Helicopter Teleoperation for Aerial Monitoring in the COMETS Multi-UAV System

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Abstract

This paper presents a helicopter teleoperation system and its integration in the COMETS multi-UAV system. COMETS (http://www.comets-uavs.org) is a project funded by the European Commission in the IST programme. The project will be demonstrated in forest fire detection and monitoring. Moreover results and video demonstration of the experiments carried out in May 2003, at Gestosa (near Coimbra, Portugal) involving monitoring of forest fires are also included.

1 Introduction

Real-time monitoring of the evolution of the fire is very useful for forest fire fighting. This monitoring involves dynamic information about the fire front and other parameters such as the flame height and the fire front width. Furthermore, the computation of the distances from the fire to the fighting means, houses, roads and utilities is also important.

Aerial cameras are usually deployed on board of conventional aerial means (helicopters, airplanes) [1]-[11]. Flights near the fire, with low visibility conditions due to the smoke, could involve significant risk. Using smaller UAVs avoids these risks and decreases the operational costs.

In order to achieve those objectives, it is necessary to add some "special" hardware on board the helicopter (see Figure 1):

- Cameras and sensors to get data about helicopter attitude and environment,
- GPS devices to obtain the position of the helicopter,
- Wireless communication systems to send all this information to the ground station to be used by the pilot and the control center.

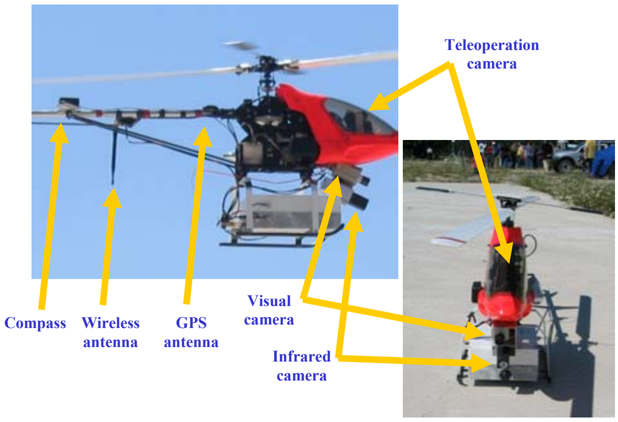

Figure 1. Teleoperated RC Helicopter.

This paper presents a teleoperation system which is integrated in the COMETS multi-UAV system.

COMETS (http://www.comets-uavs.org) is a project funded by the European Commision in the IST programme. The main objective of COMETS is to design and implement a distributed control system for the coordination of multiple heterogeneous Unmanned Aerial Vehicles (UAVs) with different autonomy degree. Currently helicopters and airships have been integrated. The system considers the cooperation of totally autonomous UAVs with purely human-piloted radio controlled aerial vehicles. This integration requires the consideration of constraints in the teleoperation system to assure the completion of missions guaranteeing strict safety conditions. The Mission Scenario of the project is forest fire detection and monitoring.

The paper is organised as follows: next section introduces the COMETS system. Section 3 presents the teleoperation station. In Section 4 experimental results are shown. The paper ends with conclusions and references.

2 The multi-UAV COMETS system

In the last years research on the coordination and cooperation of multiple UAVs and of multiple aerial and ground autonomous systems has been conducted [2] [7] [9] [11].

Several efforts are related to the coordination of homogeneous teams of aeroplanes [7]. The problems are related to the control of multiple UAVs (aeroplanes) in close-formation flight. Formation flights have been proposed as a way to deploy multiple sensors on the terrain. This strategy can be considered as biologically inspired (animals that have the ability to form formations such as flocks of birds). Multiple flying helicopters and groups of helicopters and ground vehicles are considered in BEAR. The research includes hierarchical multiagents system architectures for coordinated team efforts, vision-based pose estimation of multiple UAVs and ground vehicles, and pursuit-evasion games [11]. The cooperation between aerial and ground robots is also researched at USC. In [9] different cooperation cases are studied such as the use of an aerial robot in a marsupial-style deployment of a small wheeled robot and the localisation of an aerial robot by visually locating and communicating with a ground robot.

The main objective of the COMETS project [2] is to design and implement a distributed control system for cooperative detection and monitoring using heterogeneous Unmanned Aerial Vehicles (UAVs). Particularly, both helicopters and airships are considered.

In order to achieve this general objective, a control architecture has been designed, new control techniques are being developed, and the integration of distributed sensing techniques and real-time image processing capabilities is being considered. Figure 2 shows the overall COMETS system.

In order to test and validate these concepts and systems, COMETS considers as the goal mission the detection and monitoring of environmental disasters. Particularly, experiments and demonstrations in forest fire alarm confirmation, localisation and monitoring are being performed. This goal mission involves several challenges including:

i) control of individual UAVs flying close the fire,

ii) cooperation of multiple UAVs, which is needed due to the difficulties to obtain appropriated views (visibility problems);

iii) implementation of functions to improve the reliability of the individual UAVs and the full systems;

iv) the problem involves objective detection, localisation, automatic geo-referencing and tracking in a dynamic environment;

v) several resolution scales are required to maintain a global perspective of the affected area and to have details in some areas or around some objectives to protect;

vi) real-time fine resolution mapping of the affected area is also required.

