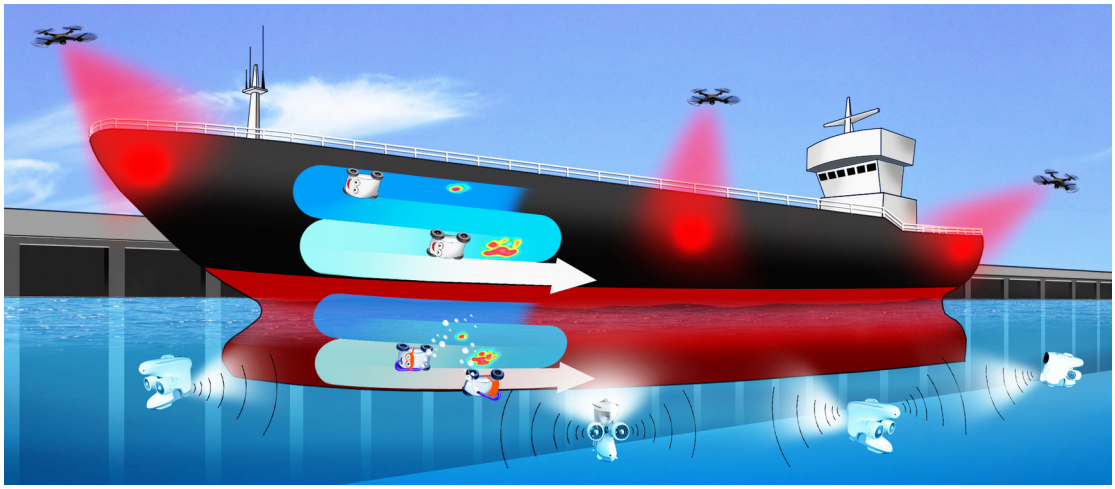
PhD Thesis Offer

Team INRIA-INSA Chroma, Lyon

Title	**Multi-Robot Planning with Spatial Constraints for Coverage Tasks**
Thesis supervisors	*Olivier Simonin, Prof. INSA Lyon* *Christine Solnon, Prof. INSA Lyon* Labo CITI, équipe Inria Chroma, INSA Lyon.
Grant	INSA grant, funded by the European project BugWright2 (2020-2024) – to start in sept/oct. 2020.
Key words	Motion Planning, topological and spatial constraints, multi-robot system, coverage problems
Contact	olivier.simonin@insa-lyon.fr christine.solnon@insa-lyon.fr



Context

This PhD thesis is funded by the european project BugWright2 (2020-2024), which aims to deploy autonomous robots for ship hull inspection and cleaning. Three types of robots will be used : magnetic-wheeled crawlers operating directly on the surface of the structure, Micro Aerial Vehicles (MAV) and small Autonomous Underwater Vehicles (AUV) for visual inspection (see figure)

This PhD thesis concerns the magnetic-wheeled crawlers operating on the surface of the structure. These robots communicate with a control station and are powered by a cable (not represented in the figure). This cable also brings pressurized water to measure the flow at the surface (with a specific sensor). The fairly heavy cable falls vertically under the robot along the hull. It is nonetheless a constraint for the robot's movement, and an obstacle for the other robots. Besides, the hull of a boat is not without reliefs or obstacles. It cannot be reduced to a simple 2D flat surface.

The thesis aims to model these constraints and to define algorithms planning the trajectory of the robots so that they achieve full coverage of the hull (or part) in minimum time. As any robotic system, the execution of the plan can be disrupted by hazards, preventing its success. Thus, we will seek to produce robust plans, but also to adapt these plans online (for example by partial re-planning).

Methodologies and objectives

Multi-robot planning is a subject that has been widely studied, and the thesis will start with a state of the art on the different existing approaches (eg. [1,2,4,5]). Then, we will aim to model the specificities of the problem, which presents unusual constraints such as cable-obstacles and a pseudo-plane surface to cover. For this, an interaction with the BugWright2 project partners will be possible, to gather the field experience of the current remote-operated system.

The integration of these spatial constraints will be at the heart of the planning solutions developed in the thesis. For this, we will consider tools such as:

- graph algorithmics for offline and online multi-agent path planning, based on exact and heuristics methods (e.g. [4],[7]).

- constraint programming, cf. [3,8], and meta-heuristics [6],

- uncertainty modeling and computation of robust plans (e.g. [4]).

The solutions developed in the thesis will be evaluated in particular by considering the criteria of time and robustness. For this, we will use a simulation tool available in the project, which we will extend to the objectives of the thesis.

Finally, once the efficiency of the solutions will be demonstrated in simulation, they will be evaluated with real robots in the framework of the BugWright2 project.

Profile and skills

The candidate will have a Master 2 level or equivalent, in computer science, AI or robotics. Experience in planning, constraint programming, or optimization will be a plus.

Application

Contact by email Olivier Simonin (olivier.simonin@insa-lyon.fr) and Christine Solnon (christine.solnon@insa-lyon.fr) with :
- a CV
- any document supporting your application.

Références

[1] Steven M. LaValle, Planning Algorithms, Cambridge University Press, 842 pages, 2006 (http://lavalle.pl/planning/)
[2] Ghallab Malik, Nau Dana S., Traverso Paolo, Automated Planning: Theory and Practice, Morgan Kaufmann, (2004).
[3] Roman Barták, Miguel A. Salido, Francesca Rossi, Constraint Satisfaction Techniques in Planning and Scheduling, Journal of Intelligent Manufacturing manuscript, 2010.
[4] Glenn Wagner, Howie Choset, Path Planning for Multiple Agents Under Uncertainty, ICAPS 2017.
[5] Yaniel Carreno, Eric Pairet, Yvan Petillot, Ronald P. A. Petrick, Task Allocation Strategy for Heterogeneous Robot Teams in Offshore Missions, AAMAS 2020.
[6] Jin-Kao Hao and Christine Solnon. Meta-heuristics and Artificial Intelligence. In A Guided Tour of Artificial Intelligence Research, volume II of AI Algorithms. Springer, 2020.
[7] A. Renzaglia, J. Dibangoye, V. Le Doze, O. Simonin, “Combining Stochastic Optimization and Frontiers for Aerial Multi-Robot Exploration of 3D Terrains”, IEEE/RSJ IROS, in Proc. pp 4121-4126, IROS 2019.
[8] Francesca Rossi, Peter van Beek, Tobby Walsh. Handbook of Constraint Programming (Foundations of Artificial Intelligence). Elsevier Science Inc., 2006.