

# Agent-Based Coverage Optimization Through Communication and Situation Aware MUAV Swarms

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**Abstract**—For efficient sensor coverage of large industrial and incident areas, fast and flexible strategies for collecting optical sensor data through an autonomous, wirelessly connected swarm of Micro Unmanned Aerial Vehicles (MUAV) is still an emerging challenge. Of particular interest are strategies for aerial coverage optimization of mobile networks and the acquisition of high quality image material targeting a photogrammetric 3D reconstruction of a region of interest. In MUAVs based swarms continuous and excellent communication links are inevitable for the success of the overall achievement of objectives. However, disregarding communication aspects in mission strategies is a common simplification. In this paper we examine an agent-based approach that targets (a) high spatial sensor coverage and (b) high quality communication links. For these key figures, the performance of the suggested algorithm is evaluated. We particularly focus on channel aware mobility and on self organizing mesh topologies of MUAV based sensor swarms.

## I. CONCEPT OF OPERATIONS

The considered operation tasks can be divided into two scenarios with similar constraints regarding the mobility behavior. A composition of the use cases is shown in Figure 1. The first area of application is the acquisition of images of certain regions of interest (ROI). Images from different MUAVs are captured and combined by mapping overlapping features. The second use case is the extension and support of mobile communication infrastructures through onboard base stations. In both cases an interconnection between the MUAVs is necessary to transmit telemetry data in order to organize the team strategies and to transfer application (payload) data. A common constraint for both applications is to maximize spatial coverage while ensuring interconnectivity of the MUAVs [1]. For the swarming strategies the MUAVs continuously need to communicate their current location and determine the wireless connection signals strengths (RSSI). Since the signal strength is not the only indicator of the network performance we also consider the network bandwidth, the available bandwidth for each robot and the resulting total throughput. Coverage optimization has been addressed using voronoi diagrams [2] and potential

fields [3]. However, most research is done with mobile communication nodes in the sense, that they are portable and once placed, stay put. Little research has been done on bio inspired agent based behavior models with coverage optimization and interconnectivity constrains using agile MUAV robots addressed in this paper.

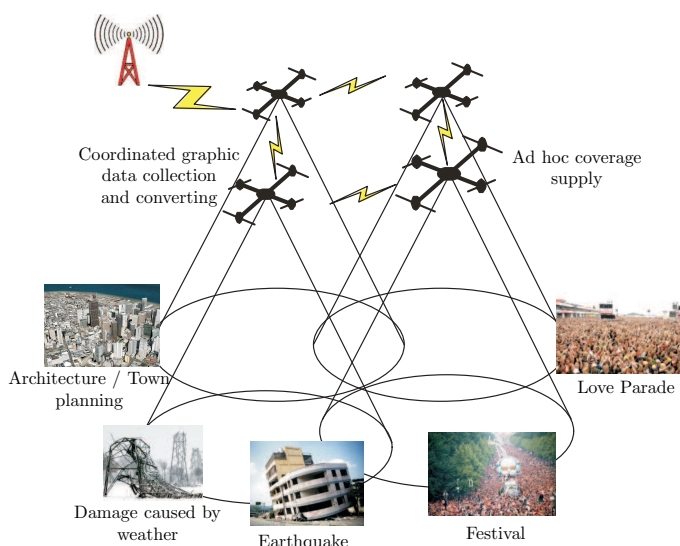


Fig. 1: AVIGLE Scenario

## II. SIMULATION ARCHITECTURE AND RESULTS

The simulation results presented in this work were created with the OMNeT++ discrete event simulation framework. Our mobility simulation is realized through custom algorithms based on the concept of steerings [4]. More specifically three complementing objectives and steerings have been identified:

- **Cluster Breathing:** local contraction and expansion in order to maximize coverage dependent on time variant channel properties
- **Cluster Fusion:** merge separated clusters to maintain overall connectivity

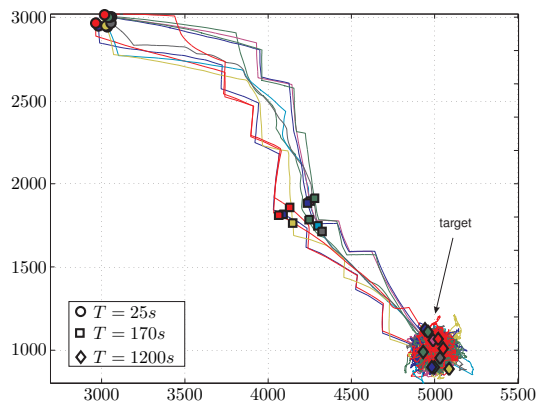


Fig. 2: Trajectory for 10 MUAVs keeping connectivity and maximizing coverage towards an Region of Interest

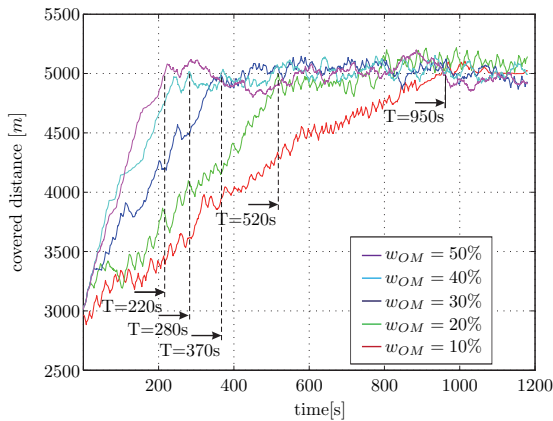


Fig. 3: Arrival Times for Movement in Target Direction for several weighting scenarios

- **Overlay Movement:** global mission objective in order to reach a specific target area

A trajectory showing the typical movement of the MUAV swarm is shown in Figure 2. The swarm is moving towards a target area while each individual agent is concurrently trying to keep an optimal connectivity to the swarm through the above mentioned algorithms. In Figure 3 a comparison of distinct weightings for the above mentioned steering behaviors have been conducted. It is possible to observe that for weightings with  $w_{OM} < 30\%$  the arrival time drastically increases.

In the full version of this paper we will show more detailed performance results while achieving a more realistic movement behavior. Perception of individual MUAVs will be taken into account while we elaborate on optimal strategies for centralized/agent based control.

#### ACKNOWLEDGMENT

Our work has been conducted within the AVIGLE-project Avionic Digital Service Platform), which is part

of the Hightech.NRW research program funded by the German ministry for Innovation, Science, Research and Technology in Northrhine-Westphalia since January 2010 for a duration of 3 years. AVIGLE is conducted in cooperation with several industrial and academic partners. We thank all project partners for their work and contributions to the AVIGLE project.

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