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XXXVI Cycle

Auction-based task allocation and motion planning for multi-robot system with human supervisor

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Research context and motivation

Research context:

- In the near future, **multiple robots** will collaborate to significantly impact different social fields: from search and rescue to industrial applications, from oceanic exploration to precision agriculture.

Motivation:

- **Multi-Robot Systems** (MRSs) have intrinsic **advantages** over Single-Robot Systems (SRSs): **parallel** system and higher **execution efficiency** than SRS when executing tasks.
- The MRS has **shared goals** composed of different tasks.

How to handle these goals?

- Combining methods including **task allocation** to plan the **scheduling**, and **motion planning** to compute the **cost** for the task allocation and to compute feasible paths to **execute** the plan. Both blocks work together to solve the **multi-robot task allocation problem** (MRTA).

Addressed research questions/problems

Problem

In real-case scenarios, MRSs are often supported and **supervised by humans.**

The dependence on humans can lead to disadvantages in situations where robots have to operate in **dangerous situations**.

Reducing the number of humans has two important **advantages**:

(i) few operators decrease confusion and coordination problems;

(ii) the number of human errors is reduced.

On the other hand, the use of **fully autonomous** robots may lead to **ethical and safety problems**.

For instance, making decisions in search and rescue applications is not an easy task for an autonomous system: where to concentrate rescue? What kind of risks to take? Whom to rescue first?

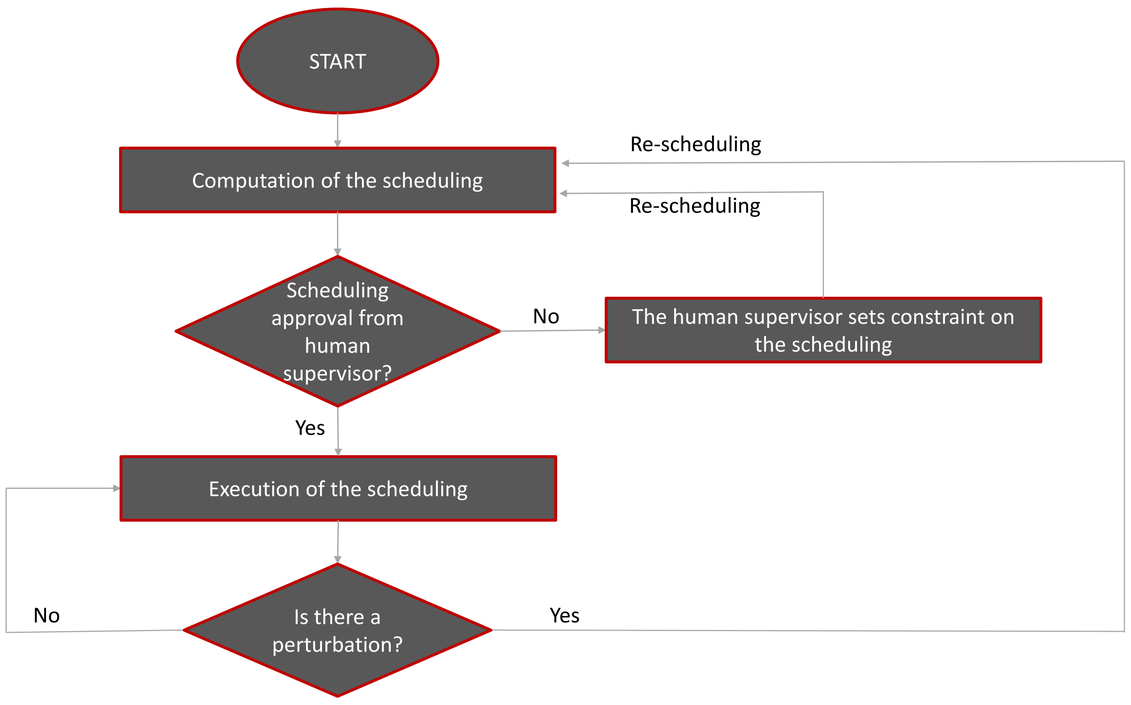
How to address the problem?

The adoption of a **human supervisor** to oversee a MRS can be a good compromise to manage **ethical and safety** issues.

The human supervisor interacts with the MRS by performing the following **actions**:

(i) approve the final scheduling before execution;

(ii) add constraints on the scheduling (e.g. force a particular robot to do a task).



