

# Adaptive Business Intelligence (ABI)

## Computing Paradigms (UCPP) or Technologies Curricular Unit (UTC) proposal for the MAP-I PhD Program<sup>1</sup>

### A – Programmatic Component

#### 1. Theme and motivation

Business organizations are increasingly using decision-making processes that are based on data. **Business Intelligence (BI)** is an umbrella term that includes methodologies, architectures, tools, applications and technologies to enhance managerial decision making [1][2]. The goal of BI is to access data from multiple sources and process these data into useful knowledge to support decision making. In 2007, a new trend emerged in the marketplace called **Adaptive Business Intelligence (ABI)** [3]. ABI systems extend the traditional BI model by encompassing two additional modules: **forecasting** [2, 4] and **optimization** [5], in order to enhance adaptability. In effect, **adaptability** is a vital component of any intelligent system and this issue is expected to gain popularity in the next years. The final ABI goal is to use computer systems that can adapt to changes in the environment, solving complex real-world problems with multiple objectives, in order to aid business managers.

The topics covered by ABI (data mining and data science, forecasting, modern optimization and adaptive systems) have a large research community, with several prestigious international scientific journals (e.g., Decision Support Systems, Machine Learning, Journal of Heuristics, Applied Soft Computing) and conferences (e.g., ACM KDD, IEEE IJCNN, ACM GECCO) available. There are also several international PhD programs that include ABI topics, such as:

- Carnegie Mellon University (CMU), USA (<http://www.cmu.edu/>):
  - **Ph.D. Program in Computer Science** (artificial intelligence, machine learning);
- Stanford University, USA (<http://www.stanford.edu/>):
  - **Ph.D. in Computer Science** (artificial intelligence, machine learning, databases, optimization)
- Berkeley University of California, USA (<http://berkeley.edu/>):
  - **Ph.D. in Computer Science** (artificial intelligence, machine learning, database management systems).

The proposed ABI unit had already **eleven** previous **MAP-I editions**, including:

- 2020-21: 6 students, at University of Porto;
- 2019-20: 3 students, at University of Minho;
- 2018-19: 4 students, at University of Aveiro;
- 2017-18: 9 students, at University of Porto;

The **assessment made by the students** on the previous editions **encourages further editions**. An anonymous questionnaire was launched in the e-learning system and the student's average responses were:

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<sup>1</sup> The same ABI curricular unit was considered by the MAP-i committee as “Computing Paradigms” (UCPP) in the MAP-i editions from 2013-2014 to 2019/20 and “Technologies” (UTC) in the previous editions (2008-9, 2010-11, 2011-12 and 2013-14).

- Question: “This teaching unit is **useful** for the PhD program”. Average responses over all ABI editions - **85%** (highly agree).

**Two ABI projects** (element B) of the 2014/15 edition resulted in **papers** published in the KDBI track of the EPIA international conference (Springer LNCS, indexed at Scopus and ISI): <http://epia2015.dei.uc.pt/kdbi/>. One of these papers [6] won the **best EPIA 2015 paper award**. Also, the ABI teachers published **international books** covering several ABI topics, namely: Business Intelligence and Data Analytics [1, 2]; and Optimization [5].

## 2 Objectives and Learning Outcomes

- To learn ABI concepts: BI, ABI, data mining, prediction, modern optimization and adaptability;
- To master the state of the art of ABI methods and models and tools;
- To perform a review essay over an advanced research ABI topic;
- To apply ABI in real-world applications.

## 3 Detailed Program

**1 - Introductory ABI concepts:** BI and ABI, data mining, prediction, optimization and adaptability, state of the art.

**2 – Using prediction and optimization to build adaptive systems:** application of data mining models and techniques in ABI (e.g., decision trees, neural networks and deep learning, support vector machine, random forests, hierarchical and relational clustering, inductive logic programming), application of optimization techniques in ABI (e.g., simulated annealing, evolutionary computation).

**3 - Conducting ABI projects and case studies:** CRISP-DM, ABI applied to real-world problems (e.g., Finance, Economy, Marketing).

**4 - Exploration of ABI tools:** Prediction and optimization tools (e.g., R [5], Python [6], WEKA/MOA/Rapidminer).

## 4 Teaching Methodologies and Evaluation

Four teaching methodologies will be applied:

- 1 - Lecture exposition of key ABI issues.
- 2 - Active learning (e.g., think-pair-share, in-class teams [7]).
- 3 - Case-based learning.
- 4 - Project based learning.

