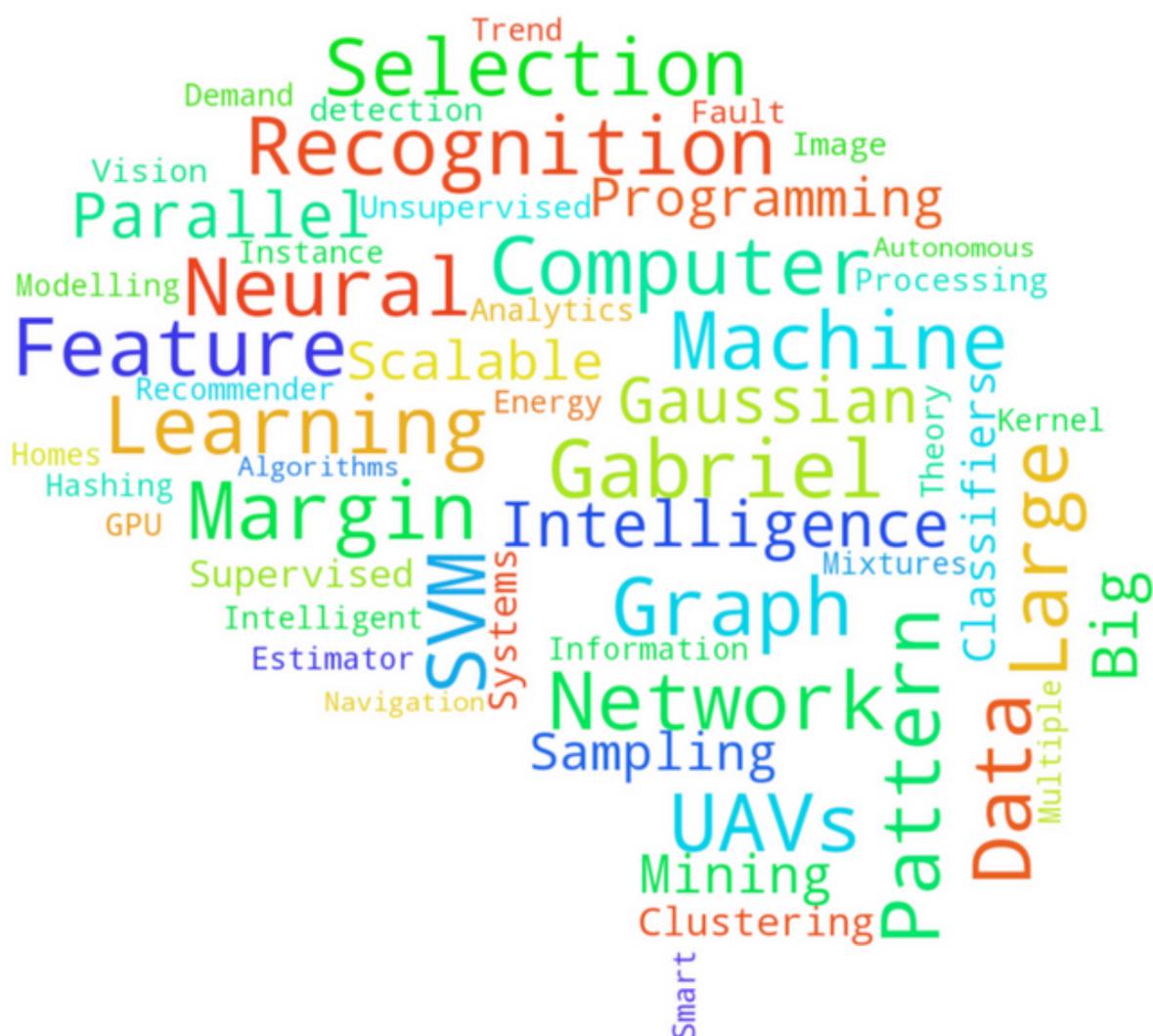


# LITC Annual Report

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COMPUTATIONAL INTELLIGENCE LABORATORY



# Foreword.

LITC, Belo Horizonte



**Prof. Antônio de Pádua Braga.**

I am very glad that we have been able to produce this annual report as a team work, with all students involved and contributing to generate the final document. We have made a few attempts in the past, none of them was accomplished with so much cohesion by the whole group. Maybe it was because LITC is becoming mature;

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*“LITC is becoming mature”*

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I have just noticed that the lab has completed 20 years in 2016 and will reach majority in the year to come. I believe this report has a special meaning, since it reflects the present spirit of students, posdocs and young professors in the lab, which is to share the responsibilities and to work together for the group as a whole. Its importance goes far beyond the production of the report itself, since it shows the present spirit of collaboration within the team. Congratulations and thanks to all those who contributed to produce this report!

