GRAN SASSO SCIENCE INSTITUTE

descrizione delle attività del nodo

Artificial Intelligence and Intelligent Systems

cini National Lab

HUB ABRUZZO MARCHE UMBRIA

www.gssi.it

AI is the result of the continuous progress of computational sciences, including mathematics, logic, algorithms, software engineering, etc.

The GSSI has particular expertise in

- algorithms,
- formal methods,
- and software engineering.

AI is a transversal expertise.

GRAN SASSO SCIENCE INSTITUTE

CS

Algorithms

Computational problems arising in networks and multi-agent systems

Software engineering

Engineering complex and heterogeneous systems

Research for and with AI

Artificial Intelligence

Applications

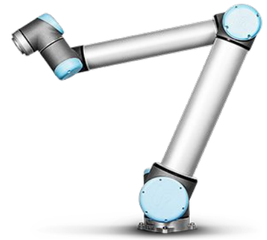
Formal methods

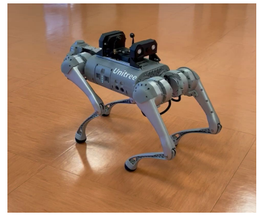
Verification and validation of complex reactive systems

Hot topics

- Quantum
- Space
- AI

Resources





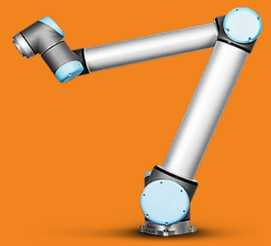
CS Group

- 7 full professors
- 6 associate professors
- 3 RTDb OR RTT (tenure track)
- 4 RTDa (temporary)
- 1 research engineer
- 19 postdocs (two of them contratto di ricerca)
- 3 adjunct professors

…and 55 PhD students

[18 (2025), 11 (2024), 11 (2023), 9 (2022), 6 (2021)]

CS Group



- Robots
  PAL Robotics’ ARI
  PAL Robotics’ TIAGo
  TurtleBot4
  Robotic arms
  Unitree GO1
- Compute
  …
- IOT
  Weather stations
  …

Research Topics and Applications

Engineering complex and heterogeneous systems

- We investigate challenges posed in the **engineering of complex and heterogeneous systems**, which **may involve AI components**, collaborate with each other, interact with humans, and operate in partially controllable and known environments.

- Some research highlights:
  - Democratization of programming and use (accessibility) of systems: we contributed mission specification patterns for service robots [TSE2023, TSE2021], domain specific languages (DLSs) for mission specification, DREAM project to facilitate the assembly of satellites in a smart factory, low-code development for smart systems.
  - Ethical-aware systems: roadmap on how to engineer digital systems for humanity [TOSEM2025] specification of ethical properties, SLEEC rules [AAAI2024, TACAS 2026, AAMAS 2026] (also in collaboration with NASA - Fret tool), reference architecture for ethical-aware systems [JSS2026], definition of ethical labels [JSS2026], evaluation framework for human augmentation or replacement by autonomous systems [AI&SOCIETY2025], model of soft ethics [AI&SOCIETY2026].
  - Modeling foundations and application of intelligent systems: foundational aspects of modeling smart and intelligent systems in the context of smart city [SOSYM2025], (urban) digital twins of cultural heritage sites, recommender systems for domain-independent systems [CAISE2025].

Verification and validation of complex reactive systems

- We investigate **formal specification, analysis, synthesis, verification and validation of concurrent and distributed systems**. This is performed at different levels of abstractions that span from languages to semantic and quantitative models, along with several analysis techniques, such as software verification.

- Some research highlights:
  - Software aging: a deep learning architecture based on code property graphs and abstract syntax trees to identify complex resource management bugs in systems software (e.g., OS, DBMS) [IEEE Transactions on Software Engineering (TSE25)]
  - Data race detection: a static analysis technique for accurate detection of data races (aka common weakness CWE-366) in multi-threaded C programs
  - Eventual Consensus: an approach based on behavioural types and choreographies to guaranteeing eventual consensus in swarm systems inspired by an industrial platform for control in industrial plants based on Typescript (ECOOP23 and a submission under review at ECOOP26)
  - Field-based testing: new methods for testing systems that evolve over-time (Body Sensor Networks - BSNs) [JSS2025] and we defined the new concept of self-adaptive testing in the field [ACM TAAS]
  - Software quality assurance: a novel autoscaling solution for dynamic workloads [TSC24], patterns of applied control for public health measures [SEAMS24], data-driven understanding of design decisions [ECSA25], performance-based analysis of federated learning systems [JSS26]

Computational problems arising in networks and multi-agent systems

We study algorithms on networks that are characterized by a **large number of distributed or autonomous entities,** and may have **temporally changing dynamic properties**.

- Some research highlights:
  - Theory of distributed computing
    - We present a new technique for showing lower bounds in the distributed setting [SODA 2026].
    - We show bounds on quantum advantage in the distributed setting [2 x STOC 2025, SODA 2026]
  - Green aware AI in autonomous systems
    - Effect on the global pollution of fair allocation of jobs to industries [AAAI 2025]
    - Overall power consumption induced by agents equally sharing resources consumption in multiprocessor systems and communication networks. [AAMAS 2024]
  - Network design and optimization problems in static and temporal networks
    - We give new approximation algorithms and hardness of approximation bounds for scheduling the availability times of the edges needed to connect a temporal graph [AAAI 2025]
    - We give new approximation algorithms for computing the maximum coverage of a set system under connectivity constraints [AAMAS 2025]

Artificial Intelligence

- We investigate intelligent agents and multi-agent systems, their algorithmic and formal aspects, as well as their integration in human-centric systems.