The COMETS system will be demonstrated in forest fire detection and monitoring. The first experiments with two helicopter and one airship have been carried out in May 2003.

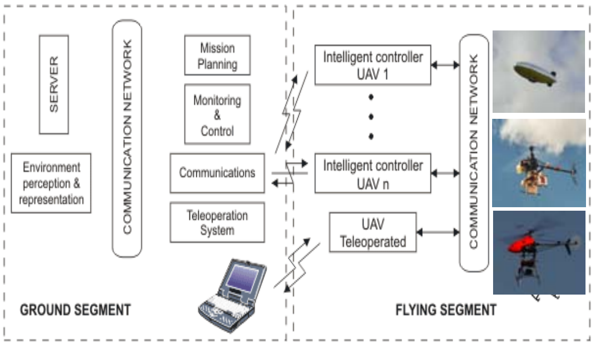

Figure 2. COMETS system.

Different UAVs have being integrated in COMETS. The Karma blimp has been developed at LAAS (Laboratoire d'Architecture et d'Analyse des Systèmes). KARMA is 8 meter long with 2.8 kilograms payload. It is an electrically propelled vehicle that can navigate up to 20km/h wind velocity. It carries on different sensors as: magnetic inclinometers, wind sensor, cameras, GPS …

MARVIN developed by the Technical University of Berlin [8], which won the AUVSI Aerial Robotics Competition in 2000, is based on a common model helicopter from series production. This helicopter has a main rotor diameter of 1.9 m and is powered by a single cylinder, 2-stroke, 2 kW petrol engine. The take-off weight off the fully equipped system is around 11 kg.

This paper is mainly concerned with helicopters initially developed by the company HELIVISION, by improving the performance of conventional radio controlled helicopters, which have been transformed by the Robotics, Vision and Control Group at the University of Seville by adding sensing, perception, communication and control functions (see Figures 1 and 3).

Figure 3. University of Seville-Helivision helicopter.

3 Teleoperation system

In the COMETS project a heterogenous group of UAV collaborate in monitoring and detection issues. That includes autonomous and remotely piloted vehicles. The teleoperation system facilitates the pilot work in low visibility conditions and makes possible the cooperation with other autonomous and remotely piloted vehicles.

Furthermore, the teleoperation systems can be also used as back-up of autonomous navigation system in case of difficult navigation conditions or difficult tasks that require human intervention.

The teleoperation system requires both hardware and software elements to perform its functions and to integrate it in the COMETS system

3.1 Hardware of the teleoperation system

The hardware of the teleoperation system is composed of both on-board and on-ground components.

The helicopter carries on a collection of devices devoted to perception and helicopter status monitoring. Thus the helicopter is equipped with:

- visual and infrared cameras,
- GPS,
- Attitude and velocity sensors

On the other hand the helicopter also carries on devices for data processing and data link with the ground station. Among them, a digital video server is used to acquire, digitalize, and send to ground the images from the on board video cameras. An on board microcontroller is also used to acquire and manage data form the other sensors.

Figure 4 shows the on board hardware devices and architecture.

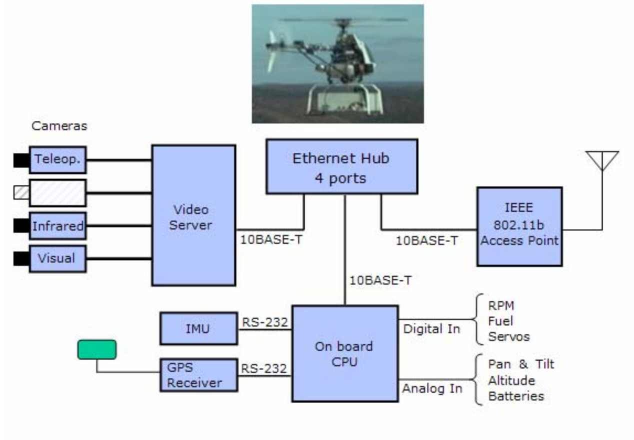

Figura 4. On board hardware setup.

The communication link with the on ground components is achieved by means of a wireless Ethernet IEEE 802.11b access point.

Figures 5 and 6 show the final setup of the devices on board the helicopter.

Figure 5. Setup for on board hardware

Figure 6. Helicopter on flight

With respect to the on ground hardware it should be remarked that the helicopter is controlled by using conventional helicopter remote control devices. Thus, an RC is used to control helicopter servos and another one is used to control the cameras. Data collected from the helicopter, as well as mission commands received from the COMETS central ground station are visualized on a notebook.

Figure 7 shows the on ground hardware setup.

