

AT
THE
HEART
OF
SYSTEMS
&
HEALTH

THE CRAN IN NANCY WAS CREATED IN 1980 AND SHEDS NEW LIGHT ON AUTOMATIC CONTROL AND THE UNIVERSE OF COMPLEX SYSTEMS.

The CRAN's work is based on the digital sciences and the laboratory is internationally recognized for its activities in the fields of **signal and image processing, control, computer and production engineering** and for its work in health with links to biology and neuroscience. Today, its fundamental and applied research allows CRAN to support changes in society and also goes beyond the traditional industrial issues - energy production, intelligent city, transport or manufacturing. In the field of health, the CRAN's research is opening towards diagnosis and care in oncology and neurology. This research also involves sociology, focus on social behaviour and the dynamics of opinion and the CRAN's researchers are also involved in the field of sustainable development working to promote and enhance the circular economy and ecological systems.

The CRAN in short...

The CRAN (joint research unit, UMR 7039) is a fundamental and applied research laboratory under the joint supervisory authority of the Université de Lorraine and the CNRS. It is more specifically attached to the CNRS Institute for Information Sciences and Technologies (INS2I) and secondarily to the CNRS Institute for Engineering and Systems Sciences (INSIS). It is part of the AM2I (Automatic control, Mathematics, IT and their interactions) scientific pole at the Université de Lorraine and of the Charles Hermite Federation while also hosting researchers from the Lorraine Institute of Oncology (ICL) and the CHRU (University Hospital and Research Centre) in Nancy.

...and in figures

270

STAFF MEMBERS
INCLUDING:

29

PERMANENT
ENGINEERS,
TECHNICIANS OR
ADMINISTRATIVE
STAFF

128

PERMANENT
RESEARCHERS

>100

DOCTORAL STUDENTS
AND POST-DOCTORAL
FELLOWS

around **10**

CONTRACT
EMPLOYEES
(researchers, engineers,
administrative staff,
interns, etc.)

3 DEPARTMENTS WITH ONE SHARED APPROACH.

Control Identification Diagnosis (CID), Sustainable Systems Engineering (ISET) and Biology, Signals and Systems in Cancer and Neuroscience (BioSiS)... Beyond the specific features of the three departments that make up CRAN, they are all driven by a shared ambition - to understand complex systems and optimise their behaviour by using data processing or building and exploiting models.

Control Identification Diagnosis (CID)



The CID Department gathers the Laboratory's research activities related to the automation of continuous and cyber-physical systems. This department's theoretical and methodological work is motivated by significant strategic and societal concerns and aims to answer to the major challenges created by the increasing complexity and integration of systems in the fields of energy, transport, environment, processes and communications. The CID department's key words are modelling and identification, analysis, control and observation, diagnosis and finally fault tolerance.

Biology, Signals and Systems in Cancer and Neuroscience (BioSiS)



The strength of the department lies in its interdisciplinary approach that brings together experimental biology, neuroscience and signal and image processing. Its research combines multi-scale analysis of biological systems and data processing in the framework of a long-term translational approach in collaboration with Nancy's CHRU and the Lorraine Institute of Oncology. All this work contributes to the development of innovative diagnostic and therapeutic methods and strategies, in oncology and neuroscience.

Sustainable Systems Engineering (ISET)



This department studies complex sustainable systems mainly with applications for industry, communication networks, transport, building and energy. Its research focuses on the development of methods, models and tools associated with evaluation and decision-making processes. The end goal of ISET's research is to enable the efficient operating, control and maintenance of systems of interest in a framework that goes further than classical performance, connectivity and dependability requirements to also take into account emerging issues linked to the responsible economy.

SCIENTIFIC TOPICS...

A whole world in equations

**The Control Identification
Diagnosis department (CID)
has made the methodology and
theory of dynamic systems the
core of its research.**

CID's scientific work has been showcased in numerous publications and cannot be separated from its tangible and industrial applications, with the latter even often inspiring this research. Numerous issues are dealt with such as the control of embedded, interconnected, multi-agent or cooperative systems for the automobile industry, optimising a steel production process, estimating and

predicting an intelligent building's behaviour, modifying a control law to compensate for a drone losing an engine and also modelling how a disease spreads or understanding how rumours develop. The department's strong point is achieving progress in knowledge while also offering innovative tools that fully take increasingly stringent implementation and security constraints into account.

Health dynamics

The study of radiation-tissue-nanoparticle interactions is one of the BioSIS department's main research themes along with enhancing the understanding of certain cognitive mechanisms. This research is carried out in close collaboration with health professionals from Nancy's CHRU and the Lorraine Institute of Oncology (ICL).

