Distributed re-planning with bounded time resources in the ARTEMIS project

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Abstract
This paper shortly presents some aspects of the ARTEMIS project dedicated to the development and testing of algorithms for distributed planning with bounded time resources. The ARTEMIS project addresses the problem of future mission management systems (MMS) for uninhabited air combat vehicles (UCAVs) acting in cooperation (possibly with other inhabited aircraft) in combat mission such as the attack of an enemy target. The challenges for such MMS are related to both the architectures and the algorithms for autonomous decision and information processing onboard such UCAVs. We present the distributed re-planning problem under time constraints and a sketch of our approach to solve it.

INTRODUCTION
Significant research efforts have been devoted to new technologies needed for the development of onboard mission management systems for uninhabited air vehicles (UAVs). As a matter of fact, current UAV systems are mostly remotely controlled by an operator that can control the aircraft flight plan by choosing way-points or targets to be achieved by an on-board auto-pilot. Current concepts of use of UAVs are very close to the use of aircraft in the early years of aviation: missions of reconnaissance, observation, etc. These concepts of use are very likely to change with progress in the area of UAV autonomy. Constraint model-based planning is a promising framework for such applications [1]. The MISURE project [2] addresses the feasibility of a mission management system using similar constraint programming techniques for a package of UCAVs involved in an attack mission. However, limited computation time resources and distribution constraints are not addressed in MISURE. The ARTEMIS project [3] takes into account these two constraints. We develop algorithms for distributed re-planning with bounded computation time resources. We also consider the possible intervention of the operator, but rather as an external event that may cause the MMS to re-plan the mission. Our efforts are more focused on the necessity of bounded time cooperation schemes among distributed planning agents in order to achieve coordination and collaboration towards common goals while dealing with communication limitations. The agent decisional architecture, inspired from autonomous robots, was prototyped using ProCoSA [4].

MISSION
The mission considered in the ARTEMIS project roughly consist in the attack by a package of 4 to 8 UCAVs of a number of targets in enemy zone. The UCAVs can organize their cooperation at planning time. The package can split in sub-groups of UCAVs that can realize sub-tasks before rejoining other. Due to communication limitations Figure 1 shows a sketch of the problem situation. Before the mission starts, a mission pre-planning phase always occur, during which:
• primary (and secondary) targets are designated,
• known threats are identified,
• the airspace is divided into a number of zones that expresses tactical constraints such as: the “attack zone”, “flight corridors”, etc. Corridors are 3D volumes associated with time constraints.

CONSTRAINT BASED RE-PLANNING
The constraint model-based planning problem is defined in a form similar to the work in [1] and [2], but in a distributed re-planning context. The implementation of each agent re-planner is made using the CHOCO [5] library. A mixed integer programming version of the re-planning problem using CPLEX [6] was also developed in order to have a reference solution on simple instances, so as to study the possible loss of performance caused by the computation time and distribution constraints in the solution of the re-planning problem. Each agent re-plans in bounded time by applying the decision-repair paradigm proposed in [7], combining a local-search scheme (such as Tabu search [8]), the management of explanations and constraint propagation techniques.
COOPERATION BETWEEN PLANNERS

The cooperation between distributed agents is based on the coordination of the distributed planners within a communication group: a group of UCAVs that can communicate with each other without limitations during the bounded time re-planning process. Different cooperation schemes have been envisioned for the ARTEMIS project. Few of them can be efficiently controlled in order to guarantee a bounded time response in all circumstances. The scheme that we selected is based on a selection of propositions [9][10] by a planning coordinator within a communication group. This type of method is not iterative and involves basically two steps. The group coordinator initiates the re-planning process. Each agent formulates a finite set of propositions about the actions it could perform. The coordinator selects a single proposition per agent such that interaction constraints are satisfied and optimizes a global criterion, at the group level. Further refinement is possible if more time is available.

CONCLUSION

We have presented the ARTEMIS project, its current status and the ongoing developments. Uncertainties are partly taken into account, for instance via some probabilities of kill or of survival. Beyond ARTEMIS, a more thorough combination of constraint based planning and a planning under uncertainty framework should be studied in order to better address real world problems.

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REFERENCES


Figure 1 : mission for a package of UCAVs.