

Shifting from the descriptive to the prescriptive

The understanding of the world through the lenses of modelling and simulation is a classic paradigm, renewed by the level of complexity of the systems that make it up today.

In order to move from the descriptive to the prescriptive, the exploration of modelling spaces and the identification of sub-spaces of interest are carried out using optimisation methods adapted to specific use cases.

These methods must be capable of handling large amounts of data, the uncertainties attached to them and the associated time constraints.



● CHALLENGES

Companies and public players must optimise the design and operations of complex systems such as transport or energy infrastructures, using simulation methods and algorithms.

● POSITIONING OF THE INSTITUTE

Optimisation irrigates many related scientific fields (scientific computing, machine learning, networks, etc.). IRT SystemX has a substantial research force in this field to provide state-of-the-art solutions, but also to carry out more upstream research on large systems, stochastic problems, sequential decision-making, solvers adapted to machine learning and finally on simulation by multi-agent systems, which are very well suited to the resolution of use cases in various fields (transport, logistics, energy, etc.).

● EXPERTISE

Continuous optimisation, discrete optimisation, stochastic optimisation, robust optimisation, operations research, planning, scheduling, meta-heuristics, game theory, mathematical programming, dynamic optimisation, integer linear

optimisation, non-linear optimisation, graph-based optimisation, multi-objective optimisation, shape optimisation, MIP (Mixed-Integer Programming) solver, multi-agent systems



Project in this field



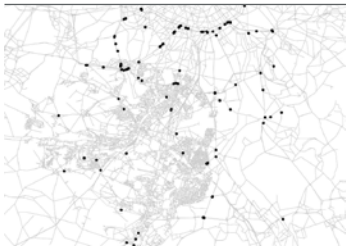
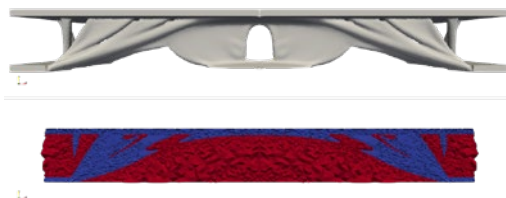
PSE project

Paris-Saclay Energies: to model the energy system in response to the needs of territorial planning and building management

- Learning of utility functions
- Dynamic optimization based on reinforcement learning for energy management

TOP project
Topology Optimization Platform: to develop numerical methods and tools dedicated to the optimal design of mechanical parts

- Deterministic and stochastic methods for uncertainty management
- Mesh refinement method



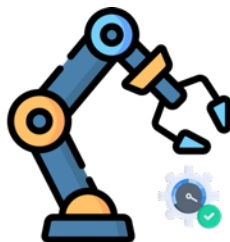
Anthropolis Chair

To define the new uses of tomorrow's urban mobility based on the development of eco-innovations

- Agent-based simulation and dynamic reinforcement learning for on-demand transport in a dynamic and multimodal context

MPO project
Improving the operation of production systems through Predictive Maintenance and its Optimisation

- Optimisation of maintenance strategies for complex industrial systems
- Optimal grouping of maintenance tasks



Roadmap

SCIENTIFIC AND TECHNOLOGICAL CHALLENGES

Optimization for large problems

RELATED RESEARCH FIELDS

- Coupling of solvers and simulation tools
- Optimisation of resource constrained problems
- Reduction of the computational burden
- Design and automatic training of neural networks (solver)

Dynamic stochastic optimisation

- Time constrained solving
- Sequential decision making and learning
- Dynamic grouping of tasks
- Hazard management

Simulation and optimisation using multi-agent systems

- Improvement of multi-agent simulation tools for scenario analysis
- Usability and replicability of Multi-Agent Systems models

Platforms and demonstrators



MATSim

Digital twin based on the multi-agent simulator MATSim:

- Graphical configuration interface
- Methods and scenarios for planning robot delivery operations
- Application to real delivery cases at the Living Lab in Lyon in the framework of the European project LEAD (Low Emission Last Mile Logistics)

Target of IRT SystemX publications in this field (HAL collection)

● JOURNALS

European Journal of Operational Research, Transportation Research, Journal of Optimization Theory and Applications, OR Spectrum, Expert Systems with Applications, International Journal of Production Research

● CONFERENCES

TRB, ROADEF (congrès annuel de la société Française de Recherche Opérationnelle et d'Aide à la Décision), BSOV, EUROGEN (International Conference on Evolutionary and Deterministic Methods for Design, Optimization and Control), CSMA (colloque national en calcul des structures), EWGT (Euro Working Group on Transportation), AMSTA (International conference on Agent and Multi-Agent System: Technologies & Applications), EURO (European Conference on Operational Research)



ACADEMIC PARTNERS



RESEARCH GROUPS AND SCHOLARLY ORGANIZATIONS



INDUSTRIAL PARTNERS



ABOUT IRT SYSTEMX

SystemX is a technological research institute (IRT) with expertise in the fields of analysis, modelling, simulation and decision support for complex systems. As the only IRT dedicated to digital systems engineering, it coordinates partnership research projects, bringing together academics and industry in a multi-sector perspective. Together, they work to solve major scientific and technological problems in four priority application sectors: Mobility and Autonomous Transport, Industry of the

Future, Defence and Security, Environment and Sustainable Development. Through use-case oriented projects, SystemX's research engineers respond to the major societal and technological challenges of our time, and thus contribute to the acceleration of the digital transformation of industries, services and territories. Located at the Paris-Saclay plateau and in Lyon, SystemX was created in 2012 as part of the future investment programme.

IN THE TEAMS

16 engineers-researchers

15 PhD projects, **9** of which have been defended (September 2021)

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