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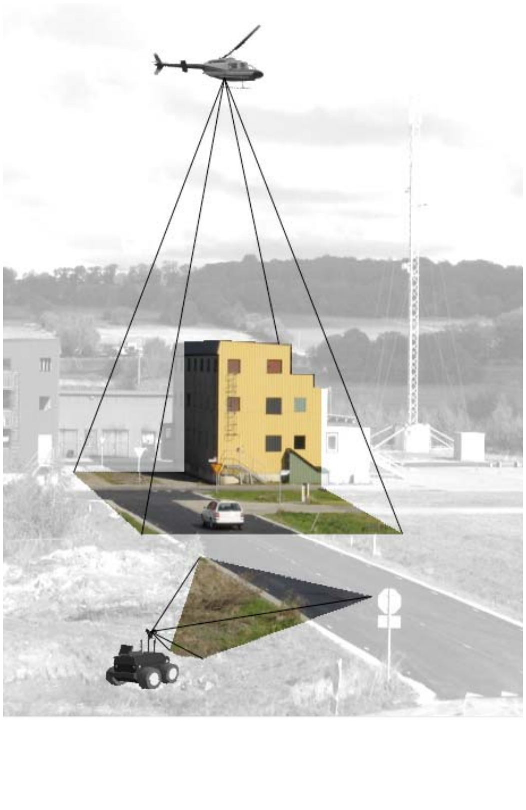
Abstract:
Autonomous mobile robotics has been a research topic studied at LAAS/CNRS since the late 70's. We have always favoured a constructive and integrative way of thinking robotics, aiming at defining robotics as a wholesome scientific discipline. A wide variety of problems are studied: environment perception and modelling, path planning, task planning, task execution control, motion control, decisional architecture, heterogeneous multi-robots systems, learning, human robot interaction...

Within field robotics, our focus is currently on aero-terrestrial multi-robot systems



Detailed research information:

An historical overview

Autonomous mobile robotics has been a research topic studied at LAAS/CNRS since the late 70's. The laboratory has always favoured a constructive and integrative way of thinking robotics, aiming at defining robotics as a wholesome scientific discipline. A wide variety of problems are studied, from the "classic" foundations of robotics (environment perception and modelling, path planning, task planning, task execution control, motion control...) to more advanced topics (decisional architecture, heterogeneous multi-robots systems, learning, human robot interaction...).

Work on field robotics has been initiated in the late 80's, with studies on the definition of planetary rovers, see figure above. Research held during the following decade has been dominated by this context, and dealt with rover autonomous navigation in unknown, unstructured environments. Pioneer work have been achieved, on environment modelling and localisation using vision, on path planning and motion control on rough terrains for articulated chassis. Work on decisional architecture for autonomous systems gained maturity, and the designed concepts lead to the development of integration tools.

At the end of the 90's, the considered applications shifted back to earth, in the context of intervention robotics for civil and defence applications. As compared with planetary exploration, such contexts present many changes: the robots and the environment are dynamics; previous knowledge on the environment can be exploited, although it is rarely accurate enough nor up to date, men can be integrated in the overall control loop... These evolutions could be understood as "eases" with respect to the planetary context, but on the contrary, they raise numerous hard challenges. In particular, the robot is not anymore a single well-defined system with clear boundaries: it is embedded within a communication system -- not systematically effective, a command system, and has too cooperate with others.

These contexts lead us to start activities in aerial robotics. An autonomous blimp project (over since 2007) has been initiated, and work on flight control and environment modelling with low altitude imagery has been achieved. With fixed-wing drones, recent work has been devoted to formation flight and autonomous ground target visual tracking.

Overall, robotics at LAAS now gathers 80 people (research scientists, university professors, visitors, postdocs and PhD students) around a dozen of robots (2 UGVs (see figures below), 4 UAVs, one humanoid, 3 indoor service robots)

Current research activities

Our focus is on aero-terrestrial multi-robot systems, which make sense for a wide range of missions (exploration, surveillance, intervention). Most of our research in field robotics is now targeted towards such systems, within which many basic robotics functionalities must be completely revisited and numerous new challenges are to be tackled. Two main threads or research, naturally not independent, is considered: environment modelling and vehicle localization from multiple sources, and distributed decision making within multiple robot systems.

Environment modelling: we aim at building and maintaining a large-scale multi-purpose composite environment model, using all the available sources of information (vision, be it monocular, binocular and panoramic, Lidars and soon probably radars, but also initial information as provided by an existing standard GIS). Within a multi-robot system, information related to the environment is at the heart of the robots autonomy and of their cooperation schemes, as it is required for a large variety of tasks: to set goals to reach, to plan motions, to assess the feasibility of perception or communication tasks, to localize the robots, etc. As a consequence, the overall environment model is a multi-layered composite structure, each layer containing the information dedicated to a given process (e.g. a digital terrain model is exploited to plan rover trajectories, a volumetric 3D model is exploited to plan perception and communication tasks, etc). Our goal is to endow a multi-robot system with the ability to build and maintain such a model, and to provide the necessary functions to update it, but also to exploit it for the purpose of the robot fleet operational needs. Two essential properties must permanently be maintained: its spatial consistency, mostly ensure thanks to distributed multirobot SLAM processes, and its symbolic (or semantic) consistency. Stochastic processes naturally constitute the core of the work on these issues.

Decision-making: we tackle the issues along two directions, always with in mind that they are to be integrated within overall distributed system architecture.

Mission planning and management centred on task allocation processes: task allocation is an essential decisional activity in multi-robot systems that set the distribution of the tasks achievement among the available robots. We consider complex missions, in which the set of tasks to achieve is not a priori known: task planning must therefore be handled incrementally and jointly with task allocation. We explicitly consider communications as tasks that must be planned, in order either to satisfy communication requirements specified in the mission, or to share information among robots. In the latter case, environment models and the model of information gathering functions are exploited to trigger communications among the robots.

Decision theoretic planning: most field robotics missions are information-gathering missions, e.g. to explore a given area, detect targets or environment modifications. The models of the environment and of the robot perception tasks play a central role in such missions, and their stochastic nature naturally leads to the consideration of a decision theoretic framework to deal with the robots actions: motions, perceptions, and communications.