Ph.D. in Information Technology:

Cataldo, and Raimondi Cominesi Final Dissertations

DEIB Seminar Room "Alessandra Alario"

February 2nd, 2016

10.30 am

First Ph.D. presentation and discussion:

Andrea CATALDO – XXVIII Cycle

"Model Predictive Control in Manufacturing Plants"

Advisor: Prof. **Riccardo Scattolini**

Abstract:

In order to prove the applicability of MPC to control problems typical of manufacturing systems, in this thesis different industrial applications have been taken into account and the adequacy of MPC in terms of "easy to design and use" and performances has been proven.

Second Ph.D. presentation and discussion:

Stefano RAIMONDI COMINESI – XXIX Cycle

"Model Predictive Control based methods for microgrid energy management"

Advisor: Prof. **Riccardo Scattolini**

Abstract:

The diffusion of distributed generation units registered at the end of the previous millennium has been, since then, rapidly increasing due to both the economical advantages of cogeneration, and the increment

of renewable energy production, connected to an effort to reduce the global greenhouse gases emission. In this scenario, with the electrical generation steadily transitioning from few large power systems to a multitude of small-size scattered units, the need for a decentralized control infrastructure has arisen.

The most promising solution to the issue, at the present day, is the one suggested by the microgrid paradigm: an evolution of the electrical infrastructure towards a new framework, where low voltage small-scale grids - indeed the microgrids - are locally controlled and interfaced with a largescale electric power backbone. Coordinating its own distributed resources and controlling the energy exchange with the main grid, microgrids have the potential to become not only active players for the regulation of the electrical network, but also independent systems, capable to separate from it, resorting to islanded operation. The control of these systems poses unique and challenging problems from countless perspectives, such as Automation, Electrical and Telecommunication Engineering, but also for the regulatory point of view.

The Thesis addresses the problem of the energy management of the microgrid, both in grid-connected and in islanded operation. To efficiently cope with the uncertainty associated to non-dispatchable generation, as well as electrical load fluctuation, different innovative MPC-based control methods are presented.

Ph.D. in Information Technology:

Annoni, and Alvizu Gomez Final Dissertations

DEIB Seminar Room

February 2nd, 2016

2.00 pm

First Ph.D. presentation and discussion:

Roberto ROSSI – XXIX Cycle

"Control of an Unmanned Aerial Vehicle equipped with a Robotic Arm"

Advisor: Prof. **Paolo Rocco**

Abstract:

Robots ability to autonomously move in the terrain, underwater and aerial domains opened a large number of new applications in industry, service robotics and search and rescue activities. In particular, the impressive growth of aerial robotics during the last decade paved the way to the birth and subsequent development of the new research field of aerial manipulation. The increase of payload capacity and dexterity of aerial vehicles, in conjunction with advances in the design of light-weight arms, enabled the conception of flying robots equipped with articulated manipulators. The present thesis aims at increasing the degree of autonomy and improving the control performance of an aerial robot composed of a quadrotor equipped with a robotic manipulator underneath. To this end, a stability control strategy which tackles the coupling dynamics of the under-actuated flying base with the robotic arm is developed. Moreover, the intrinsic kinematic redundancy of the system is exploited with two different optimization-based trajectory generation methods, in order to accomplish prescribed tasks while satisfying given constraints. Finally, contributions in the fields of the state estimation of the aerial systems and the control of interaction with the external environment are provided.

Second Ph.D. presentation and discussion:

Bruno SCAGLIONI – XXIX Cycle

“A Newton-Euler approach to modelling and control of flexible manipulators”

Advisor: Prof. **Gianni Ferretti**

Abstract:

The main subject of the thesis is the development of a closed-form model of three-dimensional flexible manipulator with links of general shape and the synthesis of a two-timescale control system able to improve the performances of the manipulator. The resulting performance are achieved by means of a controller acting on the robot joints in a "fast" timescale, coupled with a traditional system acting on the "slow" timescale. The equations of motion have been formulated in the Newton-Euler form, allowing a complete calculation of the Coriolis and gyroscopic terms of the inertial forces for the elastic degrees of freedom. The model allows considering bodies of general shape through the calculation of shape functions, which describe the geometry, as the result of the modal analysis performed by finite elements packages. A control technique is finally presented for the family of the "fast" subsystems, which is based on advanced nonconvex H-infinity control. The overall control system provides better performances with respect of the classical techniques, allowing a consistent vibration damping and a substantial increase in the control bandwidth.

