Applications: project presentation

Please don't Circulate !

Presentation anticipated to provide more time for the project

Presentazione anticipata per fornire maggior tempo per il progetto

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2017

Dipartimento di Informatica
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ML Course structure
Where we go

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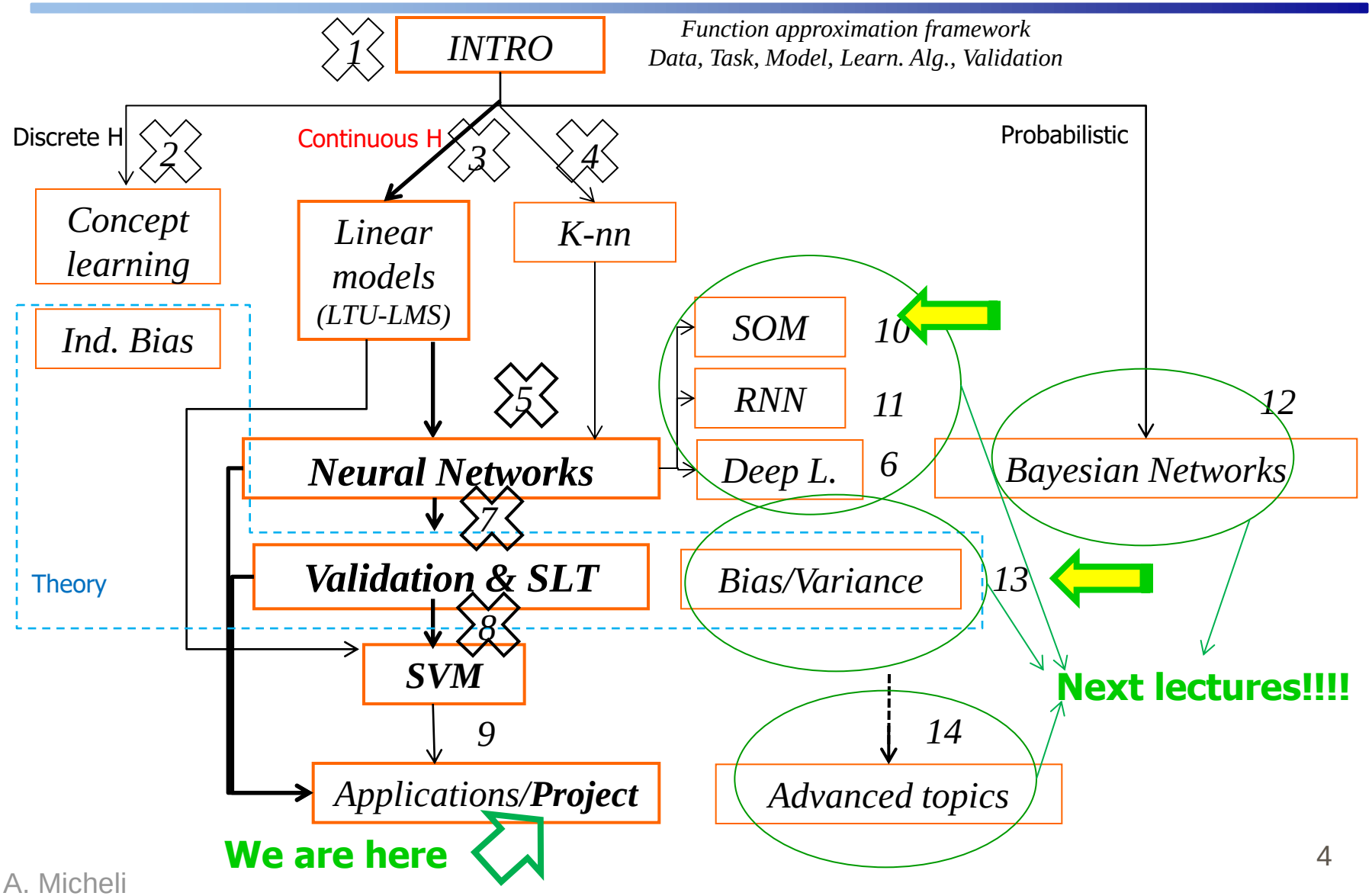

Programme

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- 6 credits programme (AA1 for 2017) is ready: please check it on moodle.
- The general programme is in (IT/EN): https://esami.unipi.it/esami2/programma.php?c=35992
- The detailed programme for ML 9 credits will be presented LATER!

