University of Campinas, Brazil,*

[2] *Faculty of Engineering, University of Sao Paulo, Brazil,*

[3]*Faculty of Geology, University of Campinas, Brazil,*

[4]*CSIRO, Australia*

**Poster 2 Pairwise Elastic Self-Organizing Maps**

Pitoyo Hartono and Yuto Take,

*School of Engineering, Chukyo University, Nagoya, Japan*

**Poster 3 Using SOMbrero to Examine the Economic Convergence of European Countries from 2001-2013**

Joel Deichmann, Dominique Haughton, Abdolreza Eshghi and Mingfei Li

*Data Analytics Research Team, Bentley University, Waltham, USA*

**Poster 4 Imputation of Reactive Silica and Available Alumina in Bauxites by Self-Organizing Maps**

Cleyton de Carvalho Carneiro[1], Dayana Niazabeth Del Valle Silva Yanez[2], Carina Ulsen[2], Stephen J. Fraser[3], Juliana Lívi Antoniassi[1], Simone P. A. Paz[4], Rômulo Simões Angélica[5] and Henrique Kahn[1]

[1]*Universidade de São Paulo, Dpto. de Engenharia de Minas e de Petróleo, Brazil,*

[2]*Universidad Simón Bolívar, Dpto. Ciencias de la Tierra, Brazil,*
[3]*CSIRO, Queensland Centre for Advanced Technologies, Australia,*
[4]*Universidade Federal do Pará, Faculdade de Engenharia de Materiais, Brazil,*
[5]*Universidade Federal do Pará, Instituto de Geociências, Brazil*

**Poster 5 Fusion of Deep Learning Architectures, Multilayer Feedforward Networks and Learning Vector Quantizers for Deep Classification Learning**

Thomas Villmann[1], Michael Biehl[2], Andrea Villmann[3] and Sascha Saralajew[4]
[1]*University of Applied Sciences Mittweida, CIG, Germany,*
[2]*University Groningen, Intelligent Systems Group, The Netherlands,*
[3]*Berufliches Schulzentrum Döbeln-Mittweida, Germany,*
[4]*Porsche AG, Electr./ Electronics Eng. - Driver Assistance Platform/ Systems, Weissach, Germany*

**Poster 6 Credible Visualizations for Planar Projections**

Alfred Ultsch and Michael Thrun
*DataBionics Research Group, University of Marburg, Germany*

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**15:20 Poster session and coffee break**

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**Session 2 Image and Signal**

**16:00 Applying the significance degree by SOM to Image Analysis of Fundus using the Filter Bank**

Nobuo Matsuda[1,],Heizo Tokutaka[2], Hideaki Sato[3], Fumiaki Tajima[4] and Reiji Kawata[5]
[1]*Dept. of Electrical and Electronic Engineering, Toyota College, Japan,*
[2]*SOM Japan Inc., Japan,*
[3]*Sato Hideaki Internist Clinic, Tachikawa, Japan,*
[4]*Dept. of Education and Human Science, Yokohama National University, Japan,*
[5]*Kawata Clinic, Iwakuni, Japan*

**16:20 Using Spatial Characteristics to aid Automation of SOM Segmentation of Functional Image Data**

Patrick O'Driscoll[1], Erzsébet Merényi[2] and Robert Grossman[3]
[1]*Department of Statistics, Rice University, Houston, Texas, USA,*
[2]*Department of Statistics and Department of Electrical and Computer Engineering, Rice University, Houston, Texas, USA,*

[3]*Department of Neurosurgery, Houston Methodist Neurological Institute, Houston, Texas, USA*

**16:40 Using Self-Organizing Maps for Clustering and Labelling Aircraft Engine Data Phases**

Cynthia Faure[1], Madalina Olteanu[1], Jean-Marc Bardet[1] and Jérôme Lacaille[2]
[1]*SAMM, Panthéon Sorbonne University, France,*
[2]*Safran Aircraft Engines, Moissy Cramayel, France*

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**17:00 Social Program: Guided Tour in Nancy**

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**19:00 Welcome Party at the Lorraine University**

**Thursday, June 29**

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**9:00** **Invited talk**

**Stochastic Self-Organizing Map variants with the R package SOMbrero**

Nathalie Villa-Vialaneix**,***INRA, Toulouse*

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**Session 3** **Applications to real world problems**

**10:00** **Application of Self Organizing Map to identify Nocturnal Epileptic Seizures**

Barbara Pisano[1], Alessandra Fanni[1], César Alexandre Teixeira[2] and António Dourado[2]

[1]*Department of Electrical and Electronic Engineering, University of Cagliari C, Italy,*

[2]*CISUC- Department of Informatics Engineering, University of Coimbra, Portugal*

**10:20** **Detection of Short Circuit Faults in 3-Phase Converter-Fed Induction Motors Using Kernel SOMs**

David N. Coelho[1], Guilherme Barreto[1] and Cláudio M. S. Medeiros[2]

[1]*Federal University of Ceara, Department of Teleinformatics Engineering, Fortaleza, Ceara, Brazil,*

[2]*Federal Institute of Ceara, Industry Department, Fortaleza, Ceara, Brazil*

**10:40** **Self-Organizing Map for Orienteering Problem with Dubins Vehicle**

Jan Faigl

*Czech Technical University in Prague, Computer Science, Czech Republic*

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**11:00** **Coffee Break**

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**Session 4** **Theoretical aspects 2**

**11:20** **An energy-based SOM model not requiring periodic boundary conditions**

Alexander Gepperth,

*University of Applied Sciences Fulda, Germany*

**11:40 Prototypes and Matrix Relevance Learning in Complex Fourier Space**

Michiel Straat[1], Marika Kaden[2], Matthias Gay[2,4], Thomas Villmann[2], Alexander Lampe[2], Udo Seiffert[3], Michael Biehl[1] and Friedrich Melchert[1,3]

*[1]University of Groningen, The Netherlands,*

*[2]University of Applied Sciences Mittweida, CIG, Germany,*

*[3]Fraunhofer Institute for Factory Operation and Automation IFF, Magdeburg, Germany,*