In the first semester LITC members jointly organized the event *AIMday - Smart Industries*, which took place at the School of Engineering in May 19th. The event was partially hosted by the lab and co-organized by UFMG, FAPEMIG, CISB (Centro de Inovação Suécia-Brasil) and University of Uppsala. The event gathered around 80 participants from Brazilian and Swedish universities and companies, who met for one day at UFMG to discuss questions proposed by the companies.

As an outcome many researchers from UFMG and from other institutions in the state of Minas Gerais have established new research cooperation links with Swedish universities and companies, supported by seed funds from

FAPEMIG and from SSF (Swedish Science Foundation). Prof Cristiano Castro initiated a cooperation in home automation with Halmstad University which also involves the local company Neocontrol. We have also started a collaboration with the industry excellence center LINK-SIC, hosted at Linköping University, and with SAAB Aeronautics.

Still within the Swedish-Brazilian cooperation framework, we have started in 2016 a two-years project with KTH (Royal Institute of Technology in Stockholm), supported by FAPEMIG, in the area of Communication Infrastructure for Smart Industry. At the moment the project involves one posdoc, one master and three undergrad research students.

In 2016 we also had finally the result of our application to CNPq in order to establish a National Institute of Science and Technology in Smart Industry (INCT Smart Industry). The institute was accredited by CNPq, however, without financial support from the funding agency. This means that INCT Smart Industry will be established in 2017 and hosted within LITC premises, however, it will demand additional efforts from us to carry on with all the original proposal without funding.

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*“INCT - Smart Industry accredited by CNPq”*

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In 2016 I was also in France for one month at Université Paris-Est, Créteil, as a visiting professor at LiSSi (Laboratoire Images, Signaux et Systemes Intelligents), a lab hosted by our colleague, Prof. Patrick Siarry. During the year we had visitors from abroad, we had new students joining the group and we had also many students that left the group after finishing their courses, so the lab was very active during the present year.

Being ahead of LITC is a huge responsibility, however, as has become clear in the joint production of this document, I am not the sole conductor of the lab. Students, posdocs and my fellow colleagues are always available to give me support and share responsibilities whenever needed. So, finally I would like to thank all group members for the endless support in 2016. Muito obrigado a todos!

**LITC annual report**  
2016

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# Events

AIMDay Smart Industries. (<http://aimday.se/smart-industries-belo-horizonte-2016/>)



The AIMday Smart Industries was hosted at the School of Engineering at UFMG (LITC) on May 19th. Besides UFMG, the event was supported and co-organized by FAPEMIG, SSF (Swedish Science Foundation), CISB (Centro de Inovação Suécia-Brasil) and University of Uppsala, University of Linköping and SACF (Swedish Academic Collaboration Forum). The event involved about 80 researchers and 8 companies to discuss current challenges in the main field of Smart Industries. The principle of the AIM-

day is that companies would present questions that are jointly discussed by researchers and company representatives during the AIMday for about one hour in parallel sessions. Funding agencies like FAPEMIG and SSF would provide immediate seed money, under application, for a limited number of projects, which are expected to have a further long term support by companies if successful in the initial phase. Companies like SAAB, Volvo Cars, Vale, Neocontrol and Ericsson participated in the event in Belo Horizonte. Presently 6 projects from different institutions were granted with seed money from SSF, among them two were proposed by LITC researchers, one with Neo-

control and University of Halmstadt and the other with LINK-SIC (University of Linköping) and SAAB Aeronautics. FAPEMIG has a call for projects open with deadline on January 31st to which we may possibly submit one or two proposals.