Notes on the formal exam subscription

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- Date for the exam: esami.unipi.it portal
- Therein you find the date for the oral (beginning)
- The prj must be delivered 10 days in advance: oral date -10 at 15.00 (see oral start time)

- Take care also to register your name in the official UNIPI (esami.unipi.it) portal for exams (look the deadline)

Next Sessions

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See the esami.unipi platform

Unofficial news:

- Deadline 8/1 for material delivery → orals start 18/1
- Deadline 4/2 for material delivery → orals start 14/2

- It is oral date -10 at 15.00 (see oral start time)
- You CAN always deliver before the deadline!

- For the following sessions consider again a minimum of 10 days in advance for the material delivery

Assessment methods
(REPETITA from introduction)

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Exam:

- **Project**
  - Students have the opportunity to develop a project realizing/applying a learning system simulator (typically a simple neural network) or applying a known one and to validate it through benchmarks. A written report will show the results.
    - Great *opportunity* to apply the concepts by yourself
    - Great *opportunity* to show your concrete understanding and effort for the exam
  - Deadline: 10 days before the oral exam session
  - **See details in this lecture for project presentation**
  - *Competition* with *blind-test*
  - New 2017: possibly also some joint proposals with CM course

- **Oral exam:** *Prj discussion + questions on all the course content*

  (see the programme/syllabi site for extensive explanation on written and oral exam: https://esami.unipi.it/esami2/programma.php?c=35992)

The main hints
(REPETITA from Introduction)

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- Follow the lectures and slides as a guide, studying *progressively* during the course

- A major hint *from past students*:

1. **FIRST study the course content**
2. **THEN apply for the project**

- Develop (implement) a self made NN simulator if you are self-motivated and with good programming skills, else apply existing tools

A premise
On the empirical approach

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- Experimental method (using ***empirical*** evidence, from experiments) is the basis of the "*scientific method*" per-se.

- In our case, the numerical simulation to test your hypothesis on the model and the quantitative parameters.
  - (you don't know the result in advance, you have to formulate your hypothesis and then to measure the empirical results/observations, to compare and reason on the results etc.)
  - If you don't have any experience with experiments, this is new for you, but it is not negative but REALLY a nice and useful* experience you take the opportunity to gain !!! Exciting or lost? Break the ice !!!

* to build a skill for any field of science.

Project General Rules

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- Please contact me if you don't like to participate to the competition
- Deliver the report at least 10 days in advance, sending by email (be sure I received it: resend the email if I do not reply with an ack.)
  - **Code** (if it is developed by you, usually well commented)
  - **The report** resuming of the implementation and the experimental aspects: Max 8 pages , 10 if by a group of 2 student , **font** 11 at least !
  - **Files** for the ML-CUP: "blind test set" + short abstract

    (see the next slides with details)

It is a tag!!!

Send files at micheli@di.unipi.it

Subject: [ML-2017] Report by Mario Rossi …

Include your name(s) & email contact information in the main text

- Bring with yourself the code to the oral exam (printed or electronic version)

Deliver by Moodle

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- Please use the moodle (elearning platform) for delivery of the prj package: code, report, cup-files.
- See Section **Prj Student Material**

After the last upload (until the deadline)

- Send email at micheli@di.unipi.it

  Subject: [ML-2017] Report by <your names>

  Include your name(s) & email contact information in the main text

  - The name used in Moodle (to find it)
  - Don't 'forget a CC to your colleague (all the group members must be included in the communications).
  - Use the moodle to deliver all the other files, not by email.

Other rules (new)

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- Autonomy: it is part of the evaluation
- **Groups**: *it is assumed groups of 2 students*
- Please motivate to me if you need to participate individually
  - 1+1=2.5!
  - Increase autonomy and never discourage
  - Best results (in the general sense) in the past editions

NEW

Possible Aims

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A) Realize a ML/NN model simulator and apply it (implementation)

- Programming language is a free choice (C++, Python are popular for ML, or even environments as Matlab or R can be considered)
- A) with CM : a coordinate prj with CM

B) Extensive experimental applications of existing ML/NN simulators (comparison)

- Simulator is a free choice (a list will be discussed in the next slides)

C) Contact me. Only in case there are reasons/impediment not to apply to A and B: we can for instance think to a report developing a ML topic or other written exam

A) or **B)**: participate to the "**ML-2017 cup**" competition.