Evaluation will include two elements:

**A** - review of ABI research article(s) (30%, individual essay); and

**B** - an ABI project that describes the application of ABI tools to real-world datasets (70%, group project of 2 to 3 students).

ABI course can be offered either in a b-learning or in e-learning mode due to restrictions on classroom teaching.

## Block Schedule Request

In the MAP-I editions from 2014/15 to 2018/19, the first semester was organized in two blocks. Since there is a strong complement (but not overlap) between the courses ABI and KDD (Knowledge Discovery from Databases), we kindly request if these two courses could be offered in distinct blocks (if KDD is accepted for the 2021/22 edition). This happened in 2014/15 but not in 2015/16 to 2020/21, where students had to (to some extent) opt between ABI and KDD, diminishing the interesting KDD → ABI or ABI → KDD course sequence that would lead to strong student background in the area of intelligent data analysis.

## 5 Bibliography

### Cited references:

- [1] A. Azevedo, M.F. Santos (Ed.). (2014). Integration of Data Mining in Business Intelligence Systems. IGI Global.
- [2] J. Moreira, A. Carvalho, T. Horváth, A General Introduction to Data Analytics, Wiley, 2018.
- [3] Z. Michalewicz, M. Schmidt, M. Michalewicz and C. Chiriac, Adaptive Business Intelligence, Springer-Verlag, Leipzig, Germany, 2007.
- [4] R. Hyndman and G. Athanasopoulos, Forecasting: Principles and Practice, Monash University, Australia, 2018.
- [5] P. Cortez. Modern Optimization with R. Springer, 2<sup>nd</sup> edition, <https://www.springer.com/gp/book/9783030728182>
- [6] K. Fernandes, P. Vinagre and P. Cortez. A Proactive Intelligent Decision Support System for Predicting the Popularity of Online News, In Proceedings of 17th Portuguese Conference on Artificial Intelligence (EPIA 2015), Springer, Coimbra, Portugal, LNCS 9273, pp. 535-546, September, 2015.
- [7] D. Johnson, R. Johnson and K. Smith, Active Learning: Cooperation in the College Classroom, 2nd edition, Edina, Interaction Book Company, 1998.

### Additional references:

- [8] S. Luke, S. Essentials of metaheuristics (second edition). George Mason University. Free access: <http://cs.gmu.edu/~sean/book/metaheuristics/>, 2015.
- [9] D. Delen, E. Turban, D. Sharda, Business Intelligence: A Managerial Perspective on Analytics, Pearson Prentice-Hall, New Jersey, USA, 2014.
- [10] P. Cortez, Data Mining with Neural Networks and Support Vector Machines using the R/rminer Tool, In P. Perner (Ed.), Advances in Data Mining, Proceedings of 10th Industrial Conference on Data Mining, Berlin, Germany, Lecture Notes in Artificial Intelligence 6171, pp. 572-583, Berlin, Germany, July, 2010.

## B Lecture Team

### 1. Summary

The lecture team includes the four members. **Manuel Filipe Santos** and **Paulo Cortez** belong to the Intelligent Data Systems (IDS) - <http://algoritmi.uminho.pt/research-teams/ids>, research group of the ALGORITMI R&D Centre, University of Minho. Both research on Adaptive Business Intelligence, Decision Support Systems and Data Mining. M.F. Santos performed his PhD in Distributed Learning Classifier Systems, while P. Cortez performed his PhD in Forecasting, Neural Networks and Evolutionary Optimization. **Rui Camacho** and **João Mendes Moreira** are from the Laboratory of Artificial Intelligence and Decision Support (LIAAD) R&D centre, <http://www.liaad.up.pt/>, of INESC-TEC and Faculty of Engineering University of Porto (FEUP). R. Camacho researches in

Inductive Logic Programming and Data Mining and J. Moreira researches in Machine Learning, Applied Data Mining and Intelligent Transport Systems. For more details, see the CVs in section B.3.

The team is willing to write didactic texts related to this unit. An example of this are the three books already published [1, 2, 5].

