Adaptive Business Intelligence (ABI)

Computing Paradigms (UCPP) or Technologies Curricular Unit (UTC) proposal for the MAP-I PhD Program

A – Programmatic Component

1. Motivation

Nowadays, 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]. The goal of BI is to access data from multiple sources and process these data into useful knowledge that can be used to support decision making. Recently, a new trend emerged in the marketplace called Adaptive Business Intelligence (ABI) [2]. ABI systems extend the traditional BI model by encompassing two additional modules: forecasting [3] and optimization [4], 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 to make better decisions, increasing efficiency and competitiveness.

Although being a recent field, the topics covered by ABI (data mining, forecasting, modern optimization and adaptive systems) have a large research community, with several prestigious international scientific journals (e.g., Data Mining Knowledge Discovery, Decision Support Systems, Machine Learning, International Journal of Forecasting, Journal of Heuristics, Applied Soft Computing) and conferences (e.g. ACM KDD, IEEE IJCNN, IEEE CEC) available. There are also several international PhD programs that include ABI topics, such as:

- Carnegie Mellon University (CMU), USA:
  - Ph.D. Program in Computer Science (artificial intelligence);
  - PhD in Algorithms, Combinatorics and Optimization (machine learning, optimization)
  - Ph.D. Program in Information Systems and Management (machine learning and data analytics);
- Stanford University, USA:
  - Ph.D. in Computer Science (artificial intelligence)
- Berkeley University of California, USA:
  - Ph.D. in Computer Science, specialization in Communication, Computation and Statistics (learning and decision-making, time series, optimization).

The proposed ABI unit had already eight previous MAP-I editions:

- 2016-17: 6 students, at University of Minho;
- 2015-16: 5 students, University of Aveiro (http://mapi.map.edu.pt/pages/93);
- 2014-15: 13 students, University of Porto (http://mapi.map.edu.pt/pages/25);
- Other editions: 2013-14: 11 students, University of Minho; 2012-13: 8 students, University of Aveiro; 2011-12: 10 students, University of Porto;

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 2016/17 and “Technologies” (UTC) in the previous editions (2008-9, 2010-11, 2011-12 and 2013-14).
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:

- Question: “This teaching unit is useful for the PhD program”. Average responses over all ABI editions - 83% (highly agree).
- Question: “Positive stimulus for an active student participation and discussion in class?”. Average responses over all ABI editions: 87% (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, one of the ABI teachers published an international book by Springer [4] and that addresses in a practical manner several optimization (and even forecasting) topics lectured in the ABI course unit.

2 Objectives and Learning Outcomes

- To learn about the ABI concepts, including: characteristics of complex business problems, BI and 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: characteristics of complex business problems, BI and ABI, data mining, prediction, modern 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 [4], Python [6], WEKA/ MOA, OPT4J, EvA2).

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 [5]).
3 - Case-based learning.
4 - Project based learning.

Evaluation will include two elements:

A - review of ABI research article(s) (30%, individual essay); and
5 Block Schedule Request

In the MAP-I editions from 2014/15 to 2016/17, 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 2017/18 edition). This happened in 2014/15 but not in 2015/16 or 2016/17, 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.

6 Bibliography

Cited references:

Additional references:
B Lecture Team

1. Summary
The lecture team includes the three members of the previous eight ABI editions (MAP-I 2008/9, 2010/11, 2011/12, 2012/13, 2013/14, 2014/15, 2015/16). Manuel Filipe Santos (M.F. Santos) and Paulo Cortez (P. Cortez) belong to the Intelligent Data Systems (IDS) - http://algoritmi.uminho.pt/research-teams/ids, research group of the ALGORITMI R&D Centre (evaluated as “ Very Good” by FCT), 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 (R. Camacho) is from the Laboratory of Artificial Intelligence and Decision Support (LIAAD) R&D centre, http://www.liaad.up.pt/, of INESC-TEC (evaluated as “Excellent” by FCT), University of Porto. R. Camacho researches in Inductive Logic Programming and Data Mining. 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 is the book “Modern Optimization with R” that P. Cortez had recently published with Springer (in 2014), see: http://www.springer.com/gp/book/9783319082622

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 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 group (www.algoritmi.uminho.pt) and coordinator of Healthy and Secure People thematic strand (http://algoritmi.uminho.pt/ts-healthy) of the R&D Algoritmi Centre, with the current research interests:
- Business Intelligence and Decision Support Systems;
- Data Mining and Machine Learning (Learning Classifier Systems);
- Grid Data Mining.

Relevant publications in the last 5 years:
He is co-author of more than 110 indexed (e.g., ISI, Scopus) publications in international conferences, books and journals (e.g., published by IEEE, Elsevier or Springer). He has more than 1174 google scholar citations and his google scholar h-index is 15 and i10-index is 33. Recently, he co-edited the book Integration of Data Mining in Business Intelligence Systems, IGI, 2014, ISBN13: 9781466664777. His relevant publications in this area, in the last 5 years, are:
[2] Sérgio Oliveira, Filipe Portela, Manuel Filipe Santos, José Machado, António Abelha, Álvaro Silva and Fernando Rua. Characterizing Barotrauma Patients in ICU – Clustering Data Mining using ventilator variables. Lecture Notes in...


