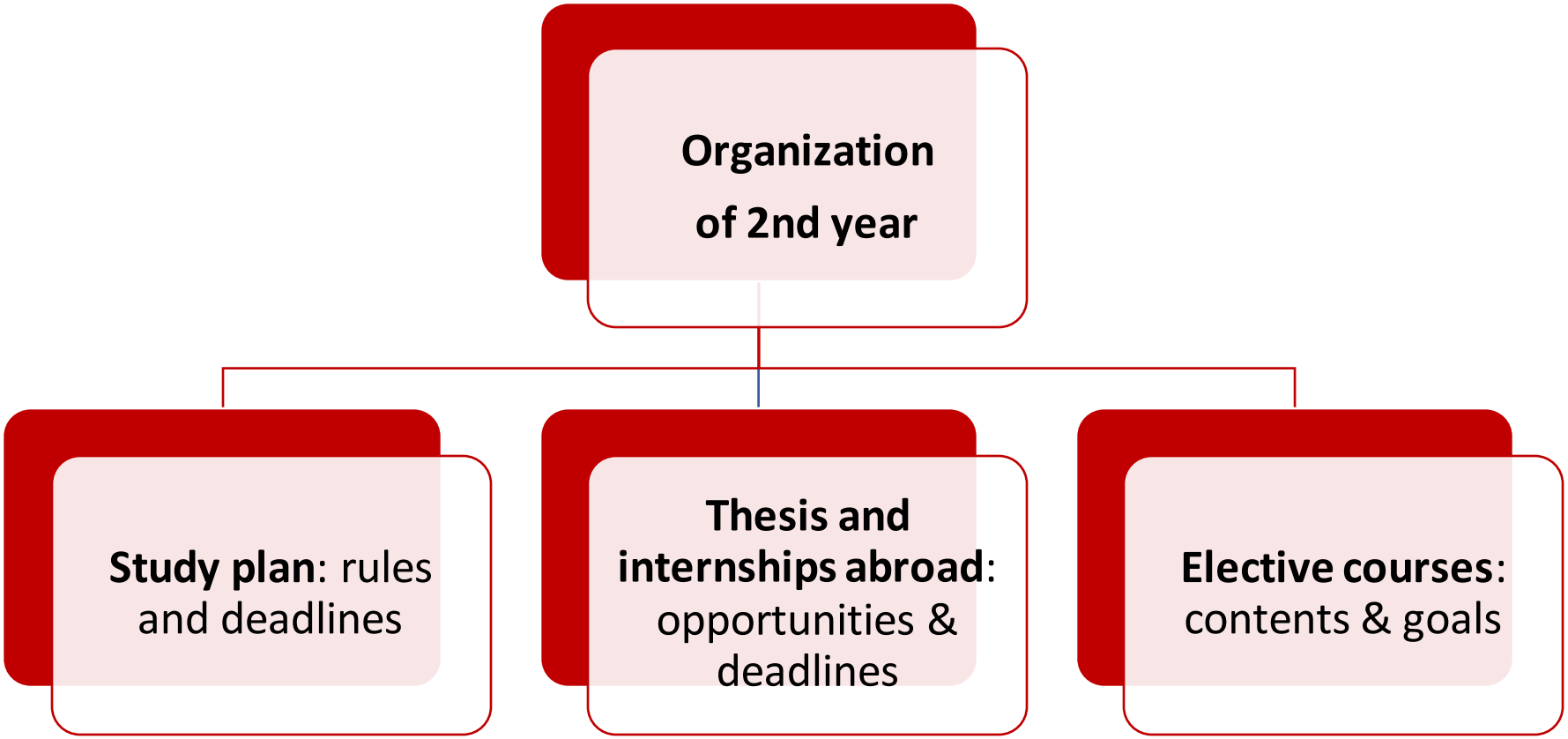
ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

2nd year – students meeting

International Master's Degree in
Artificial Intelligence



Organization of second year

Study plan

- **Who can submit the study plan?**
  - Students enrolled in the ongoing academic year

- **When can I submit the study plan?**
  - **Only in the following periods:**
    - 1st period: October/November 2022
    - 2nd period: February/March 2023

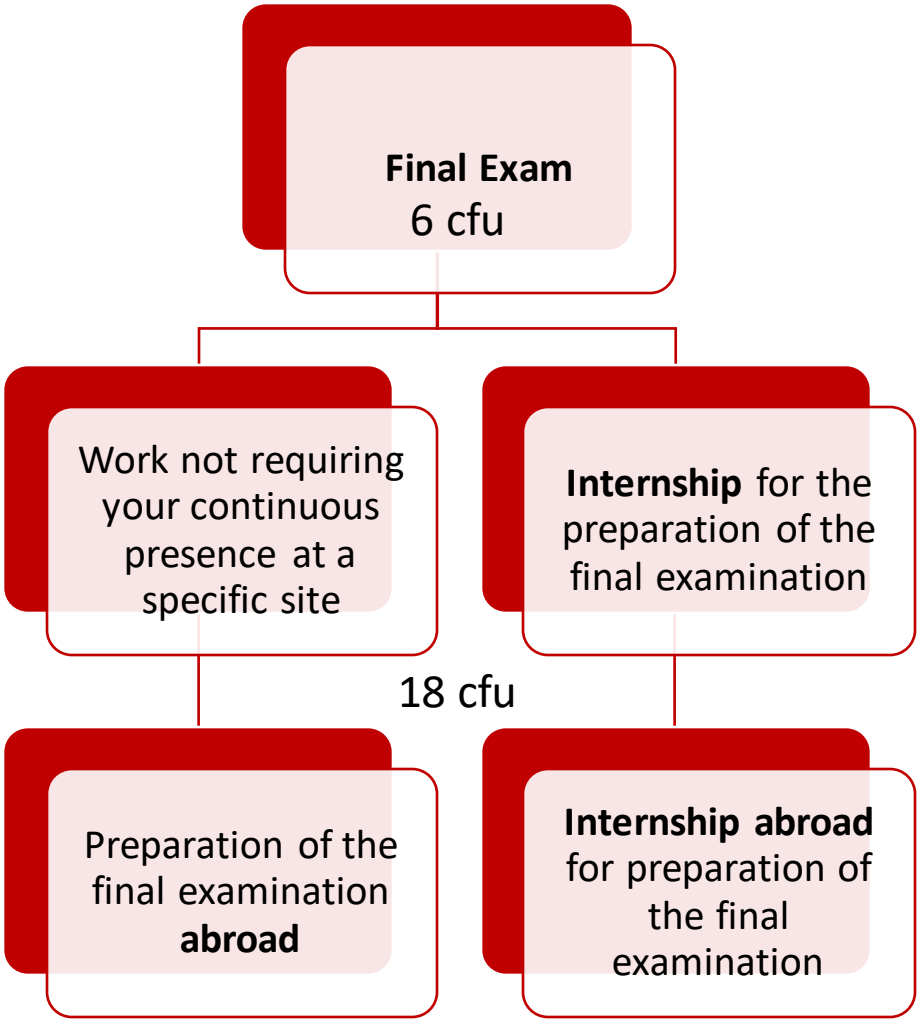
- **What are the rules?**
  - The study plan must be filled out according to the Course Structure Diagram, referring to the academic year of your first enrollment
  - Only exams in the study plan can be sat
  - If one wants to sit an exam that is not in the study plan, one must first insert the exam in the study plan (which can only be done in the two periods indicated above)

Study plan: useful contacts

- **If you need help or guidance:**
  - on administrative/procedural issues:
    Ms. Carlotta Viani
    carlotta.viani@unibo.it

  - on the content of your study plan:
    Prof. Federico Chesani
    federico.chesani@unibo.it

Structure of the final examination



What about internship?