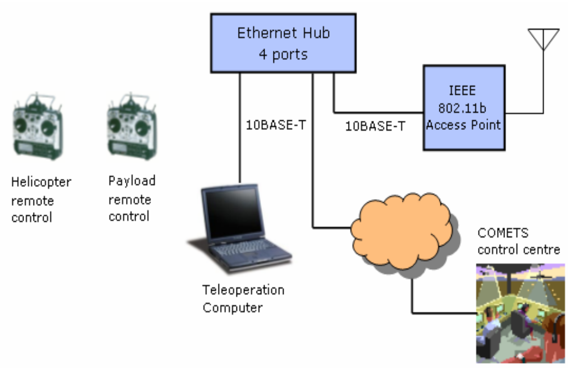

Figure 7. On ground hardware setup.

3.2 Software of the teleoperation system

The teleoperation software has three main functions:

- Helicopter communication
- Integration in the COMETS system
- Implementation of a Human Machina Interface (HMI).

The information acquired on board the helicopter (digital images, GPS data, velocity, altitude …) is transmitted over a wireless Ethernet link by using TCP/UDP/IP protocols. An important point is the variation of the available bandwidth due to distance, weather, obstacles, …

The integration in the COMETS system has two main goals. On one hand to distribute the information collected by the helicopter to the rest of the UAVs in the COMETS system and to the control centre. On the other hand, it provides to the pilot with valuable information about the position of the different UAVs as well as with waypoints to perform a specific mission, GPS corrections, etc. In this way, for instance, it is possible to perform cooperative perception and monitoring. Figure 8 shows this integration.

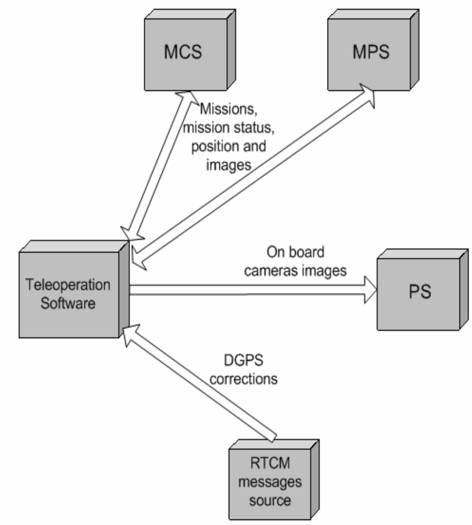

Figure 8. Software integration in COMETS.

Finally, a very important part of the teleoperation software is devoted to the Human Machine Interface. The HMI has been designed in such a way that it is possible to use a multi screen setup. Then a small screen can be placed on the pilot RC while others can be used to display more general information or just for camera control. Moreover, virtual reality glasses can be also used.

Figure 9 shows a detailed view of the instrumentation and mission tracking panel. This includes:

- GPS data,
- altitude,
- compass,
- helicopter trajectory,
- target waypoints,
- messages interchange,…

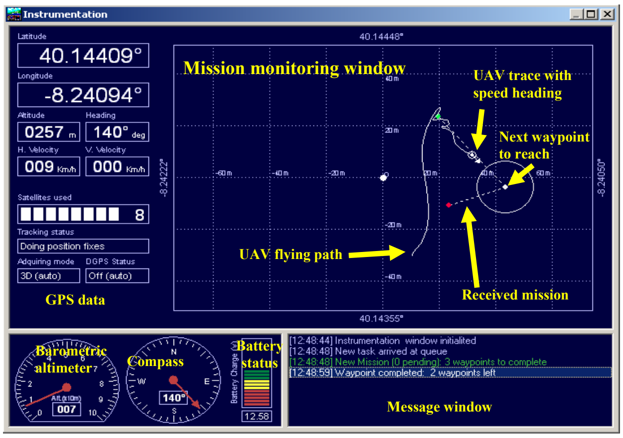

Figure 9. Instrumentation and mission tracking panel.

Moreover it is possible to show the video sequence from the on board cameras as well as to overlap relevant information to help the pilot in the mission execution, as shown in figure 10.

Figure 10. Teleoperation video camera with overlapped information.

4 Experimental results

During the days May 12 to May 18 of 2003 the COMETS system was tested in Coimbra (Portugal). In these experiments the teleoperation system performed mission tracking and fire monitoring experiments exhibiting a good overall performance.

Figure 11 shows a snap shot of the teleoperation station screen during a fire monitoring experiment. Figure 12 shows several photographs from the experimental setup. A full video of the experiments can be downloaded from the COMETS web site [2].

Figure 11. Teleoperation station screen during a fire monitoring experiment.

5 Conclusions

Unmmaned Aerial Vehicles can be a valuable tool to perform tasks such as data and image acquisition of targets and affected areas, localization of targets, tracking, map building and others, in dangerous areas.

The COMETS multi-UAV system devoted to implement a distributed control system for cooperative detection and monitoring using heterogeneous Unmanned Aerial Vehicles has been introduced. A helicopter teleoperation system and its integration in the COMETS system has been presented. Moreover results and video demonstration of the experiments carried out in May 2003, at Gestosa (Portugal) involving monitoring of forest fires have been also included.

6 Acknowledgments

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Figure 12 Fire monitoring experiments in Gestosa (near Coimbra, Portugal).

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