*[4]Fraunhofer Institute for Transportation and Infrastructure Systems IVI, Dresden, Germany*

**12:00 Adaptive Basis Functions for Prototype-based Classification of Functional Data**

Gabriele Bani[1], Udo Seiffert[2], Michael Biehl[3] and Friedrich Melchert[2,3]

*[1]University of Modena and Reggio Emilia, 41125 Modena, Italy,*

*[2]Fraunhofer Institute for Factory Operation and Automation IFF, Magdeburg, Germany,*

*[3]University of Groningen, Johann Bernoulli Institute for Mathematics and Computer Science, The Netherlands*

**12:20 Incremental learning with self-organizing maps**

Alexander Gepperth[1] and Cem Karaoguz[2]

*[1]University of Applied Sciences Fulda, Germany,*

*[2]ENSTA ParisTech, Palaiseau, France*

**12:40 Self-Organizing Maps with supervised layer**

Ludovic Platon, Farda Zehraoui and Tahi Fariza

*IBISC laboratory, UEVE/Genopole/Université Paris-Saclay, Evry, France*

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**13:00 Lunch**

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**14:00 Social Program**

**Tour to Epinal, its Museum**

**Conference Dinner, Restaurant la Chaumière, à Chantraine-Epinal**

**Friday, June 30**

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**9:00** **Invited talk**
**The eye of the beholder : visualization and interpretability in practical applications**
Alfredo Vellido**,** *Universidad Politécnica de Cataluña*

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**Session 5** **Applications to real world problems**

**10:00** **Improving Individual Predictions using Social Networks Assortativity**
Dounia Mulders[1], Cyril de Bodt[2], Johannes Bjelland[2], Alex Pentland[3], Michel Verleysen[1] and Yves-Alexandre de Montjoye[3,4]
[1]*ICTEAM Institute, UCL, Belgium,*
[2]*Telenor Research, Belgium,*
[3]*MIT Media Lab, MIT, USA,*
[4]*Data Science Institute and Department of Computing, Imperial College, UK*

**10:20** **Multidimensional urban segregation: an exploratory case study**
Marie Cottrell[1], Madalina Olteanu[2], Aurélien Hazan[2] and Julien Randon-Furling[1]
[1]*Université Paris 1 Panthéon-Sorbonne, SAMM, France,*
[2]*Université Paris-Est, LISSI, Lieusaint, France*

**10:40** **International Trade and the Propagation of Merger Waves**
M. Farooq Ahmad[1], Eric de Bodt[2] and Jarrad Harford[3]
[1]*IESEG School of management, Paris, France,*
[2]*Université Lille 2, France,*
[3]*University of Washington, Seattle, USA*

**11:00** **Metaheuristic Optimization for Automatic Clustering of Customer-Oriented Supply Chain Data**
César L. C. Mattos[1], Guilherme A. Barreto[1], Dennis Horstkemper[2] and Bernd Hellingrath[2]
[1]*UFC, Department of Teleinformatics Engineering, Fortaleza, Ceara, Brazil,*
[2]*WWU, Institut fur Wirtschaftsinformatik - ERCIS, Münster, Germany*

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**11:20** **Coffee Break**

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**Session 6 LVQ**

**11:40 Small sets of random Fourier features by Kernelized Matrix LVQ**

Frank-Michael Schleif

*University of Applied Sciences Würzburg-Schweinfurt,SCS, Germany,*
*CIG, University of Applied Sciences Mittweida, Germany,*
*University of Birmingham,School of Computer Science, UK*

**12:00 Empirical Evaluation of Gradient Methods for Matrix Learning Vector Quantization**

Michael Lekander[1], Michael Biehl[1] and Harm de Vries[2]

*[1]University of Groningen, Johann Bernoulli Institute for Mathematics and Computer Science, The Netherlands,*
*[2]Université de Montréal, Québec*

**12:20 Probabilistic extension and reject options for pairwise LVQ**

Johannes Brinkrolf and Barbara Hammer

*Bielefeld University, CITEC centre of excellence, Germany*

**12:40 Spectral Regularization in Generalized Matrix Learning Vector Quantization**

David Nova[1] and Pablo A. Estevez[2]

*[1]Millennium Institute of Astrophysics &Department of Electrical Engineering, University of Chile, Chile,*
*[2]Department of Electrical Engineering, University of Chile &Millennium Institute of Astrophysics, Chile*

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**13:00 Lunch**

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**Session 7 Relational networks and Neural Gas**

**14:00 Data Dependent Evaluation of Dissimilarities in Nearest Prototype Vector Quantizers Regarding Their Discriminating Abilities**

Marika Kaden[1], David Nebel[1], Friedrich Melchert[2,3], Andreas Backhaus[2], Udo Seiffert[2] and Thomas Villmann[1]

*[1]University of Applied Sciences Mittweida, Germany,*
*[2]Fraunhofer IFF Magdeburg, Biosystems Engineering, Germany,*
*[3]University Groningen, Intelligent Systems Group, The Netherlands*

**14:20 Nonlinear dynamic identification using supervised neural gas algorithm**

Iván Machón-González and Hilario López-García

*Department of Electrical, Electronic, Computers and Systems Engineering, University of Oviedo, Spain*

**14:40 Relational and Median Variants of Fuzzy c-Means**

Tina Geweniger and Thomas Villmann

*ACSB, University of Applied Sciences Mittweida, Germany*

**15:00 A Strategy for Time Series Prediction using Segment Growing Neural Gas**

Jorge R. Vergara[1] and Pablo A. Estévez[2]

[1]*Millennium Institute of Astrophysics, Santiago, Chile*

[2]*Department of Electrical Engineering, University of Chile, Santiago, Chile,*

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**15:20 Invited talk**

**Rademacher Complexity of Margin Multi-category Classifiers**

Yann Guermeur**,** *LORIA, Nancy, France*

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**16:20 Closing, Posters, Coffee Break**

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# Sponsors

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# ABSTRACTS
## Invited talks

**Estimator selection: the calibration issue**
Pascal Massart, *Université Paris Sud*

*Abstract*: Estimator selection has become a crucial issue in non parametric estimation. Two widely used methods are penalized empirical risk minimization (such as penalized log-likelihood estimation) or pairwise comparison (such as Lepski's method). Our aim in this talk is twofold. We shall first give some general ideas about the calibration issue of estimator selection methods. We shall review some known results, putting the emphasis on the concepts of minimal and optimal penalties which are helpful to design data-driven selection criteria. Secondly we shall present a new method for bandwidth selection within the framework of kernel density estimation which is in some sense intermediate between these two main methods mentioned above. We shall provide some theoretical results which lead to some fully data-driven selection strategy.

