CoDaS
M.Sc. on Communications Engineering and Data Science: Summer School 2025

2025 July 21st - 25th

INESC INOV-Lab / Técnico Lisboa, Lisbon, Portugal

Scope

The CoDaS Summer School 2025 features a program of lectures delivered by experts in the area of communications engineering and data science, from both academia and industry. The objective is to give students an opportunity to catch up on the "hottest topics" related to the technical area of the CoDaS M.Sc. programme. Attendees will have an opportunity to participate in stimulating discussions with lecturers, obtain useful feedback and initiate new collaborations. Lectures will provide the background on advanced wireless communications concepts as well as on machine learning and related approaches to data processing, including 6G.

Targeted Audience

The School is aimed at CoDaS students, but it is open to other students as well, including Ph.D. ones.

Dates

The School will take place from Monday, July 21st to Friday, July 25th, 2025.

General Programme and Speakers

The programme is composed of the following lectures and lecturers (a detailed description is provided at the end of this document):

- António Grilo (Técnico Lisboa / University of Lisbon, PT): "*"These data are all you have": some practical use cases of mobile operator datasets*"
- Carlos Ruiz de Mendoza (U.P.C., ES), "*Deep Reinforcement Learning for Connected Autonomous Vehicles in 6G Vehicular Edge Computing Networks*"
- Dani Korpi (Nokia Bell Labs, FI), "*AI-Native Air Interface: A Paradigm Shift in 6G?*"
- Luis M. Correia (Técnico Lisboa / University of Lisbon, PT), "*Perspectives into the Evolution of Personal Applications in 6G Networks*"
- Maximilian Schäfer (Friedrich-Alexander University of Erlangen-Nuremberg, DE), "*Synthetic Molecular Communication: Introduction, Theoretical Foundations, and Experimental Verification*"
- Ricardo Dinis (NOS, PT), "*NOS' 5G Hub*"
- Sílvia Ruiz (U.P.C., ES), "*Drones & B5G: the Next Era of Aerial Connectivity*"

- Stephan Sigg (Aalto University, FI), "*Ambient Intelligence*"
- Tim Kacprowski (Technische Universität Braunschweig, DE), "*How and Why Can ML/AI Benefit from Molecular Networks in the Biomedical Field*"

The programme also includes a panel

- "Team Building": an activity to be held at the start of the School, so that participants get to know each other better,
- "Dialogue with the Speakers": panel moderated by Luis M. Correia, where, in a very informal environment, technical themes will be discussed with the speakers, aiming at getting views and visions in the area of the school,
- "NOS' 5G Hub": visit to NOS' 5G lab (NOS is a Portuguese telecom operator), hosted by Ricardo Dinis.

General Schedule

The overall schedule is given below:

	Monday July 21	Tuesday July 22	Wednesday July 23	Thursday July 24	Friday July 25
09:00	Opening & Team Building	Lecture 2	Lecture 4	Lecture 5	Lecture 7
09:30					
10:00					
10:30	Coffee Break	Coffee Break	Coffee Break	Coffee Break	Coffee Break
11:00	Team Building	Lecture 2	Lecture 4	Lecture 5	Lecture 7
11:30					
12:00					
12:30	Lunch Break	Lunch Break	Lunch Break	Lunch Break	Lunch Break
13:00					
13:30					
14:00	Lecture 1	Lecture 3	Panel	Lecture 6	Lecture 8
14:30					
15:00					
15:30	Coffee Break	Coffee Break	Coffee Break	Coffee Break	Coffee Break
16:00	Lecture 1	Lecture 3	Visit to Industrial Lab	Lecture 6	Lecture 8, Closure
16:30					
17:00					

Detailed Schedule

The detailed schedule will be as follows:

- Mon., July 21st
  - AM:
    - Luis M. Correia*: Opening and Team Building*
  - PM
    - Dani Korpi: "*AI-Native Air Interface: A Paradigm Shift in 6G?*"
- Tue., July 22nd
  - AM:

