ScuDo

Scuola di Dottorato ~ Doctoral School

WHAT YOU ARE,TAKES YOU FAR

XXXIV Cycle

A New HW/SW architecture for Autonomous Mobile Robots in Smart Production Lines

Ivan Lazzero

Supervisor: Prof. Marina Indri

Research context and motivation

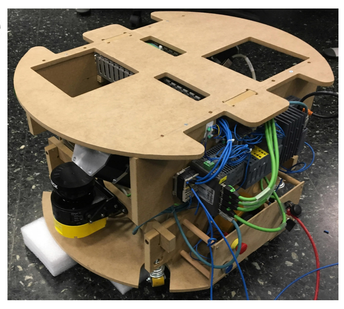
The general research purpose, established within an industrial doctorate agreement between Politecnico di Torino and COMAU, is to develop new methodologies and technologies for the design and integration of Automation Systems (AS).
This new paradigm is not oriented to the punctual design of a single AS, but to the management and aggregation of mechanical, electronic and commercial software components (COTS) in order to obtain a specialized AS.
This approach deals with different topics: from the search for new standard solutions on the market, to the development of new integration methodologies and communication protocols in order to achieve a dynamically changing environment.
The aim of the project is then the development of methodologies and approaches for the integration of electronic and mechanical components available on the market within general purpose software architectures in order to define an AS with high performance and low cost which can benefit from the action of advanced control techniques.
Particular emphasis will be given to issues concerning the integration of sensors of different nature, the fusion of the acquired data and the optimal use of the obtained information.
In order to guarantee a wide flexibility of integration on different systems, the introduction in the software architecture of a layer of virtual sensors is assumed,
making use of the data available to generate information also on signals not directly measured, and able to allow an easy integration of additional real sensors.
The final objective will be to develop advanced control schemes and facilitate human-machine interaction for the use of these AS in professional but not necessarily industrial environments.

Addressed research questions/problems

The chosen case study, defined by Politecnico di Torino and COMAU, concerns the conception and development of a new generation of AGVs, to be used no more as pure logistic transporters but as multi-purpose industrial autonomous mobile vehicles within more intelligent, versatile and dynamic production lines (as in the scenario depicted in the paper published in SENSORS), guaranteeing the safety levels required in the industrial scenario.

In close collaboration between the innovation's COMAU team, a mechanical, SW and HW solution is being developed to ensure the highest standard of safety while maintaining the leanest architecture possible (details are available in the paper presented at ETFA 2019).

In this scenario the high challenging question is "how is it possible to change the dynamic response of the system when external conditions change?". For example, the controller of the vehicle must be able to cope with very high variations of the load, the possible presence of an additional 6-DoF robot on the top of the vehicle, as well as with a forklift, or with the effects of its interaction with other vehicles to achieve a wider moving platform.



Future work

The next steps in the short term are:
- Start-up of the physical demonstrator that has been assembled in the last months
- Validation of the inverse dynamic model that has been developed
- Implementation of the SW architecture inside a demonstrator

The steps in the medium term are:
- Usage of the validated dynamic model to develop the best vehicle movement strategies
- Addition of auxiliary degrees of freedom to the system to test its simplicity of integration

Submitted and published works

- Indri, Marina; Lachello, Luca; Lazzero, Ivan; Sibona, Fiorella; Trapani, Stefano (2019) "Smart Sensors Applications for a New Paradigm of a Production Line", In: SENSORS, 19:3 (650), ISSN: 1424-8220
- Indri, Marina; Lazzero, Ivan; "A new HW/SW architecture to move from AGVs towards Autonomous Mobile Robots" In proceeding of 24th IEEE Conference on Emerging Technologies and Factory Automation (ETFA 2019)