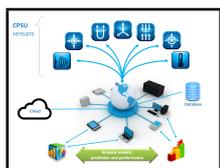


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# Research Collaboration Projects.

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## UFMG-KTH (Sweden) Communication Infrastructure for Smart Industry



This project with KTH (Royal Institute of Technology, Sweden) is supported by FAPEMIG. It is aimed at research on network in-

frastructures for Smart Industries and smart energy systems. Its main objective is the study of methodologies and technologies for communication networks of smart CPS (Cyber Physical Systems), aiming at industrial problems. The project started in the middle of 2016 and involves four students and one posdoc at the moment.

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## UFMG-IEAv-INPE UAV Navigation

During 2016 the collaboration project on Unmanned Aerial Vehicles (UAVs)

navigation by images with IEAv (Instituto de Estudos Avançados, Ministry of Defense) and INPE (Instituto de Pesquisas Espaciais) was also active. The projects were funded by CNPq/Universal and MCT/Ministry of defense and involved many students and associate professors in the lab.



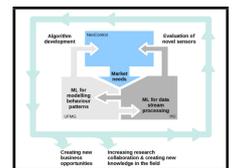
Our contributions to the project involved embedding learning algorithms into small microsystems for online positioning and also the study of methods to correct both projective and spectral distortions in images captured by UAVs.

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## UFMG-Halmstad University (Sweden)-Neocontrol Smart Home Automation

This project started in 2016 with seed money from SSF (Swedish Science Foundation) for projects initiated during the AIMday Smart Industries. It involves Halmstad University as a

partner and also the local company Neocontrol, a local company that produces home automation equipments. The project involves developing new solutions for home automation problems based on sampled data and machine learning models.



The collaboration project is designed to investigate the potential of new products and services by combining networks of sensors and actuators from the Brazilian company Neocontrol with methods for intelligent processing in residential and hotel buildings. The initial step of the project has the objective to survey the market needs and map these requirements to research and development activities within the area of sensor evaluation and algorithm development for intelligent processing. Ultimately a demonstrator will be developed and showcased in an existing realistic home-based setting. The results of the algorithm development and demonstrator tests will be used in

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a final report where the business opportunities and future plans for larger project are assessed.

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### INCT Smart Industry

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This project puts together researchers from twelve Brazilian and eight international universities, namely Universidade Federal de Minas Gerais (UFMG ? Host Institution), Centro Federal de Educação Tecnológica de Minas Gerais (CEFET-MG), Universidade de Campinas (UNICAMP), Universidade Federal do Rio de Janeiro (UFRJ), Universidade Federal Rural do Rio de Janeiro (UFRRJ),

Universidade de Goiás (UFG), Universidade Federal de Pernambuco (UFPE), Universidade de Pernambuco (UPE), Universidade Federal do Rio Grande do Norte (UFRN), Instituto Federal de Educação, Ciência e Tecnologia do Rio Grande do Norte (IFRN), Faculdades de Campinas (FACAMP), Universidade Federal de Lavras (UFLA), California Institute of Technology (CALTECH, USA), University of Coventry (UK), University of Lancaster (UK), University of Ruhr-Bochum (Germany), University of M $\ddot{A}$ nster (Germany), University of Swinburne (Australia) and University of California (USA). The leading postgraduate programs involved are qualified as levels 7 and 6 by CAPES: UFMG (Electrical Engineering, Level 7 CAPES), UNICAMP (Electrical Engineering, Level 7 CAPES), UFRJ (Computing and Systems, Level 7

CAPES) and UFPE (Computação, Level 6 CAPES).

The project was supported by the following thirteen companies: EMC Big Data Research and Development Center (RJ, Brazil), Vallourec of Brazil (Belo Horizonte, MG), ENACOM (Belo Horizonte, MG), A3Data (Belo Horizonte, MG), Go-Geo (Goiânia, GO), Bluelux (Belo Horizonte, MG), Nitryx (Campinas, SP), Algar (Uberlândia, MG), Open-cadd (São Paulo, SP), Red & White (Goiânia, GO), TNK (Belo Horizonte, MG), INOVAX (Rio de Janeiro, RJ), and Ferrous (Belo Horizonte, MG). These companies have a large spectrum of lines of businesses that cover most areas targeted by this project.

