Productive Robots and the SMErobot Project

Nilsson, Klas; Johansson, Rolf; Robertsson, Anders; Bischoff, Rainer; Brogårdh, Torgny; Hägele, Martin

Published in:
Book of Abstracts of Third Swedish Workshop on Autonomous Robotics

2005

Productive robots and the SMErobot project

K. Nilsson[1], R. Johansson[2], A. Robertsson[2], R. Bischoff[3], T. Brogårdh[4], M. Hägele[5]

[1]Dept. of Computer Science , Lund Inst. of Technology, Sweden, klas@cs.lth.se
[2] Dept of Automatic Control, Lund Inst. of Technology, Lund University, Sweden
[3] KUKA Roboter GmbH, Germany
[4] ABB Automated Technologies Robotics, Sweden
[5] Fraunhofer-Institut für Produktionstechnik und Automatisierung (IPA), Germany

Extended Abstract

The need for keeping manufacturing and workplaces in Europe calls for new ideas and concepts for productive robots with focus on their usefulness for Small and Medium sized Enterprises (SMEs). The activities from the Robotics Research at LTH, [3], [4], [2], and in particular those related to the SMErobot project [1] comprise efforts in this direction. The SMErobot project is a recently started four-year-project of the 6th Framework Programme of the EC "to create a new family of SME-suitable robots and to exploit its potentials for competitive SME manufacturing". To this purpose the goal is not to create fully autonomous robots for all possible tasks, but rather to create semi-autonomous robots and to allow for human-robot interaction in a safe way. An introductory motivation and some of the main issues of the SMErobot project now follow, [1].

More than 228 000 manufacturing SMEs in the EU are a crucial factor in Europe's competitiveness, wealth creation, quality of life and employment. To enable the EU to become the most competitive region in the world, the Commission has emphasized research efforts aimed at strengthening knowledge-based manufacturing in SMEs as agreed at the Lisbon Summit and as pointed out at MANUFUTURE-2003. However, existing automation technologies have been developed for capital-intensive large-volume manufacturing, resulting in costly and complex systems, which typically cannot be used in an SME context. Therefore, manufacturing SMEs are today caught in an *automation trap*: they must either opt for current and inappropriate automation solutions or compete on the basis of lowest wages.

In total, the SMErobot initiative is set to offer an escape out of the automation trap through:

- Technology development of SME robot systems adaptable to varying degrees of automation, at a third of today's automation life-cycle costs;
- New business models creating options for financing and operating robot automation given uncertainties in product volumes and life-times and to varying workforce qualification.
- Empowering the supply chain of robot automation by focusing on the needs and culture of SME manufacturing with regard to planning, operation and maintenance.

One of the key components in this development is the possibility of humans and robots to share tasks and to share the same workspace in a safe way.

The Safe Human-aware Space-Sharing Robot: Currently, robots have to work behind fences to ensure operator safety because of risks due to high-energy motions and control/software faults. For SMEs – which typically are engaged in small-series production – this poses a significant problem in terms of installation cost and time and lack of interaction and tuning during production. Intrinsically safe robots are identified to be the cornerstone of future manufacturing concepts such as the space-sharing co-worker for human-robot cooperation. Initial research towards safe robot systems has mainly investigated safety issues of specific robot components. It is recognized that an intrinsically safe robot requires research towards safe mechanics, human motion perception, and safety-conformable layouts and controls. New robot structures and kinematical ideas for high-performance, low-inertia, low-cost robots are of major interest in this area, see Fig. 1. In applications where this is not physically possible, a complementary approach based on active dependable control and human-aware motions is needed.

Another main issue of the project is programming and task description.

The Robot Capable of Understanding Human-Like Instructions: Today, programming depends on explicit specification of coordinates, motion commands and process parameters. The programming effort is tremendous and drastically increases the life-cycle costs for a typical workcell. In the absence of highly skilled robotic programmers, relatively easy tasks take an average of 40 hours of programming for the average SME, but programming should be as simple as telling a colleague to perform a certain task. Therefore, future robot instruction schemes require the use of intuitive, multi-modal interfaces and preferably human communication channels, such as speech and gestures. Identification and localization of work pieces, automatic generation or adaptation of programs and process parameters are also required for minimizing programming efforts.