- **Internship for the final examination**
  - It can be added in the study plan as of the 2nd year
  - Students interested in it must:
    1. add it to their study plan;
    2. find a hosting organization where to carry out the work
       - search is done autonomously
       - best to plan in advance
       - academic supervisor

  ➢ More info here

Grants opportunity for thesis abroad

- 2 calls per year – Fall/late Spring (https://bandi.unibo.it/)
- Min 3 months – Max 6 months
- Students interested in it out must:
  1. find a hosting organization where to carry out the work
     - search is done autonomously
     - best to plan in advance
     - academic supervisor
  2. apply to the call (Studenti Online)
  3. present their project to the commission

- Additionally, focussed calls (NII, Datalogic)

If you need help or guidance:

on administrative/procedural issues:

Ms. Clarissa Caramagno
clarissa.caramagno2@unibo.it

Final examination

- To graduate, you must defend your final project (thesis)
  - Graduation dates in July, October, December, February, and March

- Before that, you must have:
  1. sat all the exams in your study plan and had them recorded
  2. paid all tuition fees
  3. filled-in the Alma Laurea questionnaire on Studenti Online

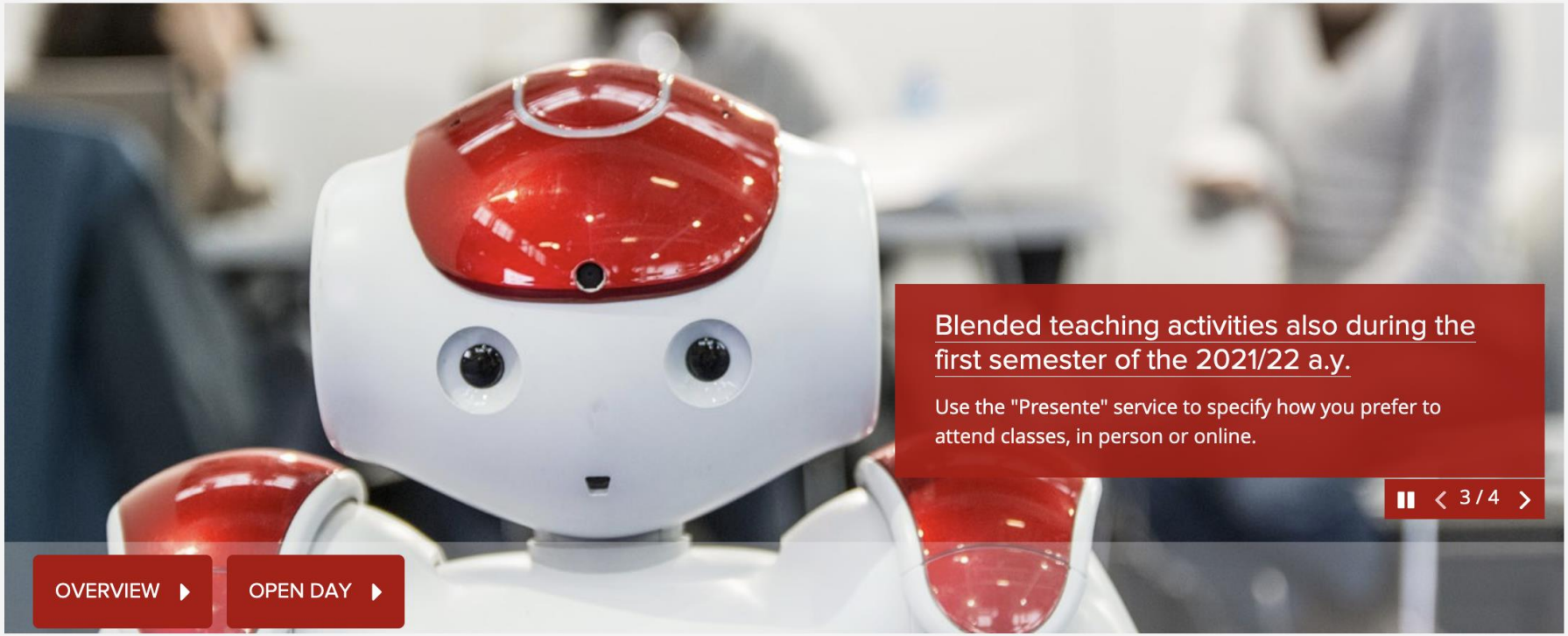
- The Student Administration Office will verify all requirements and contact you if there are any issues

ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

SECOND CYCLE DEGREE/TWO YEAR MASTER IN

ARTIFICIAL INTELLIGENCE

COVID-19 - Resuming activities safely - **The measures adopted by the University of Bologna**



PROGRAMME TYPE
Laurea Magistrale (Second cycle degree/Two year Master - 120 ECTS)

PLACE OF TEACHING
Bologna

LANGUAGE
English

TYPE OF ACCESS
Open access with assessment of personal competencies

DEGREE PROGRAMME CLASS
LM-18 - Computer science
LM-32 - Computer systems engineering

DEGREE PROGRAMME DIRECTOR
Paolo Torroni

DEPARTMENT
Computer Science and Engineering - DISI

LEARNING ACTIVITIES
Course structure diagram

Course structure diagram

Data Mining, Text Mining and Big Data Analytics

- Gianluca Moro, Stefano Lodi, Claudio Sartori (name.surname@unibo.it)
- Gianluca Moro: Module of Text Mining (October-December 2022)
- Stefano Lodi: Module of Big Data Analytics (November-December 2022)
- Claudio Sartori: Module of Data Mining (November-December 2022)
- Main objective: Designing and Implementing Data Analysis and Knowledge Discovery for Big Data and Text Corpora
  - At the end of the course, the student understands how a possibly very large set of data can be analyzed to derive strategic information and to address "data-driven" decisions. The student has a knowledge of the main data-mining tasks such as data selection, data transformation, analysis and interpretation, with specific reference to unstructured text data, and with the issues related to analysis in "big data" environments.
- During the lessons teachers will propose internships, research & industrial thesis, even in projects our team is carrying on with companies and research centers
- Single exam session for the 3 modules with multiple choice questions and an individual project, on one or more topics, discussed with one of the teachers
- https://www.unibo.it/en/teaching/course-unit-catalogue/course-unit/2021/446610 (to be updated)

ALMA MATER STUDIORUM
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Data Mining module

What will I be able to do at the end of the course?

- Understand the CRISP methodology for the definition of a Data Mining process
- Given a Data Mining problem, define the steps for the solution according to the CRISP methodology
- Use the machine learning techniques learned in other courses/modules as a part of the data mining process
- Evaluate the effectiveness of the machine learning techniques used
- Understand the concepts and the architectures of Data Warehouses
- Read and understand the schema of a Data Warehouse
- Understand the concepts of Data Cube and OLAP

This module is the natural complement of the course/module of Machine Learning of your first year

Big Data Analytics module

What will I be able to do at the end of the course?

- Configure the big data distributed processing framework Apache Hadoop for a small cluster of computers
- Write Python scripts that carry out simple data analyses of large data sets using the Apache Hadoop implementation of the MapReduce programming model
- Write data transformation scripts using the Python API to the Apache Spark big data analytics engine
- Write Python scripts in Apache Spark which compute Machine Learning models, using the Apache Spark Machine Learning library MLlib
- Understand the distributed programming techniques for writing Python distributed programs using the unstructured API of Apache Spark, from examples of data mining algorithms implemented in the API

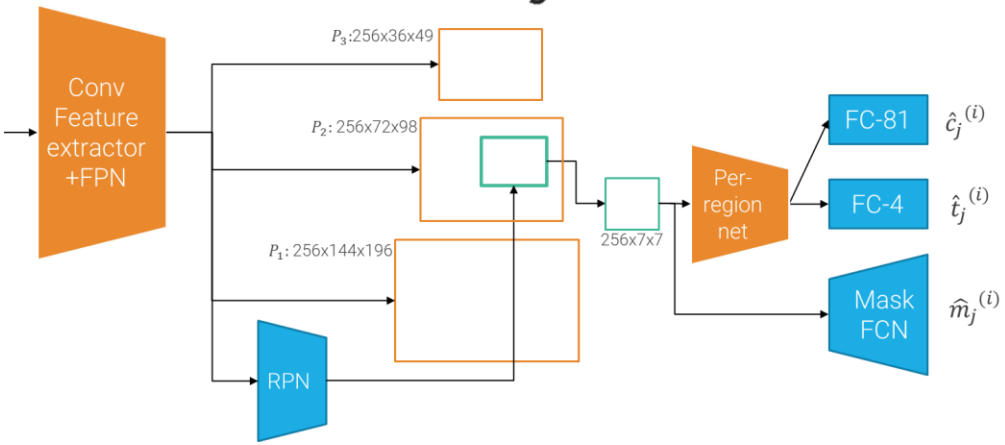
Text Mining module

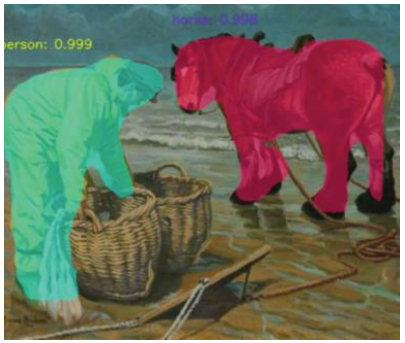
What will I be able to do at the end of the course?