Participation in R&D projects in the last 5 years:
He participated in various R&D projects, being Coordinator/Principal Investigator of 4 projects, namely:
- Deus Ex Machina – Symbiotic technology for societal efficiency gains NORTE-01-0145-FEDER-000026.
- INTELLITAG - Intelligent tagging systems.
- GridClass – Learning Classifiers for Grid Data Mining, Principal Investigator, Approved for founding FCT GRID/GRI/81736/2006, 2008-2011

Supervision of Graduate Students:
Supervised more than 25 MSc theses and 10 PhD theses. Currently he is supervising 2 PhD students and 1 pos-doc.

Other relevant topics of his CV:
- **Co-organized** the EPIA 2007 – 13th Portuguese Conference on Artificial Intelligence.
- **Reviewer** of several conferences (e.g. AAMAS, EPIA, ICEIS, ICAART, MEDI) and journals (e.g. European Journal of Operational Research, Intelligent Decision Making Support Systems);

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 Coordinator of the Information Systems and Technologies (IST) research group of ALGORITMI Centre (with 48 PhD researchers). His current research interests are in the fields of: Business Intelligence 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 one hundred and thirty indexed (e.g., ISI, Scopus) publications in international conferences and journals (e.g., published by IEEE, Elsevier or Springer). He has more than 3090 google scholar citations and his google scholar h-index is 26 (http://scholar.google.com/citations?hl=en&user=fQ42U-8AAAAJ). His relevant publications in the last 5 years are:


**Participation in R&D projects in the last 5 years:**
He participated in 4 R&D projects, namely:


**Supervision of Graduate Students in the last 5 years:**
Supervised 1 Postdoc, 4 PhD theses and 10 MSc theses. Currently he is supervising 5 PhD students.

**Other relevant topics of his CV:**
- **Associate Editor** of the Expert Systems (Wiley, ISI, since 2013) and Neural Processing Letters (Springer, ISI, from 2008 to 2015) journals.
- **External Evaluator of International R&D projects** from France (ANR), Poland (NCBR), Israel and Romenia (UEFISCDI).
- **Program Committee Member** more than 70 conferences/workshops, such as: IDEAL 2016, IBERAMIA 2016, ACM WIMS'17, ECAI2010, IEEE IJCNN 2017.
- **Co-organizer** of 22 Workshops, such as: Machine Learning track of IBERAMIA 2012; Knowledge Discovery and Business Intelligence (KDBI EPIA 2015); Ubiquitous Data Mining (UDM-IJCAI 2013; UDM-ECAI 2012).
- **Invited lecturer** in the International Summer School of Neural Networks in Classification, Regression and Data Mining (2010; 2012).
- Acted as **external examiner** of 22 MSc and 6 PhD thesis.
- **Author** of the open source RMiner library, which facilitates the use of Data Mining applications in R ([http://www3.dsi.uminho.pt/pcortez/rminer.html](http://www3.dsi.uminho.pt/pcortez/rminer.html)).
- He was **vice-president** of the Portuguese Association for Artificial Intelligence (APPIA, from 2012 to 2015).
- He has a **strong post-graduate teaching experience**, having taught 33 MSc course units and 9 PhD course units in MAP-I Universities, University Institute of Lisbon and Universitat Politècnica de Catalunya – BarcelonaTech.
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:


**Participation in R&D projects in the last 5 years:**
He participated in various R&D projects:
- **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 28 MSc theses and 6 PhD theses. Currently supervises 5 PhD students and 10 MsC students.

- **Other relevant topics of his CV:** Co-organized VecPar 2016
- Co-organized the **ECML/PKDD 2005** – European Conference on Machine Learning and the European Conference on Principles and Practice of Knowledge Discovery in Databases.
- Was guest editor of the Machine Learning journal Vol. 64, N. 1/2/3, 2006.
- Belongs to the editorial board of the International Journal of Computational Intelligence in Bioinformatics and Systems Biology (IJCIBSB)
- Made review work for the following international journals: Journal of Computational Intelligence; IEEE journal of Systems Man and Cybernetic (SMC-B); Data & Knowledge Engineering (DKE), journal of Artificial Intelligence Research (JAIR); Machine Learning journal.
- Made review work for the following international conferences: IJCAI, ECML, ICML, AAAI, PAKDD, ICLP, ADMA and others.
- Was evaluator of several project proposals from the Compuer Science Department from Katholieke Universiteit Leuven, Belgium.
- Is "International Colaborator" of "Núcleo de Apoio à Pesquisa para Aprendizado de Máquina em Análise de Dados" in USP, Brasil.
- Was an external examiner in a Phd thesis from University of New South Wales, (Australia)