Ph.D. in Information Technology:

Annoni, and Alvizu Gomez Final Dissertations

DEIB Conference Room

February 2nd, 2016

4.00 pm

First Ph.D. presentation and discussion:

Andrea ANNONI – XXIX Cycle

“Control Strategies in Large Photonic Integrated Circuits”

Advisor: Prof. **Andrea Ivano Melloni**

Abstract:

Nowadays, due to the everlasting increase of internet traffic and energy consumption for data transmission and data processing, integrated photonics technologies are envisioned as a viable alternative to power hungry electronics. To reach this objective, it is necessary to handle more and more complex functions in the optical domain; this objective can be realized only if photonic circuits reach a higher level of complexity, interconnecting many devices on the same chip to realize a so-called ``system-on-a-chip''; but the lack of adequate tools to reliably control the manufacturing and operation of photonic integrated circuits when scaled up to hundreds of optical functional elements, prevents to establish an equivalent of the Moore's law in photonics circuits. This work contributes to fill some of the existing gaps that are currently preventing to move from a single-device level to a new system-on-a-chip paradigm; the work shown here, lays in the framework of the FET European project BBOI (Breaking the Barrier of Optical Integration, www.bboi.eu) which objective is to remove the limitations of current Silicon-On-Insulator photonic platforms through the exploitation of radically new concepts and enabling technologies for the realization and control of photonic devices.

Second Ph.D. presentation and discussion:

Rodolfo Enrique ALVIZU GOMEZ – XXIX Cycle

“Advance Optical Routing Techniques in the Software Defined Era”

Advisor: Prof. **Guido Maier**

Abstract:

Paradoxically, with an ever-increasing traffic demand, today transport-network operators experience a progressive erosion of their margins. The operational complexity, the use of manual configuration, the static nature of current technologies together with fast-changing traffic profiles lead to: inefficient network utilization, over-provisioning of resources and very high Capital expenditures (CapEx) and Operational expenses (OpEx). The alarms of change are set for network operators, and Software Define Networking (SDN) is accepted as a concrete solution to reduce CapEx and OpEx and to boost network innovation. The implementation of SDN in transport networks (T-SDN) gained big momentum in the last years, however in the networking industry, the transport network will be perhaps the last segment to embrace SDN, mainly due to the heterogeneous nature and complexity of the optical equipment composing it.

This thesis starts with a deep dive into a fascinating technological adventure that provides an organic analysis of the T-SDN development and evolution. Our work is the first to consider contributions from the whole transport network ecosystem composed by: academic research, standardization bodies, industrial development, open source projects and alliances among them. After creating a comprehensive picture of T-SDN, we provide an analysis of many open issues that are expected to need significant future work, and give our vision in this path towards a fully programmable and dynamic transport network. Then, assuming the deployment of T-SDN technologies, we propose operational research formulations and heuristic algorithms for two advanced routing techniques: dynamic optical routing and multipath optical routing. Among our contributions we can highlight the novel use of spatio-temporal (tidal) traffic demand prediction to improve the dynamic routing decisions, and the first-time proposal of two techniques to mitigate the differential delay, recognized as the main problem of multipath routing: 1) Differential delay equalization using unconventional routing cycles (e.g., loops), which exploits the nature of optical communications in which delays are deterministic, 2) Transparent differential delay compensation technique based on fiber delay lines, that avoids the use of conventional electronic buffering. Finally, based on our background regarding T-SDN and advanced routing algorithms, we implemented two SDN use cases. The first use case is a T-SDN network Orchestrator for multi-domain networks, with the following capabilities: cross-domain segment routing, application-aware path selection, and multipath routing. The second use case is a path manager and the related automated testbed for evaluating Multipath TCP (MPTCP), that allowed us to deploy differential delay-aware algorithms and to experimentally demonstrate the impact of delay and differential delay on the overall performance of MPTCP.