CentraleSupélec within

LISN, UMR 9015

LABORATOIRE INTERDISCIPLINAIRE DES SCIENCES DU NUMÉRIQUE

LISN, located on the Orsay campus, is a research laboratory created in January 2021, as the result of the union of 7 LIMSI research groups and 7 LRI research teams. It is a Joint Research Unit (UMR) with CNRS, University Paris-Saclay, INRIA and CentraleSupélec. LISN is a multidisciplinary research laboratory that brings together researchers and teacher-researchers from different disciplines in the Engineering and Information Sciences, as well as Life Sciences and Human and Social Sciences.

LISN hosts about 400 people, including 170 researchers and 150 Ph. D students. Its research forces cover a broad spectrum of fundamental and applied research in computer science and engineering science. It is composed of five departments corresponding to interdisciplinary themes.

Research Departments

ALGORITHMS, LEARNING, AND COMPUTATION

The main research axes concern computational models and their robustness (from high performance computing to quantum computing, including neural networks, and distributed algorithms), processing architectures (graphs, distributed processing), and methods (eg. continuous optimization, combinatorics, stochastics; statistical learning and information theory). The teams which composed this department are Learning and Optimization (A&O, team transverse with Data Sciences department), Graphs, Algorithms and Combinators (GALaC), and Parallel Systems (ParSys).

INTERACTION WITH HUMANS

The Human-Centered Interaction Department brings together researchers from 6 internationally renowned teams. It focuses on Human-Computer interaction with a multidisciplinary approach combining computer science, signal processing, and humanities, to design not only innovative hardware and software interfaces but also to explore social interaction and collaboration between humans and computers.

The range of this research allows the department to develop work that is both fundamental and application-oriented, to evaluate the relevance of these models in their real use, and methodological, on the design and evaluation aspects.

FLUID MECHANICS AND ENERGY MECHANICS

The field of mechanical and energy engineering must rapidly advance to address societal issues such as global warming, energy and health crises. Unprecedented volumes of data from experiments and field measurements, affordable large-scale simulations, and a wealth of efficient numerical tools put the understanding, modeling, optimizing, and controlling of nonlinear multiphysics phenomena at stake within reach.

The approach of this department lies at the interface between computer science, physics and applied mathematics. We wish to preserve an equilibrium between interdependent activities: understanding fundamental turbulent fluid mechanics phenomena; tackle large-scale complex multiphysics coupled problems and take advantage of our physical knowledge while considering data as an inherent part of modeling, experiments, and simulations. In this context, we are very open to recent machine learning developments which provide a powerful information-processing framework that can augment our current lines of research with broad-spectrum applications in the energy, transport, health and environment sectors.

DATA SCIENCE

The Data Science department brings together 4 teams with complementary expertise, covering the modeling, collection, management, analysis and construction of data and knowledge. Digital traces of all human activities are available today in all fields. The available data is often massive, heterogeneous, dynamic and of variable quality (the 4 Vs: Volume, Variety, Velocity, Veracity). The Data Science department is therefore interested in responding robustly to the challenges of the 4 Vs in terms of scaling up, with respect to data volume and velocity, and in terms of resisting biases regarding diversity and quality.

The expertise of the members of the Data Science department covers a wide spectrum: databases, data mining, semantic web, knowledge representation, algorithmics, combinatorics, stochastic and distributed optimization, machine learning and neural networks (supervised, unsupervised, structured), communication networks, simulation, validation and transfer to industry.

LANGUAGE SCIENCE AND TECHNOLOGIES

Language is an essential vector for human communication, the recording and transmission of information and knowledge. Its modeling and computer processing are major challenges for the advancement of knowledge and technology in a field with a strong societal impact, and are an intrinsic part of Artificial Intelligence.

Transversal actions

The departments work together on five cross-cutting actions. The aim is to develop new directions and take advantage of the originality and diversity of the expertise of LISN members.

- Deep Learning for Physics and Physics for Learning.
- Computer sciences and SHS
- Arts and Sciences
- Visualization and exploration of big data
- Responsible Research