## 2. Coordinator

Manuel Filipe Santos (MFS)

## 3. CVs

### 3.1 Manuel Filipe Santos

**Biography:** Manuel Filipe Santos received his Ph.D. in Computer Science (Artificial Intelligence) from the University of Minho (UMinho), Portugal, in 2000. He is associate professor with habilitation at the Department of Information Systems, UMinho, teaching undergraduate and graduate classes of Business Intelligence and Decision Support Systems. He is the head of Intelligent Data Systems lab and the coordinator of the Information Systems and Technology group ([www.algoritmi.uminho.pt](http://www.algoritmi.uminho.pt)) of the R&D ALGORITMI Centre, with the current research interests: Business Intelligence; Intelligent Decision Support Systems; Data Mining and Machine Learning (Learning Classifier Systems); and Grid Data Mining. He is part of the steering committees of the master's course in Engineering and Management of Information Systems and the Doctoral Program in Information Systems and Technology.

### Relevant publications in the last 5 years:

He is co-author of more than 296 indexed (e.g., ISI, Scopus) publications in international conferences, books and journals (e.g., published by IEEE, Elsevier or Springer). He has more than 1430 scopus citations, 3009 google scholar citations. His scopus h-index is 18 and google scholar h-index is 26. His relevant publications in this area, in the last 5 years, are:

1. Applied Pervasive Patient Timeline in Intensive Care Units, André Braga, Filipe Portela, Manuel Filipe Santos, António da Silva Abelha, José Machado, Álvaro Silva, Fernando Rua, Hospital Management and Emergency Medicine: Breakthroughs in Research and Practice, 567-579, IGI Global, 2020
2. Step towards pervasive technology assessment in intensive medicine, Filipe Portela, Manuel Filipe Santos, José Machado, António da Silva Abelha, Fernando Rua, Hospital Management and Emergency Medicine: Breakthroughs in Research and Practice, 213-229, IGI Global, 2020
3. Data extraction and exploration tools for business intelligence, Cardoso, M., Guimarães, T., Portela, C.F., Santos, M.F., Advances in Intelligent Systems and Computing, Elsevier, 2020.
4. A data mining study on pressure ulcers, Mota, F., Abreu, N., Guimarães, T., Santos, M.F., DATA 2019 - Proceedings of the 8th International Conference on Data Science, Technology and Applications, 2019, Pages 251-258.
5. A regression data mining approach in Lean Production, Bragança, R., Portela, F., Santos, M., Concurrency Computation, Volume 31, Issue 22, 25 November 2019

6. Adaptive business intelligence in healthcare - A platform for optimising surgeries, Ferreira, J., Portela, F., Machado, J., Santos, M.F., Advances in Intelligent Systems and Computing, Volume 932, 2019, Pages 611-620
7. Iron value classification in patients undergoing continuous ambulatory peritoneal dialysis using data mining, Peixoto, C., Peixoto, H., Machado, J., Abelha, A., Santos, M.F., ICT4AWE 2018 - Proceedings of the 4th International Conference on Information and Communication Technologies for Ageing Well and e-Health, Volume 2018-March, 2018, Pages 285-290
8. Data mining classification models for industrial planning, Bragança, R., Portela, F., Vale, A., Guimarães, T., Santos, M., Communications in Computer and Information Science, Volume 721, 2017, Pages 585-594

#### **Participation in R&D projects in the last 5 years:**

He participated in various R&D projects, being Coordinator/Principal Investigator of 8 projects, namely:

- CONTROLO INTELIGENTE DE INFEÇÃO HOSPITALAR, Referência 02/SAMA2020/2019;
- Apoio à Decisão Inteligente na otimização de tempos de resposta e de recursos para melhoria da qualidade de serviço, Referência 03/SAMA2020/20;
- Gestão inteligente de internamento como forma de aumentar a qualidade e eficiência, Referência 04/SAMA2020/2019;
- Data Science aplicada à diabetes para aumento de qualidade de vida do doente e de racionalização de custos, Referência 01/SAMA2020/2019;
- ICDS4IM - Intelligent Clinical Decision Support for Intensive Medicine DSAIPA/DS/0084/2018
- Deus Ex Machina – Symbiotic technology for societal efficiency gains NORTE-01-0145-FEDER-000026.
- INTELLITAG - Intelligent tagging systems.

#### **Supervision of Graduate Students:**

He has supervised/co-supervised more than 86 MSc theses, 12 PhD theses and 2 postdoc. Currently he supervises/co-supervises 9 PhD and 22 MSc students.