Let us see details for A) and B) and then the cup details.

A) Model implementation

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Realize 1 ML model simulator : typically a **MLP Neural Networks (with regularization techniques)**

This is the typical project case, allowing you to realize a simple models by your original code, and to experiments all the variants that you like, and have fun;-)

Examples:

- [**typical case**] **Implement a MLP with backpropagation, momentum, and regularization L2:**
  try the regularization and other hyperparameters effects

- Backprop with variants for the weights upgrade : Quick-prop, Rprop, … or other gradient based techniques.

Other models (but not for the CUP):

- MLP for classification: LMS versus Cross-entropy*
- Bayesian models: contact me.
- **SVM**: see A) with CM

General note: you can exploit numerical libraries, e.g. NumPy, Armadillo (C++), ..

Special case <A) with CM>

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A) with CM: A coordinate prj between ML and CM

See a detailed list of proposals later and/or within the CM course

- You will provide 1 report for ML with the basic A) results + the new result with the CM technique (comparison)
- AND 1 report for CM (according to CM teachers rules)

Categories (examples) [through CM approaches] :

- (improved) NN training by new descent methods algorithms
  - see many examples in the lectures NN2 Heuristics
  - [comparing wrt the basic gradient descent with momenutum and L2 regularization]
- Non-differentiable optimization for Piece-Wise linear functions
  - PWL or ReLU activation function or *L1 regularization*
  - [comparing wrt the basic gradient descent with momenutum and L2 regularization]
- SVM/SVR implementation (through different approaches), applied with kernels...
  - [for this case NN comparison is not need]

The proposal must be agreed by ML AND CM teachers!!!

You can still compete for the ML-CUP with your results.

<A) with CM> only for group of 2 students.

These are challenging prjs
More (double?) effort!, volunteer choice!

Notes on <A) with CM>:

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Further details on<A) with CM>:

- More effort? It is because you like to try and show something more and not something less! This fully exercises your full understanding of the singular parts (by adapting them to the combined construction)
- For may cases it is useful to refine the literature basis (provide by us) to see previous studies of the impact of the used methods for the ML area.

- L2 regularization is the Tikhonov with norm-2 penalty
- L1 uses norm-1 penalty (we will discuss it later)
- (see lecture on linear models and NN-part2)
- Also ask for PWL if you are interested, ReLu will be discussed later

- Note that the aim is not to improve the performance/results obtained with the basic approach, but to critically exercise the use of CM approaches for ML*
- Unforeseen issues? Discussed by a case-based approach*

B) Compare models

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- **Extensive experimental applications of existing ML/NN simulators**
- Compare different models/ existing tools e.g.:
  - SVM or NN by standard library versus basic models (linear, k-nn, naïve bayes, …) implemented by yourself or by standard software tools
  - Compare NN vs SVM vs other models (even not included in the ML program) within the same software tool.
  - Compare 3 or more models even from different sw tools.
  - Compare different software tools for the same model (e.g. SVM).
  - Compare different software tools.
- (also for fairness wrt A) the B case implies a larger effort on the comparison among models (including accurate validation) and to the experimental part
- The report can include also evaluation on the sensitivity to the hyperparameters values (for different models), efficacy, efficiency, predictive performance (of course!) but also issues of tool usage, usability, richness of the set of hyperparameters etc. (for different tools)
- Repetita: you can still apply to the CUP competition just selecting the best model to apply.

For both A) and B) cases

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- For **NN heuristics** see the lecture on "Neural Networks: part 2"
- Try the effects of different configurations/ hyperparameters values according to your experimental schema

  (and explain the schema in the report)
  - In any case include the momentum and a regularization approach (weight decay, early stopping, ….). See all the **(!)** indications
- If you use a library, please not limit yourself to default values!
- You are free to choice the **model selection/assessment-evaluation** strategy:

  whose fitness for the problem at hand is evaluated:
  - Directly from the description in the report
  - Through the results on the blind test set

Simulators/Software Tools

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- Software / Tools to be used for **B case**
- Or you can use a tool as an "oracle" to compare with your simulator for the **A case** (helping in assessing its correctness)

- If you use a library you must specify in the report the complete link to the source !!! (for both A and B cases)