- Design and implement knowledge discovery tasks for text corpora
  - Text representation, indexing and similarity, identification of relevant terms, Ranking-based Information retrieval and evaluation methods
  - Dimensionality reduction and feature selection methods for textual data; *lab*
  - Novel latent semantic analysis method to discover underlying explanations of phenomena; *lab: discovering explanations of aircraft accidents from flight reports*
  - SOTA language models and representation learning with deep metric learning *lab:* text classification, topic analysis, sentiment analysis & opinion mining
  - Neural self-supervised and multi-modal learning; *lab: search engines development for large fashion corpora of texts and images with quadratic and linear attention*
  - Extractive and abstractive text summarization of long docs in low-resource regimes; *lab: summarization of legal cases with training on a few dozen instances*
  - Learning knowledge graphs from unstructured text with Graph Neural Networks & graph attention methods; *lab: extracting n-ary relations from medical literature for modeling & explaining biological processes*
  - Memory-based neural networks for text mining, *retrieval-memory-based chatbot*
- *we'll also present new published SOTA results, we also achieved on some of these topics*

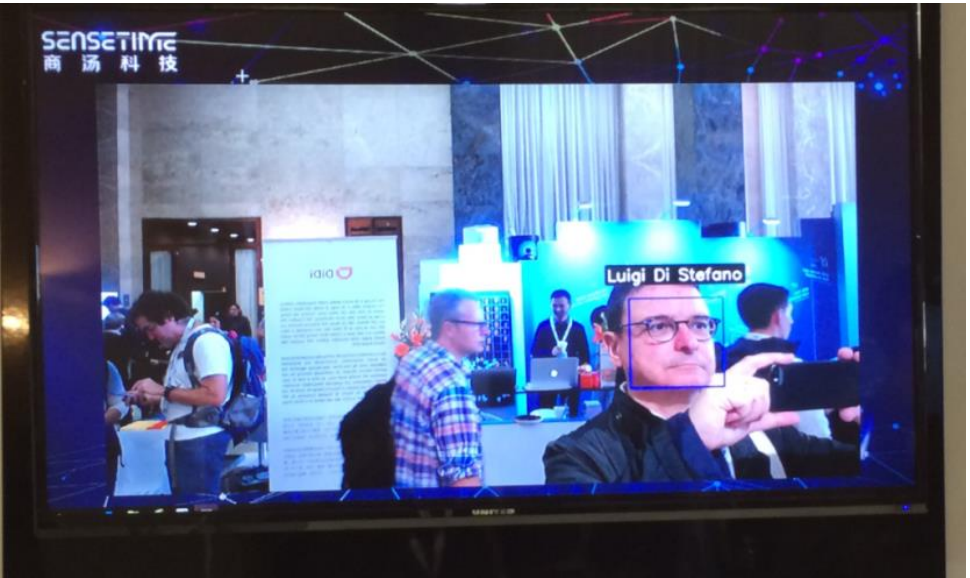
Machine Learning for Computer Vision

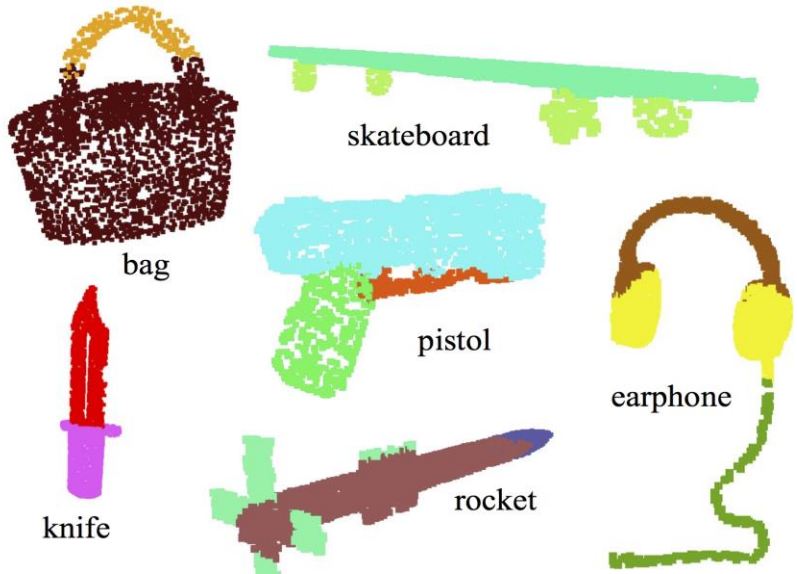
- Instructor: Samuele Salti
- Period: first semester (from September to December)
- Main objective: Train the students to **master the most popular modern machine-learning approaches to computer-vision tasks**, in particular specialized deep-learning architectures.
- Topics: image classification, object detection, semantic and instance segmentation, metric learning & face recognition, depth prediction, 3D data
- **4 hands-on sessions**, based on PyTorch



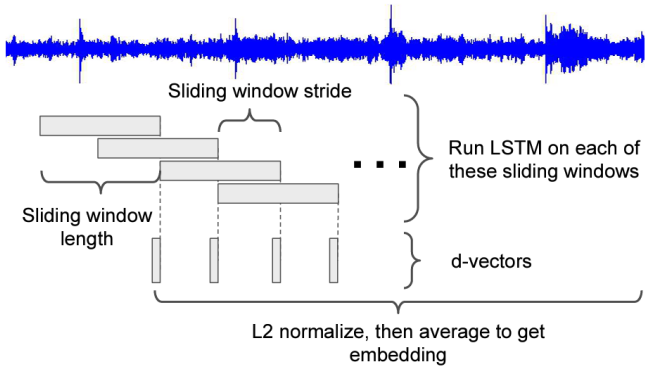


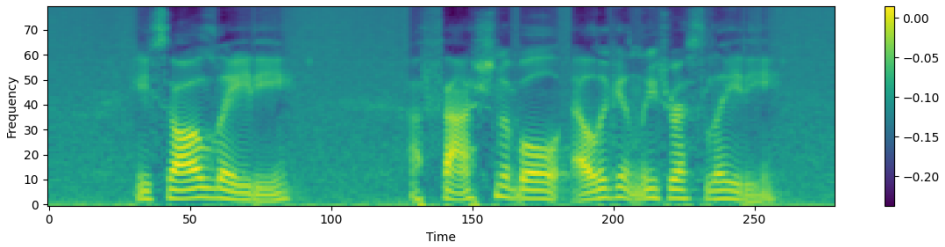
What will I be able to do at the end of the course?



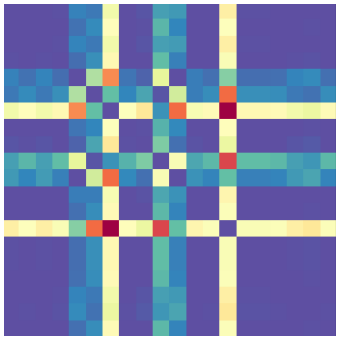


… and beyond

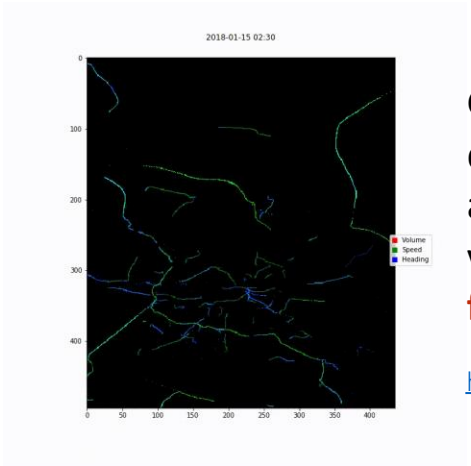




Alessoi Falai, **Speaker identification**, ML4CV project work



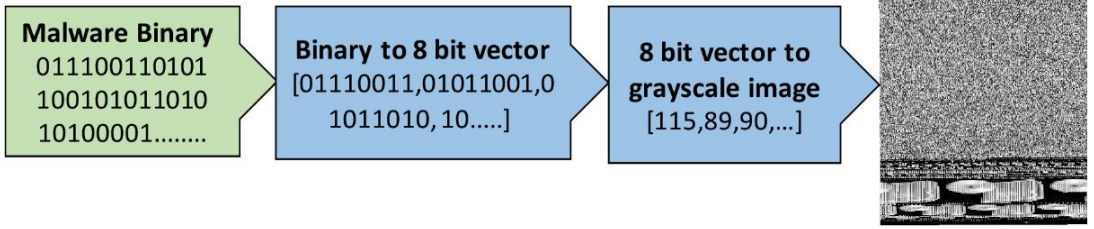
F. Parascandolo, D. Domenichelli – DL approaches to **financial forecasting**, CNN on Gramian Angular Difference Field - ML4CV project work



GPS probes and traffic data can be successfully analyzed as images or videos, e.g. for **traffic forecasting**

https://www.iarai.ac.at/traffic4cast/

Even computer programs can be converted into images, e.g. for **malware detection**



Artificial Intelligence in Industry
Project Work in Artificial Intelligence in Industry

- **Michele Lombardi**
- 1st Semester

- The main goal is let students familiarize with ***how to tackle industrial problems*** (in a broad sense). The emphasis will be on ***looking at the big picture***, picking the ***right tools***, and ***combining them***, using ***both simple and advanced techniques***.

