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Flexible Assembly Systems through Workplace-Sharing and Time-Sharing Human-Machine Cooperation (PISA)

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Abstract

PISA is a European Integrated Project (IP) in the research area "next generation of flexible assembly technology and processes". The general aim of the project is to develop intelligent assist systems (IAS) in order to support the human worker instead of replacing him. Thus, flexibility should not be reached through fully automated assembly systems but should instead support the better integration of human workers. This paper gives a report on the project, launched in September 2006.

Keywords

Human-machine cooperation, human-centered automation, reusability, reconfigurability, assembly systems, cooperating robots.

1. PISA Overview

The growing number of product variants, smaller lot sizes, accelerated time to market and shorter life-cycles of products have lead to increasing demands on assembly equipment and concepts. They must achieve a high degree of flexibility with respect to variants, low-cost adaptability of products and quick amortisation within a sustainable equipment concept. In order to master these challenges, innovative approaches and technologies are required [1]. The performance of existing automation techniques is often insufficient. As a solution to this problem, hybrid, i.e. human-integrated, approaches are proposed. The idea is to combine human flexibility, intelligence and skills with the advantages of sophisticated technical systems. Such systems should help the human worker instead of replace him. Intelligent assist systems (IAS) offer a rational, advanced method for the assembly of complex products on demand and at significantly reduced cost [2]. Since today neither the technology nor the tools for planning and managing IAS are available, the aim of the project is their prototypical development, including demonstration based on use-cases. One breakthrough of this project shall be to fill the gap between manual and automated assembly by introducing novel IAS technology and providing planning and integration tools to make this new technology applicable. A second breakthrough shall be the re-configurability of assembly systems and the reusability of assembly equipment. On the one hand this is related to a modular structure of assembly systems including standard hardware and software interfaces of assembly equipment. On the other hand, methods and tools are needed for reconfiguration planning, re-programming, life-cycle and equipment management and knowledge-bases for assembly solutions. Each breakthrough shall lead to an increase in production capacity and productivity, to reduce the cost of investment and re-arrangement and to react more quickly to market demands.

2. PISA Objectives

A skilled and motivated workforce still provides the most capable and reliable resource for the flexible (or customised) assembly of complex products. Recent studies have clearly demonstrated that flexibility can be improved by combining the benefits of human capabilities with sophisticated automation equipment in so-called hybrid flexible automation systems, providing a rational advanced concept for producing high-tech products with growing complexity at significantly reduced cost [3]. However, a reliable technological basis for hybrid systems does not yet exist, and the performance of existing flexible automation techniques (e.g. industrial robots) is quite limited in their ability to cooperate with and assist the human worker in a shared and reconfigurable assembly space [4]. The existing standards do not permit workspace-sharing and cooperation.

Therefore, the prime objective of the IP-PISA project is to establish a new generation of modular flexible assembly methodology by developing concepts, formal methods, standards and safety frameworks, tools and underlining technologies to allow integration and cooperation between human workers and highly flexible devices and equipment in a qualitatively new and efficient manner. The main idea is to make a break with traditional paradigms regarding flexibility, cost, accessibility and applicability of high-tech assembly solutions, as well as conventional human-machine interaction. The project development concerns the following next-generation flexible assembly equipment and planning tools:

i. A new generation of passive collaborative robots (COBOTS) and intelligent assist devices. They combine the benefits of industrial robots with those of passive handling devices. They also provide low-cost, operator-friendly solutions for the assembly of complex and variable volume products.

ii. Modular assembly robots which represent the next generation of sensor-based robotic systems. They integrate visual and compliance control feedbacks, reconfigurable control systems and sophisticated grasping and tooling devices. They are capable of time-sharing with human workers and provide an efficient solution for capacity flexibility when workforce availability is lower or product volume varies.

iii. Assistant robots based on standard robotic systems. They are equipped with additional sensors and control functions and are capable of sharing the same workspace and assembly process operations with a human worker. This approach offers a promising short-term solution for flexible, reconfigurable assembly of highly customised products.

iv. Assembly process design and simulation tools involving the knowledge-base of standardised processes and environmental models; interactive robots and human-in-loop models which allow for a realistic design for assembly, planning and the optimisation of assembly system structures and process variations (virtual assembly system). These tools will also be very useful for the training and skill improvement of assembly workers.

v. Reusable and reconfigurable electro-mechanical and control equipment; design and planning tools, including tight interfaces to assembly processes and parameters. This includes concepts and methods which support the planning and reconfiguration of new-generation hybrid flexible assembly lines for specific production systems and market demands.