- In the following some examples: an exahustive list is out of our scope and it is even impossible to keep it updated!!!
- The best one is the one that is more useful FOR YOU.
  - Check also the documentation and of it still have maintenance/developments (new releases, support, …)

Simulators/Software General ML: examples (older)

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- **Torch** (NN, SVM, AdaBoost, K-nn, Bayesian, …) started as C++ library, now Lua/GPU emphasis !!!
- **Scikit-learn** (Python open source, many tools for preprocessing, model selection, linear models, regularization, SVM, DT, … … NN only from version 0.18 – even if still in a basic form, but wrappers for other sw exists) [JMLR 2011]
- **Shark** *(evolutionary and gradient-based algorithms, NN, kernel-based learning methods, SVM, …[JMLR 2008]): C++ library
- **Dlib-ml** (Bayesian networks and kernel-based methods, clustering, anomaly detection, and feature ranking, … [JMLR Jul 2009]): C++ library
- **Shogun** (SVM, HMM, K-NN, LDA,…[JMLR 2010]): C++/Python
- **Mlpack** (C++, armadillo matrix library, basic models, no NN/SVM, [JMLR 2013])
- **MLlib** Sparke scalable ML library (NumPy, R, Hadoop), NO NN yet [JMLR 2016]
- For Python: e.g. PyMVPA, MLPY , PyML, Plearn, **PyBrain, ...**

Environments:

- For **R** (Statistical Computing language)
- For **Matlab*** and **Octave**

JMLR= http://jmlr.csail.mit.edu/mloss/

Other examples (NN & Deep) (newer)

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- **PyBrain** [JMLR 2010]: various NN architectures
- **Torch** (renewed for deep learning/GPU, coll. with Facebook, Google, Twitter …)
- **Theano** (and Pylearn2): also for deep learning, GPU etc. wrappers with scikit-learn, … (stop dev. on 9/17)

  See http://deeplearning.net/software_links/
- **TensorFlow** (Google), open source, C++/Python like (API, interface). Include deep neural networks. Since November 2015!
- **Keras** is a high-level neural networks library (Python) capable of running on top of either TensorFlow ,Theano , CNTK , MXNet, Deeplearning4j (+Wrappers vesrus Scikit-Learn API)
- **Caffe** is a deep learning framework, originally developed at UC Berkeley. It is open source, C++, with a Python and MATLAB interfaces
- **OpenNN** (Open Neural Networks Library) C++

Historical:

- **Stuttgart Neural Network Simulator: C, since 1995!**
- **SOM_PAK: C++ /** SOM toolbox (free)

Popular Supporting Libraries

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- **Panda**: software library written for the Python programming language for data manipulation and analysis
- **NumPy** (**SciPy**), **Armadillo** (C++): numerical/linear algebra libraries

- https://en.wikipedia.org/wiki/List_of_numerical_libraries
- https://en.wikipedia.org/wiki/Comparison_of_linear_algebra_libraries

General note: you can exploit such numerical libraries for your code!

Simulators/Software General ML: examples (2)

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And many other…(started as DM tools).

- **Weka** (DM and ML Software in Java)
- RapidMiner
- Orange (JMLR 2013, C++/Python)
- ….
- Many commercial software ! …→ "*predictive analytics*"

Visual workbench approaches are popular for commercial tools:

- E.g. (by students) **Knime**: data analytics platform: DM but also ML/NN (open source/commercial**!**)
- Major sw developers have now ML branch: azure (Microsoft), google, facebook, IBM, Amazon ….

Others & Others (from companies/commercial)

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Just to witness what happens (not for your prj expect*):

- Google: google prediction (service) / **TensorFlow** *
- IBM: Watson
- Microsoft : Azure (platform and services)/ The Microsoft Cognitive Toolkit, **CNTK***, is a deep learning framework developed by Microsoft Research.
- Amazon Machine Learning (service) / **DSSTNE***: Deep Scalable Sparse Tensor Network Engine (open, Deep ML)
- Facebook: FBLearner Flow, …

- ……

Simulators for SVM

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- **LIBSVM** (C++)
- SVM light (C)
- Torch (C++)
- JKernelMachines (Java library for learning with kernels [JMLR 2013]).