**Visualization of Complex Networks**
Jean-Daniel Fekete, *INRIA, Université Paris Sud*

*Abstract*: Network visualization is progressing at a fast pace, allowing large, complex, dynamic networks to be visualized and explored interactively. However, outside of the visualization field, the old-fashioned network visual representation is still dominant. I will show how research, from my group at Inria and others, have tackled the problem and provided new solutions. These solutions are built on several grounds: HCI, visualization, graph theory, and more recently image processing and machine-learning to evaluate the effectiveness of the visual representations for different tasks. I will show examples of applications from various fields such as social network analysis and brain functional network analysis.

**Generative models for urban mobility analysis**
Etienne Côme, *IFSTTAR, France*

*Abstract*: The development of smart technologies and the advent of new observation capabilities have increased the availability of massive urban datasets that can greatly benefit urban studies. For example, a large amount of urban data is collected by various sensors, such as smart meters, or provided by GSM, Wi-Fi or Bluetooth records, ticketing data, geo-tagged posts on social networks, etc. Analysis of such digital records can help to build decision-making tools (for analytical, forecasting and display purposes) with a view to better understanding the operating of urban systems, to enable urban stakeholders to plan better when extending infrastructures and to provide better services to citizens. Although some of the devices used to record these datasets were not initially designed for the analysis of urban mobility, their usefulness is obvious. We will detail several analyses of such massive datasets using generative modeling tools which are particularly well suited to encode prior knowledge available on the task at hand. Our presentation will focus on the analysis of Bike-Sharing data and ticketing logs with cases study in Rennes and Paris.

**Stochastic Self-Organizing Map variants with the R package SOMbrero**
Nathalie Villa*, INRA, Toulouse*

*Abstract*: Self-Organizing Maps (SOM) are a popular clustering and visualization algorithm. Several implementations of the SOM algorithm exist in different mathematical/statistical softwares, the main one being probably the SOM Toolbox [Kohonen, 2014]. In this presentation, we will introduce an **R** package, *SOMbrero*, which implements several variants of the stochastic SOM algorithm. The package includes several diagnosis tools and graphics for interpretation of the results and is provided with a complete documentation and examples.

**The eye of the beholder: visualization and interpretability in practical applications**
Alfredo Vellido, *Universidad Politécnica de Cataluña*

*Abstract*: Modern data science has knowledge discovery processes at its core. The road from raw data to manageable information and, from there, to

knowledge extraction is by no means straightforward. In many practical applications of data analysis, knowledge extraction may not even be enough by itself, unless such knowledge is shown to be actionable. Machine Learning, hand in hand with Statistics, is playing an increasingly important role in these applications. Such role is likely to be curtailed, though, unless we guarantee the interpretability of models and results. At a moment in time in which society at large and the natural sciences have become data-rich, interpretability becomes key, as legislation at the European Union level is about to be passed that will grant subjects a "right to explanation", guaranteeing individuals the right to ask for an explanation of any algorithmic decision made about them. This brief talk will focus on unsupervised learning and visualization to illustrate the problem of model interpretability. It will draw examples mostly from the field of biomedicine, in which interpretability can be a hard constraint on the applicability of Machine Learning methods.

**Rademacher Complexity of Margin Multi-category Classifiers**

Yann Guermeur, *LORIA, Nancy, France*

*Abstract*: In the framework of agnostic learning, one of the main open problems of the theory of multi-category pattern classification is the characterization of the way the confidence interval of a guaranteed risk should vary as a function of the fundamental parameters which are the sample size *m* and the number *C* of categories. This is especially the case when working under minimal learnability hypotheses. We consider margin classifiers based on classes of vector-valued functions with one component function per category. The classes of component functions are uniform Glivenko-Cantelli and the vector-valued functions take their values in a hypercube of *R^C*. For these classifiers, a well-known guaranteed risk based on a Rademacher complexity applies. Several studies have dealt with the derivation of an upper bound on this complexity. This article establishes a bound which is based on a new generalized Sauer-Shelah lemma. Under the additional assumption that the \gamma-dimensions of the classes of component functions grow no faster than polynomially with \gamma^-1, its growth rate with *C* is a *O*(\sqrt (*C*) \ln (*C*). This behaviour holds true irrespective of the degree of the polynomial.

# Session 1 Theoretical aspects_1

**Motivated Self-Organization**

Nicolas Rougier[1] and Yann Boniface[2]
*[1]Inria Bordeaux Sud-Ouest, Talence, France, [2]Loria - Vandoeuvre-lès-Nancy, France*

*Abstract*—We present in this paper a variation of the self-organizing map algorithm where the original time-dependent (learning rate and neighborhood) learning function is replaced by a time-invariant one. The resulting self-organization does not fit the magnification law and the final vector density is not directly proportional to the density of the distribution. This leads us to introduce the notion of motivated self-organization where the self-organization is biased toward some data thanks to a supplementary signal. From a behavioral point of view, this signal may be understood as a motivational signal allowing a finer tuning of the final self-organization where needed. We illustrate this behavior through a simple robotic arm setup.

