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TOWARDS AN AERIAL ROBOT FOR A REMOTE SENSING PLATFORM

JOSÉ LUIZ DE SOUZA PIO [1,2], CAMILLO JORGE DE OLIVEIRA [1]
MARIO FERNANDO MONTENEGRO CAMPOS [1]

[1]UFMG – Universidade Federal de Minas Gerais – Departamento de Ciência da Computação
Av. Antonio Carlos, 6627 – Pampulha – Belo Horizonte – MG, Brasil.
{josepio, camillo, mario}@dcc.ufmg.br

[2]UA – Universidade do Amazonas -Departamento de Ciência da Computação
Av. Gen. Rodrigo Otávio Jordão Ramos, 3000 – Manaus- Am, Brasil.

Abstract. Aerial robots are autonomous agents that are capable to fly autonomous and execute extended tasks with a significant degree of autonomy. A special kind of these robots are the airships or blimps. This work shows the applicability of an airship with capabilities and ability to act individually and sensing environmental data. We also describe a generic software architecture for developing and running in a robotic airship system.

Keywords: remote sensing platform, robotic airship.

1. Introduction

In Remote Sensing, a device to detect the electro-magnetic radiation reflected or emitted from an object is called a remote sensor or simply sensor. A vehicle to carry the sensor is called a platform. Typical platforms are satellite and aircraft, but they can also include radio-controlled airplanes, balloons, kites for low altitude remote sensing, as well ladder trucks for ground investigations (Lillesand and Kiefer, 1994). The key factors in the selecting a platform are the altitude, which determines the ground resolution of the sensor, and the mission goals.

An easy and low cost solution for a useful remote sensing platform is autonomous dirigibles. They exhibit a number of characteristics that separate them from other types of aerial sensing platforms. They require less power to remain aloft than airplanes and helicopters. They are safer to operate, a fact that is especially important for operation at low altitudes and with low velocity. They are be able to hover above an region, with low noise, at low turbulence, and very low vibration, making them ideal platforms for sensing operations such as atmospheric particle matter measurements, land use survey, and environment surveillance. Airships can collected data describing the extent of a forest area and could be used to develop effective spraying programs to control deforestation and burning process. Another typical application is in regions difficult to access and with limitated logistic support, like wetlands. Wetlands are difficult to monitor because they are often inaccessible from the ground. Airships could delineate wetlands from non-wetlands and could track wetland health (Kantor, 2000).

This work describes our robotic airship project, a remote sensing platform with autonomy to navigate, decide and perform tasks that are difficult for other platforms to do, with less noise, less vibration and a low cost.

2. Related Works

Recent advances in autonomous robotic systems have fostered interest in robotic airships. The applicability of these vehicles in environment surveillance, monitoring forest resources, search and rescue are shown in Elfes et al (1998) where the AURORA Project (Autonomous Unmanned Remote monitoring Robotic Airship Project) is described. The components of an air-ground robotic ensemble composed of one or more airship with one or more ground robot are shown in Elfes et al (1999). Azinheira (2002) show recent advances in the AURORA Project describing a control and automatic hovering using image-based visual servoing with the robotic airship. More recently, Lacroix (2000) presents the current status of the development of LAAS/CNRS autonomous blimp. The use of solar energy as a renewable source of power for airships is discussed in Kantor (2001).

3. System Configuration

We designed an experimental indoor airship as proof of concept for vision based navigation (**Figure 1**). An adequately sized vehicle (10m long) would be able to carry environmental sensors safely and accurately through airspace of interest. The airship will be able to operate over an extended period of time, allowing it to collect data over large geographical areas or large volumes of airspace. It is composed of a balloon, a gondola and a remote controller. The gondola is a rigid structure attached to the bottom of the balloon. It contains the motor controllers, a microprocessor, a radio receiver and the two thrusters for propulsion in the horizontal and vertical planes. Additionally, a CCD camera with a video link was mounted on the gondola, as shown in **Figure 2**.

Figure 1 – The experimental airship

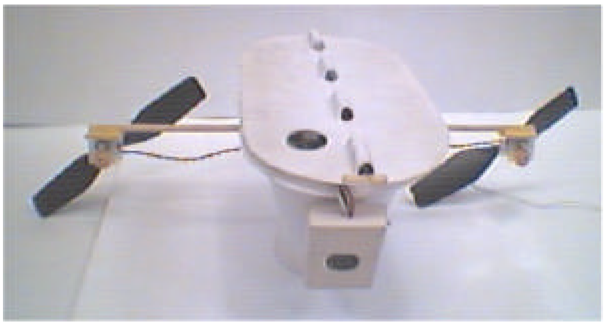

Figure 2 – The gondola and the CCD camera

The robot is designed as a modular system, divided in two majors parts: the onboard system and the ground system (**Figure 3**). The onboard system acquires images and sensor data to sent it for the ground system. The ground system receives images and sensors data. These data are transformed in control signals that are sent back to the robot by a radio link.

