



Artificial  
Intelligence  
and  
Intelligent  
Systems

**ini** National Lab

**Francesca Scozzari**

Referente nodo CINI AIIS Chieti-Pescara

# University of Chieti-Pescara - Node composition

Ud'A

The AIIS (Artificial Intelligence and Intelligent Systems) node of the University "G. d'Annunzio" of Chieti-Pescara (Ud'A)

- **Gianluca Amato**
- **Alessia Amelio**
- **Luciano Caroprese**
- **Piero Chiacchiaretta**
- **Fabio Fioravanti**
- **Luigi Ippoliti**

- **Maria Chiara Meo**
- **Gianpiero Monaco**
- **Christian Morbidoni**
- **Luca Moscardelli**
- **Maurizio Parton**
- **Francesca Scozzari**

# Automated Reasoning and Trustworthy AI

**Gianluca Amato – Fabio Fioravanti – Maria Chiara Meo – Francesca Scozzari**

- Automated reasoning for AI systems
- Formal methods
- Verification of software and smart contracts
- Argumentation frameworks for AI explainability

# Machine Learning and Intelligent Systems

**Alessia Amelio – Luciano Caroprese – Christian Morbidoni – Maurizio Parton –  
Gianluca Amato – Francesca Scozzari**

- Machine Learning and Deep Learning
- Reinforcement Learning
- Explainable AI
- Pattern recognition and information retrieval
- AI applications in social media, cultural heritage, and bio-signal analysis

# Multi-Agent AI and Algorithmic game theory

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## **Gianpiero Monaco – Luca Moscardelli**

- Multi-agent systems
- Algorithmic game theory
- Optimization in social and communication networks

# AI for Sustainability, Climate, and Health

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## **Piero Chiacchiaretta – Luigi Ippoliti**

- AI models for climate impact on human health
- Sustainable and data-driven policy support
- Spatial and spatio-temporal statistical learning
- Integration of statistical and machine learning techniques

# Research Topics and Activities

## Coalition Formation Games

- Teamwork and coalition formation
- In many situations, individuals carry out activities in groups rather than by themselves
  - it is of crucial importance to consider the satisfaction of the members of the groups
- In environmental sustainability, teamwork among different stakeholders (individuals, communities, businesses, and governments) is essential for achieving common goals
  - reducing pollution and carbon emissions
  - addressing environmental and climate issues
  - managing natural resources sustainably

## A Concurrent Language for Interacting Argumentative Agents

- Modelling the behaviour of concurrent agents that interact and reason in a dynamic environment is a difficult task
  - requires tools that can effectively capture different types of interactions, such as persuasion and deliberation, while helping agents make decisions or reach agreements
- Argumentation theory provides formal frameworks for representing and evaluating interacting arguments
  - define a language for modeling the interaction of concurrent and argumentative agents in a distributed system
  - allow the representation of different types of dialogues
  - describe the reasoning process employed by agents

# Research Topics and Activities

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## Automated Reasoning for Verification

- Verification problems for programs written in different programming languages, business processes, networks, and in general software systems
  - modeled as satisfiability problems for Constrained Horn Clauses (CHC).
- develop methodologies for transforming CHCs and verifying their satisfiability, with applications in:
  - verification of reachability properties for imperative programs manipulating arrays and Algebraic Data Types (e.g. lists and trees)
  - verification of relational properties among programs (e.g. equivalence, functionality, injectivity, monotonicity, non-interference)
  - verification of reachability and controllability properties of business processes defined using BPMN with time extensions.

## Machine Learning to Forecast Particulate Matter and Trace Gas Emissions for Air Quality Assessment

- Use of particulate matter (PM) data to evaluate air quality
  - in particular PM10 and PM2.5 concentrations
  - employ machine learning techniques to analyze and interpret continuous data from regional air quality monitoring stations
- the integration of meteorological parameters into the machine learning models enhances the accuracy of predictions about air quality variations under specific environmental conditions
  - ability of AI to provide deeper insights into environmental health impacts

# Research Topics and Activities

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## Machine Learning Models for Ecological Footprint Prediction

- Comprehend the effects of human activity on the ecosystem
  - studies predictive models for ecological footprint, measuring the speed in consuming resources and generating waste compared to the speed of nature in absorbing human's waste and generating resources
  - artificial neural network, random forest and K-nearest neighbor regression have been constructed and evaluated for predicting the total ecological footprint of consumption from multiple energy inputs and population number
  - time series vector autoregression prediction models of the ecological footprint based on energy parameters have been generated

# Research Topics and Activities

## Social Sustainability and LLMs

- Creating and supporting digital environments that are safe and supportive for all individuals
- Combating online misogyny aligns with Sustainable Development Goal 5
  - Generative Pretrained Language Models have raised important questions about their safety and fairness
    - explore their use to enforce online safety
    - generative LLMs are flexible tools to implement data analysis automation task, including hate speech detection and stance/polarity estimation
- Collaboration in the RightNets PRIN project, led by University of Macerata and University of Sapienza
  - enhancing Social Media monitoring dashboards with AI tools in order to more effectively monitor political and electoral debate on social media