        - António Grilo: "*"These data are all you have": some practical use cases of mobile operator datasets*"
    - PM
        - Sílvia Ruiz, Antoni Gelabert-Fons, Mario Garcia-Lozano: "*Drones & B5G: the Next Era of Aerial Connectivity*"
- Wed., July 23rd
    - AM:
        - Maximilian Schäfer: "*Synthetic Molecular Communication: Introduction, Theoretical Foundations, and Experimental Verification*"
    - PM
        - Luis M. Correia*: Panel*
        - Ricardo Dinis: "*NOS' 5G Hub*"
- Thu., July 24th
    - AM:
        - Carlos Ruiz de Mendoza: "*Deep Reinforcement Learning for Connected Autonomous Vehicles in 6G Vehicular Edge Computing Networks*"
    - PM
        - Luis M. Correia*: "Perspectives into the Evolution of Personal Applications in 6G Networks"*
- Fri, July 25th
    - AM:
        - Tim Kacprowski: "*How and Why Can ML/AI Benefit from Molecular Networks in the Biomedical Field*"
    - PM
        - Stephan Sigg: "*Ambient Intelligence"*

Credits

The students wanting to get credits (ECTS) from the School will have to deliver a report (guidelines will be circulated) with the state of the art in one of the topics addressed in the School, to be delivered 2 weeks after the end of the school, which will be evaluated and graded.

The number of credits will be 2 ECTS, for those that are evaluated successfully.

Supporting Texts

Attendees will get an electronic version of all presentations, during the School.

Language

The School will be entirely held in English.

WiFi

INESC INOV-Lab / Técnico Lisboa is part of the EDUROAM network, so colleagues from other European Universities that are part of this network will have direct access to the WiFi network. Still, WiFi access will be available for all participants during the event, instructions for access being given upon arrival.

Location

The School will take place at the Auditorium of INESC INOV-Lab, Técnico Lisboa, Lisbon, Portugal, located at R. Alves Redol 9, 1000-029 Lisbon. An overview of the location can be seen at https://grow.tecnico.ulisboa.pt/local-info/address.

Visa

Portugal is a member of the European Union's Schengen Area (https://www.schengenvisainfo.com/schengen-visa-countries-list).

Attendees requiring a visa should contact the School's organisers (contact below) as soon as possible, for obtaining an Invitation Letter.

Travel

Lisbon Airport, which is located almost inside the city, is 3.5 km North of Técnico Lisboa' campus. You may use either subway, bus or taxi to reach it. Detailed information is available at https://grow.tecnico.ulisboa.pt/local-info/getting-here.

Accommodation

Accommodation for students will be made available at a university's dormitory. Detailed information will be provided upon registration.

Details on nearby hotels can be found at http://grow.tecnico.ulisboa.pt/local-info/accommodation, and a map is available at http://grow.tecnico.ulisboa.pt/wp-content/uploads/2014/03/map_hotels_3.pdf. We suggest Hotel Holiday Inn (the hotel marked with 1 on the map), which is just a couple of hundred metres away from the building where the School will take place, another possibility being is Hotel Turim Alameda (marked 2 on the map), which is not much farther away. Given that Lisbon is a very touristic place, it's advised that you book hotel quite in advance. In any case, do not hesitate to contact us, if you need any assistance on this matter.

Grants

CoDaS students have grants to cover travel expenses, being exempt from paying the Registration Fee.

All other attendees must pay the Registration Fee.

Registration

The Registration Fee is 170 €, to cover meals expenses.

Students willing to attend the School need to fill in the Registration Form available at https://docs.google.com/forms/d/e/1FAIpQLSd26O18edGPWku6wv3a9KIz4F7d0qA8tuPojXliQkjoxOQygA/viewform?usp=header. Registration must be done until Friday, June 27th.

Social Events

A social dinner will be offered to attendees and lecturers on Thursday, July 24th.