Cooperations

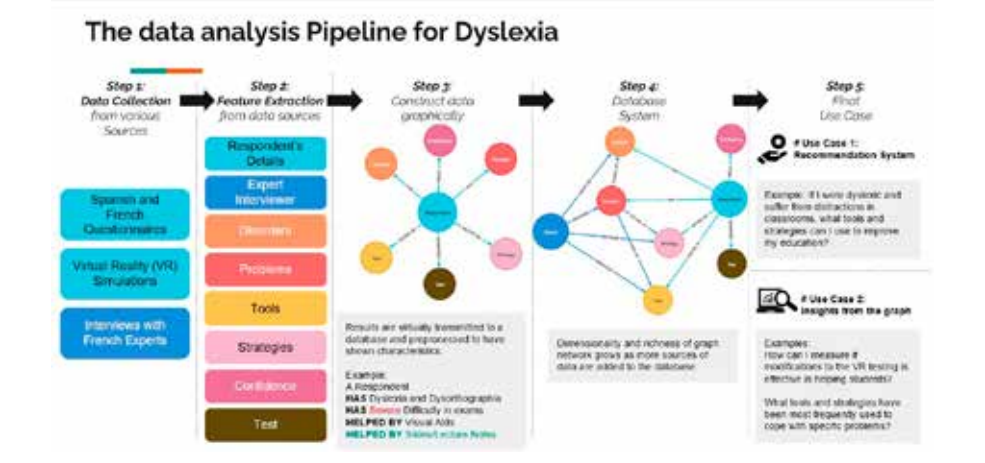
The laboratory participates in a large number of national and international projects, including those funded by ANR, the French National Research Agency, by Digiteo and by the European Union (in particular the KIC ICT Labs from EIT). LISN members participate in many editorial boards of international journals and program committees of international conferences. The laboratory is also highly productive, with over 4000 publications in last five years, and is strongly involved in software production and transfer.

LISN is a member of ED STIC, SMEMAG and SSMH and participates in the Graduate Schools *Computer Science, Engineering and Systems and Sport, Movement and Human Factors* of the University Paris-Saclay. LISN is also a partner in System@tic Paris Region, a world-class competitiveness cluster with more than 200 industrial, academic and institutional members in the area of complex software and systems. LISN is strongly involved in the Investments for the Future programs launched in 2010 by the French government. It leads the Equipex Digiscope, the Labex Digicosme, participates to the IRT SystemX, the DataIA Institute, the labex LASIPS, the SaclayIA research equipment which includes the Lab-IA platform, managed by people from LISN.

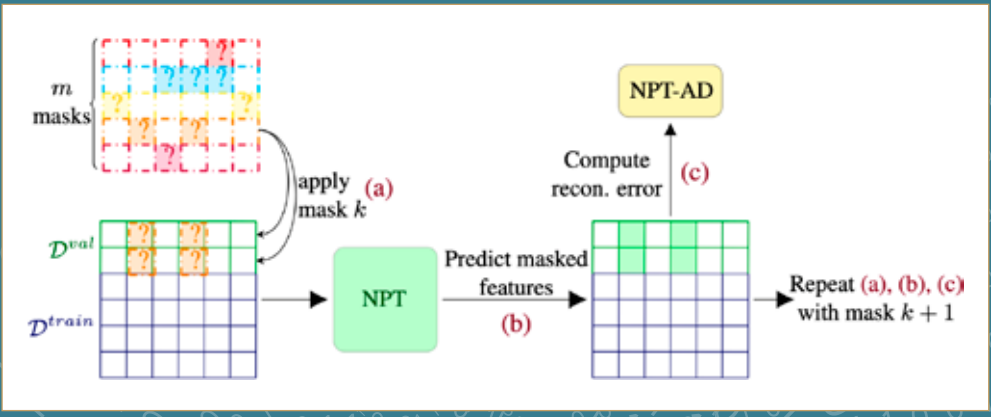
Application Domains

- Health
- Automotive,
- Bioinformatics,
- Telecommunications,
- Transportation,
- Energy,
- Transport,
- Bank/Finance.

EXAMPLES OF STUDIES



The data analysis Pipeline for Dyslexia



In order to enhance anomaly detection methods, we propose to rely on Non-Parametric Transformers to learn to rebuild the masked features of normal samples. This is the first anomaly detection method to combine both feature-feature and sample-sample dependencies. It outperforms existing state-of-the-art methods based on both the F1-Score and AUROC on 37 datasets.

RESEARCH THEMES

MACHINE LEARNING AND STOCHASTIC CONTINUOUS OPTIMIZATION

AI for good
- Learning causal models
- Handling biases; enforcing stability; providing explanations

ML and background knowledge: from differential partial equations to Neural Nets
- More robust numerical engineering (NE)
- More complex models / resolution

Learning to learn (Auto-ML)
- Algorithm/hyper-parameter selection
- Search for neural architectures ; invariances

BIOINFORMATICS

Biological sequences and structures
- Statistics and Machine Learning for Population Genetics
- Algorithmic of Molecular Structures

Computational Systems Biology
- Modelling and simulation of biological networks
- Steady-state and dynamics analysis for biological networks
- Synthetic biology

