I. **Aims of the activity**

1. To introduce the fundamental principles, techniques, and applications of Machine Learning.
2. To cover the principles, design and implementation of learning programs which improve their performance on some set of tasks by experience.
3. To offer a broad understanding of machine learning algorithms and their use in data-driven knowledge discovery and program synthesis.
4. To offer an understanding of the current state of the art in machine learning in order to conduct original research in machine learning.

II. **Specific competencies acquired**

**Professional competencies**

1. Understanding the concepts, methods and models used in Machine Learning.
2. Understanding the principles, design, implementation and validation of learning systems.
3. Learning to conduct incipient original research in machine learning.

**Transversal competencies**

1. The ability to apply machine learning techniques in solving real world problems.
2. Responsible execution of lab assignments, research and practical reports.
3. Application of efficient and rigorous working rules.
4. Manifest responsible attitudes toward the scientific and didactic fields.
5. Respecting the professional and ethical principles.
III. **Course content**

2. Decision Tree learning.
3. Artificial Neural Networks.
4. Support Vector Machines.
5. Bayesian Learning.
6. Instance based learning.
8. Reinforcement Learning.

IV. **Bibliography**


**Optional bibliography**


**Journals**

5. *IEEE Transactions on Pattern Analysis and Machine Intelligence* - [http://www2.computer.org/portal/web/tpami/](http://www2.computer.org/portal/web/tpami/)
7. others

**Papers**

Ross Quinlan’s papers - [http://www.rulequest.com/Personal/](http://www.rulequest.com/Personal/)
Conferences


ML repository
http://archive.ics.uci.edu/ml/

SBSE repositories
http://promise.site.uottawa.ca/SERepository/
http://openscience.us/repo/

Other data sets
https://vincentarelbundock.github.io/Rdatasets/datasets.html

V. Activity and grading

Each student should prepare and present the following:

(1) A theoretical research report on a learning technique, based on some recent research papers.
   a) a written paper of about 10 pages
   b) an oral presentation
      - an one-page outline of the presentation

You should present a survey on some recent research results on the considered topic.

The paper will contain theoretical considerations on the selected topic and compulsory sections regarding:
   1. existing or possible applications of the selected topic
   2. advantages and disadvantages of the selected approach (here you can present your own opinions)

(2) Two practical projects (software) have to be completed. The projects will have to demonstrate the use of two learning techniques for some specific tasks.

Requirements

- The first project will be developed using an open source ML software:
  1. Python libraries (Scikit-learn, Keras, etc)
  2. WEKA http://www.cs.waikato.ac.nz/ml/weka/
  3. RapidMiner http://rapid-i.com
  4. Orange http://www.ailab.si/orange/
  5. ROCKIT http://xray.bsd.uchicago.edu/krl/KRL_ROC/software_index.htm
  7. MATLAB
The first project will contain:

(a). description of the programming software you use, including used features;
(b). problem definition;
(c). comments about the solution.

Deadlines

Lab 2 – installation of ML software + component (a) project 1
Lab 3 – component (b) project 1
Lab 4 – component (c) project 1 + project 1 demonstration

• The second project will be fully implemented, without using existing ML environments.

The second project will contain:

(a). problem definition;
(b). comments about the solution (problem analysis);
(c). a short design documentation;
(d). the electronic version of the source code, test files and any other files required to test the project.

Deadlines

Lab 5 – components (a) + (b) project 2
Lab 7 – project demonstration + components (c) + (d) project 2

(3) The final exam, to take place in the examinations session.

Identical projects will NOT be considered.

The final grade will be computed as follows:

10% Class attendance
20% Theoretical research report (written and presented)
20% Practical project 1 (written, documented and demonstrated)
20% Practical project 2 (written, documented and demonstrated)
30% Final exam (written paper in exams session)

A minimal final grade of 5 is required to pass the course.
Remarks

- The title of the theoretical research report and the presentation date must be chosen by end of week 4.
- The time planning for the research report can be consulted at www.cs.ubbcluj.ro/~gabis/ml.
- The grade at the theoretical report is composed by considering the following:
  - the papers must fulfill the requirements of a research paper:
    ▪ suggestive title corresponding to the contents;
    ▪ about 10 lines abstract;
    ▪ introductory section, detailing the purpose of the paper;
    ▪ a section integrating the topic of the paper in the general field;
    ▪ a few main sections, according to your topic;
    ▪ concluding remarks and further work section;
    ▪ bibliography of 5 to 10 titles; the bibliography entries have to be written correctly and completely; all the bibliography items have to be cited in the text;
  - the one-page outline has to correspond both to the written text and to the oral presentation, and has to be self-explanatory for the intended audience;
  - the oral presentation itself.
- The grading is done as follows:
  - 1.0 p = abstract and introduction;
  - 3.0 p = structure of main sections;
  - 1.0 p = concluding remarks;
  - 0.5 p = bibliography accuracy;
  - 0.5 p = one-page outline;
  - 3.0 p = quality of oral presentation
  - 1.0 p = QA.
- All the written materials will have to be provided by e-mail at least one day in advance of the presentation date.

VI. Time planning

- During the lecture hours on weeks 1-10 you can attend lectures on topics from Section III.
- The theoretical report will be allocated about 15 minutes each (questions and discussions included) and will be presented during the lab hours on weeks 11, 12 and lecture hours on weeks 11 - 14.

VII. Retake session

In the retake session, all activities can be reconsidered, excepting the oral presentations (the maximum grade for a report is 6).
VIII. Possible topics for the Theoretical Report (not an exhaustive list)

The topics below are suggestions. You may choose other machine learning related topics.

1. Artificial neural networks
2. Recurrent neural networks
3. Time delay neural networks
4. Long-short term memory networks
5. Deep learning
6. Convolutional neural networks
7. Self organizing maps
8. Hebbian learning
9. Unsupervised learning in recurrent neural networks
10. Semi-supervised learning
11. Radial Basis Function networks
12. Decision Trees (fuzzy, lazy, etc)
13. Bayesian learning
14. Machine learning in bioinformatics
15. Machine learning in software engineering
16. Belief network learning
17. Instance based learning
18. Case based reasoning (learning)
19. Inductive logic programming
20. Boosting algorithms (Adaboost, Epsilon Boost, Gradient boosting, etc)
21. Bagging algorithms
22. Deep Reinforcement Learning
23. Temporal difference learning
24. Q-learning
25. Autoencoders
26. Adaptive clustering
27. Hierarchical clustering
28. Partitional clustering
29. Support vector machines
30. Kernel methods in machine learning
31. Association rule mining
32. Hidden Markov Models
33. Semi-supervised learning
etc