The aim of the BioSIS department's work in the field of oncology is to improve the performance of radiotherapy for brain tumors by using radiation-activated nanoparticles and to integrate multi-scale exploration techniques that include the tumor environment and its impact on post-treatment tumor responses. The study of circulating nucleic acids from patients' liquid biopsies and running clinical trials to demonstrate the interest of these acids for theranostics also contributes to improving their management. Further-

more, the department capitalises on the latest advances in photonics to characterise the optical properties of biological tissues in vivo and to support preoperative diagnoses and surgical decisions. In the field of neuroscience, the department studies cerebral visual recognition mechanisms using original methodological approaches for the identification and localisation of cognitive networks. This theme is opening up new research avenues in the fields of neuropsychiatry and neurodegenerative diseases.

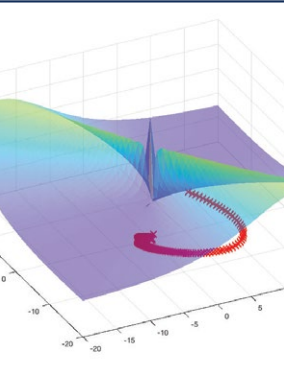
A search for balance

The ISET department's rich partnerships with the socio-economic world mean it embodies the fertile synergy between fundamental and applied research in many ways.

The ISET department's research focuses on themes involving important societal issues by studying the human, technical and environmental dimensions of new Cyber-Physical Production Systems CPPS in addition to their classic performance levels. In this way ISET explores the interactions between complex systems and intelligent objects for steering and control applications. This means banking on adaptability, sustainability and resilience forming the basis for the concept of the Industry of the Future/Industry 4.0. ISET

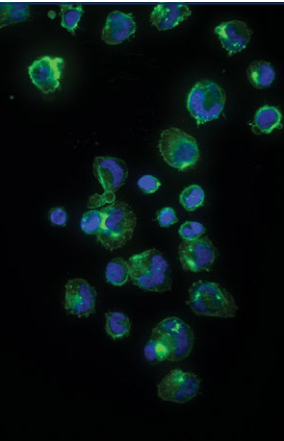
aims to make communication networks more observable and «greener» by working on the environmental impact of data transfers. The department studies systems engineering and more specifically such systems' operating safety both to make them more secure right from the design phase and to define the optimal maintenance frequency, successfully restore performance levels remotely and use predictive technologies to prevent faults.

... & FIELDS OF APPLICATION



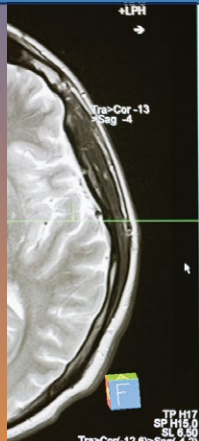
CID's research projects

- Fault Tolerant Control - Fault diagnosis and safety (CduSur)
- Control, Optimization, Communication (CO2)
- Control and Observation of Non-linear Systems (COSsyNL)
- Identification and Modelling of Dynamic Systems (iModel)



BioSiS's research projects

- Neuroscience of Systems and Cognition
- Multidimensional Signals
- Photo Diagnostics, Imaging & Biomedical Optics
- Tumor Environment & Radiation Therapy for Brain Tumors
- Liquid Biopsies & Therapeutic Optimization



ISET's research projects

- Intelligent System and Objects in Interaction (S&O-2I)
- Green Networking (GN)
- Operational dependability, PHM and maintenance (S-PHM2)



23 TECHNICAL PLATFORMS AND RESOURCES ACT AS SKILL CENTRES OF COMPETENCE TO SERVE RESEARCHERS.

AUTOMATION & ROBOTICS

Laboratory on cables

Robot system to study insects

Hydrogen production (Hydrogène)

Electrical fault-tolerant control system

INDUSTRY CONSTRUCTION & BUILDINGS

Building information modelling (BIM)

3D software solutions (INC)

THE CIRCULAR ECONOMY

Recycling products for industry (PROGRESS 4.0)

Product regeneration

THE ENERGY TRANSITION

The technical management of buildings (Éco-Sûr)

Automation, artificial intelligence, simulation

NON-DESTRUCTIVE CONTROL

Multimodal Imaging (PIM)

Traceability, identification

NUCLEAR ENERGY

Safe industrial process control (CISPI)

Industrial process control

MAINTENANCE

Predictive maintenance for industrial systems (TELMA)

Prognostics and Health Management (PHM)

PRODUCTION SYSTEMS

Multi-Agent systems (TRACILOGIS - CP2)

Artificial Intelligence, Digital Twin

AERONAUTIC AND SPACE

Embedded Ethernet networks in space launchers (RElanS)

Real-time digital networks

ONCOLOGY

Spectral Imaging (PhotoVivo)

Optical methods in clinical practice

Medical Devices (PhotoVivo)

Medical image processing

Fluorescence Imaging

Image guided surgery

Irradiation and Preclinical Imaging Platform (OptiRAD)

Multimodal imaging and image-guided radiotherapy

Liquid Biopsies

Patient management and residual disease monitoring

NEUROSCIENCE

Multi-Scale EEG Instrumental Platform (ICEM)

Cerebral visual recognition mechanisms |

Identification and localisation of cognitive networks

Discover all our platforms and technical resources by scanning this QR code.