The INCT Smart Industry was accredited by CNPq in 2016 and will start activities in 2017. ■

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## Visitors

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We were pleased to host two visiting professors in 2016. Professor Gonzalo Acuña, from University of Santiago de Chile (USACH) was with us for two months while Professor Vasile Palade, from Coventry University (UK), visited us for one week. Prof. Acuña was self funded, while Prof. Palade was supported by FAPEMIG within a project led by ENACOM, a company that is also our partner within INCT Smart Industry. Their short biographies follow next.

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### Gonzalo Acuna

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Gonzalo Acuña received a B.Sc degree in Electrical Engineering (1980) from Universidad de Chile. His Ph.D. on Automatic Control was obtained from the Institut National Polytechnique, Grenoble, France in 1995 in Dynamic Neural Network Modeling of Bioprocesses. Since 1997, he has been with the Computer Engineering Department of the Universidad de Santiago de Chile (USACH) where he is now a Full Professor.

As a Professor and researcher he has co-authored many book-chapters, journal and conference papers. He has also supervised several post-graduate students on Master, Doctorate and Post-Doctorate levels. As a research leader he has received many grants from Chilean government research agencies. He has served in many program committees of various international conferences, among them:

Latin American Conference on Informatics (CLEI), Latin American Conference on Automatic Control (CLCA) and Latin American Conference on Computational Intelligence (LA-CCI).

His research topics include software sensors design, neural networks and SVM modeling and prediction of non-linear dynamic systems and development of grey-box models with applications in biotechnological, mining and geophysical processes among others.

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### Vasile Palade

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Dr. Vasile Palade is a Reader in Pervasive Computing in the Faculty of Engineering and Computing and a member of the Cogent Computing Applied Research Centre at Coventry University. He previously had academic and research positions at the University of Oxford - UK (Departmental Lecturer in the Department of Computer Science), University of Hull - UK (Research Fellow in the Department of Engineering) and the University of Galati - Romania (Associate Professor in the Department of Computer Science and Engineering).

His research interests lie in the area of machine learning/computational intelligence, and encompass mainly neuro-fuzzy systems, various nature inspired algorithms such as swarm optimization algorithms, hybrid intelligent systems, ensemble of classifiers, class imbalance learning.

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Application areas include Bioinformatics problems, fault diagnosis, web usage mining, among others.

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### Jens Lundström

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Jens Lundström received the M.Sc. in Computer System Engineering from Halmstad University, Sweden in 2005. He received the Tech. Licentiate degree in Information Technology from Å-rebro University, Sweden and the PhD degree in Information Technology from Halmstad University in 2012 and 2014 respectively. Since

2016 he works as an Assistant Professor at the Department of Intelligent Systems, Halmstad University. The main fields of his research interests are anomaly detection, machine learning, representation learning as well as machine learning applied to the domain of health care and smart homes. When he was visiting us, he gave a seminar lecture entitled *Ongoing Research about Intelligent Systems applied to Smart Homes*.



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## 2015-2016 Publications

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### Journal Papers

AZEVEDO COSTA, M.; DE SOUZA RODRIGUES, T.; DA COSTA, A. G. F.; Natowicz, R.; PADUA BRAGA, A.. Sequential selection of variables using short permutation procedures and multiple adjustments: An application to genomic data. *Statistical Methods in Medical Research*, v. 1, p. 1-2, 2015.

Gardeaux, V.; Chelouah, R.; WANDERLEY, M. F.; Siarry, P.; BRAGA, A. P.; Reyat, F.; Rouzier, R.; Pusztai, L.; Natowicz, R.. Computing Molecular Signatures as Optima of a Bi-Objective Function: Method and Application to Prediction in Oncogenomics. *Cancer Informatics*, p. 33, 2015.

SAAVEDRA, D.; OLIVEIRA, L. C.; Saturnino, D.M.; BRAGA, A. P.; Cardoso, M.. Modelling of downflow lo-solids cooking in a continuous digester. *Appita Journal*, v. 68, p. 67-71, 2015.