Contacts

If you need any information or help, please contact:
Mrs. Vera Almeida
Tele.: +351-213 100 432
Email: vera.almeida@inov.pt

Organisation and Scientific Programme Committee

The School is organised by the CoDaS M.Sc. Programme, and hosted by INESC INOV-Lab, an R&D institute within Técnico Lisboa, with the support from the European Union.

The School's Scientific Programme Committee is composed of:

- David Ricon (U.P.C., ES)
- Luis M. Correia (Técnico Lisboa / University of Lisbon, PT)
- Stephan Sigg (Aalto University, FI)
- Lars Wolk (Technische Universität Braunschweig, DE)
- Olivier Gaudoin (Grenoble INP / UGA, FR)

Detailed Programme

António Grilo (Técnico Lisboa / University of Lisbon, PT): He was born in Portugal in 1973. He holds the Ph.D. degree in Electrical and Computer Engineering from IST, where he is currently Associate Professor. Since 1996, he has been working in European Commission (EC) projects related with communication networks. He is currently a Researcher with INESC INOV-Lab, Lisbon, in the Intelligent Communication Networks research area. He is the author or coauthor of more than eighty scientific articles on subjects related with communication networks. His current research interests include UxV networks, Internet of Things, Edge Computing, and applications of Artificial Intelligence in Communication Systems and Networks.

"*"These data are all you have": some practical use cases of mobile operator datasets*": In academic research, authors often prioritize the development of new algorithms, assuming that the available data will align with algorithmic requirements—an assumption that holds true for simulated datasets. However, real-world datasets provided by mobile operators are typically generated by network equipment, each with its own set of variables and sampling frequencies. This raises a fundamental question: "What can be achieved with these data?". This lecture will showcase recent works by Master's students, where industry-provided data not only shaped research objectives but also transformed dataset constraints into compelling challenges. These constraints led to innovative approaches in fault detection, energy consumption analysis, and coverage optimization, demonstrating how real-world data can drive meaningful discoveries.

Carlos Ruiz de Mendoza (U.P.C., ES): He is a part-time researcher and final-year Ph.D. candidate in Telematics Engineering at the Universitat Politècnica de Catalunya (UPC). His research focuses on the application of artificial intelligence—particularly deep reinforcement learning—to the management of computational and network resources in vehicular edge computing environments for connected autonomous vehicles operating over emerging 6G infrastructures. His publications explore AI-driven methods for intelligent resource allocation, optimal placement of Virtual Network Functions (VNFs), and federated learning techniques applied to next-generation vehicular networks, with a particular emphasis on beyond-5G (B5G) and 6G architectures. He has contributed to several national and European research initiatives on autonomous and intelligent network infrastructures, including AI@EDGE (H2020)—a project on trustworthy, reusable AI platforms for edge computing beyond 5G; TRUE5G-UPC, a Spanish project focused on zero-touch automation and orchestration in future 5G services; and 5Growth (H2020), where he researched near-optimal VNF placement using reinforcement learning in edge-enabled 6G networks. He currently balances his research with his work as a financial analyst, where he applies data analysis and optimization techniques. Earlier in his career, he specialized in the design of networked audio systems, large-scale sound reinforcement solutions, and acoustic environments, and developed software for professional audio applications. He earned his Master's degree in Applied Telecommunications and Engineering Management from UPC in 2021.

"Deep Reinforcement Learning for Connected Autonomous Vehicles in 6G Vehicular Edge Computing Networks": As we move toward the 6G era, autonomous mobility is becoming deeply intertwined with edge intelligence. In this session, we'll explore how Connected Autonomous Vehicles (CAVs) can tap into the city's own computing infrastructure—through Vehicular Edge Computing Networks (VECNs)—to make intelligent, low-latency decisions while navigating complex urban environments. The talk introduces a framework that unifies incremental path planning with real-time resource allocation, allowing CAVs to adapt both their routes and computing strategies dynamically as they move. At the heart of the system is a mechanism for assigning Virtual Network Functions (VNFs) to street-level edge nodes, ensuring that critical services remain responsive even when the network is congested or operating near capacity. We model this dynamic optimization problem as a Markov Decision Process (MDP) and solve it using a Rainbow Deep Q-Network (DQN). A key innovation is a resource-aware action pre-filtering mechanism, which limits the agent's decisions to only those that are physically and operationally viable, in real time. To validate the framework, we developed a digital