- Weka (Java)
- mySVM
- SVM in R
- ….
- http://www.support-vector-machines.org/SVM_soft.html

Applications for the PRJ

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Your results will include:

1) MONK benchmarks

2) The CUP data set (competition)

In the report: results for 1) and 2)

1) MONK benchmark [repetita]

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- Difficulty of assessing implementation correctness:
- A first test *("collaudo")* **Monk data set**
  - **The results *must* be reported in the prj report: performance and learning curve plots for the 3 monk tasks**

    http://archive.ics.uci.edu/ml/datasets/MONK's+Problems
  - 3 tasks of binary classification, small artificial data set, "not difficult" (a small NN with few units achieve a very high accuracy, up to 100%, with small time of convergence)
  - There is a report with previous results using MLP (and others ML models)
    - chapter 9 http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.45.2363

Solve it!

  - Input encoding: 1-of-k → correspond to introduce 17 input units (see also sec 1.1)
  - TS includes TR, which is a bad practice, but does not change here (since 100% accuracy is 100% accuracy also on the test set !!)

- Other sources of data sets for software tests: http://archive.ics.uci.edu/ml/

  UCI Machine Learning Repository (more than 390 data sets !)

Monk data set results

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- Please see examples of plots (learning curves for MSE and Accuracy) in previous lecture on NN:

  the "Neural Networks: part 2" lecture (file: ML-**-NN-part2-…pdf)

Note:

- that results were obtained with 1 output unit for classification
- Examples of Hyperparameters were specified in the slides

  - Good results on the MONK benchmark does not garantee the simulator correctness
  - Bad results on the MONK benchmark for sure require revision of the code/setting

2) ML CUP !

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ML-CUP17

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I provide to you 1 data set for the cup

For the data set:

- I provide a training set and a blind test set (examples without target values)
- Apply 1 or more models selecting the final one that you think it is more accurate through the training set (used for training and validation, and your internal test).
- Report in the report document the TR/VALIDATION (and test) errors, in the original scale i.e. MEE for the 2017 cup (see next slides).
- Apply your final model to the blind test producing an output for each example of the blind test set and record them into an output file
- Provide with the report the output file containing the blind test results
- Test result: the accuracy on the blind test set will be automatically computed
- The final results will be summarized on the web site using your nicknames
- Glory to the winner! ;-)

Tasks and Data

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- **Regression** on 2 target variables, i.e. x,y coordinates in a 2D space
  - FAQ: regression = linear output unit
  - 2 target variables: 1 NN with 2 output units, or 2 NNs, 2 SVR, ….

- 1016 training examples
- Column 1: pattern name (id)
- Central columns: 10 variables with continuous values (from a noise source, real sensor data)
- Last 2 column: target of two continuous value variables : x and y.

- Blind Test set: 315 patterns, with the same input format (of course without the 2 target columns)

Task & Errors 2017

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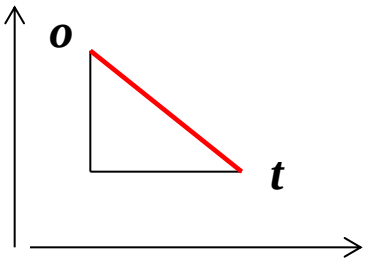
Report in the original scale the following error measure (**Euclidian distance**) :

- **Mean Euclidian Error** (it is the error used for the competition performance evaluation), *where N=number of data, p=pattern, o=output, t=target*

$$E_{MEE} = \frac{1}{N}\sum_{p=1}^{N}\|\boldsymbol{o}_p - \boldsymbol{t}_p\|_2 = \frac{1}{N}\sum_{p=1}^{N}\sqrt{(o_{p,x} - t_{p,x})^2+(o_{p,y} - t_{p,y})^2}$$

Distance between 2 points in 2 dim space



- Typically you will also observe the (root) mean squared error (that is the typical loss used for the LMS training approach)

$$E_{MSE} = \frac{1}{N}\sum_{p=1}^{N}(\boldsymbol{o}_p - \boldsymbol{t}_p)^2=\frac{1}{N}\sum_{p=1}^{N}\left((o_{p,x} - t_{p,x})^2+(o_{p,y} - t_{p,y})^2\right)$$

MEE <> RMSE since sum(root(a), root(b)) <> root (sum(a,b))

What is provided 2017

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- Training sets
  - ML-CUP17-TR.csv
- Blind test sets (without target)
  - ML-CUP17-TS.csv

!!!!!