Research collaboration

LEONARDO

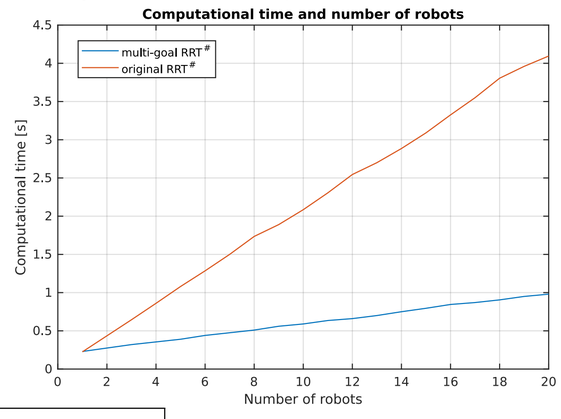
Politecnico di Torino

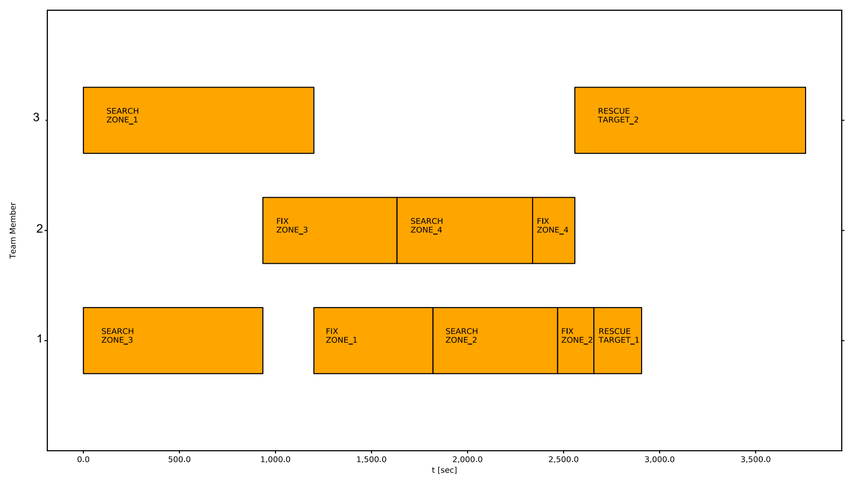
Submitted and published works

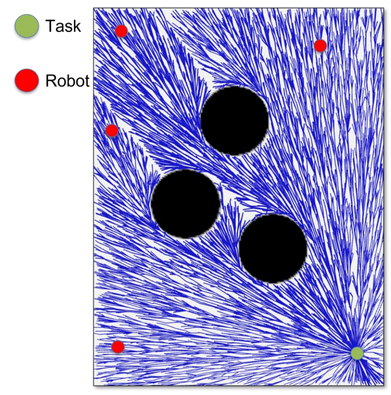
- Galati G., Primatesta S., Grammatico S., Macrì S. and Rizzo A. (2022).“*Game-theoretical trajectory planning enhances social acceptability for humans*”, Scientific reports (Submitted)

Novel contributions

- We propose an **auction-based** for a heterogeneous team in a dynamic scenario with **human supervision** considering precedence between tasks, priority between goals, and re-allocation due to a perturbation also caused by the human supervisor;
- The use of the **multi-goal $RRT^{\#}$ algorithm** takes full advantage of the inherent properties of the auction;
- Unlike the state of the art that apply the auction to plan an **autonomous team**, our study builds a system that **supports** the final decisions of the human supervisor.



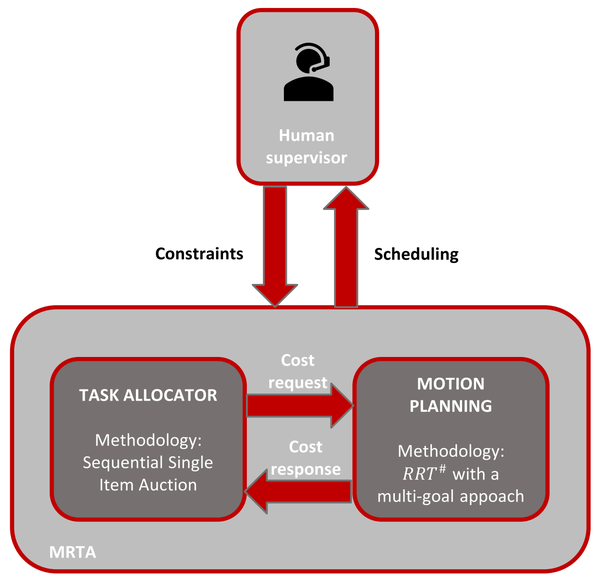




Adopted methodologies

To solve the multi-robot task allocation (MRTA) problem we designed two blocks:

1. The **task allocator** is based on a sequential single item auction;
2. The **motion planning** is based on a $RRT^{\#}$ with a multi-goal approach.



Future work

- Improvement of the **solution’s quality** by adding a heuristic approach after the auction;
- Management of **collaborative task**, i.e. task handled by multiple drones simultaneously;
- Include considerations on the **communication** that may be unreliable due to environmental factors (e.g. adverse weather conditions);
- **Different plans** can be scheduled by changing the cost function of the motion planning. Then, the human supervisor should have the possibility to choose the most appropriate plan based on the scenario.

List of attended classes

Hard skills:

- 01QTVRS – Behavioural theories (08/02/2021, 3 CFU)
- 01QTEIU – Data mining concepts and algorithms (01/02/2021, 4 CFU)
- 02RBYKI – From science to business: how to get technology out of laboratories and into practical applications (08/07/2021, 4 CFU)
- 01QSARP – Heuristics and metaheuristics for problem solving: new trends and software tools (15/03/2022, 4 CFU)
- 02SFURV – Programmazione scientifica avanzata in Matlab (27/04/2021, 6 CFU)
- 01QFFRV– Tecniche innovative per l’ottimizzazione (26/02/2021, 4 CFU)

Soft skills:

- 01UNRRV – Entrepreneurship and start-up creation (02/07/2021, 8 CFU)
- 01RISRV – Public speaking (13/01/2021, 1 CFU)

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