ISPR Final Lecture

INTELLIGENT SYSTEMS FOR PATTERN RECOGNITION (ISPR)

DAVIDE BACCIU – DIPARTIMENTO DI INFORMATICA - UNIVERSITA’ DI PISA

DAVIDE.BACCIU@UNIPI.IT
Lecture Outline

○ 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**
- **Lectures**
- **Your expectations before the course**
- **Your interpretation of the lectures based on your idea of the course**

**How is your view of ISPR after having taken 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
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
- Generation
- Creativity
- Search & strategize
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

- **Reinforcement learning**
  - Learn to act with fuzzy directives
  - Highly dynamic and non-stationary
  - Tools to handle non differentiable and combinatorial problems
A Convergence of Neural-Generative Paradigms

- Need the **efficacy and efficiency** of neural 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 learning paradigms and models are best to start with for addressing a given PR problem
- Know what challenges your 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, continual learning
  - Bootstrapping-based learning targets, policy gradient as trial-and-error, bias-variance control, learning-simulation integration
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)

Faculty
Alessio Micheli (coordinator)

Davide Bacciu  Claudio Gallicchio  Vincenzo Lomonaco  Antonio Carta

Associates
Daniele Castellana, Postdoc
Andrea Ceni, Postdoc
Andrea Cossu, Ph.D. Student
Valerio De Caro, Ph.D. Student
Alessio Gravina, Ph.D. Student
Francesco Landolfi, Ph.D. Student
Riccardo Massidda, Ph.D. Student
Michele Resta, Ph.D. Student
Danilo Numero, Ph.D. Student
Andrea Valenti, Ph.D. Student
Asma Sattar, Ph.D. Student
Domenico Tortorella, Ph.D. Student

Other Collaborators
Daniele Atzeni, Smart Industry Ph.D.
Dario Balboni, Data Science Ph.D.
Student
Giacomo Lanciano, Data Science Ph.D.
Student
Edoardo Urettini, AI Ph.D. Student
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 UNIPI)
- ~50 members
- Coordinating 3 EU Projects and 1 KA; participation in 2 H2020 projects and 3 industrial projects
- 15M 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
  - Driving-simulator setup

- **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)
TEACHING-PAIILab Driving Platform
PAI Lab @ 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

- Learning for structured data
- Deep learning and neural networks, generative models, kernel methods
- Pervasive AI (distributed, embedded, continual)

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

Recurrent neural networks
- (Deep) Reservoir computing and randomized networks
- New paradigms of dynamic memory
- Neuromorphic computing and dynamical systems

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
- Learning-symbolic integration & reasoning
- 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
- Algorithmic reasoning
- ...

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

- EU EIC Pathfinder EMERGE: Emergent awareness from minimal collectives (2022-2026)
- 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)
- MIT-UNIPI international project on deep learning for optimization problems
- MPS industrial collaboration on graphs and continual learning for critical events monitoring
- H&M Industrial collaboration on Deep Learning for Graphs
- Buonappetito SRL industrial collaboration on deep learning for graphs
- Cornelis Network industrial collaboration on Pervasive AI
- Intel-Dell Industrial competence centre on AI
- Member of CLAIRE-AI network
- Member of ELISE catalogue of AI research nodes
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
TEACHING - Motivation & Vision

A human-centric perspective on autonomous CPSoS applications
TEACHING - Motivation & Vision

A human-centric perspective on autonomous CPSoS applications

Paradigmatic shift needing support at computing and system level
TEACHING - AI Vision
Learning modules as application building blocks
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
HORIZON EIC EMERGE (2022-2026)

Blue sky research project on emergent collaborative consciousness of (simple) things

EMERGE CONSORTIUM
UNIPI
TU Delft
University of Bristol
LMU Munchen
Da Vinci Labs
EMERGE – Neural computing on Dynamical systems

UNIPI Team: D. Bacciu, A. Frangioni, G. Iommazzo, D. Numeroso
Midterm 4 – Reinforcement Learning

- Out next week
- Format
  - Read 1 paper on a course topic
  - From a list of referenced papers
  - Prepare an 8 slides presentation with the following (rough) content
    - Introduction to the problem
    - Model description
    - Key catch of the model, represented by a commented equation
    - Key (empirical) result
    - Comment on novelties, strong points and weaknesses
- Deliver the presentation by the 31-05-2022
Final Projects (Alternative to MIDTERMS)

- List to be released on the course Moodle by next week
- Survey
  - Read at least 3/4 relevant papers on a topic
  - Prepare 10 pages report + 1 presentation (for oral day): 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 (for oral day) describing the software and its validation
Final Projects – What to Deliver?

○ Two things need to be delivered (by the Appello deadline)
  ● A written report or the code for 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

1a) Subscribe on Esami if you have 4 positive midterms

1b) Deliver your presentation, report or code

2) Arrange an exam date

Typically ≥ 5 days

3) Presentation Day

Official appello date
Presentation, Report & Code Delivery

Fixed and strict deadlines for handling the presentation, report and/or code to me

1. 31/05/2022 h. 14.00
2. 21/06/2022 h. 14.00
3. 08/07/2022 h. 14.00

Delivery through the ISPR moodle

- Submit presentation, report, code in a single archive file (no data!!!!!)
On the Oral-Presentation Day

- Oral exams will be held in-person unless you are formally exempted by UNIPI
  - Check for room information and dates on the Moodle
  - All students are welcome to attend

- Non-midterm students will first deliver their presentation

- All students will be subject to an oral exam on models, algorithms and applications discussed during the course lectures
  - C. Gallicchio and V. Lomonaco lectures are not part of the exam programme
FAQs

○ 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?
Concluding

- I hope you have enjoyed the course
- I will be out of my office:
  - 28 May-03 June
  - 13 Jul-22 Jul
  - 09-31 August

Enjoy the rest of your AI curriculum