WHERE:

- **ML section on Moodle: https://elearning.di.unipi.it/**
- With files for data, info (slides and txt), report-demo, results-demo

- Note: edition 2010, 2011, 2012, 2013, 2014, 2015, 2016 **are NOT used this edition/ year**

What to produce 2017 (I)

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- Output file in a simple text/*txt* format. The name is:
  - *team-name*_ML-CUP17-TS.csv
- Using the following format
  - First 4 rows are for comments :
    - # your name/names
    - # team (nickname max 8-10 char) for the web results
    - # data set name (ML-CUP17 v1)
    - # date (e.g. 20 Dec 2016)
  - Table with 315 rows and 3 columns (comma separated values):
    - id, output_x, output_y
    - id ordered from 1 to 315 (exactly as for the file ML-CUP17-TS.csv)
    - A demo file: ***output_template_example-with-random-output-ML-CUP17-TS.csv*** (which is filled with random-output values for demo)

PLEASE, double check the output file format!!!!

If it is not OK we cannot evaluate it automatically→ jump to the the rank bottom !

Repetita: you can send only 1 *team-name*_ML-CUP17TS.csv file (assuming it is your best result)

What to produce (II)

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- File: team-name_abstract.txt, in a simple text/*txt* format
- With a very short (5 rows) description of the used model and validation technique.

- HENCE, you have to send (for the cup):
  - *team-name*_ML-CUP17-TS.csv
  - *team-name*_abstract.txt

- Along with (see the "Project general rules" slide at the beginning of this lecture)
  - Your code
  - Your written report (with results on 3 MONKs and the CUP)

Results

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- Initially I will personally communicate the result to the single participant
  (for fairness with participants following in time)
- At the end of next year it is possible to publish the final ranking
- And the winner ;-)

- Criteria for the winner on the task: accuracy (MEE) and possibly the quality of final plot of the results (at the discretion of the jury ;-))

Finally

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- The report
- Other hints/request for the prj
- FAQs

The report

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- See the DEMO/Template file: **ML-17-Report-template-v*.doc**

- Check the last version (vx.y)

- The demo file includes descriptions of the information to be provided by the report:
  - these are mandatory to accept the report as valid for the exam
  - double check you reported all the needed information

- Please follow such basic organization for your document

A zoom for Screening phase:

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- Initially you will try different values of hyper-parameters
- (if you think interesting) Significant cases of leaning curves for can be reported
- **but for yourself** plot them for various combination* →the screening phase is essential for yourself to learn from this experience [see next slide demo]
- Results of this kind (also from the grid search could be part of the appendix)

