Ph.D. in Information Technology: Thesis Defenses

February 16th, 2021
online by Teams – at 8.30

Riccardo MADERNA – XXXIII Cycle

Enhancing human-robot collaboration for flexible manufacturing in Industry 4.0

Supervisor: Prof. **Paolo Rocco**

Abstract:

The current global economy is increasingly characterised by quickly changing markets and mass customization. Advances in industrial robotics and human-robot collaboration are playing a key role to provide companies with an adaptable and powerful tool capable of enhancing efficiency and flexibility of manufacturing processes. Humans leverage their superior cognitive and manipulative skills to perform operations that are difficult to automate, robots relieve operators from repetitive and laborious tasks.

The thesis proposes a framework to control the production of multi-product assembly lines, consisting of several humans and robots working together in a shared workspace. A dynamic scheduling algorithm has been developed to organise the complex work-flow and fully exploit the available flexibility, ensuring the optimal use of resources and the smart management of unexpected events. Scheduling decisions are obtained by simulating the future evolution of a Digital Twin of the system. Therefore, monitoring the human activity in real-time is crucial to correctly track the state of the process. Two different strategies have been developed, which account for the fact that humans can perform the same operation in many ways and with different speeds, occasional errors, and short pauses.

Additionally, the convenience of introducing collaborative robots in the kitting process has been investigated. At present, kitting is usually performed manually by human operators, but robots can help to reduce the operator's effort and increase productivity. Thus, an online scheduling algorithm to guide the picking operations of the human and the robot is also presented in the thesis.

Stefano SPINELLI – XXXII Cycle

Optimization and control of smart thermal-energy grids

Supervisor: Prof. **Marcello Farina**

Abstract:

This thesis deals with the development of novel algorithms and methodologies for the optimal management and control of thermal and electrical energy units operating in a networked configuration.

The transformation of the energy and utility industry is characterized by a transition from centralized to distributed generation, that requires the introduction of new paradigms for the energy management and control. Multiple and integrated energy vectors - i.e., electrical, thermal, etc. - must be considered together. On-site generation complements the standard utility sources. This enhances the flexibility of the generation, as well as the complexity of the overall system. The smart thermal-energy grid is a large-scale networked system, where a set of common resources are shared by the producers and where the main objective is to sustain efficiently the time-varying demand of different forms required by a set of consumers, providing the optimal scheduling and the economic dispatch of the units. The integrated multi-utility configuration requires also a dynamic control of the operating point of each unit, considering the interaction among the subsystems and the fluctuation of the demands.
The aim of the work is to foster the creation of a smart thermal-energy grid (smart-TEG), by providing supporting tools for the modeling of subsystems and their optimal control and coordination.
The configuration and the dimension of the problem intrinsically pose the main issue of its tractability with standard centralized approaches. Therefore, the distribution of control intelligence is the key point to reach a plant-wide dynamic optimal control. Hierarchical and distributed schemes are proposed in this thesis to address optimally the management and control issues of the smart-TEG. This includes advanced distributed optimization schemes accounting for mixed integer variables and predictive and constrained control solutions. Real industrial case-studies provide the specifications, data for modeling identification and parameter estimation, and offer suitable test-beds for the validation of the proposed control schemes.
The performances of the proposed algorithms are shown in simulations and, whenever possible, with on-field testing.

PhD Committee

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