- The course will be delivered as **a set of simplified industrial use cases**, making extensive use of systems like Jupyter notebooks and Docker containers.

- The result is a sort of **cookbook**, from which the students will be able to **draw ideas** when faced with real-world problems.

What will I be able to do at the end of the course?

Generally:

- Dealing with time series
- Combine Optimization and Machine Learning methods
- Build hybrid ML/statistical models
- Take into account constraints in Machine Learning models
- Physics-Informed ML

What will I be able to do at the end of the course?

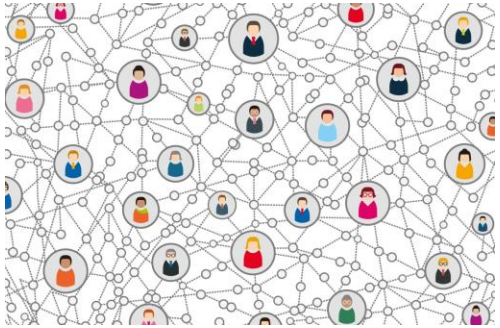
Some specific examples

Anomaly detection and predictive maintenance for industrial components

Process optimization for production or finishing machines

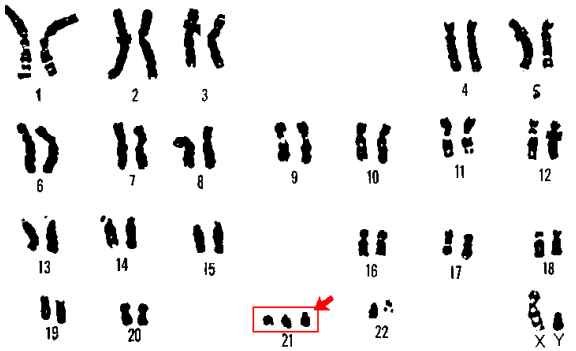
What will I be able to do at the end of the course?

Some specific examples



Understand and predict epidemic processes, and provide automated support for decision makers

Prediction and decision support for medical processes



Diagnose and investigate medical conditions

What will I be able to do at the end of the course?

Some specific examples

Maintenance, analsys, and decision suport for High Performance Computing

Operating testing robots

Analysis and interpretation of times series of natural origin

Multi-Agent Systems
Project Work in Multi-Agent Systems

- **Professors**: Andrea *Omicini* & Roberta *Calegari*
- **Period**: February-June 2023
- **Main objective**: Design and build intelligent systems as multi-agent systems

Why this course?

- AI is serious stuff, nowadays
  - we may toy with AI techniques, and tell ourselves "This is AI!"
  - but, it is mostly not — not just that
- We are heading towards real-world **intelligent systems**
  - and, we are doing that *fast*
- *Systems* call for **engineering**
  - which is *not* just *technologies*
  - but also *models* (principles, abstractions, …) and *methodologies* (guidelines, tools, …)
- For instance, a *fundamental question* that intelligent systems engineers should ask themselves is

  How should we combine & integrate *intelligent components* in order to build **intelligent systems**?

- … a problem that cannot be solved at the mere technology level
  - as anyone knowledgeable about basic software engineering principles easily understands

… and the answer is…

Multi-Agent Systems

- As the richest and most expressive source of abstractions, technologies, and methodologies for the *engineering of intelligent systems*
- Working as a conceptually-coherent *integration framework* for all present and (presumably) forthcoming AI techniques
- Encompassing
  - symbolic, sub-symbolic, and non-symbolic approaches
  - traditional / industry-standard technologies and methods as well as novel, research-driven ones

At the end of the course, students will be able to…

- Understand the conceptual and technical *foundation* of (intelligent) multi-agent systems
- Precisely frame existing *AI techniques* in terms of agent-oriented abstractions, and grasp their specific role in the general context of intelligent systems
- Build complex computational and socio-technical systems using agent-oriented *technologies* and *methodologies*
- Design and engineer **intelligent systems as multi-agent systems**, by integrating heterogeneous AI techniques and methods in an effective and methodologically-sound way

Final exam

PROJECT

- On a student-selected topic in the area of agent-based intelligent systems spanning from theory to implementation
- Some examples at

https://apice.unibo.it/xwiki/bin/view/Courses/Series/Mas/Projects/

✓ Different student paths before the course are accounted for both during the course (mostly in the lab classes) and in the project selection & evaluation

81683 - INTERNET OF THINGS (6 cfu)+
91286 - PROJECT WORK IN INTERNET OF THINGS (3 cfu)

Professors' names:

Luciano Bononi (module 1) , email: luciano.bononi@unibo.it
https://www.unibo.it/sitoweb/luciano.bononi/en

Marco di Felice (module 2) , email: marco.difelice3@unibo.it
https://www.unibo.it/sitoweb/marco.difelice3/en

Period: 2° Semester (Feb 2022 – June 2022)

81683 - Internet of Things

- Main objective: to introduce the enabling technologies, protocols, software architectures and applications for the development of the emerging Internet of Things (IoT) paradigm (and its synergy with AI, Big/Open Data, Digital Twin, etc.)
- Introduction to IoT systems: definitions, applications, enabling technologies
- IoT components: **from sensors to gateway**
  - (Arduino, STM32 Nucleo, ESP8266) (BLE, IEEE 802.15.4, Z-Wave, etc.), (LoRA, Dash7, Spirit, etc.), (6LoWPAN, RPL), etc.
- IoT components: **from gateway to cloud**.
  - XMPP, CoAP, MQTT, AMQP, WebSocket, cloud/fog/edge computing, IoT Platforms, IoT and Big data
- IoT components: **from cloud to applications**.
  - Web of Things and Semantic Web 3.0, Machine learning principles, sensor data analysis, AllJoyn, Google Thing, Apple Home[illegible] IoT Platforms (e.g. AWS IoT)
- IoT Open **Issues and bottlenecks**.
  - privacy, security, energy efficiency, sca[illegible]

LESSONS
DEMOS
LIVE EXPERIENCE in LAB

What will I be able to do at the end of the course?

- to understand the **architectures and methodologies** at the basis of the Internet of Things (IoT) and IoT Platforms

- to understand **network protocols**, integration of mobile and pervasive **end-devices**, **middleware** platforms for M2M-based **IoT systems**, **edge/distributed/gateway** computing principles, new services, **service platforms** and **innovative application** scenarios

- create/exploit **synergy** with Web Of Things, AI, Machine learning, Big/Open Data, Digital Twin, Mobile Apps, etc.

- Final Exam: Seminar + Project

IoT Prism Lab

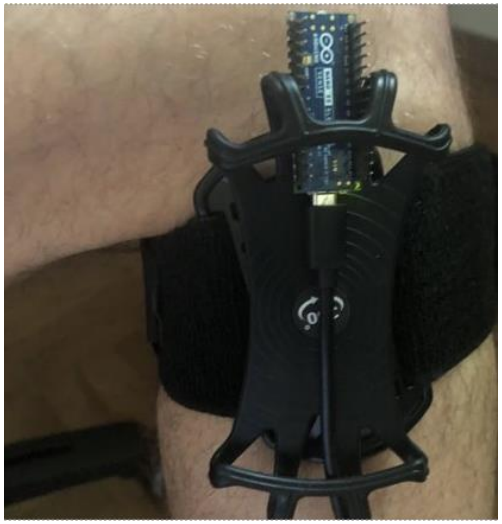
Research Lab at University of Bologna

More details here:
http://iot-prism-lab.nws.cs.unibo.it/
https://site.unibo.it/iot/en/teaching-1/the-iot-course

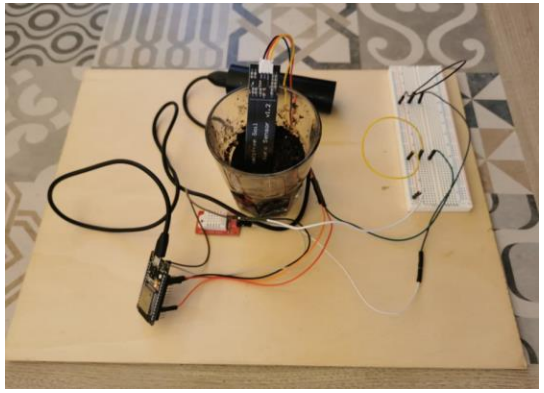
What will I be able to do at the end of the course?

