PHD PROPOSAL

Titre/Title	**Coordination and cooperative control of an autonomous connected fleet of heterogeneous robots**
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Laboratoire/Laboratory	Institut de Recherche en Informatique, Mathématiques, Automatique et Signal – (IRIMAS) UR 7499, Université de Haute-Alsace, France Karlsruhe Institute of Technology (KIT, Germany)
Lieu (si hors UHA)/ Place (if it is out of UHA)	University of Haute-Alsace, ENSISA, Mulhouse
Mots clés/Key words	coordination, cooperative control, heterogeneous robot fleets, autonomous robotics, fault tolerant control, energy minimization.
Descriptif du sujet/ Project description	**Context and motivation** As robotics becomes more and more widely used in various fields of application, the technological challenges of managing fleets of heterogeneous, connected, and autonomous robots are opening up an important field of research. Also, in an energy context eager to provide innovative solutions, the coordination and cooperation of intelligent robots to carry out complex tasks provide an original response to the problem. These cooperative aspects are supported by the heterogeneous nature of the fleet. This heterogeneity is provided by robots of different characteristics but with complementary natures with the aim of carrying out a task (parcel deliveries, personal assistance, production or manufacturing, distributed sensing, military applications, etc.) in a cooperative way. In this context, work involving mobile robots coupled with quad-rotor UAVs is currently being extensively studied. This ability to provide aerial support for complex tasks offers an innovative solution, but also includes challenges in terms of automatic control design as well as in coordination architecture. The aim of this research is to contribute to the theoretical and methodological development of improved cooperative control techniques for a heterogeneous robot fleet. This project will be lead in collaboration between the KIT (Germany) and the IRIMAS-UHA (France) in the framework of the Digital Process Engineering for Sustainable Materials and Energy chair. **Objectives** The idea of managing a heterogenous robot fleet composed of a drone fleet in cooperation with mobile robotic bases is the focus of this PhD. project. The main objective is the coordination of the robots operating in a constrained, shared (other robots, etc.) and uncertain (obstacles, etc.) navigation space. This includes the ability to adapt to faults or/and loss of efficacy of robots. Application examples cover the coordinated “delivery” of objects to a dynamic *rendez-vous* point or the realization of a dynamic robotic sensor network allowing for distributed measurements and coverage.

The outcome of these tasks is a cooperative framework for fleet management. It will be assumed that low-level controllers as well as localization and perception systems are functional, making the work dedicated to high-level fleet management, such as fleet planning and coordination. Therefore, the major contributions expected of this work are in the proposition of new fault-tolerant high level coordination architecture as well as in their real-time reconfiguration according to the navigation situation. The aim of the project is to develop a methodology for designing, simulating, and validating these control architectures under real-life conditions. These approaches will be based on techniques such as consensus control, platitude and MPC. The formalization of problems in the form of constrained optimization problems is the theoretical framework particularly well suited to address this problem. The minimization of the global energy spent of the fleet required to achieve the mission is an interesting topic will be also considered as a hard constraint.

Program

The various tasks envisaged to carry out this thesis project are as follows:

- Literature review on swarm robotics, heterogeneous robot teams, coordination control architectures
- Evaluation in simulation of some selected control architectures available in the literature but adapted to our specific problem
- Proposition of novel high-level fleet management control architectures under faults conditions
- Evaluation the performance (energy consummation, etc.) and scalability of the proposed methods through simulation

References

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T. Abukhalil, M. Patil, S. Patel, and T. Sobh. 2016. Coordinating a heterogeneous robot swarm using robot utility-based task assignment (RUTA). In Proceedings of the IEEE 14th International Workshop on Advanced Motion Control. 57–62

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Applications

To apply for the thesis position, please send the following documents to Prof. Michel Basset (michel.basset@uha.fr) and Prof. Thomas Meurer (thomas.meurer@kit.edu).

- A complete CV
- A cover letter
- Provisional transcript(s) of your master's and/or engineering grades
- Recommendation letter(s)