### **3.2 Paulo Cortez**

#### **Biography:**

**Paulo Cortez** (PhD, Habilitation) is **Associate Professor** (with tenure) at the Department of Information Systems, University of Minho. He is also **Member of the Directive Board** of the ALGORITMI Centre. His current research interests are in the fields of: Business Analytics and Decision Support Systems; Data Mining and Machine Learning; Neural Networks and Evolutionary Computation; and Forecasting.

#### **Relevant publications in the last 5 years:**

He is co-author of more than 160 indexed (e.g., ISI, Scopus) publications in international conferences and journals (e.g., published by IEEE, Elsevier or Springer). He has more than 8500 google scholar citations and his google scholar h-index is 39 (<http://scholar.google.com/citations?hl=en&user=fQ42U-8AAAAJ>). His relevant publications in the last 5 years are:

- [1] Pereira, P. J., Cortez, P., & Mendes, R. (2021). Multi-objective Grammatical Evolution of Decision Trees for Mobile Marketing user conversion prediction. **Expert Systems with Applications**, 168, 114287.
- [2] Gonçalves, J. N., Cortez, P., Carvalho, M. S., & Frazão, N. M. (2021). A multivariate approach for multi-step demand forecasting in assembly industries: Empirical evidence from an automotive supply chain. **Decision Support Systems**, 142, 113452.
- [3] Zola, P., Cortez, P., & Brentari, E. (2021). Twitter alloy steel disambiguation and user relevance via one-class and two-class news titles classifiers. **Neural Computing and Applications**, 33, 1245-1260.
- [4] Zola, P., Ragno, C., & Cortez, P. (2020). A Google Trends spatial clustering approach for a worldwide Twitter user geolocation. **Information Processing & Management**, 57(6), 102312.
- [5] Cortez, P., Pereira, P. J., & Mendes, R. (2019). Multi-step time series prediction intervals using neuroevolution. **Neural Computing and Applications**, 32(13):8939-8953.
- [6] Gonçalves, S., Cortez, P., & Moro, S. (2019). A deep learning classifier for sentence classification in biomedical and computer science abstracts. **Neural Computing and Applications**, 32 (11), 6793-6807.
- [7] P. Zola, P. Cortez, M. Carpita, Zola, P., Cortez, P., & Carpita, M. (2019). Twitter user geolocation using web country noun searches. In **Decision Support Systems**, 120:50-59 (ISI impact factor 3.565)
- [8] S. Gonçalves, P. Cortez, S. Moro. A Deep Learning Approach for Sentence Classification of Scientific Abstracts, **ICANN 2018 proceedings**, LNCS 11141, pp. 479-488 (ISI, Scopus)
- [9] P. Afsar, P. Cortez and H. Santos. Automatic human trajectory destination prediction from video. In **Expert Systems with Applications**, 110:41-51 (ISI impact factor 3.768)
- [10] Insights from a text mining survey on Expert Systems research from 2000 to 2016. P. Cortez, S. Moro, P. Rita, D. King and J. Hall. In **Expert Systems**, 35(3):e12280 (ISI impact factor 1.430)
- [11] N. Oliveira, P. Cortez, N. Areal. (2017). The impact of microblogging data for stock market **prediction: Using Twitter to predict returns, volatility, trading volume and survey sentiment** indices. In **Expert Systems with Applications**, 73, 125-144 (ISI impact factor 2.981)
- [12] C.R. Sá, C. Soares, A. Knobbe, P. Cortez. (2017). Label Ranking Forests. In **Expert Systems**, 34:1 (ISI impact factor 0.947)

### Participation in R&D projects in the last 5 years:

He participated in 19 R&D projects, including:

- **Evolvable Mechanisms of Cyber-Physical Systems**, prospective project of the Digital Transformation (DTx) Collab, January 2019 to December 2023 (Coordinator).
- **Artificial Intelligence for Business Processes (FOF.BI.57)**, P2020, Consortium: ALGORITMI/CCG, UMinho and Bosch, July 2018 to December 2021 (Coordinator).
- **IRMDA - Intelligent Risk Management for the Digital Age**, Project Individual P2020, Consortium: ALGORITMI/CCG, UMinho and Wedo Technologies, November 2018 to December 2019 (Coordinator).
- **TexBoost - Less Commodities more Specialities (PP1, CCG team)**, Project: n° 24523, Programa Mobilizador, Aviso N°10/SI/2016, Consortium: ALGORITMI/CCG, UMinho; Citeve and others, July 2017 to June 2020 (Coordinator of PP1).
- **PROMOS - Predicting and Optimizing Marketing Campaigns For Mobile Devices**, Project: NORTE-01-0247-FEDER-017497, December 2016 to November 2019 (Coordinator)

### **Supervision of Graduate Students in the last 5 years:**

Supervised 1 Postdoc and 4 PhD theses. Currently he is supervising 12 PhD students.