twin of Barcelona's Eixample district, replicating the city's topology, realistic traffic behavior, and time-varying load conditions. Experimental results show that the agent not only finds efficient paths but also maintains high-quality service delivery, even as background traffic and network demand intensify.

Dani Korpi (Nokia Bell Labs, FI): Dani Korpi received the M.Sc. and D.Sc. degrees (Hons.) in communications engineering and electrical engineering from the Tampere University of Technology (TUT), Finland, in 2014 and 2017, respectively. He is currently a Senior Specialist with Nokia Bell Labs, Espoo, Finland. His Ph.D. thesis received the Best Dissertation of the Year Award from TUT, as well as the Finnish Technical Sector's Award for the best doctoral dissertation in 2017. His current research focuses on applying machine learning to wireless communications, especially on the physical layer. In particular, he is working on building a native foundation for machine learning in 6G radio networks.

"AI-Native Air Interface: A Paradigm Shift in 6G?": Applying artificial intelligence and machine learning (AI/ML) in radio networks has gained significant research interest in the recent years. This has built momentum for making the 6G standard "AI-native", to ensure that various AI-based use cases and enhancements can be supported in the next generation cellular networks. This lecture will cover the most important findings related to several different AI/ML applications in the physical layer of the radio system, and also reflect on their applicability for 6G systems. In particular, various alternative ML-based receiver architectures will be presented and benchmarked against conventional algorithms. The lecture will also touch upon end-to-end optimized links, where certain elements of the transmitter are replaced with neural networks and trained jointly with the receiver. Lastly, measurement results of PoC systems are presented, which demonstrate that AI-based solutions can provide performance gains also in real-world environments.

Luis M. Correia (Técnico Lisboa / University of Lisbon, PT): He was born in Portugal, in 1958. He received the Ph.D. in Electrical and Computer Engineering from IST (Univ. Lisbon), where he is currently a Professor in Telecommunications, with his work focused on Wireless & Mobile Communications, with the research activities developed in INESC INOV-Lab. He has acted as a consultant for the Portuguese telecommunications operators and regulator, besides other public and private entities, and has been in the Board of Directors of a telecommunications company. He has participated in 34 projects within European frameworks, having coordinated 6 and taken leadership responsibilities at various levels in many others, besides national ones. He has lectured 81 advanced training courses for industry and academia at the national and international levels. He has supervised 240 M.Sc./Ph.D. students, having edited 6 books, contribute to European strategic documents, and authored over 550 papers in international and national journals and conferences, for which served also as a reviewer, editor and board member. Internationally, he was part of 43 Ph.D. juries, and 96 research projects and institutions evaluation committees for funding agencies in 13 countries, and the European Commission and COST. He has been the Chairman of Conference, of the Technical Programme Committee and of the Steering Committee of 25 major conferences, besides other several duties. He was a National Delegate to the COST Domain Committee on ICT. He has launched and served as Chairman of the IEEE Communications Society Portugal Chapter, besides being involved in several other duties in this society at the global level. He is an Honorary Professor of the Gdańsk University

of Technology (Poland) and a recipient of the 2021 EurAAP Propagation Award “for leadership in the field of propagation for wireless and mobile communications”.