SILVESTRE, L.; Lemos, A.P.; BRAGA, J. P.; BRAGA, A. P.. Dataset structure as prior information for parameter-free regularization of extreme learning machines. *Neurocomputing (Amsterdam)*, v. 169, p. 288-294, 2015.

FARIA, ALEXANDRE WAGNER CHAGAS; DA SILVA, ALISSON MARQUES; DE SOUZA RODRIGUES, THIAGO ; COSTA, Marcelo Azevedo ; BRAGA, ANTONIO PADUA . A Ranking Approach for Probe Selection and Classification of Microarray Data with Artificial Neural Networks. *Journal of Computational Biology*, v. 22, p. 953-961, 2015.

Torres, L.C.B.; COELHO, F.; SILL TORRES, F.; BRAGA, A.P.; CASTRO, C.L.. Distance-based large margin classifier suitable for integrated circuit implementation. *Electronics Letters*, v. 51, p. 1967-1969, 2015.

HORTA, EULER GUIMARÃES; CASTRO, CRISTIANO LEITE DE; BRAGA, ANTÔNIO PÁDUA. Stream-Based Extreme Learning Machine Approach for Big Data Problems. *Mathematical Problems in Engineering (Print)*, v. 2015, p. 1-17, 2015.

LIMA, R.N. ; DE ALMEIDA, G.M. ; BRAGA, A.P. ; Cardoso, M.. Trend modelling with artificial neural networks. Case study: Operating zones identification for higher SO<sub>3</sub> incorporation in cement clinker. *Engineering Applications of Artificial Intelligence*, v. 54, p. 17-25, 2016.

Coelho, Frederico ; BRAGA, ANTONIO P. ; VERLEYSSEN, MICHEL. A Mutual Information estimator for continuous and discrete variables applied to Feature Selection and Classification problems. *INT J COMPUT INT SYS*, v. 9, p. 726-733, 2016.

MOTA, H. O. ; VASCONCELOS, F. H. ; CASTRO, C. L.. A Comparison of Cycle Spinning Versus Stationary Wavelet Transform for the Extraction of Features of Partial Discharge Signals. *IEEE Transactions on Dielectrics and Electrical Insulation*, v. 23, p. 1106-1118, 2016.

Medeiros, T. H. ; Rocha, H. P. ; Torres, F. S. ; Takahashi, R. H. C. ; Braga, A. P.. Multi-objective Decision in Machine Learning. *Journal of Control, Automation and Electrical Systems*, p. 1-11, 2016.

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- Torres, L.C.B.; CASTRO, C. L.; BRAGA, A. P.. Gabriel Graph for Dataset Structure and Large Margin Classification: A Bayesian Approach. In: European Symposium on Artificial Neural Networks, 2015, Bruges. Proceedings of the European Symposium on Artificial Neural Networks, 2015.
- PINTO, D.; Lemos, A.P.; BRAGA, A. P.. An affinity matrix approach for structure selection of extreme learning machines. In: European Symposium on Artificial Neural Networks, 2015, Bruges. Proceedings of the European Symposium on Artificial Neural Networks, 2015.
- TORRES, LUIZ C.B.; CASTRO, CRISTIANO L.; BRAGA, ANTONIO P.. A parameterless mixture model for large margin classification. In: 2015 International Joint Conference on Neural Networks (IJCNN), 2015, Killarney. 2015 International Joint Conference on Neural Networks (IJCNN), 2015. p. 1.
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- REZENDE, T. M. ; CASTRO, C. L. ; MOREIRA, S. G. . Reconhecimento de Expressões Faciais em Sinais da Língua Brasileira de Sinais (LIBRAS) usando os classificadores K-NN e SVM. In: XII Simpósio de Mecânica Computacional, 2016, Diamantina - MG. Anais do SIMMEC 2016, 2016. p. 101-109.
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# Doctorate Thesis

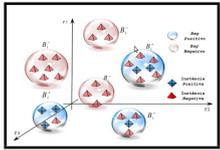
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## New approach for Multiple Instance Learning based on instance selection by kernel density estimation.