Screening demo

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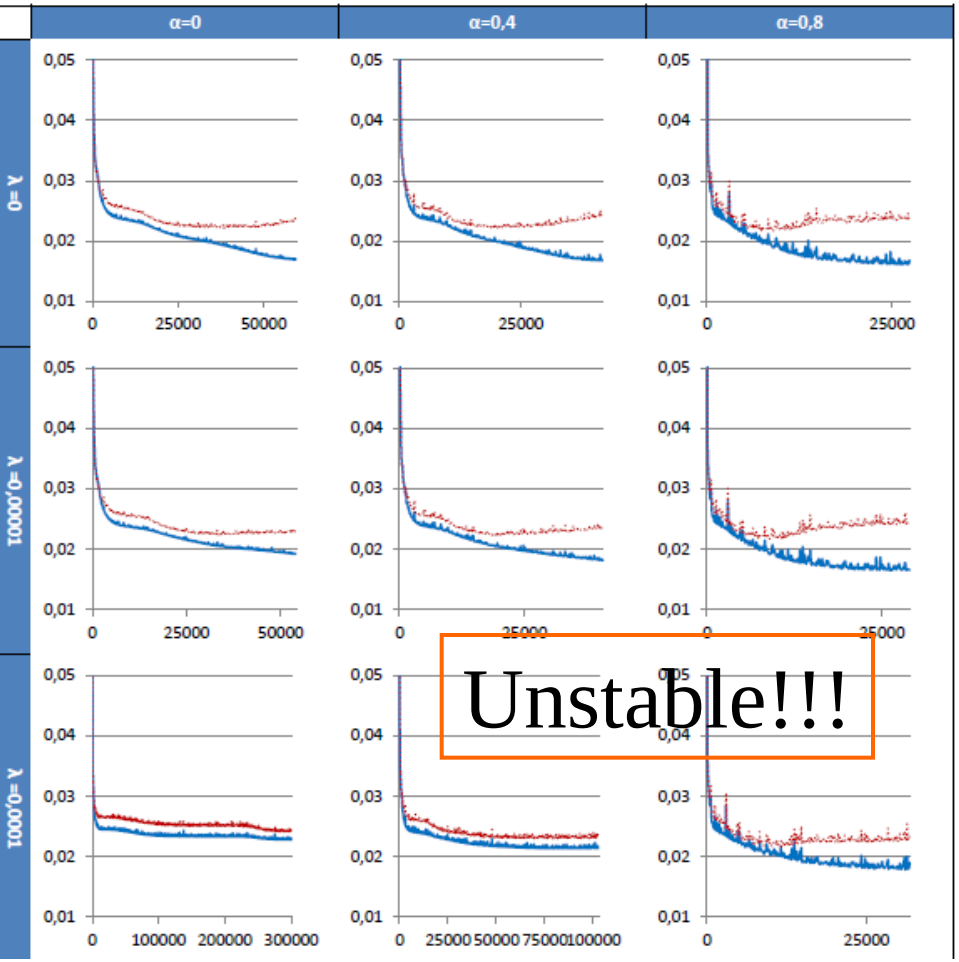
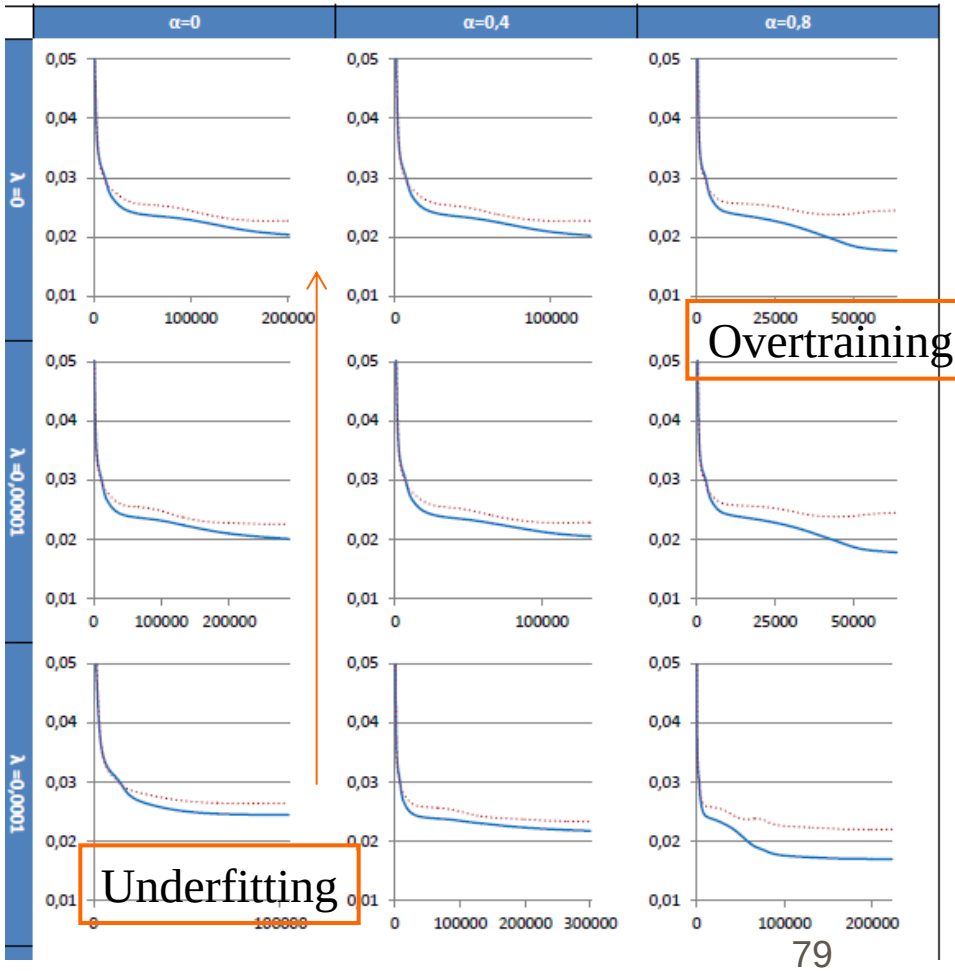
- Some instances of screening phase (don't mind of the specific demo hyper. values, look to behavior changes…and make the same with your values)





