

# Knowledge Discovery from Data Bases

## Proposal for a MAP-I UC

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## 1 Knowledge Discovery from Data Bases

*“We are deluged by data: scientific data, medical data, demographic data, financial data, and marketing data. People have no time to look at this data. Human attention has become the precious resource. So, we must find ways to automatically analyze the data, characterize trends in it, and automatically flag anomalies.”* (Han e Kamber, 2006).

The development of information and communication technologies make possible collect data with high degree of detail that might be automatically transmitted at high-speed. Some examples of real-world applications include: TCP/IP traffic, queries in search engines over Internet, records of telecommunication calls, SMS, emails, stock market, sensors in electrical grid, etc. For illustrative purposes, we present some numbers: The number of daily phone calls is around 3 billion; the number of SMS is 1 billion daily, the number of sent emails is around 30 billion.

Most of this information will never be seen by a human being. Taking this into account, tools for automatic real-time data analysis are of increasing importance. The computer processes, analyze, and filter the data, selecting the most promising hypothesis. Some typical applications include: user modeling, activity monitoring, sensor networks, classification, intrusion detection, etc.

Scientific areas: Data Mining, Machine Learning, Computer Science.

### 1.1 Main Goals

At the end of the semester the students should be able to:

1. Formulate a decision problem as a data mining problem;
2. Identify the basic tasks in knowledge discovery from data bases;

3. Identify and use the main methods in solving data mining problems;
4. Apply the main methods and algorithms for each mining task;
5. Apply the main methods and algorithms in real-world problems and adapt to new contexts.

## 1.2 Program

- Introductory Concepts
  - Introduction to Knowledge Discovery in Data Bases
    - \* From OLAP to *On-Line Analytical Mining*;
    - \* Data Mining tasks;
  - Cluster Analysis
    - \* Cluster Analysis: concepts and methods;
    - \* Partitioning and Hierarchical Methods;
  - Association Analysis
    - \* Frequent pattern mining;
    - \* Frequent Sequence mining;
  - Predictive Data Mining: Classification and Regression.
    - \* Optimization Methods;
    - \* Probabilistic Methods;
    - \* Search based Methods;
  - Evaluation in Predictive Data Mining.
    - \* Evaluation: goals and perspectives;
    - \* Loss Functions and Cost-benefit analysis;
    - \* Bias-Variance analysis;
  - Ensembles and Multiple Models
    - \* Concepts and methods;
    - \* Combining Homogeneous Models;
    - \* Combining Heterogeneous models;
- Advanced Topics
  - Time-series Analysis
    - \* Concepts and methods;

- \* Linear and non-linear approaches;
- Text Mining
  - \* Concepts and methods;
  - \* Information retrieval;
  - \* Document classification;
- Web Mining and Link Analysis
  - \* Concepts and methods;
  - \* Web and Structure mining;
  - \* Link analysis;
- Data stream Mining
  - \* Concepts and methods;
  - \* Summarizing data streams;
  - \* Knowledge discovery from data streams;
- Data Mining Standards and Processes

### 1.3 Teaching Methods and Evaluation

The teaching method consists of theoretical-practical classes. The evaluation consists of home-works and a final exam.

### 1.4 Bibliography

Recommended books:

- *Data Mining, Concepts and Techniques*, Jiawei Han e Micheline Kamber, Morgan Kaufmann, 2006
- *Principles of Data Mining*, D. Hand, H. Mannila, P. Smyth; The MIT Press, 2002
- *Machine Learning*, Tom Mitchell; McGraw Hill, 1997.
- *Guide to Intelligent Data Analysis: How to Intelligently Make Sense of Real Data*, Michael R. Berthold, Frank Klawonn, Frank Hoppner, Christian Borgelt, Springer, 2010
- *Intelligent Data Analysis*, Michael Berthold e David Hand; Springer, 1999.

Other books of interest:

- *Knowledge Discovery from Data Streams*, J. Gama; CRC Press, 2010.
- *Introduction to Data Mining*; Pang-Ning Tan, Michael Steinbach e Vipin Kumar; Addison-Wesley; 2006.
- *Pattern Recognition and Neural Networks*, Ripley, B.D.; Cambridge University Press, 1996.
- *Data Mining: Practical Machine Learning Tools and Techniques with Java Implementations*, I. Witten and E. Frank; Morgan Kaufmann, 2000.
- *Data Mining, Descoberta de Conhecimento em Bases de Dados*, M. Filipe Santos, Carla Azevedo, FCA-Editora de Informatica, 2006

## 1.5 Software

The use of software tools has the main goal of solving practical problems, the study, analysis, and evaluation in small-scale applied problems as a formative perspective. We choose two software tools, frequently used in data mining teaching:

- R (Ihaka e Gentleman, 1996)  
R is a statistical oriented programming language. The interface is command line.
- WEKA (Witten e Frank, 2005)  
Weka is machine-learning oriented software. It uses a graphical interface, with the possibility to develop sequences of tasks. The Knowledge Explorer allows decomposing a complex problem into sub-problems in a graphical environment.
- Knime or Rapid-Miner  
New generation of data mining tools.