Other issues include easy installation by Plug-and-Produce technologies, task description techniques, calibration, sensor-fusion, and generation of robot programs. The combination with safe robots that understand human-like instructions should form a new generation of robots, with the continued need for further development and integration with other types of robot technology.

There will be a need for robot work cells to adapt to variations in production flow or in maintaining the production rate in the presence of uncertainties. When the physical or logical layout of the production process has to be restructured or when new equipment is installed, SME employees, who today do not engineer robotized production, should be able to compose and configure the equipment. Work cells should be adaptable in case of work-piece variations or reconfigured when production volume or product changes occur. The goal is to create work cell designs resulting in "zero-changeover time" when adapting or reconfiguring to product variants, and the deployment of a typical robot work cell within *less than three days* (instead of weeks). Several concepts of self-configurable work cells have been suggested in the past with little success, mainly owing to high costs of the modular components, lack of compatibility with third-party components, shortcomings in the robot's intelligence for dealing with variable product geometries/locations/processes, and owing to lack of integration of planning and configuration tools within typical CAD systems.

Mechanisms and Architecture for Plug-and-Produce: To be able to plug and produce without operator intervention, there is a need for standardized protocols and software interfaces, which allow the automatic configuration of all components upon setup of the workcell. Grippers, tools, sensors, part transport and feeding devices have to be automatically interfaced to the cell, initiated and started. The consortium has the power to set European and worldwide standards for these interfaces and plug-and-produce mechanisms. The software mechanisms needed to support such radically improved flexibility differs from current practices in that fragile/hard-coded implementations are replaced by secure software techniques.

Robot Task Generation based on Product/Process Data: Programs and process information should be generated from CAD data, in addition to intuitive instruction schemes. Both user and CAD input need to be combined and converted into task instructions that can be understood by the robotic workcell. The generated motions from ideal CAD data have to be adjusted to current workpiece and process requirements. Thus, the adaptation of the robot requires adaptation and optimization of trajectories and process data. First algorithms are available, but need to be better integrated with sensor-based motion control and the programming system in general. The consortium has novel ideas, which make fast, easy and intuitive calibration of CAD data to cell equipment, tools and work objects possible without any measuring devices. The robot operator can make use of process models and CAD geometries without knowing anything about CAD systems or the process model representations. This also means full coherence between on-line and off-line representation, and SMEs can make direct use of process and geometry data from more advanced customers.

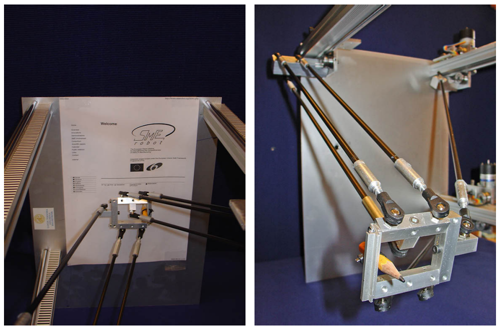

Fig. 1. Portable LTH-prototype of the Gantry-Tau parallel kinematic manipulator (PKM) concept, based on the ideas and patents of T. Brogårdh, ABB Robotics, see [5] and references therein.

Acknowledgment This work has been funded by the European Commission's Sixth Framework Programme under grant no. 011838 as part of the Integrated Project SMErobot.

References

[1] SMErobot (2005) `http://www.smerobot.org`

[2] `http://www.robot.lth.se`

[3] R. Johansson , A. Robertsson, K. Nilsson, T. Brogårdh, P. Cederberg, M. Olsson, T. Olsson, G. Bolmsjö, "Sensor Integration in Task-level Programming and Industrial Robotic Task Execution Control", *Industrial Robot: An International Journal*, Vol. 31, No. 3, pp. 284-296, 2004

[4] A. Blomdell, G. Bolmsjö, T. Brogårdh, P. Cederberg, M. Isaksson, R. Johansson, M. Haage, K.Nilsson, M. Olsson, A. Robertsson, and J.J. Wang, "Extending an Industrial Root Controller – Implementation and Applications of a Fast Open Sensor Interface" (In press), *IEEE Robotics & Automation Magazine*, September 2005.

[5] H. Cui, Z. Zhu, Z. Gan, and T. Brogårdh, "Kinematic analysis and error modeling of TAU parallel robot" *Robotics and Computer-Integrated Manufacturing*, vol.21, No. 6 pp. 497–505, 2005