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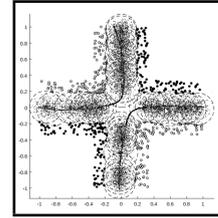
Alexandre Wagner C. de Faria

Multiple Instance Learning (MIL) is a generalization of the supervised learning. MIL has been used in numerous applications where the instance labeling for individual instance, for the learning step, is sometimes not possible or unfeasible in practical way. For dealing with this family of problem, MIL proposes a new paradigm by assigning a single label (positive or negative) to a set of instances, called bag. More formally, a bag is labeled positive if it contains at least one positive instance, and it is labeled negative if all instances are certainly negative. Although there is a considerable number of algorithms to work with MIL in the literature, few works provides balanced outcomes for the majority of the datasets. Furthermore, a deeper analysis, among



the existing methods, is not available. In this work are proposed two new algorithms based on instance selection by likelihood computation, using Kernel Density Estimation. The approach uses the LogitBoost algorithm as classifier. The instance selection approach aim to identify the most representative instances in each positive bag, eliminating possible instance noise inside those bags, in this way, perform a more robust learning step. Statistical tests, have demonstrated that the proposal methods are comparable with the best literature algorithms, overcoming all in some datasets. It is also developed in this work a new application based on the proposed method in order to select patients that best represent each class in a Leukemia dataset. After experiments, it was possible to reduce the training patients by half, and nd slightly better results than those when is used all patients in the dataset.

margin classifiers where the information necessary is obtained from the geometric structure of data. Through the Gabriel graph, the data set is turned into a planar graph, where the edges with vertices of distinct labels corresponds to the samples which are on the margin of separation between the classes. These edge set is named as support edges and forms the basis for the development of a family of methods, such as a decision-maker for multi-objective learning of neural networks; a strategy for selecting parameters in RBF neural networks. Finally, the design of new large margin classifiers. Results with benchmarks known in the literature show that our approaches maximize the margin and increase the classifier generalization ability.




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## Support Edges Classifier (clas): Learning Methods Based on Gabriel's Graphs.

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Luiz Carlos B. Torres

This work presents a methodology directed to pattern classification problems. The goal is to design large



# Master Dissertations

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## Incremental Learning with Partial Memory Via Gabriel's Graph.

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Marcus Vinicius de F. Diadelmo

This work presents the development of incremental learning algorithms with partial memory, where the partial memory is obtained by the Gabriel graph structure. Four incremental techniques are proposed. In three of them, the partial memory is obtained by Gabriel graph and noise elimination. Besides considering Gabriel graph and noise elimination, the fourth incremental technique selects relevant patterns from a discrepancy measure of the data true distribution. Statistical tests to evaluate the methods were performed. These tests evaluate the equivalence

of the incremental approach with the traditional approach (data separated into training and test), and also the comparison of the incremental algorithms with some others in the literature. The comparative results show that the developed techniques are efficient and have the particularity of not requiring experts to determine the parameters (in most technics). A brief analysis of the influence of the size of the data window indicates that the window size might not be a decisive parameter for the success of the algorithms.

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## Prediction of electric energy demand with artificial neural networks and Fourier series analysis.

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Evandro L. de Oliveira

The model of the electricity market in Brazil is due to its division the state monopoly. This model has regulations that divide this energy sector divisions that offer this service, creating a competitive environment. The trend in the market that competes for electricity is that companies seek ways to provide for the needs of its customers, improving the quality of service provided. For this, companies analyze market behavior, check the critical points and elaborate control and intervention strategies in these points. Whereas the electricity demand of the plan Brazil is strategic, this work shows that demand forecasting methodologies using indicators of socio-economic performance indicators and historical weather of electricity demand. The proposed models are based on neural networks artificial, statistical algorithms, trend identification and analysis of algorithms exogenous variables. The way to apply the methods demonstrated in this work enables the achievement of behavior future demand of the National Inter-connected System (SIN) with an average very close to its historical series hit.

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## Evaluation of feature extraction techniques applied to UAV navigation based on images.