“*Perspectives into the Evolution of Personal Applications in 6G Networks*”: The talk starts by presenting a look into already existing technologies, which enables to establish a perspective for future user interface devices and services (e.g., information access, Internet of Things and geo-location), i.e., the so-called wearables. Then, potential services are identified, after which research challenges for mobile and wireless communications networks are presented. Afterwards, Body Area Networks are addressed, together with their applications. The modelling of bodies, antennas and other devices is then discussed. The bridging with the deployment of mission critical networks (i.e., security and emergency networks) is the presented, namely aspects of a proper and efficient service differentiation and implementation, which is still to be fully understood and taken into account. Radio and network aspects are addressed regarding adaptability and flexibility, looking at radio links quality and capacity, virtualisation / slicing and cloud / edge networking, regarding the quite different characteristics that services present. Conclusions are presented at the end.

Maximilian Schäfer (Friedrich-Alexander University of Erlangen-Nuremberg, DE): Maximilian Schäfer (S'15, M’19, SM’25) received his Ph.D. degree in electrical engineering from Friedrich-Alexander University of Erlangen-Nuremberg (FAU), Germany in 2019. Currently he is a Postdoctoral Researcher at the Institute for Digital Communications at FAU. His research is focused on multidimensional systems theory and signal processing with applications in the modelling, design and analysis of molecular communication systems, as well as audio signal processing. Since 2023, his work has expanded to the development of experimental molecular communication systems. Maximilian has given several invited talks and tutorials on the modelling of molecular communication systems and on the Internet of BioNanoThings, including a tutorial at the IEEE Global Communications Conference in 2024. He has received a fellowship from the Bavarian Research Institute for Digital Transformation and the Bavarian State Ministry for Science and Art for his research on the Internet of BioNanoThings. He also received multiple Best Paper Awards including two from the ACM International Conference on Nanoscale Computing and Communication in 2022 and 2024. He serves as a Steering Committee Member of the Workshop on Molecular Communications, as the Educational Services Coordinator of the Technical Committee "Molecular, Biological and Multi-Scale Communications” of the IEEE Communications Society, and as an Associate Editor for the IEEE Transactions on Molecular, Biological and Multi-Scale Communications.

“*Synthetic Molecular Communication: Introduction, Theoretical Foundations, and Experimental Verification*”: In recent years, synthetic molecular communications (MC) has emerged as a new field of research in information theory and communication engineering with strong links to several other disciplines, including biology, nanotechnology, and medicine. MC is expected to provide connectivity in environments that are not suitable for conventional communication systems based on electromagnetic (EM) waves, such as the human cardiovascular system, bio-processes, and water pipes, and facilitate novel applications such as the Internet of BioNanoThings (IoBNT), targeted drug delivery, and interfacing with animals and plants. Although some concepts known from conventional communication systems are applicable in MC, there are also many new aspects and differences. In

this tutorial, we will first provide a broad introduction to synthetic MC, reviewing different forms of MC occurring in nature, the propagation of molecules, and potential applications. Subsequently, we will introduce communication-theoretical models for MC channels, discuss phenomena such as degradation and dispersion, and unveil concepts for MC system design. Finally, we will present an overview of state-of-the-art experimental MC systems and provide case studies for applications of MC concepts, including bio-process control and olfactory systems.

Ricardo Dinis (NOS, PT): Ricardo Dinis holds a degree in Electrical and Computer Engineering from Instituto Superior Técnico (IST) in Lisbon and has over 25 years of experience in the Mobile Telecom Industry. He has expertise in radio network planning, optimization, and architecture design, backed by a deep understanding of telecom networks and their evolution. Throughout his career, he has managed several technological pilots, led network system design, and worked in the deployment of 3GPP networks, contributing to the evolution of mobile communications. Currently, he is the Mobile Network Analytics and Innovation Manager at NOS, overseeing the virtualization of engineering processes and the transition of data analytics to the Cloud. As an innovation leader, he has managed multiple European and national research projects, focusing on 5G use cases across various sectors, particularly in C-V2X applications on advanced mobility, including autonomous driving, drones, and first responder communication systems. He has played a key technical role in major projects like Horizon Europe 5G-MOBIX (5G for CCAM in cross-border corridors), MIT Portugal C-Tech (Smart City Platform for Urban Planning), CEF Digital 5G Healthcare, and 5G.RURAL, focusing on healthcare applications and connectivity solutions for low-density rural communities, as well as the implementation of NOS 5G National Testbed under PRR funding. Beyond his industry contributions, he has been actively involved in academic research, co-supervising multiple master's theses and co-authoring research papers in the telecom field.

