Univ. Grenoble Alpes
*Université de l'innovation*

# M2 Research Internship

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| **Internship subject** | Supervision of autonomous robotic systems based on SAT and SMT solvers |
| **Supervisors** | Damien Pellier, Humbert Fiorino |

**Duration :** 5 months
**Research laboratoiry:** Laboratoire d'Informatique de Grenoble, 700 avenue Centrale, 38058 Grenoble cedex 9
**Keywords:** Artificial intelligence, automatic planning, industrial planning, SAT and SMT Solvers

## 1. Context

There are many robotic applications where it is necessary to supervise the actions of a fleet of autonomous robots or UAVs. We find this issue for example in industrial robotics where mobile robots have to collect and prepare orders to be shipped, in military robotics where robots (surface, submarine or flying drones) have to coordinate to achieve a complex mission, in service robotics where mobile robots have to move in a hospital to bring analysis results, samples or drugs between different departments. Whatever the application domain, each robot is able to perform specific tasks and roles with its own performance levels. To date, the supervision, i.e. the coordinated planning of the activities of the different robots according to their capabilities is still largely performed by human operators in an ad hoc manner.

In parallel in Artificial Intelligence, automated planning or simply planning [1] aims at developing algorithms to produce action plans that can be carried out by one or more autonomous robots. The planning software that incorporates these algorithms is called a planner. The difficulty of the planning problem depends on simplifying assumptions that are taken for granted, e.g., on the execution time of actions, their stochastic effects, the complete and/or noisy observability of the environment, etc. A typical planner handles three inputs described in a formal language such as PDDL (Planning Domain Description Language) that uses logical predicates:

- a description of the initial state of a world,
- a description of a goal to be reached and,
- a set of possible actions (sometimes called operators).

Each action is specified by preconditions that must be satisfied in the current state of the robot for it to be applied, and postconditions (calculation of the new state produced). The interest of planning in this context is to use a descriptive language allowing to model easily the missions while leaving the complexity of their optimization and their replanning according to the hazards to a planner. To understand concretely what planning is and to run a planner on simple examples, you can consult the PDDL4J project web page: https://github.com/pellierd/pddl4j. The Laboratoire d'Informatique de Grenoble (LIG) and more particularly the MARVIN team is a specialist in this research domain. Many techniques exist to solve a planning problem.

## 2. Objectives of the internship and expected results

The Master 2 student recruited will (1) develop a state of the art on automatic planning tools based on SMT solvers [2] adapted to the application contexts of autonomous robotics, (2) develop a prototype planner based on one or more encodings of an automatic planning problem (PDDL) into an SMT problem, (3) evaluate the performances of the developed prototype on community benchmarks.

## 3. Profile of the candidate looking for

The candidate must have:

- be registered in Master 2
- advanced programming skills (design and implementation), especially in Java
- knowledge of how to take users into account in interactive systems
- a good academic level attesting to his ability to combine practice and theory
- a level of professional oral and written English
- general knowledge in the fields of data analysis and artificial intelligence is a plus
- an appetite for industrial issues

## 4. Procedure and contact

Send to Damien.Pellier@imag.fr:

- Your Master 2 diploma with your marks
- Your CV

Applications are managed on a case-by-case basis. You will be informed promptly by email of the admissibility of your application and if you are invited to a first interview.

## 5. References

[1] M. Ghallab, D. Nau and P. Traverso, "Automated Planning", Morgan-Kaufman, 2017.

[2] C Barrett, R Sebastiani, S Seshia, and C Tinelli, "Satisfiability Modulo Theories." In Handbook of Satisfiability, vol. 185 of Frontiers in Artificial Intelligence and Applications, (A Biere, M J H Heule, H van Maaren, and T Walsh, eds.), IOS Press, Feb. 2009, pp. 825–885.