ISPR Final Lecture

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Intelligent Systems for Pattern Recognition (ISPR)
• Course wrap-up
  • A-posteriori view of the course
  • Final take home messages

• Overview of ML research @UNIPI
  • The CI&ML group
  • The Pervasive AI Laboratory
  • Research themes and projects
  • Opportunities

• ISPR Final exam

• Conclusions & Discussion
Course Posterior Analysis

\[ P(ISPR|D) = P(ISPR)P(D|ISPR) \]

- Hypothesis
  - How is your view of ISPR after having taken the course?

- Lectures
  - Your expectations before the course

- Your interpretation of the lectures based on your idea of the course
Deep Learning – Any Change in Perception?

What society thinks I do

What my friends think I do

What other computer scientist think I do

What mathematicians think I do

What I think I do

What I actually do
A Modern View on Pattern Recognition (I)

Dealing with complex data

- Large scale
- Multimodal
- Information in context
- Raw and noisy
A Modern View on Pattern Recognition (II)

The goals are well past recognition

Understanding, reasoning and explaining

Creativity

Generation
The Course in 1-Slide

• Old-school **pattern recognition**
  • Building blocks: convolution, filters, spectral analysis

• **Generative models**
  • Infer knowledge rather than just predict
  • Learn a generative process
  • Introduce prior knowledge
  • How to approximate distributions
  • How to sample distributions

• **Deep Neural Network**
  • Efficient and high predictive performance
  • Non-parametric and non-linear
  • Work on noisy, raw and heterogeneous data
A Convergence of Paradigms

• Need the **efficacy and efficiency** of discriminative models with the **interpretability and generative ability** of probabilistic-based models

• Modular approach
  • E.g. CRF on the top of CNN for semantic segmentation
  • Easily incorporate prior knowledge

• Inbreeding of paradigms
  • CRF as discriminative-generative models
  • Variational and generative DL
After Completing This Course, Hopefully...

- Know **which ML models are best** to start with for addressing a given PR problem
- Know **what challenges** your ML model will need to solve to realize a PR application
- Know **a bag of tricks** to modify a model to suit your needs
  - Message passing, variational approximations, sampling, latent representations, feature functions
  - Batch normalization, pretraining, end-to-end differentiability, distribution learning with NN, enhancing memory, attention
Machine Learning is the New Algorithmics

Can you derive EM for GMM?

When do you need to check your gradient?

Implement a Gaussian/edge filter
### ML Research @ UNIPI

#### Computational Intelligence & Machine Learning Group (CIML)

[https://ciml.di.unipi.it/](https://ciml.di.unipi.it/)

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<th>Faculty</th>
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<tr>
<td>Alessio Micheli</td>
<td>(coordinator)</td>
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<td>Davide Bacciu</td>
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<td>Claudio Gallicchio</td>
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<td>Vincenzo Lomonaco</td>
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<td>Antonio Carta</td>
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<td>Giacomo Lanciano</td>
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Pervasive AI Laboratory (PAI Lab)

A joint initiative by Dipartimento di Informatica @ UNIPI and Istituto Scienza e Tecnologia dell’Informazione @ CNR

pai.di.unipi.it pai-info@isti.cnr.it

Features

- Coordinators– Davide Bacciu (UNIPI) and Patrizio Dazzi (ISTI-CNR)
- ~40 members
- Coordinating 2 H2020 Projects and 1 KA; participation in 2 H2020 projects and 3 industrial projects
- 10M Euro secured grants

Focus

- AI as a ubiquitous component in ICT systems
- Design communication and computing systems to support pervasive AI
PAILab @ UNIPI - H2020 TEACHING Laboratory

• **Focus**
  - Efficient machine learning for streaming data analysis
  - Learning from human state

• **Human-system interface**
  - High quality wearable sensors (EEG, GSR, Inertial, ...)
  - EEG headset
  - Environmental microphones
  - Wide-screen display
  - SW for data collection & demoing

• **Edge computing facilities**
  - Jetson nano GPUs
  - Open-CL enabled FPGAs (Intel Arrya)
  - Gateway PC
  - SoC board for automotive-grade embedded applications
  - SW library for data stream processing (AI loads)

• **HPC facilities @ ITC**
  - 16x R74xd cluster (2x Intel XGold 6240R, 24 cores per socket, 768 GB RAM, Mellanox ConnectX-5)
  - 1x server (4x Intel XPlatinum 8260L, 768 GB RAM, 2 TB Optane, Mellanox ConnectX-5)
PAILab @ CNR - AI@Edge Laboratory

• **Focus**
  - Edge and distributed computing for AI-based systems
  - Focus on autonomous vehicles, computer vision and 3D graphics, IoT/CPS, critical and industrial applications
  - Complementary to ICAR’s AI datacenter

• **Resources**
  - Nvidia Jetson development kits
  - Intel Arria SoC FPGA
  - Integrated imaging & camera
  - 5G networking
  - Wearable and environmental sensors
  - Edge and dense servers
  - Rovers/UAV
  - 3D printing
Research Overview

- Long standing on learning for structured data processing
- Deep learning and neural networks, probabilistic models, kernel methods

Funded by Italian, European and industrial projects
Topics of current research (I)

**Recurrent neural networks**
- (Deep) Reservoir computing and randomized networks
- Theoretical properties of neural memories
- New paradigms of dynamic memory

**Learning with structured data**
- Learning non-isomorph transductions
- Deep learning for graphs
- Graph generation
Topics of current research (II)

Learning Fundamentals

- Continual learning
- Federated learning
- Learning representations
- Reinforcement learning and learning under weak/self/noisy supervision
- Theoretical properties of deep NNs

Pervasive AI

- Distributed learning
- In-silico embedded intelligence
- AI on GPU/FPGA/Cluster computing
- ML as a service & ML-based application development
- Trustworthy & human-centered learning
Topics of current research (III)

Trustworthy Neural Systems
- Protecting neural representations
- Robust, safe and secure deep learning
- Interpretability

Applications of learning systems
- Recommendation systems
- Machine vision & multimedia
- Bioinformatics
- Chemistry
- Robotics
- Autonomous Vehicles
- Physio-signal processing
And many other things...

