Scuola di dottorato SIDRA 2014
"Unmanned Aerial Vehicles"

Coordinator: Lorenzo Marconi (Università di Bologna)

Confirmed Speakers: Robert Mahony (Australian National University)
Roberto Naldi (Università di Bologna)
Giuseppe Notarstefano (Università di Lecce)
Paul Pounds (The University of Queensland)

School Summary:

Due to their agility and manoeuvrability, miniature Unmanned Aerial Vehicles (UAVs) have been considered in a large variety of military and civil applications, ranging from surveillance, aerial photography, search and rescue, etc. From an aeromechanical viewpoint it is worth distinguishing two main classes of vehicles. The first one is given by rotary-wing UAVs such as helicopters, multi-rotors or ducted-fans. These systems rely on the presence of propellers / rotors to compensate for the gravity force and, since they are able to perform stationary flight (i.e. to hover), they are often denoted as Vertical Take-Off and Landing (VTOL). The second one is given by fixed-wing configurations, such as airplanes. Fixed-wing configurations are able to fly more efficiently with respect to rotary-wing configurations, as they take advantage from the aerodynamic lift forces generated by the wings in order to counteract the gravity force. In this context, the course will address modelling, control, guidance and navigation aspects of both VTOL and fixed-wing miniature UAVs.

More specifically the course will be organized as follows.
The first day will be entirely focused on modelling and control of VTOL aerial vehicles. The dynamical model of some VTOL and Fixed-Wing configurations is derived. Control allocation techniques are proposed so as to handle possible actuator redundancy. The structural properties of the dynamical models of the vehicles are then pointed out, linking the particular configuration and the choice of the control outputs to the stability of the zero dynamics of the system. The problem of controlling the vehicle for tracking a desired set of outputs is then addressed. By considering nonlinear tools, such as Input-to-State Stability (ISS), robust nonlinear control strategies are introduced able to deal with parametric uncertainties and exogenous disturbances. This part of the course will link to the notions and tools introduced in the first part of the week where nonlinear control systems are addressed.
In the second day the topics of navigation and guidance of UAVs are dealt with. Attitude estimation based upon nonlinear complementary filters will be presented. As far as the guidance layer is concerned, advanced strategies, such as teleoperation techniques and visual-servoing, will be addressed. Technological details pertaining the design and prototyping of miniature aerial systems will be also presented. The day will conclude with a flight demonstration of some aerial prototypes.
In the last day of the course, actual research directions and relevant international project will be introduced.

Course Language: English

Teaching aids and instructional materials: Slides will be mainly used as teaching aids. All the slides used in the course will be available on the web by mid-June.

Program

Thursday July 10th 2014	
8:30 – 10:15	Introduction, modeling of different configurations of VTOL UAVs
11:00 – 12:45	Control of VTOL UAV: control allocation, structural properties of the dynamical model
15:00 – 16:30	Control of VTOL UAV: cascade control strategy, attitude control on SO(3)
17:00 – 18:30	Modeling and Control of fixed-wing aerial vehicles: analogies and differences wrt VTOL vehicles

Friday July 11th 2014	
8:30 – 10:15	Navigation layer: nonlinear complementary filters
11:00 – 12:45	Guidance layer: teleoperation
15:00 – 16:30	Guidance layer: visual servoing
17:00 – 18:00	Introduction to technological elements
18:00 – 18:30	Flight demo

Saturday July 12th 2014	
8:30 – 10:15	Research directions and international projects
11:00– 12:45	Research directions and international projects

Coordinator: Lorenzo Marconi (Università di Bologna)

Confirmed Speakers: Robert Mahony (Australian National University)
Roberto Naldi (Università di Bologna)
Giuseppe Notarstefano (Università di Lecce)
Paul Pounds (The University of Queensland)