Ph.D. in Information Technology
Thesis Defenses

October 14th, 2024
at 9:00 a.m.
Room Alpha

Tareg Mahmoud Hassan MOHAMMED – XXXV Cycle

AUTOMATIC CONTROL SOLUTIONS TO ENHANCE THE RELIABILTY OF AIRBORNE WIND ENERGY SYSTEMS
Supervisor: Prof. Lorenzo Mario Fagiano

Abstract:

Airborne wind energy (AWE) is a technology that captures wind energy and transforms it into electricity using a flying apparatus connected through a tether to the ground. It holds substantial promise in working in conjunction with traditional wind turbines to mitigate CO_2 and other greenhouse gas emissions, thus combating global warming. However, more research is required to optimize the use of AWE technology; Given the current status of AWE technology, there are significant challenges to its successful implementation that must be addressed. These challenges include 1) ensuring fully autonomous operation even beyond standard operating conditions and 2) enhancing the system's robustness and failure tolerance. This thesis introduces strategies to enable autonomous operation beyond nominal operation condition, and to increase system reliability by applying fault tolerance control (FTC) for Airborne Wind Energy Systems (AWES). Specifically, this study introduces FTC algorithms tailored for Vertical Take-Off and Landing (VTOL) pumping cycle AWES, the method has been tested in a verified simulation environment, a control surface failure has been injected at different points during production phase, and the proposed FTC algorithm effectively maintained system performance. Additionally, a "standby" safety mode is proposed for operating AWES outside its nominal operational conditions; this mode notably enables AWES to function when wind speeds fall below the operational cut-in point, the method has been tested in verified simulator in wind speed from 0 to 12 m/s, the results indicate that the method successfully kept the kite aloft even at 0 m/s wind speed, and shows robust performance in higher wind speed. Moreover, in this research the developed AWES simulator has been validated using experimental data, which is considered one of the contributions of this research given the limited availability of validated simulators in the AWE domain. This simulator is considered a crucial instrument for exploring AWES failure modes and assessing the corresponding mitigation strategies.

Massimiliano Maurizio DE BENEDETTI– XXXIII Cycle

BATTERY STORAGE SYSTEM MANAGEMENT AND OPTIMIZATION IN HETEROGENEOUS ENVIRONMENT
Supervisor: Prof. Luca Bascetta

Abstract:

The proliferation of Distributed Energy Resources (DERs) and the electrification of transport systems with the introduction of Electric Vehicles (EVs) is posing several challenges related to their

coordination, control, and optimal operation. In particular, a key element is the Battery Energy Storage System (BESS) which needs to be controlled so as to fulfil the requirements of different DERs and EVs applications.
In particular, both Virtual Power Plant (VPP) and Electric Vehicle Routing (EVR) require the coordination of multiple units to solve an optimization problem where different contrasting objectives are traded-off. Given the large size of the problem and the consequent high computational effort involved, the constraints on the time available to obtain a solution, and the fact that the information needed even just to formulate the problem is available only locally to the involved units, approaches resorting to a distributed architecture where computational capabilities of the units are exploited appear the natural solution to go. This in turn entails that BESSes have to be able to solve locally a part of the global optimization problem related to VPP and EVR. The distributed nature of the application scenario, coupled with an high computational effort, implies that the embedded control system of both Battery Energy Storage System and Electric Vehicles has to be able to solve locally a subsection of the global optimization problem related to the VPP and EVR.
In this thesis, we shall formulate a quite general planning problem called Constrained Sequential Battery Planning (CSBP) that is able to solve a local optimization problem and that can be implemented directly on the embedded computational system onboard of a BESS. The introduced CSBP is able to account for all the constraints and requirements involved in the formulation of both VPP and EVR. We shall then show how it can be integrated into a distributed control approach to solve both the VPP and EVR global optimization problems thus providing a solution with low computational effort and scalable in the number of BESSes.

PhD Committee

Alessio La Bella, **Politecnico di Milano**
Prof. Alessandra Parisio, **University of Manchester**
Prof. Ahmad Hably, **Grenoble INP (Université Grenoble Alpes)**