Adaptive Business Intelligence (ABI)

Technology Curricular Unit (UTC) proposal for the MAP-I PhD Program

A – Programmatic Component

1. Motivation

Nowadays, business organizations are increasingly moving towards decision-making processes that are based on information. **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, transform these data into information and then into knowledge.

Very recently, a new trend emerged in the marketplace called **Adaptive Business Intelligence (ABI)** [2]. Besides transforming data into knowledge, ABI also includes the decision-making process. BI systems often include elements of databases, data warehouses and data mining [1], while ABI systems encompass 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, productivity and competitiveness.

Although being a recent field, the topics covered by ABI (i.e. 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, IEEE Trans. Neural Networks, International Journal of Forecasting, IEEE Trans. Evolutionary Computation, Journal of Heuristics, Applied Soft Computing) and conferences (e.g. ACM KDD, ACM CIKM, ACM ICIS, IEEE ICDM, IEEE IJCNN, IEEE CEC) available.

There are also several international examples of Computer Science PhD programs that include ABI topics, such as:

- **Carnegie Mellon University (CMU), USA:**
  - Ph.D. Program in Computer Science (machine learning, optimization);
  - Ph.D. Program in Computation, Organizations and Society (machine learning and advanced artificial intelligence concepts);
  - Ph.D. Program in Machine Learning (data mining, machine Learning, database management systems, optimization);

- **Standford University, USA:**
  - Ph.D. in Computer Science (databases, data mining, machine learning, modern optimization)

- **Berkeley University of California, USA:**
  - Ph.D. in Computer Science, specialization ins Communication, Computation and Statistics (database management systems, data mining, decision support);

- **University of Texas at Austin, USA:**
o Ph.D. in Computer Science (database systems, data mining, machine learning, neural networks, reinforcement learning);

- Auburn University, USA:
  o Ph.D. in Computer Science and Software Engineering (database systems, artificial intelligence, machine learning, evolutionary computation and modern optimization, neural networks)

The proposed ABI unit had already two previous MAP-I editions:
- 2008/09 lective year, at University of Porto (http://www.map.edu.pt/i/2008/courses); and
- 2010/11 lective year, at University of Minho (http://www.map.edu.pt/i/2010/Courses). Note: an anonymous questionnaire was launched in the ABI e-learning system and the students average response was 83% (where 100% means I completely agree) to the question: “this teaching unit is useful for the PhD program”.

2 Objectives and Learning Outcomes

To learn about the basic 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, 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, support vector machine, learning classifier systems, hierarchical and relational clustering, inductive logic programming), application of optimization techniques in ABI (e.g., heuristic search, hill-climbing, tabu-search, 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: DM and optimization tools (e.g. R, WEKA, SAS Enterprise Miner, Rapidminer, Evolution Machine, SCS-C, Aleph, Moss), BI tools (e.g., SAS, MS SQL Server).

4 Teaching Methodology 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 three elements:
A - review of ABI research article(s) (20%); and
B - an ABI project that describes the application of ABI tools to real-world datasets (80%);

5 Bibliography

Cited references:

Additional references:

B Lecture Team

1. Summary

The lecture team includes the three members of the previous two ABI editions (MAP-I 2008/9 and 2010/11). **Manuel Filipe Santos (MFS)** and **Paulo Cortez (PC)** belong to the Business Intelligence Group (BIG) 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. MFS performed his PhD in Distributed Learning Classifier Systems, while PC performed his PhD in Forecasting, Neural Networks and Evolutionary Optimization. **Rui Camacho (RC)** is from the Laboratory of Artificial Intelligence and Decision Support (LIAAD R&D centre, evaluated as “Very Good” by FCT), University of Porto. RC 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. If necessary and funds are available, one of the team members can visit CMU for the curricular unit accreditation.

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 also researcher at the Business Intelligence Group (big.dsi.uminho.pt) 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:**

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, being Principal Investigator of 2 projects, namely:
- Intcare – Intelligent Decision Support System for Intensive Care Medicine
- Gridclass – Learning Classifier Systems for Grid Data Mining

**Supervision of Graduate Students:**

Supervised 13 MSc theses and 2 PhD theses. Currently he is supervising 9 PhD students.

**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);
- **Co-organizer of** the Knowledge Discovery and Business Intelligence - KDBI 2009 and 2011 thematic track of EPIA; WISA/CISTI 2011 and Intelligent Systems/ESM 2011.

**3.2 Paulo Cortez**

**Biography:**
Paulo Cortez (PhD in Computer Science) is an Associate Professor at the Department of Information Systems, University of Minho, where he teaches undergraduate and graduate classes of Computer Programming and Business Intelligence. He is also researcher at the Business Intelligence Group of the R&D Algoritmi Centre, with the research interests including (http://www3.dsi.uminho.pt/pcortez):

- Business Intelligence and Decision Support Systems;
- Data Mining and Machine Learning;
- Neural Networks and Evolutionary Computation;
- Forecasting.

Relevant publications in the last 5 years:

He is co-author of more than sixty publications in international conferences and journals (e.g. published by IEEE, Elsevier or Springer). His relevant publications in the last 5 years are:


[18] 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 (Scopus)


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

He participated in 4 R&D projects, being Principal Investigator of 1 project, namely:


Supervision of Graduate Students:

Supervised 1 PhD thesis and 10 MSc thesis. Currently he is supervising 4 PhD students.

Other relevant topics of his CV:

- **Associate Editor** of the **Neural Processing Letters** journal (Springer, ISI).
- **Reviewer** of several ISI journals (e.g. Expert Systems, Data & Knowledge Engineering, Neurocomputing) and conferences (e.g. IJCNN, DMin, ICDM, PPKDD).
- **Co-organized** the Knowledge Discovery and Business Intelligence - KDBI 2009 thematic track of EPIA;
- **Invited lecturer** in the International Summer School of Neural Networks in Classification and Data Mining (2003-06;2008; 2010).
- Acted as **external examiner** of 11 MSc and 3 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).

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), with the current research interests:
- Inductive Logic Programming;
- Data Mining and Machine Learning;
- Relational Data Mining;
- Applications of Bioinformatics.

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, being Principal Investigator of 1 project, namely:

ILP-Web-Service: An Inductive Logic Programming based Web service

Supervision of Graduate Students:

Has supervised 2 MSc theses and 2 PhD theses. Currently supervises 5 PhD students.

Other relevant topics of his CV:
• 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).