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Juan Camilo F. Galindo

This work presents a comparative study of feature extraction methods applied to the problem of position estimation for autonomous navigation of UAVs. Based on an initial study of the existing methods, this work also proposes two novel feature extraction algorithms invariant to the affine transformation and with a low computational cost. The first proposal is a modification of ASIFT algorithm. The method utilizes the data provided by the INS to reduce its computational cost. The second proposal is also based on the affine invariance property of the ASIFT algorithm, but uses the SURF method for extracting candidate feature points. The proposed methods are compared with SIFT, SURF and ASIFT to aerial images registration taken from UAVs. The evaluation metrics used in the comparative study to measure the performance of feature extractors are the amount of extracted points in each image, the amount of matched points, the distance-error of matched points, and the computational cost measured by the time of execution. The numerical experiments showed that the proposals are able to improve the accuracy and reduce the complexity of ASIFT



algorithm, which means that can be used for autonomous navigation of UAVs

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## Strategies for increasing the geographic position estimation robustness in UAVs through images.

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Brayan Rene Acevedo Jaimes

In this work, different approaches to improve the geographical position estimation process through UAV (Unmanned Aerial Vehicles) images are proposed. In first place, two new template matching approaches with low processing time were developed aiming to make a more robust autonomous navigation of the aircrafts without the need to use GPS (Global Position System) signal. The first uses an adaptive Canny edge detector and the second one uses thresholding. With these techniques, it is possible to solve the edge overestimation and the noise inclusion that affect the image comparison and, consequently, the position estimation. In second place, two approaches to correct projective distortion, scale adjustment, rotation and translation in UAV images were developed when the camera position is not perpendicular to earth. The first of them is a technique that uses the (previous) knowledge of UAV tilt angles provided by the aircraft inertial sensors to obtain the homographic matrix and correct the image. These angles compose the rotation parameters of the homographic matrix that is also composed by other concatenated matrices that representing the camera intrinsic parameters and the image translation. The second approach presents a robust correction of projective and spectral distortions in images captured by UAVs. This technique is based in the keypoints matching extracted between the UAV image and the georeferenced one. It also uses the SURF and MSAC algorithms in order to estimate the parameters that compose the homographic matrix and, thus, the image is corrected. The evaluation of the proposed approaches considered different land types (forest, urban and highway) in the tests application. Also, the evaluation with images obtained from different sensors with distortion of perspective, scale, rotation, and translation is considered. The evaluation metrics were the mean distance error in the position estimation and the processing time. Now, for the perspective distortion correction, metrics like the keypoints number extracted on each image, the estimated matching number between images, efficiency, recall, precision and processing time were considered. The obtained results throughout the different tests applied in the techniques are promissory, have low processing time and indicate that they can be used in real flight conditions.



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## Internal Seminars

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Seminars presented by LITC members and visitors

### **Github, how it can help you?**

*Gustavo Lacerda, UFMG, Brazil 22-Mar-2016*

### **Use of prior information to improve MLPs**

*Yuri Souza, UFMG, Brazil, 26-Apr-2016*

### **Autonomous Navigation of VANTs Based on Orbital Images and Optimization Methods.**

*Ramon Correa, UFMG, Brazil, 3-May-2016*

### **Incremental Learning via Support Edges Classifier (CLAS).**

*TMarcus Diadelmo, UFMG, Brazil, 24-May-2016*

### **Cluster Methods for Large Data Volumes.**

*Gustavo Lacerda, UFMG, Brazil, 7-Jun-2016*

### **Prediction of electric energy demand with artificial neural networks and Fourier series analysis.**

*Evandro Lopes, UFMG, Brazil, 21-Jun-2016*

### **Fault detection - a possible application for MIL.**

*Victor Caetano, UFMG, Brazil 06-Sep-2016*

### **A Study of Methods of Feature Extraction Applied in the Problem of the Estimation of the Position of a Vant in Autonomous Navigation with Computer Vision.**

*Juan Camilo Fonseca Galindo, UFMG, Brazil, 11-Oct-2016.*

### **Analytics for the process industry - mining data for system identification and for control structure selection.**

*Victor André Carvalho Bittencourt, Linköping University 25-Oct-2016.*

### **Ongoing Research about Intelligent Systems applied to Smart Homes.**

*Jens Lundstrom Halmstad University, Sweden 20-Sep-16*

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SECTION C

# Members



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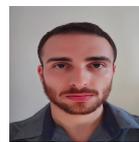
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