- Generative and unsupervised deep learning
- Computational creativity: music generation and style transfer; visual arts
- Medical imaging
- Integrating learning and reasoning
- ...

Contact if interested in M.Sc. and Ph.D. projects
Active Projects & Initiatives

- EU H2020 TEACHING: A computing Toolkit for building Efficient Autonomous applications leveraging Humanistic INtelliGence (2020-2023)
- EU H2020 TAILOR: Trustworthy AI Integrating Learning, Optimization and Reasoning (2020-2023)
- CLAIRE: European AI Task force on COVID-19
- Intel-Dell Industrial competence centre on AI
- H&M Industrial collaboration on Deep Learning for Graphs
- Industrial research project: learning to predict critical events in sensor timeseries (2021)
- Industrial research project: Deep and Bayesian learning for perceived stress prediction (2019-2021)
- Regional project PH-REMIX: Remixing tools for multimedia data (2020-2022)
- Regional project PRE-MED2: Precision Medicine for Preventing Type 2 Diabetes: a Step Forward (2020-2023)
H2020 TEACHING (2020-2023)

A computing toolkit for building efficient autonomous applications leveraging humanistic intelligence

Short Facts
10 partners
5 countries
4M Euro

UNIPI role
**Davide Bacciu** (Project Coordinator)
**Claudio Gallicchio** (AI WP leader)

www.teaching-h2020.eu
A human-centric perspective on autonomous CPSoS applications
A human-centric perspective on autonomous CPSoS applications

Paradigmatic shift needing support at computing and system level
**TEACHING** - Conceptual Architecture & Approach

- **Autonomous CPSoS applications need intelligence**
- **Human-centric AI as a distributed service leveraging PEC feedback**
- **Mixed edge/cloud orchestration & software-level abstraction platform**
- **Human-state must be accounted for in autonomous system operation**
- **Dependable system engineering for mission-critical CPSoS with AI components**
- **Native support for AI & dependability (computing and communication)**
H2020 TAILOR (2020-2023)

Trustworthy AI - Integrating Learning, Optimisation and Reasoning

ICT-48 Network of research excellence centres on foundations of Trustworthy AI

- 55 partners; >75 affiliated labs
- Research program to address grand challenges
- Connectivity fund for active dissemination to the larger AI community
- Network collaboration activities (exchanges, events, joint supervisions)

tailor-network.eu
• UNIPI role
  • Partner member
  • Member of CLAIRE network seed project H2020 TAILOR
  • CLAIRE national office for Italy (Attardi, Bacciu)

• CLAIRE COVID-19 Task Force
  • Coordination of Bioinformatics workgroup
  • Working on drug-repurposing, viral-hosts interaction analysis, genomics, clinical data analysis
  • Soon to be become a WG on AI for Health

claire-ai.org

claire-ai.org
Midterm 4

• Out next week

• Format
  • Read 1 paper on a course topic
  • From a list of referenced papers
  • Prepare a 5 minutes presentation for the oral day with the following (rough) content
    • Introduction to the problem
    • Model description
    • Results
    • Comment on novelties, strong points and weaknesses

• Deliver the presentation by the Appello deadline
Final Projects (Alternative to MIDTERMS)

• List already on the course Moodle

• Survey
  • Read at least 3 relevant papers on a topic
  • Prepare a presentation: not a simple summary but find connections between the works and highlight open problems

• Software
  • Develop a software implementing a non-trivial learning model and/or an application relevant for the course
  • Prepare a presentation describing the software and its validation
Final Projects – What to Deliver?

• Two things need to be delivered (by the Appello deadline)
  • A written report on the project
  • A presentation on the project

• Presentation will last 15 minutes and will be given on the oral day

• Presentation tips
  • (Survey) Summarize the ideas, models and results
  • (Software) Describe the implemented model, the library and the experimental validation
  • My suggestion is to keep the number of slides around 15 (tops)
Final Exam Timeline

1) Deliver your presentation, report or code

2) Arrange an exam date

Typically >=5 days

Temporal slots for oral exams will be made available on the Esami platform

3) Presentation Day
Fixed and strict deadlines for handling the presentation, report and/or code to me

1. 11/06/2020 h. 18.00
2. 02/07/2020 h. 18.00
3. 22/07/2020 h. 18.00

Delivery through the ISPR moodle

- Midterm: submit presentation in PDF
- Project: submit presentation, report, code in a single archive file (no data!!!!)
On the Oral-Presentation Day

• At least until July 2021 exams will be held online on the TEAMS of the ISPR course
  • Check for specific calendar items on the Team
  • All students are welcome to attend

• I will ask questions after the presentation
  • On the content of the talk
  • On associated models
  • On other models, algorithms and applications discussed during the course lectures
• What is the **language** for the report and the presentation?
  • Both need to be written in English, but the presentation can be given in either Italian or English
  • The oral exam can be in either Italian or English (your choice)

• How long do **midterms last**?
  • Until September exams (included)
  • Yes, I will keep them even if you give the exam and fail it (not if you fail it because of plagiarism though)

• Other questions?