**Fault Tolerance of Self Organizing Maps**

Cesar Torres-Huitzil[1], Oleksandr Popovych[2,3] and Bernard Girau[3]
*[1]Cinvestav Tamaulipas, Mexico, [2]Igor Sikorsky KPI, Ukraine, [3]University of Lorraine / LORIA, France*

*Abstract*—As the quest for performance confronts resource constraints, major breakthroughs in computing efficiency are expected to benefit from unconventional approaches and new models of computation such as brain-inspired computing. Beyond energy, the growing number of defects in physical substrates is becoming another major constraint that affects the design of computing devices and systems. Neural computing principles remain elusive, yet they are considered as the source of a promising paradigm to achieve fault-tolerant computation. Since the quest for fault tolerance can be translated into scalable and reliable computing systems, hardware design itself and the potential use of faulty circuits have motivated further the investigation on neural networks, which are potentially capable of absorbing some degrees of vulnerability based on their natural properties. In this paper, the fault tolerance properties of Self Organizing Maps (SOMs) are investigated. To assess the intrinsic fault tolerance and considering a general fully parallel digital implementations of SOM, we use the bit-flip fault model to inject faults in registers holding SOM weights. The distortion measure is used to evaluate

performance on synthetic datasets and under different fault ratios. Additionally, we evaluate three passive techniques intended to enhance fault tolerance of SOM during training/learning under different scenarios.

**An evolutionary building algorithm for Deep Neural Network**

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*Abstract*—The increase of the computer power has contributed significantly to the development of the Deep Neural Networks. However, the training phase is more difficult since there are many hidden layers with many connections. The aim of this paper is to improve the learning procedure for Deep Neural Networks. A new method for building an evolutionary DNN is presented. With our method, the user does not have to arbitrary specify the number of hidden layers nor the number of neurons per layer. Illustrative examples are provided to support the theoretical analysis.

**Visualizing Data Sets on the Grassmannian Using Self-Organizing Mappings**

Michael Kirby and Chris Peterson
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*Abstract*—We extend the self-organizing mapping algorithm to the problem of visualizing data on Grassmann manifolds. In this setting, a collection of k points in n-dimensions is represented by a k-dimensional subspace, e.g., via the singular value or QR-decompositions. Data assembled in this way is challenging to visualize given abstract points on the Grassmannian do not reside in Euclidean space. The extension of the SOM algorithm to this geometric setting only requires that distances between two points can be measured and that any given point can be moved towards a presented pattern. The similarity between two points on the Grassmannian is measured in terms of the principal angles between subspaces, e.g., the chordal distance. Further, we employ a formula for moving one subspace towards another along the shortest path, i.e., the geodesic between two points on the Grassmannian. This enables a faithful implementation of the SOM approach for visualizing data consisting of k-dimensional subspaces of n-dimensional Euclidean space. We illustrate the resulting algorithm on a hyperspectral imaging application.

**SOM-empowered Graph Segmentation for Fast Automatic Clustering of Large and Complex Data**

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*Abstract*—Many clustering methods, including modern graph segmentation algorithms, run into limitations when encountering "Big Data", data with high feature dimensions, large volume, and complex structure. SOM-based clustering has been demonstrated to accurately capture many clusters of widely varying statistical properties in such data. While a number of automated SOM segmentations have been put forward, the best identifications of complex cluster structures to date are those performed interactively from informative visualizations of the learned SOM's knowledge. This does not scale for Big Data, large archives or near-real time analyses for fast decision-making. We present a new automated approach to SOM-segmentation which closely approximates the precision of the interactive method for complicated data, and at the same time is very fast and memory-efficient. We achieve this by infusing SOM knowledge into leading graph segmentation algorithms which, by themselves, produce extremely poor results segmenting the SOM prototypes. We use the SOM prototypes as input vectors and CONN similarity measure, derived from the SOM's knowledge of the data connectivity, as edge weighting to the graph segmentation algorithms. We demonstrate the effectiveness on synthetic data and on real spectral imagery.

# Session 2 Image and Signal

**Applying the significance degree by SOM to Image Analysis of Fundus using the Filter Bank**

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*Abstract*—This paper describes the filtering effects on classification performance with applying significance degree by SOM to the image analysis

using filter bank preprocessing and Subspace Classifier. In our proposed method, a series of analysis concerning accuracy were first conducted in the cases of single filter and filter bank, and examinations on significance degree by SOM were conducted based on green(G) and blue(B) color channels. The difference of the filtering effect between two color channels was compared with using the significance degree. We show that the difference of the filtering effect between two channels can be clarified by using the significance degree by SOM.

**Using Spatial Characteristics to aid Automation of SOM Segmentation of Functional Image Data**

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*[1]Department of Statistics, Rice University, Houston, Texas, USA, [2]Department of Statistics and Department of Electrical and Computer Engineering, Rice University, Houston, Texas, USA, [3]Department of Neurosurgery, Houston Methodist Neurological Institute, Houston, Texas, USA*

*Abstract*—We propose a new similarity measure, Combined Connectivity and Spatial Adjacency (CCSA), to be used in hierarchical agglomerative clustering (HAC) for automated segmentation of Self-Organizing Maps (SOMs, Kohonen [1]). The CCSA measure is specifically designed to assist segmentation of large, complex, functional image data by exploiting general spatial characteristics of such data. The proposed CCSA measure is constructed from two strong indicators of cluster structure: the degree of localization of data points in physical space and the degree of connectivity of SOM prototypes (as defined by Tasdemir and Merényi [2]). The new measure is expected to enhance cluster capture in large functional image data cubes such as hyperspectral imagery or fMRI brain images, where many relevant clusters exist with widely varying statistical properties and in complex relationships both in feature space and in physical (image) space. We demonstrate the effectiveness of our approach using the CCSA measure on progressively complex synthetic spatial data and on real fMRI brain data.

