PhD. Position: Mission planning for a fleet of autonomous robots

Location: Laboratoire d'Infomratique de Grenoble (LIG) – Marvin team, Grenoble, France (with some periods at ONERA, Toulouse, France)

Duration/Dates: 2024-2027

Student profile: Computer Science

Gross salary: ∼2100€/month + possibility to be assistant lecturer (DCCE contract)

Supervisors:

- Damien Pellier (LIG, France) – `damien.pellier@imag.fr`
- Alexandre Albore (ONERA, France) – `aalbore@onera.fr`

Phd Description

One of the primary challenges in developing autonomous systems is defining decision-making functions, such as the task scheduler or planner. This challenge is particularly pronounced in complex underwater missions, where robotic systems (UAVs) comprise a diverse fleet of autonomous and/or teleoperated vehicles tasked with performing intricate operations. Each UAV possesses the capability to execute tasks and fulfill roles with its unique performance characteristics. These tasks encompass activities like deploying or retrieving vehicles, reaching designated areas, mapping terrain, inspecting objects, relaying information, and more.

These missions demand sophisticated and automated fleet planning and replanning. This involves considering the overarching objective while optimizing the allocation of roles and tasks to the available robotic systems. This optimization process takes into account multiple objectives related to time, quality, and the quantity of resources mobilized, each assigned varying degrees of importance.

To address this problem, the proposed PhD subject aims to utilize AI Planning approaches [1], particularly hierarchical approaches (HTN) [1]. These approaches enable the definition of complex environments and provide the flexibility to describe mission planning problems at various levels of granularity. However, it's worth noting that the representation used in general HTN planning does not explicitly incorporate time, and there is no commonly accepted standard language for hierarchical planning with temporal constraints within the community.

Nonetheless, a recent development in this area is the introduction of a syntax and semantic formulation for describing Temporal HTN problems in HDDL2.1 [2]. The primary objective of this thesis is to build upon this work and develop a hierarchical temporal planner capable of generating complex missions. As our needs for expressivity evolve, the planner will adapt accordingly. The development of such a planner will significantly advance the state of the art, as there are currently very few planners that operate under this paradigm.

In addition to evaluating the proposed planners, an industrial case study will assess the effectiveness of the approach and its integration into robotic platforms. This evaluation will utilize simulation tools and sea trials to ensure practical applicability.

[1] To get acquainted with AI Planning, we highly recommend installing and testing the PDDL4J library, which can be found at this address: `http://pddl4j.imag.fr/`.

Expected Results

We wish to develop three contributions during this thesis:

- To develop an HTN Temporal planner
- To propose an approach (based on the planning algorithm) to specify recovery strategies (actions to be taken in case of failure in the plan execution)
- To integrate the approach on a robotic platform, real or simulated, and assess the effectiveness of the approach.

Candidate Profile

We are looking for a candidate with expertise in at least one of the following areas: **constraint programming, SAT, SMT, heuristic search, optimization, linear optimization, operations research, or planning**.

The ideal candidate should have:

- A master's degree (M2) in computer science with a successful research experience.
- Advanced programming skills (design and implementation), especially in Java, C++ or Rust
- Strong academic background demonstrating the ability to bridge theory and practice.
- Proficiency in both spoken and written professional English.
- General knowledge in the field of artificial intelligence.
- Preferably be a citizen of the European Union (EU) due to the sensitive nature of the research conducted.

Procedure and Contact

Please send the following documents to `Damien.Pellier@imag.fr` and `aalbore@onera.fr`:

- Your master's degree (M1 and M2) certificate in computer science/applied mathematics with your grades.
- Your CV.
- At least one letter of recommendation.
- Your master's thesis and any publications, if applicable.

We invite interested candidates to familiarize themselves with automated planning and complete the online tutorial at http://pddl4j.imag.fr/. We also invite candidates to complete one of the following exercises: Monte Carlo tree search or SAT planning, available at this address: http://pddl4j.imag.fr/repository/exercices/, and to share the code with us on GitHub.

Applications are processed on a rolling basis. You will be promptly notified by email regarding the acceptability of your application and if you are invited for an initial interview.

References

[1] M. Ghallab, D. Nau, and P. Traverso. *Automated Planning: Theory and Practice*. The Morgan Kaufmann Series in Artificial Intelligence. Morgan Kaufmann, Amsterdam, 2004.

[2] D. Pellier, A. Albore, H. Firino, and R. Bailon-Ruiz. HDDL 2.1: Towards Defining an HTN Formalism and Semantics with Time. In *ICAPS workshop on HTN Planning*, 2023.