- Projects (some more examples in next slides)
  - Multiprotocol IoT Bridge Platform (data visualization, storage, bridging)
  - SenSquare: IoT service middleware
  - Arrowhead: toolchain for Industrial IoT and Service Oriented Architectures
  - WoT and Digital Twin
  - Mobile Crowdsensing and Crowdsourcing platforms
  - Activity recognition and context awareness
  - Drones and autonomous systems (e.g. drone swarms)
- Systems' Design and frameworks development and adoption
- Thesis in international Projects and Collaborations
  - e.g. http://iot-prism-lab.nws.cs.unibo.it/proposals/
- PhD programs, e.g. Computer Science (CS), Data Science (DS), or Structural and Environmental Health Monitoring and Management (SEHM2)

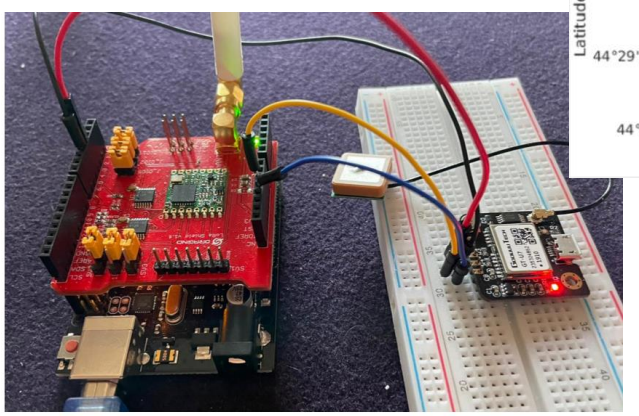
What will I be able to do at the end of the course?

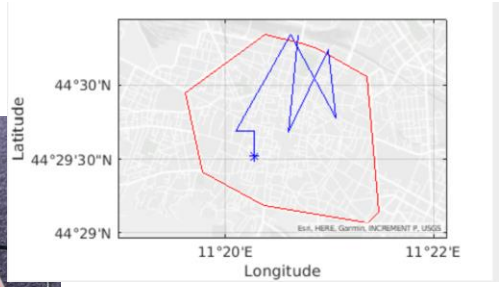


Human Activity Recognition
Edge AI + embedded systems
Author: Alessandro Ghibellini



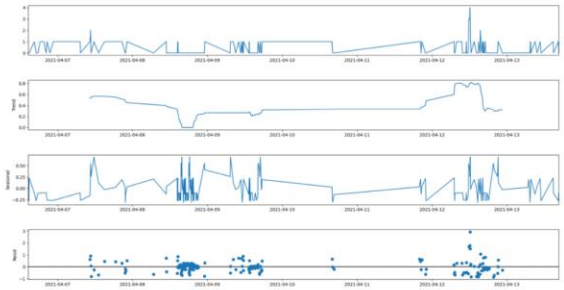
Smart Pot System
Remote monitoring of indoor gardens
Author: Damiano Bellucci

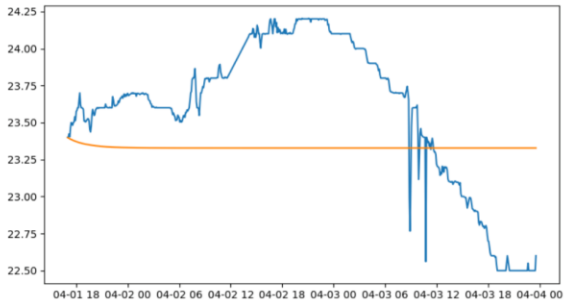




Low-power tracking of bicycles
LoraWAN stack
Authors: Rafael Trozzo, Facundo Farall, Gonzalo Davidov

What will I be able to do at the end of the course?

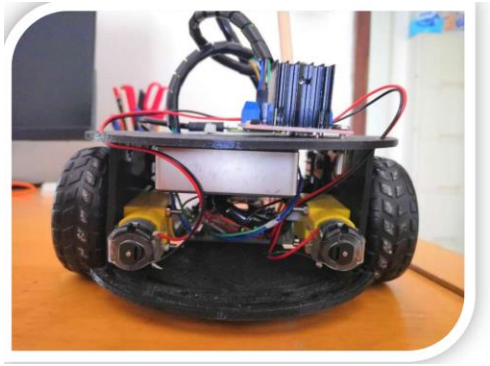


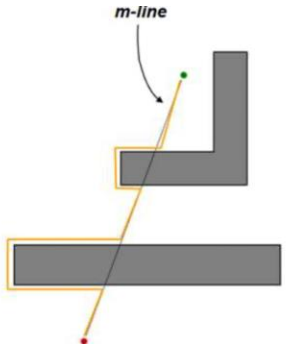


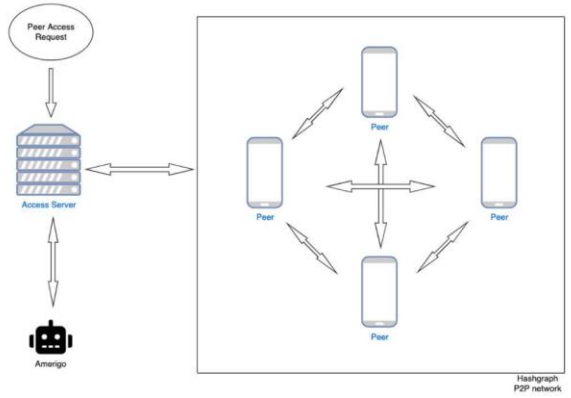
SafeLab

Access Control and People counter with proximity sensors and the Web of Things

Author: Christian Castiglione







Amerigo

Self—steering, autonomous robot, Block-chain enabled (Hedera Hashgraph)

Author: Bruno Quintero Panaro, Nunzio Maccarrone

91259 - ARCHITECTURES AND PLATFORMS FOR AI
Project Work in Architectures and Platforms for AI

- ***Professor:*** ,
  Gianluigi Zavattaro (DISI)→module 1
  Luca Benini (DEI) → module 2
- ***Period:*** first semester
- ***Learning Outcomes***: to gain a good understanding of:
  - parallel programming in HPC,
  - the requirements of machine-learning workloads for computing systems,
  - the main architectures for accelerating machine learning workloads and heterogeneous architectures for embedded machine learning.

What will I be able to do at the end of the course?

- Understand parallel programming patterns (embarassingly parallel, decomposition, master/worker, scan, reduce,..)
- Gain practical knowledge of Shared-Memory parallel programming considering multicore architectures (with OpenMP) or GPUs (with CUDA), with application examples and project exam taken from the field of machine learning
- Understand ML and DL as a workload for a computer architecture and gain the ability to assess the computational and memory requirements of modern neep neural network (DNN) topologies
- Acquire working knowledge of optimization approaches to improve computational efficiency on DNN workloads: efficient algorithms and iso-accuracy transformations (Winograd, FFT…), approximation techniques (sparsification and training)
- Optimize DNN computations for execution on RISC-V cores, through a range of ISA and hardware architecture-aware software optimization techniques

Knowledge Engineering

- Valentina Presutti and Andrea Giovanni Nuzzolese
- Second period
- This course is key to develop expertise in symbolic AI (crucial also for developing neuro-symbolic AI systems)
- The objective of the course is to provide the students with **advanced semantic modelling capabilities** and a proper knowledge of the state of the art in **ontology and knowledge graph engineering**.
- The project as well as the practices during classes make the students face **realistic project scenarios** and become expert in using the available methods and tools for knowledge engineering
- Master theses are available in both academic and industry contexts
  - Research projects (working within European projects, possibility of theses in collaboration with European/international partners)
  - Companies developing KG-based technologies: startups, foundations (e.g. Wikidata), etc.

Knowledge graphs – the origin

The term knowledge graph is around since 1972

The semantic web with RDF and the *linked data* paradigm has introduced knowledge graphs on the web

(Tim Berners Lee – W3C note, 2006 https://www.w3.org/DesignIssues/LinkedData.html)

The term "knowledge graph" gained popularity with the 2012 annoucement of the Google Knowledge Graph

https://www.youtube.com/watch?v=mmQl6VGvX-c&t=59s

Google

Miles Davis

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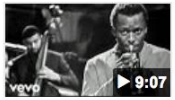
About 124,000,000 results (0.85 seconds)

Miles Davis - Wikipedia
https://en.wikipedia.org/wiki/Miles_Davis
Miles Dewey **Davis** III (May 26, 1926 – September 28, 1991) was an American jazz trumpeter, bandleader, and composer. He is among the most influential and ...
Miles Davis Quintet · Miles Davis discography · So What (Miles Davis · Betty Davis

Miles Davis - Wikipedia
https://it.wikipedia.org/wiki/Miles_Davis Translate this page
Miles Dewey **Davis** III (Alton, 26 maggio 1926 – Santa Monica, 28 settembre 1991) è stato un compositore e trombettista statunitense jazz, considerato uno dei ...
Discografia di Miles Davis · Miles Davis Volume 1 · Miles Davis and Horns · Dig

Miles Davis | Official Site
https://www.milesdavis.com/
Miles Davis' 'Bitches Brew' Explored At Mondo.NYC Panel October 6. September 29, 2017. More News. 11Albums. (1945 - 1955) ...