Data integration of biological data
- Scientific workflows
- Biological data ranking

HETEROGENEOUS MASSIVE DATA AND KNOWLEDGE

Goals: Algorithms and methods for heterogeneous graph data

Scientific contributions
- Ontology management & reasoning
- Mining big data graphs for discovering knowledge
- Managing incomplete and uncertain data
- Applications to social networks, biological data, personal data

ALGORITHMS FOR NETWORKED SYSTEMS

Goals: design efficient modeling, control and performance optimization algorithms, tailored for:

- Networked
- Distributed systems

Scientific contributions
- Both theoretical: Development of new, Mathematical modeling, Techniques and proofs
- ... and applied: Development of innovative tools, For the optimal planning and Resource allocation in networks

Objectives: Establish theoretical building blocks for the design and optimization of networked systems, including:

- Algorithmic Game Theory
- Control Theory
- Distributed Algorithms
- Discrete Event Simulation

INTERACTION OFF-THE-DESKTOP

- Creating new forms of interaction on devices ranging from mobile phones, tablets and interactive paper to large digital tabletops, wall-size displays, virtual and augmented reality
- Exploring how new interaction paradigms, e.g. multi-surface and whole body interaction, can significantly improve the user experience
- Affective and social interactions
- Modeling of human behavior and activity

NATURAL LANGUAGE PROCESSING : SPOKEN, WRITTEN AND SIGNED LANGUAGE

Scientific contributions

Both theoretical
- linguistic: linguistic variation, prosody, phonetics
- machine learning

... and applied:
- speech recognition
- automatic machine translation (from speech to speech, written to signed language, ...)
- information extraction
- dialog system and chatbot
- language generation (written and signed)

FLUID MECHANICS AND ENERGY ENGINEERING

Scientific contributions
- Fluid mechanics, mass and heat transfer, energetics
- Modeling/simulations/numerical methods/experiments, machine learning, data assimilation, uncertainty quantification
  - understand fundamental turbulent fluid mechanics phenomena via simulations + experiments
  - tackle large-scale complex multiphysics coupled problems
  - combine our physical knowledge + data considered as an inherent part of modeling, experiments, and simulations
- Robustification, optimization et control of physical processes

Methodology
- Uncertainty quantification, stochastic modelling, high-dimensional approximation
- Physics-informed statistical learning & information theory, data assimilation and inference
- Reduced-order modeling, control of high dimensional dynamic / chaotic systems, optimal control, robust optimization
- Direct numerical simulations, HPC, fluid dynamics analysis

Industrial Partners

- AIRBUS,
- ATOS
- BULL
- DAIMLER
- DASSAULT
- EDF
- FACEBOOK
- IBM
- L'OREAL
- LUSIS,
- MITSUBISHI
- NOKIA
- ORANGE
- PHILIPS
- QWANT
- SAP
- SCHNEIDER
- SIREHNA
- SNCF
- STMicroelectronics
- SYSTRAN
- THALES
- TOTAL SA...

Academic Partners

University of Vienna Austria (AU), University of Montreal (CA), Concordia University Montréal (CA), Toronto University (CA), MacMaster University Hamilton, TU Dresden (GE) , Pisa University (IT), Milano University (IT), University of Tokyo (JP), Kyoto University (JP), Vrije Universiteit Amsterdam (NL), ETH Zürich Switzerland (CH), Imperial College London (UK), University of Manchester (UK), University of Oxford (UK), University of California at Berkeley (US), Davis (US), San Diego (US), Santa Cruz (US), City College of New-York (US), University of Minnesota Minneapolis (US), Stanford University (US), Universidade Federal do Rio de Janeiro (Brazil), National institute of Informatics (Japan)...

Partnerships & Collaborations

Cap Digital, Medicen, SATT Paris-Saclay

Key figures*

• Professors, Associate Professors & Researchers	10
• PhD Students	4
• Publications of the year (WoS)	4

*CentraleSupélec only

https://www.lisn.upsaclay.fr/

Director: Sophie ROSSET

+33 (0)1 69 15 58 58

sophie.rosset@lisn.upsaclay.fr

Deputy Director: Michel BEAUDOUIN-LAFON

+33 (0)1 69 15 69 10

michel.beaudouin-lafon@lisn.upsaclay.fr

Deputy Director: Didier LUCOR

+33 (0)1 69 15 72 26

didier.lucor@lisn.upsaclay.fr

"Belvédère" Premises
Bât 507
Rue du Belvédère
91405 Orsay cedex

"Plaine" Premises
Bât 650 Ada Lovelace
1, Rue Raimond Castaing
91190 Gif-sur-Yvette