ROBOTIZATION IN CONSTRUCTION

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Abstract

Robotization is a term frequently used in particular with reference to the car industry. With the development of service robots, however, we may expect that these technologies will be increasingly applied in construction as well. The objective of this paper is to map the state of the art in automation worldwide presenting some solutions for use in the building industry.

KEYWORDS: robot, robotics, robotization, automatica, industrial robot, service robot

INTRODUCTION

Robots are used to replace boring and dangerous manual work. The current state of the art in robotics witnesses a transition from simple "grip – move – put down" work operations towards more complex concepts. Present-day robots work not only individually, but also in pairs or in groups. There are even cases of abandoning the policy of strict separation of robots from company employees for safety reasons as today's robots show a significantly higher level of reliability. Another new trend involves the robot-human cooperation in situations requiring the use of e.g. intuition. The issues of robotization on a global level are addressed by IFR (International Federation of Robotics), an international non-profit organization founded in 1987 on the occasion of the 17th international symposium on robotics and associating nearly all robot manufacturers worldwide plus 10 national robotics associations. These include associations like the German VDMA, American RIA, Japanese JARA, South-Korean KOMMA, Italian SIRI or Spanish AERATP. The IFR's head office is in Frankfurt, Germany. The main mission of the federation is to promote the research and development of robots and their practical applications. The federation also promotes the cooperation of manufacturers and research establishments on the international level. IFR annually publishes a study devoted to robotics worldwide. The publication contains detailed statistical data gathered from 50 countries split according to the branch of application and the type of robots. IFR also organizes professional symposiums and conferences which, starting from 2010, will also encompass Automatica, the international trade fair oriented towards robotics and robotization, held every 2 years in Munich.

STATE OF THE ART IN ROBOTIZATION WORLDWIDE

The car industry may serve as an example of a branch where using robots has almost become a must. This is also evident from Fig. 2, *The implementation of robots in 2007 and 2008 in individual branches,* which implies that the stocks of robots installed in the car industry are markedly ahead of the other branches. Based on the outputs from the latest Automatica trade fair of 2008, two new directions of the development in robotics may be traced:

1) cooperation of the human operator with the robot

2) use of service robots

ad 1) This method is suitable for use in small and medium-sized businesses. Thanks to an increasingly better quality level of sensors and machine vision, it has been continuously improved. It is also fit for use in construction which, as it is, still occupies a rather marginal position in terms of robotization.

ad 2) By the end of 2008, the total of 63 000 service robots had been allocated for industrial purposes (milking, **underwater works**, cleaning pools, **demolitions**), of them 9 000 for military needs. It is estimated that in 2009 to 2012, 49 000 service robots will be implemented for industrial purposes and 11.6 million for domestic purposes. The greatest growth is expected in robots for milking and cleaning, followed by medical care robots and mobile robot platforms for miscellaneous uses. Due to the demographic development and as a consequence of improving technology, more and more service robots have been used in the care of handicapped persons in the last ten years.

The situation in the development and practical implementation of robots has been, like in the majority of other sectors, suffering from the global recession started by the crisis on the American mortgage market in summer 2007.

In 2008, IFR reported a worldwide stagnation in the sales of industrial robots falling down to 113 300 units. While the first half of the year still promised a record growth in sales, in the second half, due to the escalation of the crisis (in the 4th quarter in particular), there was a dramatic drop in both the sales and orders. In this respect, some stagnation had already been noticeable in the years 2007 and 2008, even though the figures had remained on a relatively high level. There was a mere drop by 6% as compared to the peak figures of 2005, as is evident from Fig. 1. This high level of sales has two reasons:

1) car industry, the leading branch in process automation, had raised investments into automation and robotization to boost productivity in developing countries and also to increase the shares in traditional markets and

2) a series of “non-automobile“ branches, such as the chemical industry, metallurgy, machine industry, food and electrical industry, allocated large funds into robotization with the aim of optimizing processes.

This global trend, however, was interrupted by the financial crisis.