### **3.3 Rui Camacho**

**Biography:** Rui Camacho received his Ph.D. in Electrical Engineering and Computers from the University of Porto (UP), Portugal, in 2000. He is Associate Professor at the Informatics Engineering Department of the Faculty of Engineering at UP, teaching undergraduate and graduate classes of Machine Learning and Data Mining. He is also researcher at the Laboratory of Artificial Intelligence and Decision Support (LIAAD) that is part of INESC-TEC, with the current research interests:

- Inductive Logic Programming;
- Parallel Algorithms for Data Mining
- Data Mining and Machine Learning;
- Relational Data Mining;
- Applications of Chemoinformatics;
- Applications of Bioinformatics;
- Applications of Biomedicine.

### **Relevant publications in the last 5 years:**

His most significant publications for the field in the last 5 years are:

- [1] Goncalves, CAO; Camacho, R ; Goncalves, CT; Vieira, AS; Diz, LB; Iglesias, EL; “Classification of Full Text Biomedical Documents: Sections Importance Assessment”, 2021, APPLIED SCIENCES-BASEL, vol. 11, N. 6
- [2] Michael A P Domingues; Rui Camacho ; Pedro Pereira Rodrigues; “CMIID: A comprehensive medical information identifier for clinical search harmonization in Data Safe Havens”; 2021; J. Biomed. Informatics, vol 114
- [3] Cavadas, B; Leite, M; Pedro, N; Magalhaes, AC; Melo, J; Correia, M; Maximo, V ; Camacho, R ; Fonseca, NA ; Figueiredo, C ; Pereira, L; “Shedding Light on the African Enigma: In Vitro Testing of Homo sapiens-Helicobacter pylori Coevolution”; 2021; MICROORGANISMS, vol 9, N. 2
- [4] Bruno Cavadas; Rui Camacho ; Joana C Ferreira; Rui M Ferreira; Ceu Figueiredo ; Alvis Brama; Nuno A Fonseca ; Luisa Pereira; “Gastric Microbiome Diversities in Gastric Cancer Patients from Europe and Asia Mimic the Human Population Structure and Are Partly Driven by Microbiome Quantitative Trait Loci”; 2020, MICROORGANISMS, vol 8,N. 8
- [5] Mafalda Falcão Ferreira, MSc.; Rui Camacho; Luís Filipe Teixeira, “Using Autoencoders as a Weight Initialization Method on Deep Neural Networks for Disease Detection”, BMC Supplements, BMC MEDICAL INFORMATICS AND DECISION MAKING, vol 20, N. 5; 2020
- [6] Empowering Distributed Analysis Across Federated Cohort Data Repositories Adhering to FAIR Principles; Artur Rocha ; José Pedro Ornelas ; João Correia Lopes ; Rui Camacho ; 2019, ERCIM NEWS, vol 2019, N. 118
- [7] *Carlos Adriano Gonçalves, Eva Lorenzo Iglesias, Lourdes Borrajo Rui Camacho, A. Seara Vieira, Célia Talma Gonçalves: LearnSec: A Framework for Full Text Analysis. HAIS 2018: 502-513*
- [8] Artur Rocha, Rui Camacho, Jeroen Ruwaard e Heleen Riper, “Using multi-relational techniques to discriminate blended therapy efficiency on patients based on log data”, ISII, Vol. N. pp , 2018
- [9] *Noé Vázquez, Sara Rocha, Hugo López-Fernández, André Torres, Rui Camacho, Florentino Fdez-Riverola, Jorge Vieira, Cristina P. Vieira, Miguel Reboiro-Jato: EvoPPI: A Web Application to Compare Protein-Protein Interactions (PPIs) from Different Databases and Species. PACBB 2018: 149-156*

- [10] "Co-expression networks between protein encoding mitochondrial genes and all the remaining genes in human tissues", João Almeida, Joana Ferreira, Rui Camacho, Luisa Pereira, BIBM 2017

### **Participation in R&D projects in the last 5 years:**

He participated in various R&D projects:

- EUCAN\_CONNECT – Connecting Europe and Canada in personalized & preventive health care, H2020 project
- RECAP - "Research on European Children and Adults born Preterm", H2020 project :
- E-COMAPERD - "European Comparative Effectiveness Research on Internet-based Depression Treatment", H2020 project
- NanoStima (Norte2020) project
- ICE.Mobilidade (SI IDT – 13843/2011) projecto QREN;
- IC4Depression (projecto europeu).
- FCT project : ADE - Adverse Drug Effects Detection

Principal Investigator of the project: **ILP-Web-Service: An Inductive Logic Programming based Web service**

### **Supervision of Graduate Students:**

Has supervised 55 MSc theses and 7 PhD theses. Currently supervises 8 PhD students and 5 MSc students.

## **3.4 João Mendes Moreira**

### **Biography:**

**João Mendes Moreira** (PhD, 2008) is associate professor at the Department of Informatics Engineering, University of Porto and senior researcher at the Laboratory of Artificial Intelligence and Decision Support (LIAAD) from INESC TEC, Porto. His current research interests are in the fields of: Business Intelligence and Decision Support Systems; Supervised Machine Learning; Intelligent Transportation Systems; Precision Agriculture.

### **Relevant publications in the last 5 years:**

His most significant publications for the field in the last 5 years are:

[1] J Moreira, A Carvalho, T Horvath, A general Introduction to Data Analytics, Wiley, 2019

[2] M Bhanu, J Mendes-Moreira, J Chandra, Embedding Traffic Network Characteristics Using Tensor for Improved Traffic Prediction, IEEE transactions on Intelligent Transportation Systems 22 (6), 3359-3371, 2021.

[3] Kemilly Dearo Garcia, Cláudio Rebelo de Sá, Mannes Poel, Tiago Carvalho, João Mendes-Moreira, João MP Cardoso, André de Carvalho, Joost Kok. An Ensemble of Autonomous Auto-Encoders for Human Activity Recognition, Neurocomputing, 439: 271-280, 2021.



[4] PJS Ferreira, JMP Cardoso, J Mendes-Moreira, kNN Prototyping Schemes for Embedded Human Activity Recognition with Online Learning, *Computers* 9 (4), 96, 2020.

[5] MS Sirsat, J Mendes-Moreira, C Ferreira, M Cunha, Machine Learning predictive model of grapevine yield based on agroclimatic patterns, *Engineering in Agriculture, Environment and Food* 12 (4), 443-450, 2019.

[6] D Gomes, J Mendes-Moreira, I Sousa, J Silva, Eating and Drinking Recognition in Free-Living Conditions for Triggering Smart Reminders, *Sensors* 19 (12): 2803, 2019.

[7] Pedro Mendes-Moreira, Zlatko Satovic, João Mendes-Moreira, João Pedro Santos, João Pedro Nina, Silas Pêgo, Maria Carlota Vaz Patto, Maize participatory breeding in Portugal: Comparison of farmer's and breeder's on-farm selection, *Plant Breeding*, 136: 861-871, 2017.

### **Participation in R&D projects in the last 5 years:**

He participated in various R&D projects:

- Safe Cities - Inovação para Construir Cidades Seguras, POCI-01-0247-FEDER-041435 (Safe Cities), início: 01-04-2019
- Projet in copromotion PROMESSA: Entities: StrongStep, FEUP, INESC TEC and Fraunhofer-AICOS. Role: Principal Researcher from FEUP & INESC TEC [Jul 2019 – Jun 2022]
- SPARC project: Improving regional transportation services using GPS data. Financed by the Indian government. Role: Foreign Principal Researcher [Apr 2019 – Mar 2021]
- Researcher of the FCT project CONTEXTWA: Middleware and Context Inference Techniques from DataStreams for the Development of ContextAware Services using Mobile Devices [Jul 2016 – Jun 2019].
- Researcher of the P2020 project SmartFarming: The project intends to develop an innovative agronomy management tool that will provide, on the one hand, a simplification of agricultural processes and, on the other hand, the optimization of them [1-10-2016 – 30-9-2018].
- Researcher of the FP7 project MAESTRA: Learning from Massive, Incompletely annotated, and Structured Data. Project reference: FP7-ICT 612944 [1-2-2013, 31-1-2017].

### **Supervision of Graduate Students:**

He has supervised/co-supervised 62 MSc theses, 2 PhD theses and 2 postdoc. Currently supervises/co-supervises 12 PhD students and 2 MsC students.