FAMUOS: A Multi-UAV System for Aerial Reconnaissance in Rescue Scenarios

M. Quaritsch, R. Kuschnig, V. Mersheeva, D. Wischounig-Strucl, S. Yahyanejad, E. Yanmaz, G. Friedrich, H. Hellwagner, Ch. Bettstetter, B. Rinner
Alpen-Adria Universität Klagenfurt, 9020 Klagenfurt, Austria
markus.quaritsch@aau.at

1 Introduction

Small-scale unmanned aerial vehicles (UAVs) have recently gained a lot of interest for various applications such as surveillance, environmental monitoring and emergency response operations. These battery-powered and easy-to-steer aerial robots with less than 1 m in diameter and about 1 kg in weight can be equipped with different sensors such as cameras and thus promptly acquire aerial images.

This paper reports on FAMUOS (Fully Autonomous Multi-UAV Operation System), a UAV system of the third generation where multiple networked UAVs act autonomously and its application during a real-world fire service drill. The goal of our system is that multiple UAVs cooperate and build an overview image of a defined area within minutes and thus allow the first time responders to assess the situation and coordinate their forces. We have developed a first prototype of our multi-UAV system and applied it in a real-world, large-scale fire service drill.

2 FAMUOS: System Description

The goal of FAMUOS is to operate multiple UAVs as autonomous as possible so that a single person can easily operate a set of five to ten UAVs. The user simply defines the high-level tasks, i.e., the area to be covered by the overview image, and assigns certain quality parameters such as the image resolution, update interval, etc. This is done through a simple user interface where the user sketches the area of interest (cf. Fig. 1 and Fig. 2 a). Everything else is done by the system itself as outlined in the following.

The *Mission Control* on the ground station takes the high-level tasks defined by the user and breaks it down into individual flight plans for the UAVs [1, 2, 3]. A flight plan basically consists of a sequence of waypoints (in GPS world-coordinates) and according waypoint actions such as *set orientation* or *take picture*. The UAV's on-board *Drone Control* executes these initial flight plan. Each UAV periodically reports its position to the ground station for monitoring the mission status. The acquired images are pre-processed on-board the UAV (assess image quality, extract image features, multi-resolution JPEG2000 encoding, etc.), annotated with certain meta-data and then sent to the ground station for computing the overview picture [4, 5] which is displayed on the user interface (cf. Fig. 2 b). Thus, the user is always aware of the current status of the mission execution.

Computing optimal plans for the individual UAVs is a computationally expensive task.

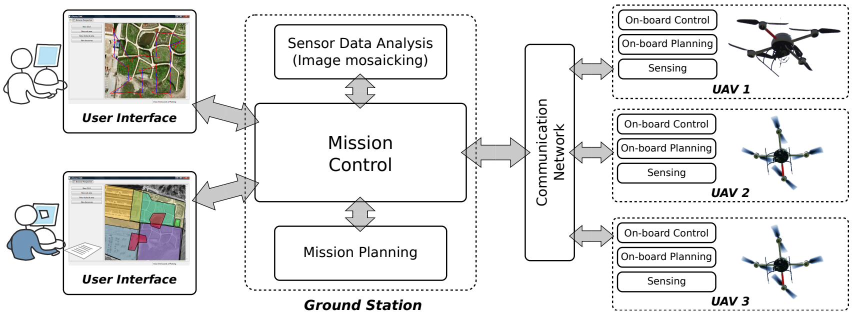
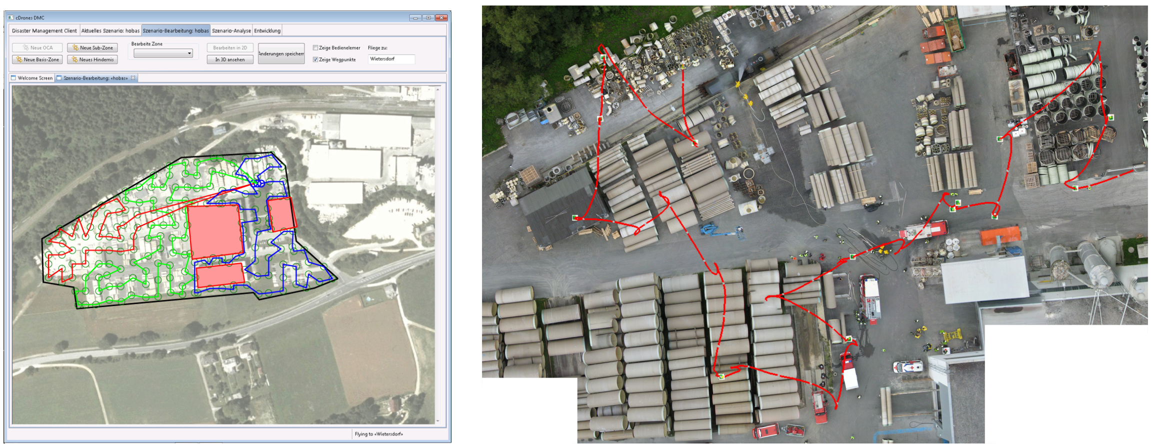


Figure 1: System Architecture



(a) User interface with observation area and planned routes.

(b) Part of the generated overview image and the UAV's flight trajectory.

Figure 2: Demonstration during fire service drill.

And in rescue situations time is an important factor. Thus, the mission control on the ground station computes initial flight routes for every UAV which can be adopted during mission execution either by sending updated plans from the ground station to the UAVs or by the UAV's on-board drone control. An adaptation of the flight routes may also be required in case the *Sensor Data Analysis* unit—either on the ground station or on-board the UAV—detects that certain areas need to be covered again (e.g., some already taken images were discarded because of bad quality).

3 Aerial Support for Fire Fighters

We applied and demonstrated our multi-UAV system in practice during a large-scale, real-world fire service drill with more than 10 fire brigades and about 400 fire fighters [6]. The assumption was that a railway car with dangerous goods (acid) is leaking. The UAVs are used to assess the situation at first without bringing people's life in danger. Thus, high-resolution images of the affected area are required within minutes. After the primary danger has been averted the UAVs have been used to monitor the progress of securing the hazardous liquid by updating the overview image periodically.

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