A Mixed-Initiative System for Human-Robot Interaction with Multiple UAVs in Search and Rescue Missions

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We present a mixed-initiative system suitable for human-multiUAVs interaction in search and rescue missions. This work is framed within the SHERPA project [13] which aims at developing a mixed ground and aerial robotic platform that supports search and rescue activities in a real-world alpine scenario, like searching for missing persons, patrolling a dangerous area, etc.. One of the original aspects of the SHERPA domain is the presence of a rescue operator that works in team with a set of aerial vehicles in order to accomplish the rescue mission. In this context, the rescuer plays the role of the *busy genius* of the team which is co-located with the robots and operative in the rescue scenario. Differently from typical human-multidrones interaction scenarios [4, 10], here the *busy genius* is not dedicated to the robots control, instead he might be deeply involved in a specific task, or present and capable to directly operate the robots, or only able to provide sketchy, although high-value, inputs. This scenario requires a framework that supports adjustable autonomy, from explicit teleoperation to a complete autonomy for the robots, and an effective and natural mixed-initiative interaction between the human and the robots [9].

The framework presented in this work should allow a single human operator to supervise and orchestrate the operations of a set of UAVs by means of a natural multimodal communication (using gestures, speech, joypad, tablet interface, etc.) supported by adjustable autonomy. In the proposed approach, we assume a high-level supervisory system that can compose and execute structured robotic tasks while the human rescuer can provide interventions when necessary. These interventions range from abstract task assignments for the multi-drone system (e.g. new areas to explore, search strategies definition, paths to follow, etc.) to navigation adjustments (e.g. deviations from planned paths or trajectories) or precise maneuvering of single robots (e.g. inspection in cluttered environments).

More specifically, the proposed human-robot interaction framework combines a multimodal interaction module [11, 7] with a hybrid mixed-initiative supervisory system [2]. The latter is composed of a multirobot supervisory system interacting with single robot supervisors. For each supervisor, the executive control cycle is managed by a BDI (Belief Desire Intention) system [5] that orchestrates task planning, switching, decomposition, and execution. The robotic activities are represented as hierarchical tasks which are continuously instantiated and supervised by the executive system depending on the environmental events and the human requests. In this setting, the operator is allowed to continuously interact with the supervisory systems at different levels of abstraction (from

high-level tasks assignment/switching to path/trajectory adjustments) while these human interventions are interpreted, monitored, and integrated exploiting the planning and execution control loops. Indeed, following a mixed-initiative planning and execution approach [6, 3], these interventions can be associated with system reconfigurations which are managed by task/path/trajectory replanning activities. Analogously to [2], these plannig/replanning engines are strictly intertwined in order to address mission, path, and control constraints.
In order to evaluate the effectiveness of the proposed system, as a preliminary case study, we designed a simulated rescue and search environment where a human operator interacts with a set of UAVs in order to accomplish typical searching tasks [12, 1] in an alpine scenario.

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