CentraleSupélec within
LMF, UMR9021

FORMAL METHODS LABORATORY

CentraleSupélec
université PARIS-SACLAY

LMF Laboratoire Méthodes Formelles

cnrs

université PARIS-SACLAY

école normale supérieure paris—saclay

The *Laboratoire Méthodes Formelles* (LMF) was founded on 1 January 2021 as a joint research centre of University Paris-Saclay, CNRS, ENS Paris-Saclay, Inria, and CentraleSupélec with a main focus on formal methods. The new laboratory combines the expertise of about 100 members from the former *Laboratoire Spécification et Vérification* (LSV) and the VALS team of *Laboratoire de Recherche en Informatique* (LRI).

In our mission to enlighten the digital world through Mathematical Logic, we rely on formal methods as a tool to analyse, model, and reason about computing systems, such as computer programs, security protocols, and hardware designs. Our research targets a wide range of computational paradigms, from classical to emerging ones such as biological and quantum computing.

LMF is structured around three hubs: **Proofs** and **Models**, which lie at the heart of our historical background, and **Interactions**, that is aimed at fostering cross-fertilisation between formal methods and other domains in computing science and beyond.

Research Themes

PROOF AND LANGUAGES

Fundamentals of computing, languages and compilation

Formal Methods for Computer Arithmetic

Proof of programs

- Foundations and spreading of deductive program verification
- Reasoning on mutable memory in program verification

Mechanized evidence

MODELS

Distributed Computing

Model Checking and Synthesis

Formal Modeling of Critical Systems

Formal Testing and Monitoring

INTERACTIONS

Topology and computing applications

Formal methods for security

Formal methods for quantum computing

Formal Methods in Biology

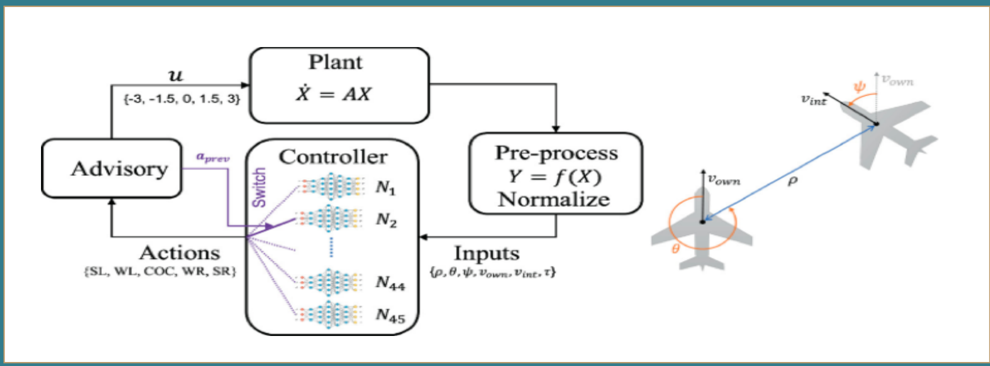
Formal Methods for Artificial Intelligence

Application Domains

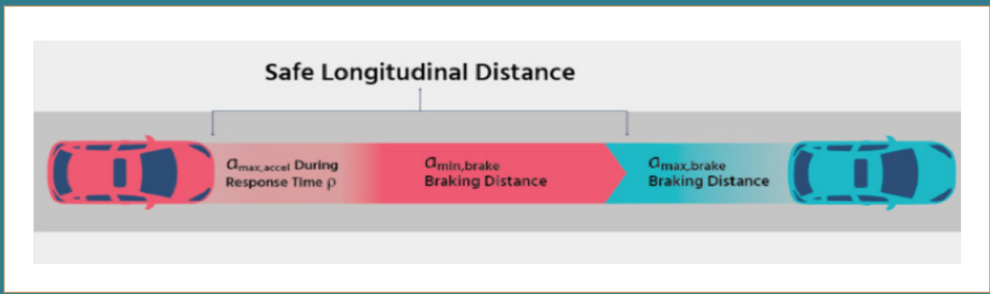
- Safety of software systems in transport
- Quantum computing
- Programming languages
- Toolchain compilation
- Specification/Certification
- Diagnosis of human behavior in accidents
- Proof of correctness of the "Responsibility-Sensitive Safety" strategy of driving autonomous vehicles
- Safety of real-time and hybrid systems: manufacturing processes, transport systems and communication networks
- Safety of dynamic systems controlled by neural networks: transport systems, medical systems
- Emotion identification by neural networks combined with rule-based inference: Therapeutic Chatbot

EXAMPLES OF STUDIES

Quantum linear optics is a versatile technology allowing, among other things, to perform quantum calculations. This new calculation model is expected to have applications in varied felds, such as high-performance computing or artifcial intelligence. The LMF collaborates with Quandela to defne linear optics' graphical languages to code and manipulate quantum algorithms.



Today more and more complex systems are controlled by neural networks, such as autonomous vehicles, a future version of traffic alert and collision avoidance systems, among others. Verifcation of their behaviour, i.e. the evolution of their outputs according to the variation of their inputs, represents a real challenge. Together with our partners, we are trying to study the formulation of their verifcation to combine deep learning and formal method techniques.



Modeling and Analyzing Cyber-Physical Systems (CPS) is a challenge for Formal Methods and a feld of active research. It is characteristic for CPS that models comprise aspects of Newtonian Physics appearing in system environments, the difficulties of their discretisation, the problems of communication and interaction between actors in this environment, and calculations respecting time bounds. We present a novel approach to address these problems developed within an IRT SystemX project for industrial partners involved in the Autonomous Car Domain.
Modeling human decision errors in critical systems is important to improve the interface of critical systems and to provide better training to operators of critical systems. We developed a formal model of belief revision and an algorithm that relies on SAT solvers to determine minimal knowledge correction sets in order to rebuild the sequence of possible mental states of a human operator that are compatible with the observed trace of his behavior. To flter among the many possibilities, we built a formal model of cognitive biases to prioritize behaviors that match known cognitive biases and are therefore more probable.

Industrial Partners

- AVSimulation
- EDF
- IRT SystemX
- PSA
- Quandela
- Renault
- Valeo

Academic Partners

CEA, INRIA, LORIA, LISN lab of Paris-Saclay University, CRIL, IRIF, IRIT - Toulouse, LACL Lab of UPEC University, Max Planck Institute for Software Systems: MPI SWS - Germany, Institute for Software Engineering and Programming Languages - Germany, AnSyMo group of Antwerp University, MDSL Lab of McGill University, Udela - Universidad de la República - Uruguay, UBA - Buenos Aires University

Key figures*

- Professors, Associate Professors & Researchers 4
- PhD students 7
- Visiting Professor 1
- Publications of the year (WoS) 5

*CentraleSupélec only

https://lmf.cnrs.fr/

Director: Patricia Bouyer-Decitre

Deputy Director: Evelyne Contejean

Administration: Marie-France Grandisson

+33 (0)1 81 87 54 50

lmf-contact@lsv.fr

LMF
4, avenue des Sciences
91190 Gif-sur-Yvette