**Using Self-Organizing Maps for Clustering and Labelling Aircraft Engine Data Phases**

Cynthia Faure[1], Madalina Olteanu[1], Jean-Marc Bardet[1]and Jérôme Lacaille[2]
*[1]SAMM, Panthéon Sorbonne University, France, [2]Safran Aircraft Engines, Moissy Cramayel, France*

*Abstract*—Multiple signals are measured by sensors during a flight or a test bench and their analysis represent a big interest for engineers. These signals are actually multivariate time series created by the sensors present on the aircraft engines. Each of them can be decomposed into series of stabilized phases, well known by the experts, and transient phases. Transient phases are merely explored but they reveal a lot of information when the engine is running. The aim of our project is converting these time series into a succession of labels, designing transient and stabilized phases. This transformation of the data will allow to derive several perspectives: on one hand, tracking similar behaviors or patterns seen during a flight; on the other, discovering hidden structures. Labelling signals coming from the engines of the aircraft also helps in the detection of frequent or rare sequences during a flight. Statistical analysis and scoring are more convenient with this new representation. This manuscript proposes a methodology for automatically indexing all engine transient phases. First, the algorithm computes the start and the end points of each phase and builds a new database of transient patterns. Second, the transient patterns are clustered into a small number of typologies, which will provide the labels. The clustering is implemented with Self-Organizing Maps [SOM]. All algorithms are applied on real flight measurements with a validation of the results from expert knowledge.

# Session 3 Applications to real world problems

**Application of Self Organizing Map to identify Nocturnal Epileptic Seizures**

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*Abstract*—A patient-specific seizure detection system for Nocturnal Frontal Lobe Epilepsy (NFLE) is proposed. Data of several patients affected by NFLE, extracted from the EPILEPSIAE database, have been used for this study. As every patient possesses different physiological characteristics, several simulations were performed in order to find the best features to be extracted from electroencephalogram (EEG) signals and to be inputted to 2-dimensional Self Organizing Maps (SOM). The proposed approach allows us the definition of simple displays capable of presenting meaningful information on the actual state of the neural activities, revealing the mapping potential of clustering the

data coming from seizure and non seizure epochs; moreover, it also suggests to use SOM as seizure early detectors. In fact, the temporal sequence of the samples in an EEG recording can be projected on the SOM, obtaining a trajectory that describes the dynamics of the brain state as captured by the EEG. The analysis of the trajectory can provide information on an eventual impending seizure event. The work shows the capability of the system to early and accurately detect Nocturnal Frontal Lobe Epilepsy seizure reaching a mean value of 77.23% and 88.94% for sensitivity and specificity respectively, and highlights the possibility to promote therapies aimed at rapid and targeted treatment of seizures.

**Detection of Short Circuit Faults in 3-Phase Converter-Fed Induction Motors Using Kernel SOMs**

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*[1]Federal University of Ceara, Department of Teleinformatics Engineering, Fortaleza, Ceara, Brazil, [2]Federal Institute of Ceara, Industry Department, Fortaleza, Ceara, Brazil*

*Abstract*—In this work we report the results of a comprehensive study involving the application of kernel self-organizing maps (KSOM) for early detection of interturn short-circuit faults in a three-phase converter-fed induction motor. For this purpose, two paradigms for developing KSOM-based classifiers are evaluated on the problem of interest, namely the gradient descent based KSOM (GD-KSOM) and the energy function based KSOM (EF-KSOM). Their performances are contrasted on a real-world dataset generated by means of a laboratory scale testbed that allows the simulation of different levels of interturn short-circuits (high and low impedance) for different load conditions. Feature vectors are built from the FFT-based spectrum analysis of the stator current, a non-invasive method known as the stator current signature. The performances of the aforementioned KSOM paradigms are evaluated for different kernel functions and for different neuron labeling strategies. The obtained results are compared with those achieved by standard SOM-based classifier.

**Self-Organizing Map for Orienteering Problem with Dubins Vehicle**

Jan Faigl
*Czech Technical University in Prague, Department of Computer Science, Czech Republic*

*Abstract*—This paper reports on the application of the self-organizing map (SOM) to solve a novel generalization of the Orienteering Problem (OP) for curvature-constrained vehicles that is called the Dubins Orienteering Problem (DOP). Having a set of target locations, each with associated reward, and a given travel budget, the problem is to find the most valuable curvature-constrained path connecting the target locations such that the path does not exceed the travel budget. The proposed approach is based on two existing SOM-based approaches to solving the OP and Dubins Traveling Salesman Problem (Dubins TSP) that are further generalized to provide a solution of the more computational challenging DOP. DOP combines challenges of the combinatorial optimization of the OP and TSP to determine a subset of the most valuable targets and the optimal sequence of the waypoints to collect rewards of the targets together with the continuous optimization of determining headings of Dubins vehicle at the waypoints such that the total length of the curvature-constrained path is shorter than the given travel budget and the total sum of the collected rewards is maximized.

# Session 4 Theoretical aspects_2

**An energy-based SOM model not requiring periodic boundary conditions**

Alexander Gepperth
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*Abstract*—We present a SOM model based on a continuous energy function derived from the original energy-based model developed in [9]. Due to the convolution that is contained in the energy function, this model can only be applied when periodic boundary conditions are imposed (toroidal SOM), leading to markedly higher quantization errors, especially for small map sizes. We introduce a simple strategy, based on the assumption of homogeneous long-term averages for input-prototype distances that allows to operate the energy-based SOM model without periodic boundary conditions, and demonstrate that its quantization errors are consistently lower especially for small map sizes. Simple experiments are conducted showing the worth of a continuous energy function, namely for novelty detection and automatic control of SOM parameters.

**Prototypes and Matrix Relevance Learning in Complex Fourier Space**

Michiel Straat[1], Marika Kaden[2], Matthias Gay[2,4], Thomas Villmann[2], Alexander Lampe[2], Udo Seiffert[3], Michael Biehl[1] and Friedrich Melchert[1,3]
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*Abstract*—In this contribution, we consider the classification of time-series and similar functional data which can be represented in complex Fourier coefficient space. We apply versions of Learning Vector Quantization (LVQ) which are suitable for complex-valued data, based on the so-called Wirtinger calculus. It makes possible the formulation of gradient based update rules in the framework of cost-function based Generalized Matrix Relevance LVQ (GMLVQ). Alternatively, we consider the concatenation of real and imaginary parts of Fourier coefficients in a real-valued feature vector and the classification of time domain representations by means of conventional GMLVQ.