Adopted methodologies

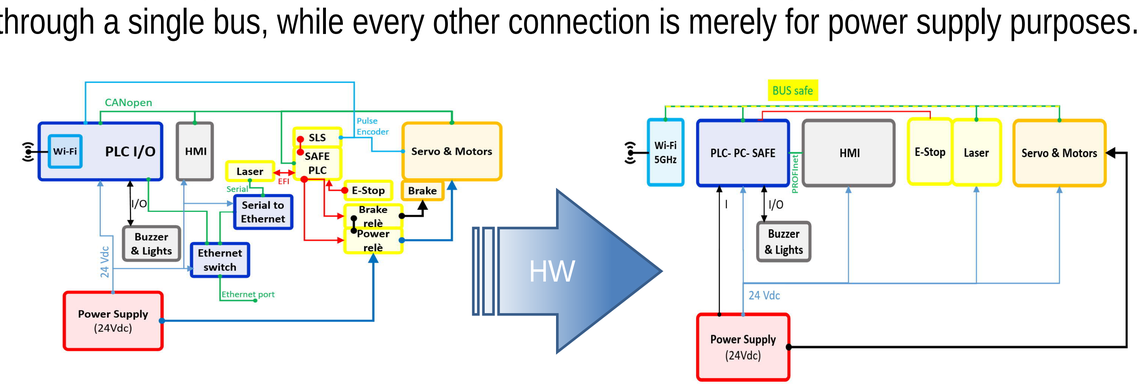
The complete research has been divided into the following main steps:
- state of the art study
- development of flexible architectures able to handle electro-mechanical components and sensors (physical and virtual)
- development of advanced control architectures
- development of user-friendly human-machine interface

During the first year the main activities were:
- state of the art analysis
- the creation of a new HW / SW architecture able to support the demands of generality and extendibility.

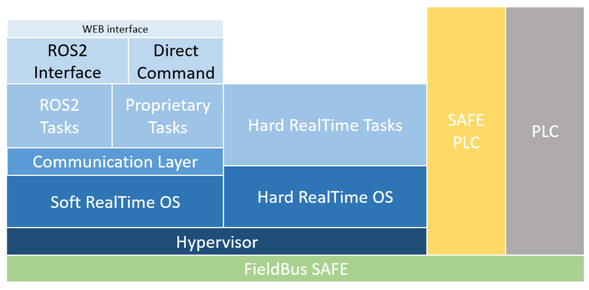
This strictly theoretical conception was supported by the research of commercial components aimed to perform assigned tasks to different actors.

Novel contributions

- Standard AGVs are characterized by a typical double-layer architecture, where the usage of non-safe drives is supported by safe relays for power control. Such a solution respects the functionality and security requirements necessary for modern industrial products, but at the price of a greater complexity, and heterogeneity of communication protocols and programming environments, with a consequent greater difficulty in integrating additional axes. The proposed architecture is mainly based on two concepts: the standardization of communication protocols and the most radical simplification. Every communications go through a single bus, while every other connection is merely for power supply purposes.



- A new concept of simplified software architecture has been designed, too, with the purpose of extending the normal capabilities of an industrial AGV. The software architecture is aimed at being modular and open, in order to be suitable both in industrial environments, including safe needs, and for academic and research purposes. The software architecture aims at answering to three main needs:
  - to ensure the safety of the AGV application;
  - to allow the addition of external software components;
  - to allow the extension of the vehicle's degrees of freedom through a simple integration management.



List of attended classes

- 02LWHRV – Communication (17/6/2019, 6.67 Points)
- 01SCSIU – Machine learning for pattern recognition (5/9/2019, 33.33 Points)
- 01SFURV – Programmazione scientifica avanzata in MatLab (8/3/2019, 37.33 Points)
- 08IXTRV – Project management (20/6/2019, 6.67 Points)
- 01RISRV – Public speaking (20/6/2019, 6.67 Points)
- 01SYBRV – Research integrity (15/7/2019, 6.67 Points)
- 01TBXRV – Vision fundamentals in service robotics (23/5/2019, 33.33 Points)

POLITECNICO DI TORINO

PhD program in
Electrical, Electronics and Communications Engineering