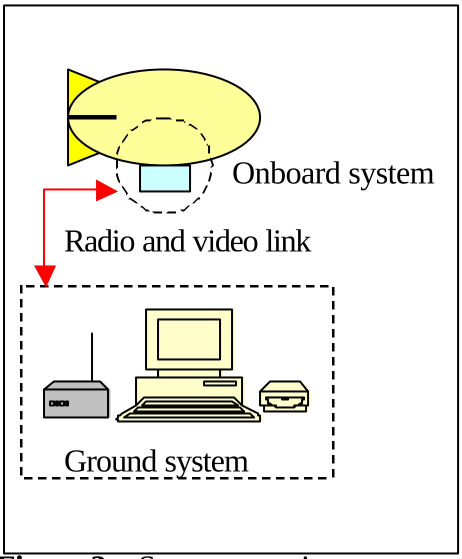

Figure 3 – System overview

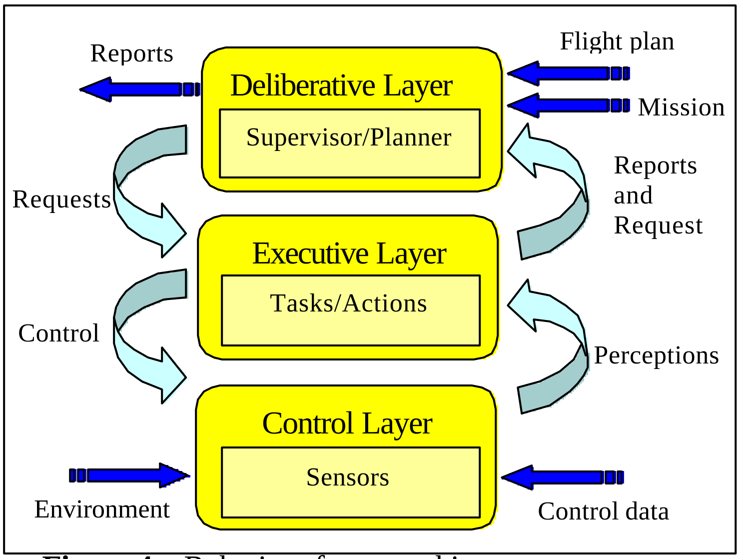

Figure 4 – Robotic software architecture

The flight control is based on strategies allowing the airship to perform five flight phases: takeoff, longitudinal transition, steady lateral navigation, steady longitudinal navigation and landing. The control strategy involves successively lateral and longitudinal control. The longitudinal control is based on a flight plan.

The robotic software architecture used in the project can be characterized as generic multi-layered architecture based in Gat (1998), as shown in **Figure 4**. Conceptually, the architecture can be viewed as consisting of three separate layers, each containing a collection of asynchronous computational processes: The deliberative layer is the higher level that include capabilities for producing tasks plan and supervising its execution, it contains a collection of high level services such as planners, trajectory planners, predictors, reports, and chronicle recognition packages. The executive layer contains a library of reactive programs, it controls and coordinates the execution of the functions and tasks that can be viewed as an augmented automaton which have local state and the ability to open channels of communication to other layers or parts of the architecture. The executive layer calls the deliberative layer services when its own packages cannot achieve mission goals independently. The control layer is responsible for the concurrent computation of feedback control loops tightly coupling sensing with actuation. In this last layer camera and sensor control processing reside.

4. Final Remarks

The development of robotic aerial vehicles will ultimately allow the acquisition of aerial-gathered and georeferencing information in such manner as to give the ability to choose the spatial and time resolution of the data to be acquired, to define geographical localizations, and to select appropriate sensorial systems, while doing so at more readily affordable costs.

Autonomous airships show potential as environmental sensing platforms, however a number of technical challenges will have to be met before they may become fully operational. Numerous practical challenges arise due to the limited payload of the airship. Some important enhancement will be made in future works. Our future efforts will include research toward developing the georeferencing and positioning module, usually facilitated by a integration of GPS (Global Position System) in differential mode and a INS (Inertial Navigation System) to providing high-accuracy position and information of sensor acquisition events.

References

Azinheira, José R. et al. Visual Servo Control for the Hovering of an Outdoor Robotic Airship, *Proceedings of the 2002 IEEE International Conference on Robotics & Automation*, Washington, USA, may, 2002.

Elfes, Alberto et al. Air-ground Robotic Ensemble for Cooperative Applications: Concepts and Preliminary Results, *2nd International Conference on Field and Service Robotics*, pp. 75-80, 1999.

Elfes, Alberto et al. Project AURORA: Development of an Autonomous Unmanned Remote Monitoring Robotic Airship, *Journal of Brazilian Computer Society* , pp. 70-78, 1998.

Gat, Erann. Three-Layer Archictectures, in *Artificial Intelligence and Mobile Robots*, edited by Kortenkamp, Bonasso, and Murphy, The MIT Press, 1998.

Kantor, George. Collection of Environmental Data From an Airship Platform. *Proceedings of the SPIE - Conference on Sensor Fusion and Decentralized Control in Robotic Systems IV*, SPIE, Vol. 4571, pp. 76-83, 2001.

Lacroix, Simon et al. The Autonomous Blimp Project of LAAS/CNRS -- Current Status and Research Challenges. *Proceedings of 8th. International Symposium on Experimental Robotics* (ISER'02), Italy, 2002.

Lillesand, Thomas M. and Kiefer, Ralph W. *Remote Sensing and Image Interpretation.* John Willey & Sons, 1994.