**Adaptive Basis Functions for Prototype-based Classification of Functional Data**

Gabriele Bani[1], Udo Seiffert[2], Michael Biehl[3]and Friedrich Melchert[2,3]
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*Abstract*—We present a framework for distance-based classification of functional data. We consider the analysis of labeled spectral data and time series by means of Generalized Matrix Relevance Learning Vector Quantization (GMLVQ) as an example. To take advantage of the functional nature a functional expansion of the input data is considered. Instead of using a predefined set of basis functions for the expansion a more flexible scheme of an adaptive functional basis is employed. GMLVQ is applied on the resulting functional parameters to solve the classification task. For comparison of the classification a GMLVQ system is also applied to the raw input data, as well as on data expanded by a different predefined functional basis. Computer experiments show that the methods offers potential to improve classification performance significantly. Furthermore the analysis of the adapted set of basis

functions give further insights into the data structure and yields an option for a drastic reduction of dimensionality.

**Incremental learning with self-organizing maps**

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*Abstract*—We present a novel use for self-organizing maps (SOMs) as an essential building block for incremental learning algorithms. SOMs are very well suited for this purpose because they are inherently online learning algorithms, because their weight updates are localized around the best-matching unit, which inherently protects them against catastrophic forgetting, and last but not least because they have fixed model complexity limiting execution time and memory requirements for processing streaming data. However, in order to perform incremental learning which is usually supervised in nature, SOMs need to be complemented by a readout layer as well as a self-referential control mechanism for prototype updates in order to be protected against negative consequences of concept drift. We present the PROPRE architecture which implements these functions, thus realizing incremental learning with SOMs in very high-dimensional data domains, and show its capacity for incremental learning on several known and new classification problems. In particular, we discuss the required control of SOM parameters in detail and validate our choices by experimental results.

**Self-Organizing Maps with supervised layer**

Ludovic Platon, Farda Zehraoui and Tahi Fariza
*IBISC laboratory, UEVE/Genopole/Université Paris-Saclay, Evry, France*

*Abstract*—We present in this paper a new approach of supervised self organizing map (SOM). We added a supervised perceptron layer to the classical SOM approach. This combination allows the classification of new patterns by taking into account all the map prototypes without changing the SOM organization. We also propose to associate two reject options to our supervised SOM. This allows to improve the results reliability and to discover new classes in applications where some classes are unknown. We obtain two variants of supervised SOM with rejection that have been evaluated on different datasets. The results indicate that our approaches are competitive

with most popular supervised leaning algorithms like support vector machines and random forest.

# Session 5 Applications in Social Sciences

**Improving Individual Predictions using Social Networks Assortativity**

Dounia Mulders[1], Cyril de Bodt[2], Johannes Bjelland[2], Alex Pentland[3], Michel Verleysen[1] and Yves-Alexandre de Montjoye[3,4]
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*Abstract*—Social networks are known to be assortative with respect to many attributes, such as age, weight, wealth, level of education, ethnicity and gender. This can be explained by influences and homophilies. Independently of its origin, this assortativity gives us information about each node given its neighbors. Assortativity can thus be used to improve individual predictions in a broad range of situations, when data are missing or inaccurate. This paper presents a general framework based on probabilistic graphical models to exploit social network structures for improving individual predictions of node attributes. Using this framework, we quantify the assortativity range leading to an accuracy gain in several situations. We finally show how specific characteristics of the network can improve performances further. For instance, the gender assortativity in real-world mobile phone data changes significantly according to some communication attributes. In this case, individual predictions with 75% accuracy are improved by up to 3%.

**Multidimensional urban segregation: an exploratory case study**

Marie Cottrell[1], Madalina Olteanu[2], Aurélien Hazan[2] and Julien Randon-Furling[1]
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*Abstract*—Segregation phenomena have long been a concern for policy makers and urban planners, and much attention has been devoted to their study, especially in the fields of quantitative sociology and geography. Perhaps the most common example of urban segregation corresponds to different groups living in different neighborhoods across a city, with very few neighborhoods where all groups are represented in roughly the same proportions as in the

whole city itself. The social groups in question are usually defined according to one variable: ethnic group, income category, religious group, electoral group, age...
In this paper, we introduce a novel, multidimensional approach based on the Self-Organizing Map algorithm (SOM). Working with public data available for the city of Paris, we illustrate how this method allows one to describe the complex interplay between social groups' residential patterns and the geography of metropolitan facilities and services. Further, this paves the way to the definition of a robust segregation index through a comparison between the Kohonen map and the actual geographical map.

**International Trade and the Propagation of Merger Waves**

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*Abstract* - Cross-border merger activity is growing in importance. We map the global trade network each year from 1988 to 2014 and compare it to cross-border merger activity. Trade-weighted merger activity in trading partner countries has statistically and economically significant explanatory power for the likelihood a given country will be in a merger wave state, even controlling for its own lagged merger activity. The strength of trade as a channel for transmitting merger waves varies over time and is affected by EU and WTO entry. Overall, the full trade network helps our understanding of cross-border merger waves and how merger waves propagate across borders.

**Metaheuristic Optimization for Automatic Clustering of Customer-Oriented Supply Chain Data**

César L. C. Mattos[1], Guilherme A. Barreto[1], Dennis Horstkemper[2] and Bernd Hellingrath[2]
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*Abstract*—In this paper we evaluate metaheuristic optimization methods on a partitional clustering task of a real-world supply chain dataset, aiming at customer segmentation. For this purpose, we rely on the automatic clustering framework proposed by Das et al. [1], named henceforth DAK framework, by testing its performance for seven different metaheuristic optimization

algorithm, namely: simulated annealing (SA), genetic algorithms (GA), particle swarm optimization (PSO), differential evolution (DE), artificial bee colony (ABC), cuckoo search (CS) and fireworks algorithm (FA). An in-depth analysis of the obtained results is carried out in order to compare the performances of the metaheuristic optimization algorithms under the DAK framework with that of standard (i.e. non-automatic) clustering methodology.