Miles Davis - So What - YouTube


https://www.youtube.com/watch?v=zqNTltOGh5c
Oct 19, 2010 - Uploaded by MilesDavisVEVO
Miles Davis' official music video for 'So What'. Click to listen to **Miles Davis** on Spotify: http://smarturl.it ...

Miles Davis - Trumpet Player, Songwriter - Biography.com
https://www.biography.com/people/miles-davis-9267992
Sep 22, 2017 - Nine-time Grammy Award winner **Miles Davis** revolutionized jazz as a musician, bandleader and composer. Read more about his life and ...

Miles Davis Discography at Discogs
https://www.discogs.com/artist/23755-Miles-Davis
Complete your **Miles Davis** record collection. Discover **Miles Davis's** full discography. Shop new and used Vinyl and CDs.

Miles Davis | Biography & History | AllMusic
https://www.allmusic.com/artist/miles-davis-mn0000423829/biography
Find **Miles Davis** biography and history on AllMusic - Throughout a professional career lasting 50…

Miles Davis
American jazz trumpeter

Available on
YouTube
Spotify
Deezer

Miles Dewey Davis III was an American jazz trumpeter, bandleader, and composer. He is among the most influential and acclaimed figures in the history of jazz and 20th century music. Wikipedia

Born: May 26, 1926, Alton, Illinois, United States
Died: September 28, 1991, Santa Monica, California, United States
Movies: Elevator to the Gallows, Scrooged, Dingo, MORE

Songs
So What


Blue In Green


Knowledge graphs

Knowledge graphs are at the core of many of the tools that we use in our daily lives: search engines, TV streaming services, personal assistants, self-driving cars ecosystems,

Knowledge graphs help to understand their customers, business decisions, product lines, etc.

Knowledge graphs

There is no agreed definition of a *knowledge graph*

We refer to the definition given in [1]

"A graph of data intended to accumulate and convey knowledge of the real world, whose nodes represent entities of interest and whose edges represent potentially different relations between these entities."

Knowledge graphs use a **graph-based data model** to capture knowledge in application scenarios that involve **integrating, managing and extracting** value from diverse sources of data at large scale

[1] Aidan Hogan et. al. Knowledge graphs. ACM Computing Surveys, Vol. 54, No. 4, Article 71

Building a KG is a difficult task

- It is difficult to design it
- It is difficult to implement it
- It is difficult to read it and describe it
- It is difficult to modify it
- It is difficult to measure it and evaluate its quality

What will I be able to do at the end of the course?

Polifonia

- Analysing and formally **modelling problems**
- Modelling **ontologies** and **knowledge graphs**
- **Querying** and reasoning over knowledge graphs
- **Evaluating the quality** of an ontology/knowledge graph
- **Integrating** large, distributed and **heterogenous datasets** based on semantic technologies
  - E.g. using knowledge extraction from text

Examples of projects:

- A smart music playlist engined by semantic relations between songs
- Modeling and integrating data from sensors capturing environmental parameters to support monitoring the conditions of Italian seas
- Modeling and creating a multimodal knowledge graph that links visual, factual and linguistic data
- Comparing translations across multiple languages by formal reasoning on their knowledge graph representations

User Experience Design
Project Work in User Experience Design

- **Professor:** Fabio Vitali
  Department of Computer Science (DISI)
- **Period:** 20 september – 20 December 2021
- **Learning Outcomes**: *Ability to design, implement and evaluate* software systems in terms of *practicality, experience, affection, meaning and value* that they may have on the target audience. Characteristics such as *ease of use, usefulness and efficiency* are fundamental for the positive evaluation of the user experience of the system.
  A seminar specifically for AI students is being held, about explanations and explainability in complex systems and Artificial Intelligence ystems.

What will I be able to do at the end of the course?

- You will be able to plan the design of the User Experience and Usability of a complex system, including Artificial Intelligence Systems.
- You will be able to identify and characterize users, tasks and contexts of use of such systems, and establish metrics for the evaluation of their *Quality in Use*.
- You will be able to carry out inspection and evaluation tasks of your designs, and verify whether and how much they match the expected target metrics.
- You will be able to plan the design of the explanation part of a complex system, , including Artificial Intelligence Systems, so as to match existing legal, ethical and commercial requirements of such systems.

Blockchain & Cryptocurrencies

- Prof. Stefano Ferretti
  s.ferretti@unibo.it

- I semester
- 6 CFU, 36 hours
- Main objective:
  provide an introduction to the main **technologies** that are currently related to the "**blockchain**" keyword

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Blockchain & Cryptocurrencies

"These circumstances mean that the demand for blockchain developers is high"
statista

merehead, Nov 2021

Blockchain & Cryptocurrencies

- Distributed ledger technologies
  - Bitcoin, Ethereum, IOTA
  - Consensus protocols, crypto hash functions and pointers, Merkle trees, etc
- Decentralized file systems
  - IPFS and related building blocks (DHTs, IPLD, MerkleDAGs, …)
- Smart contracts
  - Solidity
- Cryptocurrencies, fintech and other applications
  - Tokens, stablecoins, NFTs, liquidity pools

What will I be able to do at the end of the course?

At the end of the course

- The student knows the relevant themes related to blockchain technologies, cryptocurrencies, smart contracts and novel applications that can be built over the blockchain

- The student is able to develop simple smart contracts that can be deployed on a blockchain

Exam

- Seminar + Project
  - to be decided in agreement with the teacher
  - alone or in group
  - several proposals related to AI
    - (not only crypto prediction ...)

Project Examples

- Personal Data Management in Decentralized Systems
- Complex Queries Over DLT/DFS
- Anti-Money Laundering and Machine Learning Forensics
- Applications of NFTs
- DLTs as Complex Networks
- Security Analysis of DLTs through Simulation and Analysis
- Mobility Open Blockchain Initiative - MOBI
- DLTs for traceability
- etc.

Autonomous and Adaptive Systems

- **Professor**: Mirco Musolesi
- **Period:** February-June 2022
- **Learning objectives:** The goal of this module is to provide a solid introduction to the design of autonomous and adaptive systems from a theoretical and practical point of view. Topics will include:
  - design principles of adaptive and autonomous systems and intelligent machines;
  - Reinforcement Learning, including Deep Reinforcement Learning and Multi-Agent Reinforcement Learning
  - game-theoretic approaches to cooperation and coordination in multi-agent systems;
  - bio-inspired learning systems;
  - generative learning, artificial intelligence and creativity;
  - ethical implications of AI/autonomous systems.

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What will I be able to do at the end of the course?

- You will master the theoretical principles at the basis of the design of Autonomous and Adaptive Systems, with a focus on Reinforcement Learning (RL).
- You will be able to design and implement state-of-the-art RL algorithms for a variety of practical application scenarios: examples include the implementation of a Deep Reinforcement Learning agent that is able to play a videogame or a board game like Chess and Go or a simulation of agent societies using Multi-agent Reinforcement Learning.
- You will be able to understand the game-theoretic mechanisms at the basis of human, artificial and hybrid societies, including phenomena like the emergence of cooperation.
- You will be able to read and understand the scientific literature in this field through the discussion of recent key papers in the area.
- You will be able to use TensorFlow/Pytorch (or other similar frameworks) for implementing any (Deep) Reinforcement Learning algorithms from scratch.

Social Network Analysis

- **Professor:** Saverio Giallorenzo
- **Course website** https://saveriogiallorenzo.com/teaching/#na
- **Period** Sep. 23rd, 2021 to Oct. 29th, 2021
- **Description**

  The objective of the course is to equip students with a working knowledge on both a) the field of **Network Analysis**, its principles, practice, and usages (e.g., in computer science, forensics, archeology, literature, history, science of religion, etc.), and b) **Network Analysis Research Design**, focussed on the scientific process and the elements of a network analysis investigation.

- The course will provide students with the knowledge necessary to conduct the project exam: define, structure, and pursue their own network analysis research, on a topic of their choice — agreed with the teacher.

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- **What will I be able to do at the end of the course?**

- **Recognise** networks and network data;
- **Collect** and **manage** network data, from both a technical and technological standpoints (data formats, algorithms, and software for network data management);
- **Investigate** network data by following the principles behind known measures and metrics for networks and by using those in practice through software that automates their application;
- **Organise** network studies following the principles of the scientific method.

Complex Systems and Network Science

Ozalp Babaoglu

What is this course about?

