System Interoperability in Robotic Applications for Internal Logistic

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Amid the fourth industrial revolution rooted in digital technologies, traditional companies are progressively transformed into smart, highly automated environments. In this transformation journey, logistic processes are shifting from mostly manual logistic processes (persons to good) to fully automated logistic solutions with no need for human intervention (dark warehouse). Global economic trends like the consumer shift towards e-commerce brought by digital transformation, rising energy prices, the need for sustainability or the growing demand for staff qualified in digital technologies stress the relevance of the challenges that the transformation of logistic processes poses to companies, particularly SMEs and mid-size companies: The difficulty to automate chaotic processes (dealing with an increasing variability of shapes), lot size 1, reduced margins and shortage of physical space or qualified personnel.

As a response to these challenges, collaborative robotic solutions based on Autonomous Mobile Robots (AMRs) offer enhanced ergonomics, organizing work in such a way that each agent (human or robot) can do what it does best. Interoperability enables the synchronization of processes and the integration with other equipment like conveyors to achieve enhanced performance. Furthermore, Fleet Management Systems (FMS) based on web-based technologies allow the commoditization of robotic solutions, facilitating the management of the robotic fleet by humans. The development of a robotic platform that integrates these aspects is the main technical objective behind the project called "Logiblock" funded by the Agència Valencia de la Innovació (AVI) and the European Union under the European Regional Development Fund (ERDF). The aim of this section is to demonstrate related research, undertaken during the first months of the project, as well as in other related European projects. The chapters included in here have been developed from papers presented in this workshop entitled System Interoperability in robotic applications for internal logistics:

- ***IoT and robot control interoperability in human-robot collaboration environments***: With humans and robots working in closer proximity in many industrial applications, there is a need to merge data from both. But robots typically manage information in middleware or control environments separate from the IoT, which is often the framework for human data information. This paper presents the advantages of IoT and robot control interoperability in human-robot collaboration environments for real-time logistic applications.
- ***Mobile robotics experimentation in industrial environment***: This paper provides an overall vision of the current state of mobile robotics deployment in SME manufacturing industry. The main features that mobile robotics solutions should implement are defined from potential users' perspective based on the key actors identified in the industrial environment, considering a set of indicators has been considered to validate them. An experimentation environment and use case are defined to characterize these industrial scenarios.
- ***PlugBot Architecture for Modular Manufacturing***: PlugBot was an Austrian research project (2019-2021) in which an architecture to integrate heterogeneous (robotic) systems has been developed. Modeling system capabilities for task execution as atomic skills is a concept that allows semantic unification for orchestration of multiple skills along workflows as well as

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hardware abstraction and implementation agnostic workflow modelling without taking concrete parameters of the executing devices into account. The architecture and approach has been evaluated in multiple use cases in the manufacturing domain. Future work will include to research the applicability of the concept for mobile robots.

- ***Robotics Platforms for Internal Logistics: A Technical Architecture Proposal***: This paper presents a reference technical architecture model for robotic platforms specifically designed for internal logistics applications. The reference application is based in industry standards like ISA/IEC 62443 and the Industrial IoT Reference Architecture (IIRA).
- ***Reference Models and Standards for the Integration of Mobile Robotics for Internal Logistic Applications***: This article discusses different methods, reference models and standards that can be applied to achieve vertical integration of mobile robotics for internal logistics applications. To realize this vertical integration, we will first consider the functionalities of current enterprise information systems, i.e., ERP, MES, MON and WMS among others, that support production and logistics operations, and then, by applying the ISA-95 hierarchical model for enterprise-control integration, with its different functional levels for enterprise information systems, we will provide a standards-based framework to support the integration of AMR mobile robot fleets and the described enterprise information systems.
- ***Collaboration in the framework of the HUB4.0MANUVAL DIH for Innovation in Embedded OPC-UA IoT Systems***: This paper presents the solution adopted as a synergy of two entities, one industrial company and one academic partner, as an improvement in interoperability and future projection of developments for the connectivity of devices normally based on very specific protocols. The solution includes the use of a communication bridge (ESP32) for the implementation of an OPC-UA communication protocol by designing a client/server program based on this distribution, improving data accessibility. This solution is the result of close relations in the HUB4.0MANUVAL ecosystem between SME's and competence centers.