# Session 6 LVQ

**Small sets of random Fourier features by Kernelized Matrix LVQ**

Frank-Michael Schleif
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*Abstract*—Kernel based learning is very popular in machine learning but often quite costly with at least quadratic runtime complexity. Random Fourier features and related techniques have been proposed to provide an explicit kernel expansion such that standard techniques with low runtime and memory complexity can be used. This strategy leads to rather high dimensional datasets which is a drawback in many cases. Here, we combine a recently proposed unsupervised selection strategy for random Fourier features [1] with the very efficient supervised relevance learning given by Matrix LVQ. The suggested technique provides reasonable small but very discriminative features sets.

**Empirical Evaluation of Gradient Methods for Matrix Learning Vector Quantization**

Michael Lekander[1], Michael Biehl[1] and Harm de Vries[2]
*[1]University of Groningen, Johann Bernoulli Institute for Mathematics and Computer Science, The Netherlands, [2]Université de Montréal, Québec*

*Abstract*—Generalized Matrix Learning Vector Quantization (GMLVQ) critically relies on the use of an optimization algorithm to train its model parameters. We test various schemes for automated control of learning rates in gradient-based training. We evaluate these algorithms in terms of their achieved performance and their practical feasibility. We find that some algorithms do indeed perform better than others across multiple benchmark datasets. These algorithms produce GMLVQ models which not only better fit the training data,

but also perform better upon validation. In particular, we find that the Variance-based Stochastic Gradient Descent algorithm consistently performs best across all experiments.

**Probabilistic extension and reject options for pairwise LVQ**

Johannes Brinkrolf and Barbara Hammer
*Bielefeld University, CITEC centre of excellence, Germany*

*Abstract*—Learning vector quantization (LVQ) enjoys a great popularity as efficient and intuitive classification scheme, accompanied by a strong mathematical substantiation of its learning dynamics and generalization ability. However, popular deterministic LVQ variants do not allow an immediate probabilistic interpretation of its output and an according reject option in case of insecure classifications. In this contribution, we investigate how to extend and integrate pairwise LVQ schemes to an overall probabilistic output, and we compare the benefits and drawbacks of this proposal to a recent heuristic surrogate measure for the security of the classification, which is directly based on the LVQ classification scheme. Experimental results indicate that an explicit probabilistic treatment often yields superior results as compared to a standard deterministic LVQ method, but metric learning is able to annul this difference.

**Spectral Regularization in Generalized Matrix Learning Vector Quantization**

David Nova[1] and Pablo A. Estevez[2]
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*Abstract*—In this contribution we propose a new regularization method for the Generalized Matrix Learning Vector Quantization classifier. In particular we use a nuclear norm in order to prevent oversimplifying/over-fitting and oscillatory behavior of the small eigenvalues of the positive semi-definite relevance matrix. The proposed method is compared with two other regularization methods in two artificial data sets and a real life problem. The results show that the proposed regularization method enhances the generalization ability of GMLVQ. This is reflected in a lower classification error and a better interpretability of the relevance matrix.

# Session 7 Relational networks and Neural Gas

**Data Dependent Evaluation of Dissimilarities in Nearest Prototype Vector Quantizers Regarding Their Discriminating Abilities**

Marika Kaden[1], David Nebel[1], Friedrich Melchert[2,3], Andreas Backhaus[2], Udo Seiffert[2] and Thomas Villmann[1]
*[1]University of Applied Sciences Mittweida, Germany, [2]Fraunhofer IFF Magdeburg, Biosystems Engineering, Germany, [3]University Groningen, Intelligent Systems Group, The Netherlands*

*Abstract*—In this paper we propose a rank measure for comparison of dissimilarities regarding their behavior to reflect data dependencies. It is based on evaluation of dissimilarity ranks, which reflects the topological structure of the data in dependence of the dissimilarity measure. The introduced rank measure can be used to select dissimilarity measures in advance before cluster or classification learning algorithms are applied. Thus time consuming learning of models with different dissimilarities can be avoided.

**Nonlinear dynamic identification using supervised neural gas algorithm**

Iván Machón-González and Hilario López-García
*Department of Electrical, Electronic, Computers and Systems Engineering, University of Oviedo*

*Abstract*—The dynamic identification of a nonlinear plant is not a trivial issue. The application of a neural gas network that is trained with a supervised batch version of the algorithm can produce identification models in a robust way. In this paper, the neural model identifies each local transfer function demonstrating that the local linear approximation can be done. Moreover, other parameters are analyzed in order to obtain a correct modeling.

**Relational and Median Variants of Fuzzy c-Means**

Tina Geweniger and Thomas Villmann,
*ACSB, University of Applied Sciences Mittweida, Germany*

*Abstract*—In this article we propose a relational and a median possibilistic clustering method. Both methods are modifications of Possibilistic Fuzzy C-Means as introduced by Pal et al. [1]. The proposed algorithms are applicable for abstract non-vectorial data objects where only the dissimilarities of the

objects are known. For the relational version we assume a Euclidean data embedding. For data where this assumption is not feasible we introduce a median variant restricting prototypes to be data objects themselves.

**A Strategy for Time Series Prediction using Segment Growing Neural Gas**

Jorge R. Vergara[1] and Pablo A. Estévez[2]
*[1]Millennium Institute of Astrophysics, Santiago, Chile, [2]Department of Electrical Engineering, University of Chile, Santiago, Chile*

*Abstract*—Segment Growing Neural Gas (Segment-GNG) has been recently proposed as a new spatiotemporal quantization method for time series. Unlike traditional quantization algorithms that are prototype-based, Segment-GNG uses segments as basic units of quantization. In this paper we extend the Segment-GNG model in order to deal with time series prediction. First Segment- GNG makes a quantization of the trajectories in the statespace representation of the time series. Then a local prediction model is associated with each segment, which allows us to make predictions. The proposed model is tested with the Mackey-Glassand Lorenz chaotic time series in one-step ahead prediction tasks. The results obtained are competitive with the best results published in the literature.