## 2 Team

- **João Gama**, Professor Associado com Agregação, Faculdade de Economia, Universidade do Porto; (Coordenador)  
João Gama is a researcher at LIAAD, the Laboratory of Artificial Intelligence and Decision Support of the University of Porto, working at the Machine Learning group. His main research interest is in Learning from Data Streams. He is Member of the Editorial Board of

Machine Learning Journal, Data Mining and Knowledge Discovery, Intelligent Data Analysis and New Generation Computing. He has published around 100 articles in Journals and international conferences. He has published several articles in change detection, learning decision trees from data streams, hierarchical Clustering from streams, etc. Editor of special issues on Data Streams in *Intelligent Data Analysis*, *J. Universal Computer Science*, and *New Generation Computing*. He served as program chair at ECML 2005, ADMA 2009, and Conference chair at DS 2009 and IDA 2011. Co-chair of a series of Workshops on Knowledge Discovery in Data Streams held in conjunction with ECML-PKDD 2004, 05, 06,07, and the ACM Workshop on Knowledge Discovery from Sensor Data held in conjunction with ACM SIGKDD 2007/08/09/10. He is the Chair of Data Streams track in the ACM Symposium of Applied Computing since 2007. He edited the books *Learning from Data Streams-Processing Techniques in Sensor Networks*, published by Springer, and *Knowledge Discovery from Sensor Data*, published by CRC. He is author of a recent book in *Knowledge Discovery from Data Streams*, published by CRC.

**Projects:** Adaptive Learning Systems I and II, Knowledge Discovery from Ubiquitous Data Streams (funded by FCT), KdUbiq (EC funded), Retinae (ADI)

**Supervision:** 3 PhD students (defended), 4 PhD students (running); 14 MsC Students.

- **Pavel Brazdil**, Professor Catedrático, Faculdade de Economia, Universidade do Porto;

Prof. Dr. Pavel Brazdil got his PhD degree from the University of Edinburgh in 1981. The thesis was in the area of Machine Learning. In late 70's, when this work was carried out, there was relatively little work done in this area. In 1996 he obtained habilitation at the University of Porto and since 1998 is Full Professor. Currently he is the Coordinator of R&D Unit LIAAD-INESC Porto La. Pavel Brazdil is known for his activities in Machine Learning, Data Mining, Metalearning and Text Mining. He has participated in two international projects and was a technical coordinator of one of them (METAL, 5th FP) and participated in various international research networks. He has supervised 9 PhD students all of whom have completed their studies. He has organized more than 10 international conferences or workshops and participated in many program committees. He is a co-author / co-editor of 5 international books and has published more than 130 articles. Since 2007 he is a Fellow of ECCAI (European Coordinating Committee for Artificial

Intelligence.

- **Alípio Jorge** is an Associate professor at the Department of Computer Science of the Faculty of Science of the University of Porto and a member of LIAAD / INESC Porto L.A.. He is PhD in Computer Science by U. Porto, an MSc. by the Imperial College and BSc. in Computer Science. His research interests are Data Mining and Machine Learning. He lectures data mining and decision support. He coordinated the MSc. on Data Analysis and Decision Support Systems and is currently the director of the Masters in Computer Science. He leads research projects on data mining and web intelligence. He co-chaired international conferences (e.g. ECML/PKDD 05) and workshops. He was Vice-President of the Portuguese Association for AI.

- **Paulo Azevedo**, Professor Auxiliar, Escola de Engenharia, Universidade do Minho

Paulo Jorge Azevedo holds a PhD in Computer Science (Imperial College, University of London - 1995) and a MSc in Information Technology (Imperial College, 1991). He is an Assistant Professor at the Department of Informatics of the University of Minho, where he teaches informatics to undergraduates and data mining and data analysis related courses to post-graduate students. His research is concentrated in the fields of Machine Learning, Data Mining and its applications to Bioinformatics problems. He was the coordinator of the national FCT funded project CLASS and he currently participates in the also FCT funded projects Site-O-Matic, on web automation and P-found and ProtUnf on the analysis of induced Molecular Dynamic Simulations of Protein Unfolding. He is currently supervising several PhD and MSc students in the areas of Data Mining and Bioinformatics. Paulo Azevedo was member of several program committees, among others the PKDD 2005 conference, Principles and Practice of Knowledge Discovery and Data Mining, and the EPIA-01, 03, 05 and 09 (the Portuguese Conference on Artificial Intelligence), DS'09 (International Conference on Discovery Science) and ECML'09 (European Conference on Machine Learning). He co-organized the Workshop on Computational Methods in Bioinformatics under EPIA'2005. He has also been vice-chair of the Portuguese Society for Artificial Intelligence from 2000 to 2003

## Referências

- Han, J. e Kamber, M. (2006). *Data Mining Concepts and Techniques*. Morgan Kaufmann.
- Ihaka, R. e Gentleman, R. (1996). R: A language for data analysis and graphics. *Journal of Computational and Graphical Statistics*, 5(3):299–314.
- Witten, I. H. e Frank, E. (2005). *Data Mining: Practical machine learning tools and techniques*. Morgan Kaufmann.