Design Specifications of an UAV for Environmental Monitoring, Safety, Video Surveillance, and Urban Security

A. Alessandri, P. Bagnerini, M. Gaggero, M. Ghio, R. Martinelli
University of Genoa - Faculty of Engineering (DIPTEM)
Project description

- Project supported by the City of Genoa.
- **Objective:** devise the characteristics of an Unmanned Aerial Vehicle (UAV) for:
  - video surveillance;
  - environmental and land monitoring;
  - urban traffic monitoring;
  - analysis of the safety of civil structures.
- Design specifications of the UAV as for mechanics and control system.
Main topics of the project

- Identification of the most suitable UAV for the prescribed tasks.
- Construction of a radio-controlled prototype to be used “on the field”.
- Design specification of the control system that can ensure full autonomous capabilities.
- Cost evaluations.
Possible alternatives:
- aircraft;
- airship;
- helicopter.

The **helicopter** is the most suitable vehicle for urban monitoring and **video surveillance**:
- **hovering**;
- **landing and runway strips are not required**;
- **easy to be carried in the nearby of the operation field**;
- **high capacity of manoeuvring**;
- **reduced fuel consumption**;
- **complexity of the control system**.
Construction of a **prototype** based on a radio-controlled helicopter.
Technical modifications of the radio-controlled helicopter:
- new blades for enhanced stability;
- flight stabilizer;
- design of a new landing gear for the payload.

Onboard hardware:
- navigation sensors (GPS, compass, etc);
- videocamera;
- wireless communication system.

Software:
- video retrieval;
- management and visualization of sensor data;
- position tracking on satellite map.
Mechanics of the UAV prototype

- Engine of type “glow” (15 cm³): maximum power is 3 HP at 16000 rpm.
- The maximum weight for the payload is 3 kg.
- The fuel is a mixture of methanol, nitromethane and synthetic oil.
- The capacity of the fuel tank is 600 cm³.
- The autonomy of flight is about 20 minutes.
- Extension of the autonomy by means of an additional tank.
Onboard hardware

- Low-cost hardware for data acquisition based on the Arduino platform.
- Wireless 2.4 GHz communication system for telemetry.
- Navigation sensors (GPS, compass, accelerometer).
- Real-time video camera.

Prototype hardware on breadboard for testing
Arduino features:

- open-source hardware platform;
- I/O pins;
- powerful development tool for code generation.

Motivation of the choice:

- low cost;
- wide diffusion;
- possibility of interface with standard components.

http://www.arduino.cc
Real-time sensor data visualization.

Graphical visualization of historical sensor data.

Real-time visualization of images from the on-board camera.

Real-time tracking of the UAV position on a satellite map.
Extensive test campaign of the prototype.
Sketch of the overall system
Toward a full autonomous UAV

- Definition of a mission on a map and autonomous execution of the mission.
- Path following for UAV helicopter.
- Video surveillance and urban monitoring tasks.
The references are chosen by the pilot via the radio controller.

The sensors measure some (but not all in general) state variables that describe the UAV behavior.

The navigation system filters the sensor measurements and provides an estimate of all the state variables.

The regulator computes the inputs that are fed to the system via the actuators.
The guidance system is responsible of path following.
Safety is ensured via the fault diagnosis and recovery system.
Conclusions

- Design specifications of a low-cost urban UAV for widespread application in environmental monitoring, safety, and video surveillance.
- Construction and testing of a prototype.
- Cost evaluations.
- Integration of the UAV endowed with a high-resolution video camera with the surveillance network of the City of Genoa.