# Posters

**Self-Organizing Maps as A Tool for Segmentation of Magnetic Resonance Imaging (MRI) of Relapsing-Remitting Multiple Sclerosis**

Paulo Afonso Mei[1], Cleyton De Carvalho Carneiro[2], Michelle Chaves Kuroda[3], Li Li Min[4], Stephen Fraser[1] and Fabiano Reis[1]
*[1]Faculty of Medicine, University of Campinas, Brazil, [2] Faculty of Engineering, University of Sao Paulo, Brazil, [3]Faculty of Geology, University of Campinas, Brazil, [4]CSIRO, Australia*

*Abstract* - Multiple Sclerosis (MS) is the most prevalent demyelinating disease of the Central Nervous System, being the Relapsing-Remitting (RRMS) its most common subtype. We explored here the viability of use of Self Organizing Maps (SOM) to perform automatic segmentation of MS lesions apart from CNS normal tissue. SOM were able, in most cases, to successfully segment MRIs of patients with RRMS, with the correct separation of normal versus pathological

tissue especially in supratentorial acquisitions, although it could not differentiate older from newer lesions.

**Pairwise Elastic Self-Organizing Maps**

Pitoyo Hartono and Yuto Take,
*School of Engineering, Chukyo University, Nagoya, Japan*

*Abstract*—Visualization is one of the most powerful means for understanding the structure of multidimensional data. One of the most popular visualization methods is the Self-Organizing Map (SOM) that maps high dimensional data into low dimensional space while preserving the data's topological structure. While the topographical visualization can reveal the intrinsic characteristics of the data, SOM often fails to correctly reflect the distances between the data on the low dimensional map, thus reducing the fidelity of the visualization. The limitation of SOM to mimic the data structure is partly due to its inflexible structure, where the reference vectors are fixed, usually in two dimensional grid. In this study, a variant of SOM, where the reference vector can flexibly move to reconstruct the distribution of high dimensional data and thus can provide more precise visualization, is proposed. The proposed Elastic Self-Organizing Maps (ESOM) can also be used as nearest neighbor's classifiers. This brief paper explains the basic characteristics and evaluation of ESOM against some benchmark problems.

**Using SOMbrero to Examine the Economic Convergence of European Countries from 2001-2013**

Joel Deichmann, Dominique Haughton, Abdolreza Eshghi and Mingfei Li
*Data Analytics Research Team, Bentley University, Waltham, USA*

*Abstract* - This paper uses SOMbrero visualizations to examine two socio-economic dimensions of European states, generated by a factor analysis of time-series data from 2001-2013. We analyze SOMs for 41 countries with regard to "Old Capital" and "New Capital", two factors that are generated from 12 variables. SOMbrero reveals evidence of various convergence paths over time for these two factors. This approach also clearly uncovers the differential impacts of the European recession upon clusters of European countries. In conclusion, we demonstrate that SOMs are a useful tool for better understanding European convergence.

**Imputation of Reactive Silica and Available Alumina in Bauxites by Self-Organizing Maps**

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*Abstract* - Geochemical analyses can provide multiple analytical variables. Accordingly, the generation of large geochemical databases enables imputation studies or analytical estimates of missing values or complex measuring. The processing of bauxite is a key step in the production of aluminum, in which the determination of Reactive Silica (RxSiO2) and Available Alumina (AvAl2O3) are very relevant. The traditional analytical method for achieving RxSiO2 has limitations associated with poor repeatability and reproducibility of results. Based on the values from the unsupervised Self-Organizing Maps technique, this study aims to develop, systematically, the imputation of missing grades of the geochemical composition of bauxite samples of a database from three trial projects, for the variables: total Al2O3; total SiO2; total Fe2O3; and total TiO2. Each project was submitted to partial exclusion of AvAl2O3 and RxSiO2 values, in proportion of 20%, 30%, 40% and 50%, to investigate the SOM technique as imputation method for RxSiO2 and AvAl2O3. By comparing the imputed values from the SOM analysis with the original values, SOM technique demonstrated to be an imputation tool capable of obtaining analytical results with up to 50% of missing data. Specifically, the best results demonstrate that AvAl2O3 can be obtained by imputation with a higher correlation than RxSiO2, based on the parameters and variables involved in the study. Similarity in the nature of samples and an increase in the number of embedded analytical variables are factors that provided better imputation results.

**Fusion of Deep Learning Architectures, Multilayer Feedforward Networks and Learning Vector Quantizers for Deep Classification Learning**

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*Abstract*—The advantage of prototype based learning vector quantizers are the intuitive and simple model adaptation as well as the easy interpretability of the prototypes as class representatives for the class distribution to be learned. Although they frequently yield competitive performance and show robust behavior nowadays powerful alternatives have increasing attraction. Particularly, deep architectures of multilayer networks achieve frequently very high accuracies and are, thanks to modern graphic processor units use for calculation, trainable in acceptable time.
In this conceptual paper we show, how we can combine both network architectures to benefit from their advantages. For this purpose, we consider learning vector quantizers in terms of feedforward network architectures and explain how it can be combined effectively with multilayer or single-layer feedforward network architectures. This approach includes deep and flat architectures as well as the popular extreme learning machines. For the resulting networks, the multi-/ single-layer networks act as adaptive filters like in signal processing while the interpretability of the prototype-based learning vector quantizers is kept for the resulting filtered feature space. In this way a powerful combination of two successful architectures is obtained.

**Credible Visualizations for Planar Projections**

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*Abstract* - Planar projections, i.e. projections from a high dimensional data space onto a two dimensional plane, are still in use to detect structures, such as clusters, in multivariate data. It can be shown that only the subclass of focusing projections such as CCA, NeRV and the ESOM are able to disentangle linear non separable data. However, even these projections are sometimes erroneous. U-matrix methods are able to visualize these errors for SOM based projections. This paper extends the U-matrix methods to other projections in form of a so called generalized U-matrix. Based on previous work, an algorithm for the construction of generalized U-matrix is introduced, that is more efficient and free of parameters which may be hard to determine. Results are presented on a difficult artificial data set and a real word multivariate data set from cancer research.