- Study of Complex systems tries to answer a set of questions about the way natural, artificial and technological systems work
- It's an interdisciplinary study whose core disciplines include (among others)
  - Mathematics
  - Physics
  - Computer science
  - Biology
  - Sociology
- Uses Computational modelling as a core methodology

Questions of complexity

- Why did the Dow Jones stock index drop 1,175 points on Monday, February 5th 2018?
- Why did the forty-year hegemony of the Soviet Union over Eastern Europe collapse within a few months in 1989?
- How did the first living cell emerge from a primordial soup of amino acids and other simple molecules four billion years ago?
- How can one explain the behavior of organized groups of persons such as labor unions or a racial minorities?
- Why do rural families in countries such as Bangladesh still produce an average of 7 children a piece even when birth control is freely available?

Common properties

- Simple components — agents, actors
- Decentralized control — no distinguished "master"
- Nonlinear interactions — components act autonomously but interact with other components directly or indirectly
- Emergent behavior — the global system exhibits properties that cannot be derived or predicted from understanding behaviors of individual components

Emergent Behavior

- When considered in isolation, ants and termites exhibit extremely primitive behavior lacking any hint of intelligence or purpose

- Yet, considered in large numbers, they are capable of accomplishing remarkable tasks without any central control such as foraging looking for food or building bridges

- Starling murmurations

Networks and network science

- Interactions among agents is central to complex systems
- Networks allow us to model these interactions
- Networks play a fundamental role in the transmission of information, transportation of goods, spread of diseases, diffusion of innovation, formation of opinions, adoption of new technologies
- Understanding the structure and dynamics of these networks is essential for understanding why certain technologies dominate their competitors, or why a certain video goes viral while others don't

Course objective

- At the end of the course, you will be able to identify complex systems encountered in the wild and be able to classify them
- You will be able to build computational models of complex systems to study their behavior
- You will be able to build dynamical networks that grow to exhibit desired properties

93467 – CRYPTOGRAPHY (6 cfu)

Ugo Dal Lago, email: ugo.dallago@unibo.it
https://www.unibo.it/sitoweb/ugo.dallago/en

Period: First Semester (Sep 2022 – Dec2022)

93467 – CRYPTOGRAPHY

- *Main objective*: give a clear and accurate account on security, for the sake of providing students with the tools to *assess* (and not just to *use*) cryptographic techniques. The question which will accompany us throughouth the course is the following: *when* and *why* can a cryptographic primitive or protocol be considered secure?
- **Private key Cryptography and Pseudorandomness**.
  - Pseudorandom generators and security against passive adversaries, pseudorandom functions and active adversaries, DES, AES, and block ciphers. MACs.
- **Number-Theoretic and Algebraic Assumptions**.
  - The factoring and RSA assumptions, group theory, the Diffie-Hellman assumptions.
- **Public-key Cryptography.**
  - Security of public-key encryption, digital signatures, the El-Gamal and RSA encryption schemes.
- **The Symbolic Model.**
  - The Dolev-Yao model. The ProVerif tool.

What Will I Be Able to Do at the End of the Course?

- To have a deep understanding of the mathematical and theoretical bases of cryptography.
- To be able to assess whether a new protocol or primitive, even different from existing ones, can be considered secure.
- To know the basis of automatic protocol verification through symbolic tools like `ProVerif` or `EasyCrypt`.
- **Final Exam**: Homework and brief oral exam.
- **Internships**: we have contacts with the Max-Planck Institute on Security and Privacy (Bochum, Germany) and with Accenture (Milan, Italy).

Expert Systems

Mauro Gaspari

March-June

It is an application oriented course focused on the use of AI technologies for solving multidisciplinary applications.

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What will I be able to do at the end of the course?

Approaching complex multidisciplinary applications.
Knowledge acquisition techniques.
Knowledge modelling as a tool for multidisciplinary research.
Exploiting hybrid AI technologies for building expert systems.

Case studies.

Exam → project discussion.

Computational Ethics

- Professor: Daniela Tafani
- Period: 2nd semester (32 hours)
- Main objective: provide an introduction to ethical and metaethical issues related to the translation of ethics into computational terms.

Before asking how to put ethics (or values) in a machine or how to remove biases from a machine learning system, we need to ask what ethics is - what we are doing when we say that something is right or wrong - and whether we can characterize human moral judgment in computational terms.

What will I be able to do at the end of the course?

- You will be familiar with the main meta-ethical issues, normative ethical models, and theoretical contributions of cognitive science related to the translatability of moral judgments into computational terms.
- You will be able to reason critically about theoretical proposals related to algorithmic fairness and AI ethics.
- You will be able to avoid magical thinking and some other common mistakes.

You will be able to avoid mistakes about ethical questions

moralmachine.net

MORAL MACHINE

Home Judge Classic Design Browse About Feedback En

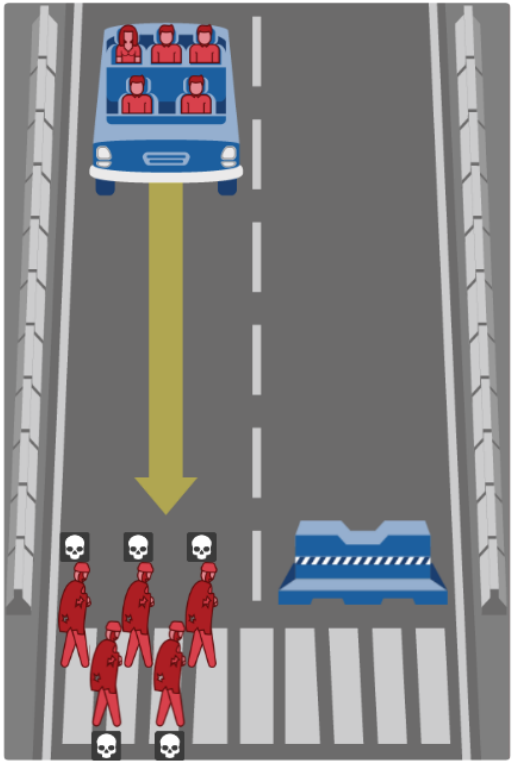
What should the self-driving car do?

1 / 13

In this case, the self-driving car with sudden brake failure will continue ahead and drive through a pedestrian crossing ahead. This will result in ...

Dead:

- 5 homeless people



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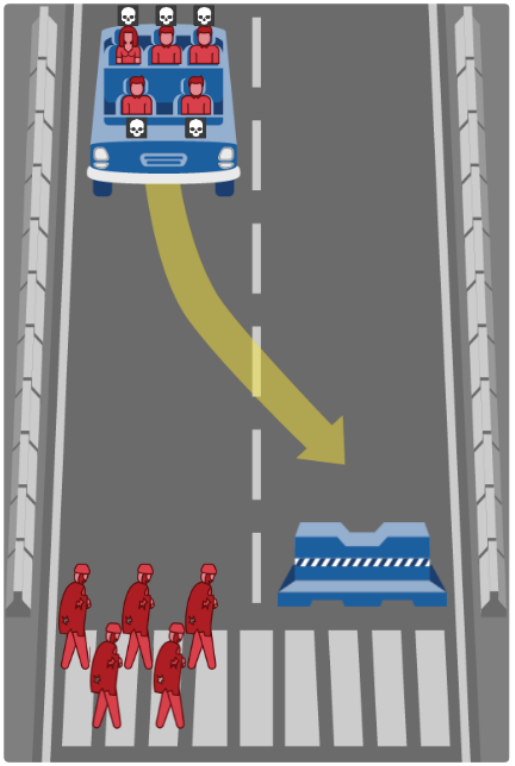

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In this case, the self-driving car with sudden brake failure will swerve and crash into a concrete barrier. This will result in ...

Dead:

- 4 men
- 1 woman

https://www.moralmachine.net/

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You will be able to avoid mistakes about the kind of answer a machine learning system is going to give you

Delphi says:

"should i commit genocide if it makes everybody happy"
- ***you should***

Delphi speculates:

Delphi's responses are automatically extrapolated from a survey of US crowd workers and may contain inappropriate or offensive results.