"*NOS' 5G Hub*": Presentation of the NOS' 5G Hub and of activities held in the area of network data processing.

Sílvia Ruiz (U.P.C., ES): She has a PhD in Telecommunication Engineering from the Universitat Politècnica de Catalunya (UPC) in 1989, is an Associate Professor in the Department of Signal Theory and Communications (TSC) since 1992, and teaches at the Castelldefels School of Telecommunications and Aerospace Engineering (EETAC), where she has served as Head of Studies and Deputy Director for International and Corporate Relations for sixteen years. Founder and Director of the Wireless Communications and Technology (WiComTec) research group. She has authored over two hundred publications in international journals, conferences, and book chapters. She has participated in many UE projects, COST actions and European Network of Excellence as well as assessed several telecom companies in specific radio communications projects. Her research interests are in the field of radio communication systems, and more specifically in radio network planning and optimization of 4G/5G/B5G heterogeneous networks.

"*Drones & B5G: the Next Era of Aerial Connectivity*": This session addresses the current challenges in drone communications for B5G Networks, including latency, reliability, and scalability. Some of the

topics that will be discussed are the channel modelling through aerial ray tracing in heterogeneous scenarios including aerial beamforming, the introduction of AI-driven connection management, regulatory considerations, future research directions towards seamless drone-network integration and some key applications including smart cities, disaster response, logistics and autonomous inspections.

Stephan Sigg (Aalto University, FI): Stephan Sigg is a Professor at Aalto University in the Department of Information and Communications Engineering. With a background in the design, analysis and optimisation of algorithms for distributed and ubiquitous systems, he focuses on sensing systems for environmental perception and Usable (perception-based) Security. Especially, his work covers proactive computing, distributed adaptive beamforming, context-based secure key generation and device-free passive activity recognition.

"*Ambient Intelligence*": We introduce the concept of radio sensing in the context of interactive systems and in the frame of human interaction. Particularly, we will talk about the operation principle of mmRadar and its use for environmental perception. We will further discuss backscatter-based systems and introduce use-cases in integrated communication and sensing, smart environments as well as physiological sensing for healthcare.

Tim Kacprowski (Technische Universität Braunschweig, DE): He is Professor for Data Science in Biomedicine at TU Braunschweig and heads the department of the same name at the Peter L. Reichertz Institute for Medical Informatics, a joint institution of TU Braunschweig and Hannover Medical School. After studying bioinformatics at Saarland University, he worked at the Max Planck Institute for Informatics and earned his PhD at the University of Greifswald. This was followed by a postdoctoral stay at the University of Southern Denmark and the leadership of the junior research group "Computational Systems Medicine" at TU Munich before he joined TU Braunschweig. His research focuses on developing and using methods in network biology, machine learning, and genetic epidemiology to understand the foundations of diseases and other phenotypes.

"How and Why Can ML/AI Benefit from Molecular Networks in the Biomedical Field": Statistics and bioinformatics have greatly advanced health-related and epidemiological research. However, progress mostly concentrates on discovering associations and biomarkers for diagnostic purposed and deeper biological insights are often missing. Additionally, newly identified biomarkers are often not stable and hard to replicate in other cohorts or populations. Even for highly-grossing drugs, we seldomly know by which mechanism exactly they work. Molecular networks model biologically meaningful relations between genes, proteins, metabolites, and other biomolecules. These relationships can be leveraged in combination with state-of-the art statistical approaches to make biomarker signatures more robust and interpretable. We will explore how we can benefit from molecular networks in supervised and unsupervised learning settings and see why, despite remaining challenges, this can boost biomedical discoveries.