- Some research highlights:
  - Influence and information diffusion [2xIJCAI2019, AAAI2020, 2xAAAI2021, TKDD2021, JAIR 2022, AIJ 2023, 2xAAAI 2023]
  - Fair division [GEB 2022, AAMAS 2024, AAAI 2025]
  - Coalition formation [SOFSEM 2021, IJCAI 2021, JAIR 2021 (2), IJCAI 2022, AIJ 2022 (2), SOFSEM 2024, AAMAS 2024, JAIR 2024, AAMAS 2025] and Machine learning in coalition formation [NeurIPS 2023, AAAI 2023]
  - Pricing in markets [AIJ 2021, JAIR 2022]
  - Expressivity and complexity of Graph Neural Networks [IJCAI 2024, IJCAI 2025]
  - AI for humanity: roadmap [TOSEM2025], normative rules [AAAI 2024], ethic-based negotiation [JSS2025], augmentation vs replacement [AI & Society], soft ethics [AI & Society]

Application fields

Our research spans the spectrum from theoretical developments to practical applications with impact on various domains, including space, automotive, robotics, Cyber-Physical Systems (CPS), Internet of Things (IoT), and smart cities.

- We have an active collaboration with various companies, including Thales Alenia Space, Sanofi, IZS, Egicon, Imola Informatica, Leonardo, Telespazio, NASA, etc.
- We have active collaborations with Gran Sasso Tech - https://www.gransassotech.org/, and we are members of the Distretto aerospaziale Abruzzese - https://www.distrettoaerospazialeabruzzo.it/
- We have various collaborations with small and medium enterprises (we offer assessment and test-before-invest services) in the context of the Digital Innovation Hub Edhiamo: https://www.edihamo.eu/

Hot Topics

Research on hot topics: **Quantum**

- Do we get any advantage from quantum communication in distributed networks?
  - We investigated this question and formally proved that, in some cases, quantum advantage is possible, while in some other cases, quantum communication cannot help in solving problems faster.
  - Our research efforts culminated in four published works in top venues of theoretical computer science: one at SODA ‘26, two at STOC ‘25, and one at DISC ‘25.

- Quantum Machine Learning for Time Series Anomaly Detection (Mitacs Globalink Research Award (GRA))
  - This project explores the potential of quantum machine learning (QML) algorithms for Time Series anomaly Detection (TAD), a crucial task in areas such as healthcare, finance, and cloud systems.
  - Idea: explore QML-based algorithms to develop more accurate and efficient solutions for detecting unusual patterns in time series data from complex systems.
  - Collaboration between GSSI and Toronto Metropolitan University in Canada

Research on hot topics: **Space**

- New architectural solutions to promote isolation, use of DevSecOps, AI onboard
- Continuous Integration and Deployment (CI/CD) and system evolution
  - Evaluation of impact of changes: Automatic detection of functions that need to be retested when code changes
- Digital twin for optimizing job scheduling in satellite operations, combining model-based artifacts and a data-driven approach
  - Modeling of tasks, optimizer, anomaly detection for analyzing telemetries
- Trustworthiness
  - AI for safety-critical functions: Experimenting Kolmogorov–Arnold Networks (KANs) for critical operations (safety bounds and transparency required in certification processes) [ICSE-SEIP 2026]
  - Guidelines for the certification of AI components to be used onboard

ASTRA ADVANCED SPACE TECHNOLOGIES AND RESEARCH ALLIANCE

Astra project with Thales Alenia Space, Opening collaboration with Telespazio, Preparing applications for ESA calls

SR SPACERAISE

SPACERAISE International school

SPACERAISE, THE INTERNATIONAL SUMMER SCHOOL FOR SPACE STUDIES AND INTERDISCIPLINARY APPLICATIONS

L'AQUILA, ITALY 04-22 MAY 2026

Week #1

4 → 8 May 2026

Robotics for Space

Week #2

11 → 15 May 2026

Artificial Intelligence for Space

Week #3

18 → 22 May 2026

Geospatial Data and Quantitative Analysis in Social Science

Research on hot topics: **Artificial Intelligence**

- Neural networks models and machine learning
  - Exploring connections between neuroscience, artificial neural network evolution, antibody design
  - Logical analysis of neural networks; expressivity, complexity, reasoning, verification
  - Learning of preferences and stable solutions in autonomous systems
- Ethical issues of AI
  - Conceptual study of trust and trustworthiness
  - Formal specification, analysis, and monitoring of ethical requirements of AI systems
  - Engineering of ethical-aware systems
  - Ethic-based negotiation
- Collective solutions emerging from individual choices in multi-agent systems
- Anomaly detection solutions (Anomalies in pills production with Sanofi, Anomalies in Large-Scale Cloud Systems - IBM log data, data cleaning and anomalies in Ocean data, Safe Satellite telemetries with Thales Alenia Space [ICSE26])

Workshop on

Logical Methods for Neural Network Analysis

Lisbon, July 25, 2026

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