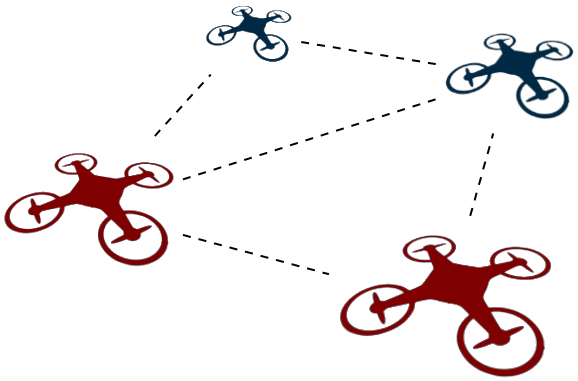
"a woman who drives the car without apologizing"
- ***It's rude***

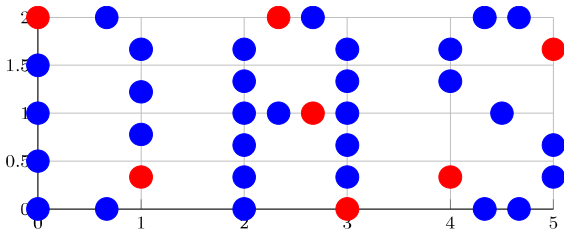
v1.0.4

https://delphi.allenai.org/

Distributed Autonomous Systems

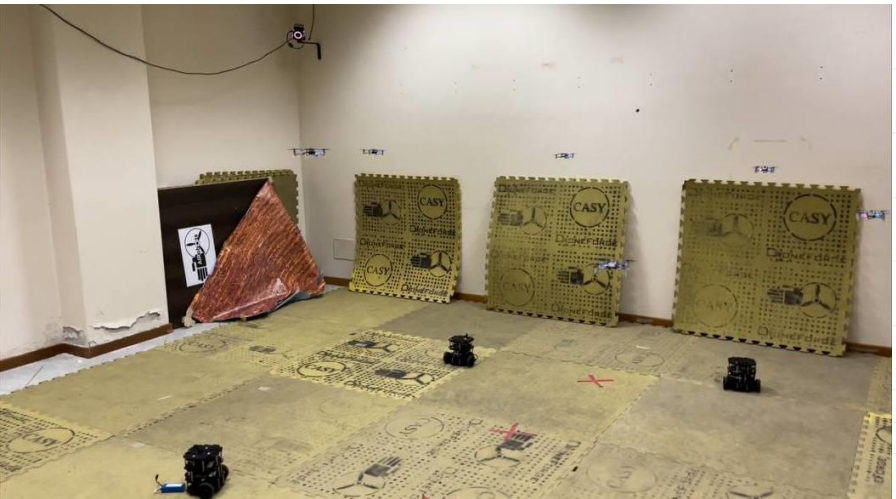
- **Professors:** Giuseppe Notarstefano and Ivano Notarnicola
- **Period:** second cycle
- **Course Objective:** modeling of a multi-agent system and implementation of distributed algorithms over networks to solve relevant application problems arising in cyber-physical learning systems, cooperative robotics and autonomous vehicles
- **Teaching Methodology:** the course provides a portfolio of the state-of-art algorithms along with their software implementation
- **Exam:** group-based project on one of the presented methodologies

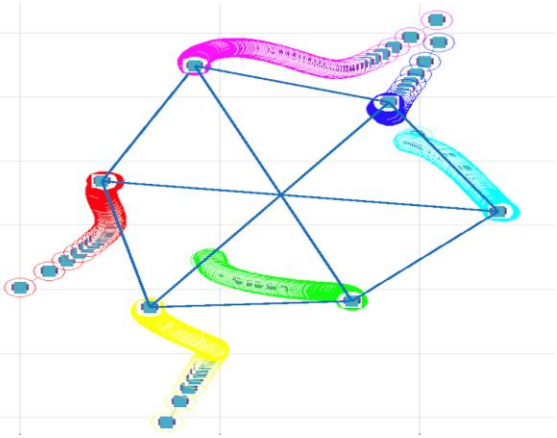


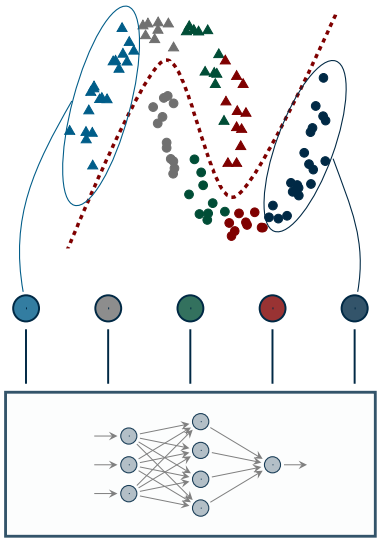


What will I be able to do at the end of the course?

- Model a distributed multi-agent system and implement the linear averaging to solve the **consensus** problem
- Model distributed control laws for robotics **formation control**
- Implement **federated** and **distributed learning** algorithms for AI
- Coding in **Python** and in **ROS2** (Robotic Operating System) of the developed algorithms







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Cybersecurity

- **Professor**: Michele Colajanni
- **Period**: First semester
- **Language**: English
- **Main objective**

  In a digital world, every activity is vulnerable to cyber attacks. At the end of the course the students can know and evaluate the most dangerous cyber threats to the society and to specific organizations and industries. Moreover, they are expected to be able to design, build and manage secure systems and applications by adopting modern preventive and defensive methodologies, strategies and technologies. Modern applications of AI to cybersecurity will be also covered.

- **Prerequisites**
  - Fundamental courses characterizing a Bachelor in Computer Science or Computer Engineering: systems, networking, software
  - Some knowledge about traditional approaches to information security (authentication mechanisms, secure protocols, firewalls) may help

Multimedia Data Management - 6 cfu

- **Ilaria Bartolini**
  Department of Computer Science and Engineering
  Multimedia Database Group
  Alma Mater Studiorum, Università di Bologna

  http://www-db.disi.unibo.it/~ibartolini/

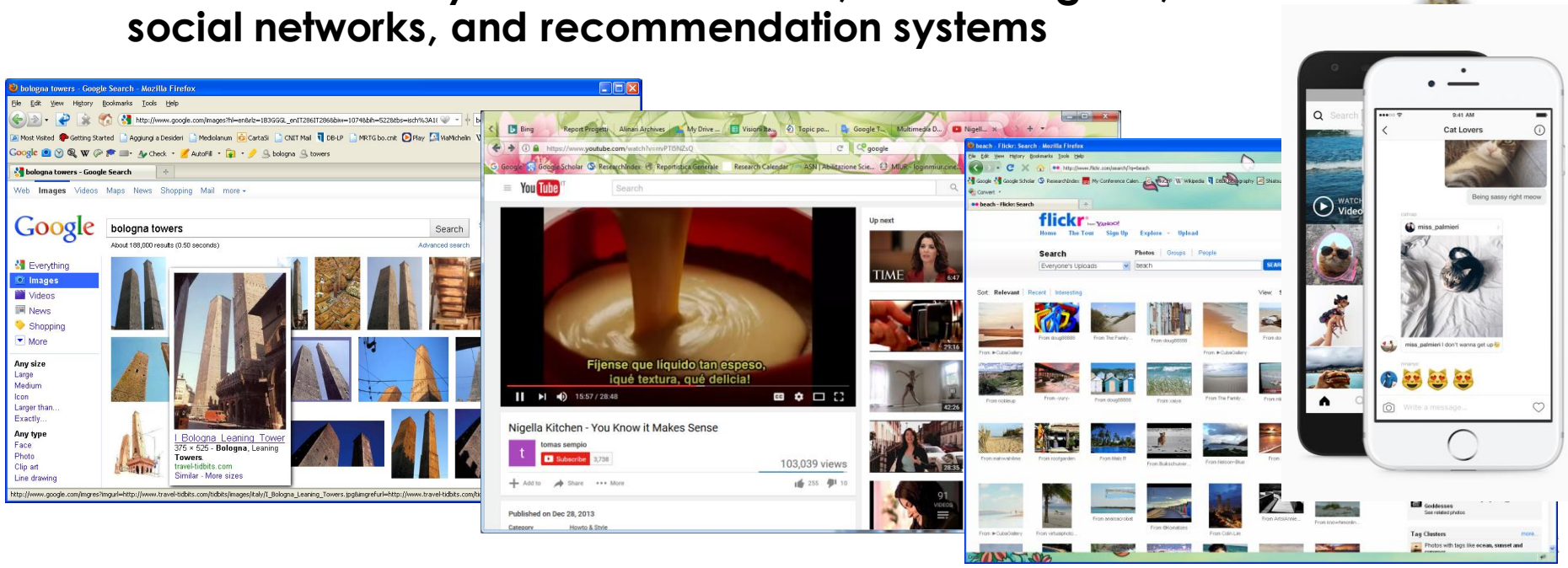
- **Period II**: February - June 2023

- **Main objective**:
  Facilitate and improve the "access" to very large unconventional data (**Big Data**), notably **multimedia (MM) data** (e.g., **textual documents, image/video/audio collections, etc.**) for general, non-expert users

+ Project Work in Multimedia Data Management - 3 cfu

What will I be able to do at the end of the course?

- The student will have the knowledge and skills required for an **effective and efficient management of MM data**, with particular attention to the problems of:
  - **MM data representation**
  - **MM data retrieval models**
  - **Interaction paradigms between the user and the MM system**, both for purposes of data presentation and exploration
- The student understands the **architecture of traditional and advanced MM systems and services, search engines, social networks, and recommendation systems**



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Thank you!

Questions?