THE CRAN & TRAINING

Every year, CRAN welcomes about **twenty new doctoral students** who are enrolled at the IAEM-Lorraine (Computer Science, Automatic control, Electrical Engineering, Mathematics) and the BioSE (Biology, Health, Environment) doctoral schools. It also hosts students from engineering schools and **students of Master on Complex Systems Engineering (ISC), Life Sciences Masters (MSV) and Health Engineering Masters (MIS) courses**. The CRAN's strong international focus is reflected in its role as a host laboratory for students in the **Erasmus Mundus GENIAL (GrEen NetworkIng And cLoud computing) master's course** of which it was one of the founding members.

Our laboratory's researchers teach in **engineering courses** at the ENSEM (National High School of Mechanical and Electrical Engineering), Polytech Nancy, Telecom Nancy and the ENSTIB (National High School of Forestry Technologies and Industries). They also teach in a dozen Masters courses run by the Faculty of Sciences and Technologies and the Faculty of Medicine in Nancy. Members of our laboratory are also involved in the BUT and Professional Licence courses at the IUTs (University Institutes of Technology) in Longwy, Nancy-Brabois and Épinal.

TECHNOLOGY TRANSFER & INDUSTRIAL PARTNERSHIPS

From its beginnings, the CRAN created and has **maintained major industrial collaboration partnerships** with EDF, CNES, ArcelorMittal, Renault and Schneider Electric along with **many institutions, organisations and SMEs/SMIs from the Lorraine region** such as CRITT BOIS, Trane, Poirot construction, Predict or SD Innovation.

Its industrial technology transfer strategy is also particularly reflected in the recruitment of an average of ten doctoral students under CIFRE contracts each year - a number that is continually increasing. The **CYBERNANO, Noviga and Deep RIVER start-ups** also derive from the CRAN.

INTERNATIONAL RELATIONS

The CRAN has strong relations for **collaboration with around twenty countries worldwide** - Algeria, Australia, Belarus, Brazil, Canada, China, Finland, Italy, Mexico, the Netherlands, Romania and the United States.

+20

EXCHANGE PROGRAMMES

+30

COOPERATION AGREEMENTS WITH UNIVERSITIES & RESEARCH CENTRES IN OTHER COUNTRIES

COLLABORATIONS AND NETWORKS

The national scientific community

The CRAN is involved in **5 research networks** which help steer and drive scientific projects within the national community: HappyBio, Information, Signal, Images and ViSion (ISIS), Modelling, Analysis and Control of Dynamic Systems (MACS), Nuclear Tools and Methods for the Fight against Cancer and Or-Nano.

The health sphere

The CRAN has a **30-year partnership with Nancy's CHRU and the Lor-**

rairie Institute of Oncology (ICL).

The laboratory has premises at the CHRU while health professionals from these institutions carry out their research at the laboratory. **The CRAN co-founded two research networks in cancer and neuroscience** - the Lorraine Cancer Research Network and the Lorraine Interdisciplinary and Translational Neuroscience Research Network.

Professional networks

CRAN is involved in **many professional associations** - the AFIS (*French*

Association of Systems Engineering), the ANOCEF (*Association of French-Speaking Neuro-Oncologists*), the GRETSI (*Signal and Image Processing Research and Study Group*), IMdR (*Institute for Risk Management*), the SAGIP (*Society for Automation and Industrial Engineering*), the SFCE (*French Society for the Fight against Cancers and Leukemias in Children and Adolescents*), the French Society for Photobiology (SFPb), the SFPMed (*Franco-phone Society of Medical Lasers*) and the SNCLF (*French Language Society of Clinical Neurophysiology*).


9 LOCATIONS IN LORRAINE

Brabois Campus – Health
Aiguillettes Campus - Undergraduates
Aiguillettes Campus - Postgraduates
Brabois Campus – Engineering - ENSEM
Bois Campus - ENSTIB
Nancy Central Hospital
The Lorraine Institute of Oncology - ICL
IUT Longwy
Polytech Nancy

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