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LONG TERM CHALLENGES FOR INDUSTRIAL ROBOTS

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ABSTRACT
Nowadays, industrial collaborative robots or cobots, have been able to work side-by-side with humans as collaborators to accomplish various manufacturing tasks in industrial environments. In addition, new cobotic and human-robot interaction systems have been developed to be able to exploit the capabilities of both humans and robots. However, there are many challenges for highly developed industrial cobotics that still need to be addressed. Accordingly, this review article provides an overview of the state-of-the-art on the major challenges of industrial collaborative robotics and explores future research issues in this area.

CHALLENGES
The widespread use of robots in standard, large-scale production such as the automotive industry, where robots (even with impressive performance, quality, and semiautomatic programming) perform repetitive tasks in very well-known environments, for some time resulted in the common opinion that industrial robotics is a solved problem. However, these applications comprise only a minor part of the industrial work needed in any wealthy society, especially considering the number of companies and the variety of applications.

The use of robots in small and medium-sized manufacturing is still tiny. Global prosperity and wealth requires resource efficient and human-assistive robots. The challenges today are to recognize and overcome the barriers that are currently preventing robots from being more widely used. Taking a closer look at the scientific and technological barriers, we find the following challenges:

Human-friendly task specification, including intuitive ways of expressing permitted/normal/expected variations. That is, there are many upcoming and promising techniques for user-friendly human–robot interaction (such as speech, gestures, manual guidance, and so on), but the focus is still on specification of the nominal task. The foreseen variations, and the unforeseen variations experienced during robot work, are more difficult to manage. When instructing a human he/she has an extensive and typically implicit knowledge about the work and the involved processes. To teach a robot, it is an issue both how to realize what the robot does not know, and how to convey the missing information efficiently.

Efficient mobile manipulation. Successful implementations and systems are available for both mobility and for manipulation, but accomplished in different systems and using different types of (typically incompatible) platforms. A first step would be to accomplish mobile manipulation at all, including the combination of legged locomotion (for stairs and rough terrain), autonomous navigation (with adaptive but predictable understanding of constraints), dexterous manipulation, and robust force/torque interaction with environments (that have unknown stiffness). As a second step, all this needs to be done with decent performance using reasonably priced hardware, and with interfaces according to the previous item. Thus, we are far from useful mobile manipulation.

Low-cost components including low-cost actuation. Actuation of high-performance robots represent about a third of the overall robot cost, and improved modularity often results in a higher total hardware cost (due to less opportunities for mechatronic optimization). On the other hand, cost-optimized (with respect to certain applications) systems result in more-specialized components and smaller volumes, with higher costs for short-series production of those components. Since future robotics and automation solutions might provide the needed cost efficiency for short-series customized components, we can interpret this as a boot-strapping problem, involving both technical and business aspects. The starting point is probably new core components that can fit into many types of systems and applications, calling for more mechatronics research and synergies with other products.

Composition of subsystems. In most successful fields of engineering, the principle of superposition holds, meaning that problems can be divided into sub problems and that the solutions can then be superimposed (added/combined) onto each other such that the total solution comprises a solution to the overall problem. These principles are of key importance in physics and mathematics, and within engineering some examples are solid-state mechanics, thermal dynamics, civil engineering, and electronics. However, there is no such thing for software, and therefore not for mechatronics (which includes software) or robotics (programmable mechatronics) either. Thus, composition of un-encapsulated subsystems is costly in terms of engineering effort. Even worse, the same applies to encapsulated software modules and subsystems. For efficiency, system interconnections should go directly to known (and hopefully standardized) interfaces, to avoid the indirections and extra load (weight, maintenance, etc.) of intermediate adapters (applying to both mechanics for end-effector mounting and to software). Interfaces can be agreed upon, but the development of new versions typically maintains backward compatibility (newer devices can be connected to old controller), while including the reuse of devices calls for mechanisms for forward compatibility to cover the case that a device is connected to a robot that is not equipped with all the legacy or vendor-specific code.

Embodiment of engineering and research results. Use or deployment of new technical solutions today still starts from scratch, including analysis, understanding, implementation, testing, and so on. This is the same as for many other technical areas, but the exceptional wide variety of technologies involved with robotics and the need for flexibility and upgrading makes it especially important in this field. Embodiment into components is one approach, but knowledge can be applicable to engineering, deployment, and operation, so the representation and the principle of usage are two important issues. Improved methods are less useful if they are overly domain specific or if engineering is experienced to be significantly more complicated. Software is imperative, as well as platform and context dependent, while know-how is more declarative and symbolic. Thus, there is still a long way to go for efficient robotics engineering and reuse of know-how.

Open dependable systems. Systems need to be open to permit extensions by third parties, since there is no way for system providers to foresee all upcoming needs in a variety of new application areas. On the other hand, systems need to be closed such that the correctness of certain functions can be ensured. Extensive modularization in terms of hardware and supervisory software makes systems more expensive and less flexible (contrary to the needs of openness). Highly restrictive frameworks and means of programming will not be accepted for widespread use within short-time-to-market development. Most software modules do not come with formal specification, and there is less understanding of such needs. Thus, systems engineering is a key problem.

Sustainable manufacturing. Manufacturing is about transformation of resources into products, and productivity (low cost and high performance) is a must. For long-term sustainability, however, those resources in terms of materials and the like must be recycled. In most cases this can be achieved by crushing the product and sorting the materials, but in some cases disassembly and automatic sorting of specific parts are needed. There is therefore a need for robots in recycling and de manufacturing. Based on future solutions to the above items, this is then a robot application challenge. An overall issue is how both industry and academia can combine their efforts such that sound business can be combined with scientific research so that future development overcomes the barriers that are formed by the above challenges.

CONCLUSION

In this article, we identified some challenges and open issues faced by researchers working on industrial cobots. This study refers to the increasing number of research related to the design and implementation of this type of systems. The current trend of industrial cobotics is to provide a flexi-ble system in which humans and robots can safely interact and cooperate to carry out the assigned tasks. This will encourage industrials to easily integrate cobotic systems. Nevertheless, even though the great progress of these systems, effective performance in this field is still far away.

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