How to evaluate your work

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- Autonomy
- Soundness and quality of the (code) simulator (including any characteristics of modularity, efficiency, ...)
- Proper operation and behavior (e.g. see the regularity of learning behavior on the plots, …)
- Pertinence of the choice for the model selection and evaluation
- **Quality of the report**: e.g. organization, rigor, soundness and synthesis of written text; motivations suitability; choices made; breadth and depth of the experimental investigation (although expressed in a concise way); **accuracy of the validation**.
- In case: difficulty of the challenge con be a plus (e.g. <A) with CM>

- The **blind test** result is just one of the possible parameters (not the most important one): very very often it strongly depends on the quality of the model and of the validation approach.

FAQ I

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- **Deadline**: 10 days in advance is the deadline, before is better (e.g. sometimes additional info are required), and later is indeed in advance for the next session.

- If my model **does not work well**?
  - Check the learning curve to find clues
  - HINT: Try to compare with respect to a known tool in the same condition
  - Autonomy is part of the evaluation

- **How many trials** ? How many do you feel useful in order to do a good model selection

- **Which trials** should I report? All the significant cases with details (experimental evidences), the other can be mentioned/synthetized in the text. Such choices are part of the quality of your work.

- **MSE** or **MEE**? You can use MSE (LMS) for training and MEE to evaluate

FAQ II

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- Is there any **check list** for material delivery?
  - Previous slide on <Project general rules> and < What to produce> (2 slides)
  - For the **report**: see the template file with [*] for mandatory info on the results
    - Template file: ML-17-Report-template-v*.doc
  - Check that cup **result file** has the proper name and format
  - Provide the following files:
    - Your code (if original, else use a link to libraries in the report)
    - Your written report (with results on 3 MONKs and the CUP)
    - *team-name*_ML-CUP17-TS.csv
    - *team-name*_abstract.txt

- **CSV** format for the results: see the files, it is a comma-separated values without spaces after the comma. Each pattern is a row. The header of input file has some rows of description beginning with #.
  - ***Example:*** output_template_example-with-random-output-ML-CUP17-TS.csv (which is filled with random-output values for demo)

FAQ III

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- **Groups** of 2 people is strongly suggested for 2017 (see previous slide)
  - For load balancing, in the case of 2 students we would expect that the report sustains work quantitatively higher than expected from a single.
  - For instance: comparison among different models (instances/algorithm/ or even models in itself).
  - You can use up to 10 pages instead of 8.
  - The evaluation (final mark) can be different for the two students (oral is different)

- What change using **MATLAB/OCTAVE/R?**
  - If you code by yourself → prj type A,
    but exploit your advantage (less time for the coding phase) to use more time in exploration/usage of advanced Matlab numerical computing functions/ possibly a comparison with other available models in the environment/extensive cross-validation/ impressive graphical results/….
  - If you use the NN toolbox → prj type B

FAQ IV

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- Plots , graphics etc.: the print is **Black&White**: it is mandatory to distinguish lines in the plots also using different lines symbols/style (to see them also in B/W)

- Report Format: free style (but **font** >= 11), typically **PDF** (include a pdf copy in any case).
- Italian or English? The language more easy for you ;-)

- Executable programs, libraries, … (**large files**): until the package is small size (that can be sent as an attachment via email) try to include everything. If you have problems send/include (in the report and in the READ-ME file) a link to download the *** accessories files *** of great dimension

FAQ V

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Even other QUESTIONS?

Enjoy !

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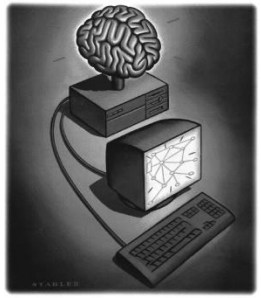
- … Now you can **enjoy** with ML !



Remember to have
FUN !!!

Future – just ahead

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- CIML@Pisa
- Didactics: other courses (ISPR, CNS,…)
- General topics for ML applications
- CIML@Pisa research

2017 Note: THIS PART WILL BE PRESENTED LATER,
If you are a AA1 student (6 credits) but you like to see them, please contact me to know the date of the lecture

DRAFT, please do not circulate!

For information

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