## Machine Learning Models for Classification of Energy Consumption

- Total energy consumption can be heavily conditioned by global demographic and economic changes
  - prediction models of energy consumption
  - demographic and economic features have been considered as predictor variables for energy consumption
- categorize energy consumption levels from demographic and economic features
  - multiclass ensembles of support vector machines and linear discriminant analysis have been adopted
  - multiple linear regression and multilayer perceptron were applied to forecast energy usage

# Research Topics and Activities

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## Forecasting Models for Climate Variables and Renewable Energy

- Accurately estimating energy production from renewable energy sources is crucial for ensuring a reliable and consistent supply, aiding in the planning and managing of the power grid
  - Predicting their power generation is notably challenging due to their dynamic behaviour, influenced by factors like time, weather parameters and location and limited availability of local real-time data, particularly for short-term forecasts
- the use of forecasting models is essential to achieve this goal
- deep learning model to forecasts essential weather variables that influence solar power potential:
  - Global Horizontal Irradiance (GHI)
  - temperature
  - atmospheric pressure
  - and relative humidity
- calculating the electrical energy production of a photovoltaic cell

# Research Topics and Activities

## Energy-Efficient Deep Learning

- Deep learning models require significant computational resources which translate into high energy consumption
- substantial environmental impact due to the carbon footprint associated with energy production
- GloNet: an efficient network architecture that can self-regulate its depth, and thus its computational needs, according to the specific requirements of the task
  - enhances both sustainability and efficiency by reducing energy consumption and minimizing environmental impact

# Research Topics and Activities

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## Health Sustainability

- analyze the Long COVID syndrome, from clinical presentation through diagnosis
- multi-omics approach integrating MRI-based radiomics and metabolomics in rectal cancer treatment predicts patient responses, potentially reducing unnecessary surgeries
  - novel machine learning model using pre-treatment MRI in locally advanced rectal cancer optimizes neoadjuvant treatments for better organ preservation
  - radiomics-based model distinguishes COVID-19 from other acute lung diseases using HRCT, aiding early and accurate management decisions
- Improve personalized medicine by enhancing predictive accuracy and treatment sustainability.

## Statistical Learning and deep models in Machine Learning

- Integrating deep neural network and classical statistical modelling approaches (e.g. Gaussian processes) to model spatio-temporal data
  - Multi-levels and nested Gaussian processes and Gaussian Markov random fields are considered to develop deep kriging and deep GMRF models for general (e.g., nonstationary, non Gaussian) spatial processes
- deep models as powerful prediction tools for a wide range of applications
  - measurement of the effect of multiple pollutants on multiple health outcomes and the associated problem of spatial confounding

# Projects having AI as central topic

**“Future Artificial Intelligence – FAIR” project - funded by PNRR Mission 4, line 1.3, European Union – NEXTGENERATIONEU, PE0000013, Spoke 9, CUP D23C24000210006**

- ▣ **Existence, Complexity and efficiency of stable solutions in green-Oriented GAMES (ECOGAMES)** The project aims at bridging the fields of game theory and environmental sustainability with a specific focus on integrating energy-efficiency in systems formed by selfish agents.
- ▣ **Smart Knowledge: Enhancing Argumentation and Abstraction for Explanation and Analysis (SMARTK)** The project aims at advancing the fields of argumentation, abstraction, and automated reasoning in knowledge representation.

# Projects having AI as central topic

## Funded by INdAM-GNCS

- ▣ **Social Interaction with Argumentation (ASIA)** The ASIA project proposes a novel combination of methodologies, techniques, and tools for argumentation analysis, machine learning, and social network analysis.
- ▣ **Modeling and Formal Verification of Dialog Systems** The project aims to explore existing literature and improve upon the methods for validating abstract argumentation frameworks that have been previously suggested, while also potentially introducing new approaches.
- ▣ **Formal Verification of Debates in Argumentation Theory** The aim of the project is to extend formal debate verification approaches in argumentation theory using new abstraction and probability-based interpretations.

# Projects having AI as central topic

## Funded by PRIN - PNRR Mission 4 - Component C2, Investment 1.1

- ❑ **Multi-objective Optimization of Digitally Manufactured Earth Building Components supported by Neural Networks (MUD-MADE)**
  - ❑ A novel AI-supported workflow for designing raw earth building components produced with digital manufacturing technology (i.e. 3D printing, Robotic arm or Laser cutter).
- ❑ **Fracture Risk evaluation in bone metastatic patients by Artificial Intelligence (FRAIL)**
  - ❑ Investigates whether AI can produce a reliable and explainable decision support system that can assist physicians in complex care decisions regarding patients affected by bone metastases.
- ❑ **Stochastic ModeLling of Compound Events (SLIDE)**
  - ❑ Innovative solutions for understanding Compound Events, quantifying their likelihood, and predicting their potential impact.
  - ❑ SLIDE adopts a comprehensive approach that exploits complex spatio-temporal data to produce statistical and ML/AI models and data-analytic methodologies.
  - ❑ one major application in the flood risk management about ground movement threshold maps for the landslide initiation.