Supervised Task Performance of an Autonomous UAV Swarm, Supporting and Implementing Fire-Fighting Procedures*

Sascha Hornauer[1], Florian Frische[2], Andreas Lüdtke[2], and Jürgen Sauer[1]

[1] Carl-von-Ossietzky University of Oldenburg, Germany
[2] OFFIS – Institute for Informatics, Oldenburg, Germany

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1 Introduction

Currently, it is not well understood, how and to what extent a swarm of agents, performing a task, benefits from supervision and guidance by a human operator. At the same time it is considered vital to keep a human operator in the loop to make informed decisions and improve the behaviour of agents in situations which can not be anticipated beforehand. There are investigations into human agent interaction, which mainly focus on aspects as the design of a graphical user interface or the optimisation of the behaviour of the agents [1]. In similar work, the way to exercise control is often chosen arbitrarily, focused on the research question at hand. We present a framework for the comparative evaluation of ways of interaction, varying in autonomy and automation according to established taxonomies [2], which was developed and tested as part of a diploma thesis. As a result we seek to devise general principles when designing ways of interaction, to anticipate repercussions in the task performance of a controlled swarm of agents.

2 Research Topic

How ways of interactions can be developed and their influence on task performance has been researched by studying agents which fly models of unmanned aerial vehicles (UAVs) in a flight simulator, to observe their interaction with a model of an operator while working on a task. A framework was implemented to simulate both the UAVs and the operator to develop various ways of interaction and assess their impact on the performance in a fire fighting scenario.

3 Methodology

The agents were designed to exhibit a self-organising swarm behaviour to supply a high degree of autonomy, while in some scenarios the modelled UAVs were

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allowed to detach from the swarm and fly more independently. The behaviour was implemented according to a concept, investigated by C.W. Reynolds, where UAVs choose their heading and airspeed depending on vectors which direction and length are calculated based on their neighbours' positions [3]. The objective for each UAV was to extinguish every single fire known before deployment or hidden ones which were revealed during the flight.

4 Results

A conducted evaluation, using the framework, showed it is possible to trace aspects of the task performance back to design decisions for ways of interactions. In most of the classes of the conducted experiments, the explored area, the time and distance needed, and the number of times where the operator had to interact, varied significantly. Waypoint based approaches lead to detours and consequently to a slower task performance, however, the distance flown could be anticipated beforehand because of a very small variation between individual UAVs. In contrast, another approach relied heavily on the operator to select the order of fires to be extinguished and so favoured experienced operators. In small groups of agents this approach lead to good results because of the parallel task execution and direct flight routes. Furthermore, in order to scale the applicability to a greater number of agents another approach was developed where the operator only agreed or revised a planned order by the system. This approach could be shown to perform for the most part indistinguishable, while it needed only one affirmation for each planned order of fires for each UAV, thus reducing the total amount of interactions.

5 Conclusion

The requirements of the scenario and the experience of the operator have to be taken into account while designing a way of interaction. The developed framework can be used to devise and evaluate various ways of interaction and anticipate shortcomings and benefits. This can contribute to any research where human interaction with a group of agents is an elementary part. Because of the adjustable scenario, the research findings are also important in search and rescue situations as well as during the development of any UAV Ground Station.

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