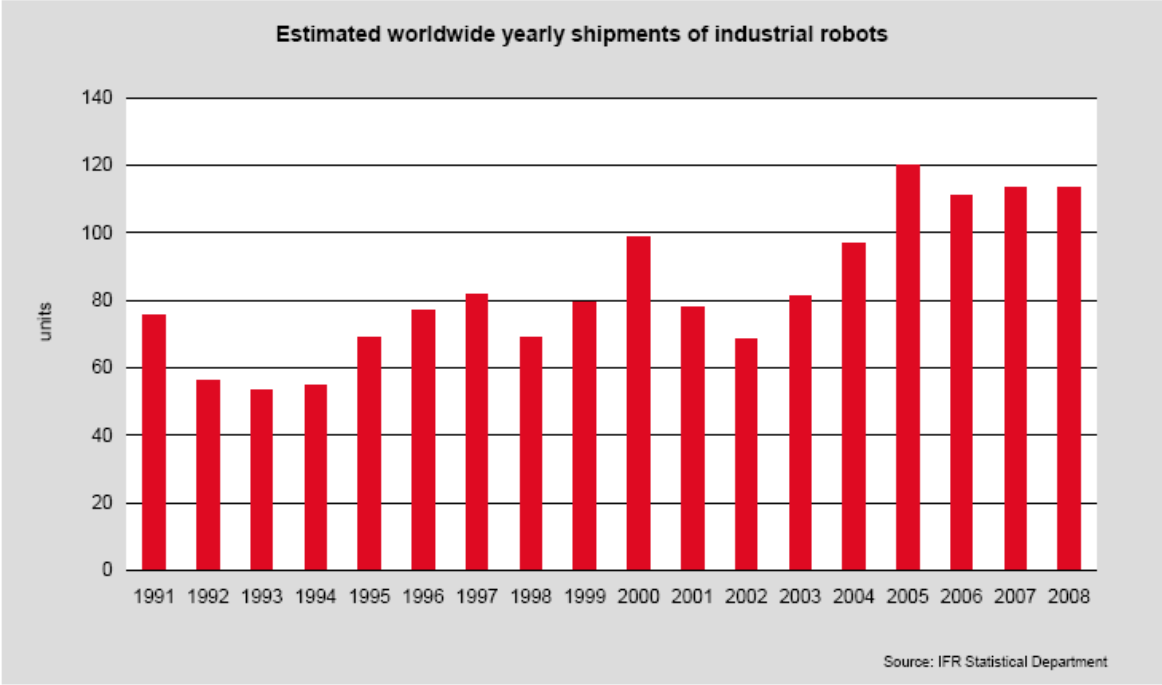

Fig. 1 Annual estimated sales of robots in units (*Source: IFR Statistical Department)*

Recent years have also seen opposing trends in the further use of robots in different parts of the world. While there has been a growth in Asia, North and South America have gone through a decline and Europe through stagnation. This development, however, does not apply to each country within the respective territory.

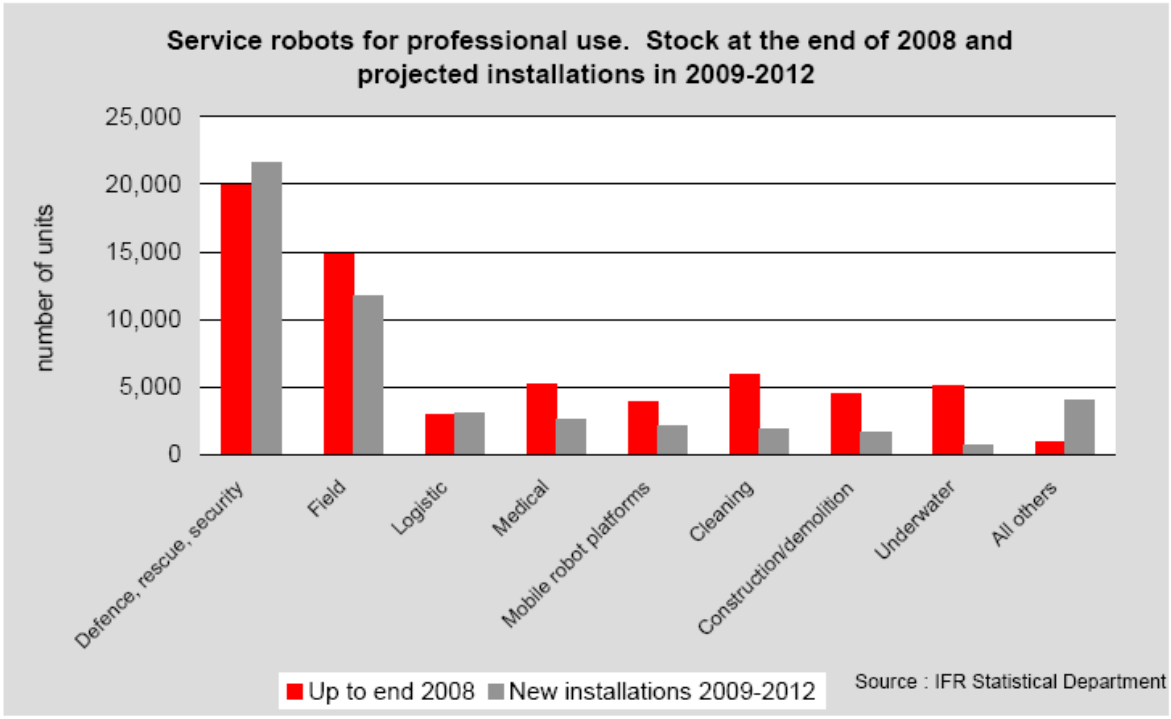

Fig. 2 Service robots for professional use split into branches (*Source: dtto IFR S. D.)*

Expected further development in robotization

In 2009 - 2012, the installation of 49 000 units of new service robots for industrial use is expected. The key sectors are: 1) defence ; 2) rescue and security applications; 3) agriculture; 4) logistics systems; 5) inspection; 6) medicine and 7) mobile robot platforms for miscellaneous uses.

Fig. 2 displays the present-day use of service robots split into individual branches – both stock up to the end of 2008, and installations projected by 2012.

In the segment of robots for domestic use, the expected sales of 4.8 million units are projected for 2009 – 2012. The sales of robots for entertainment, including robotic toys, are estimated somewhere around 6.8 million units for the same period.

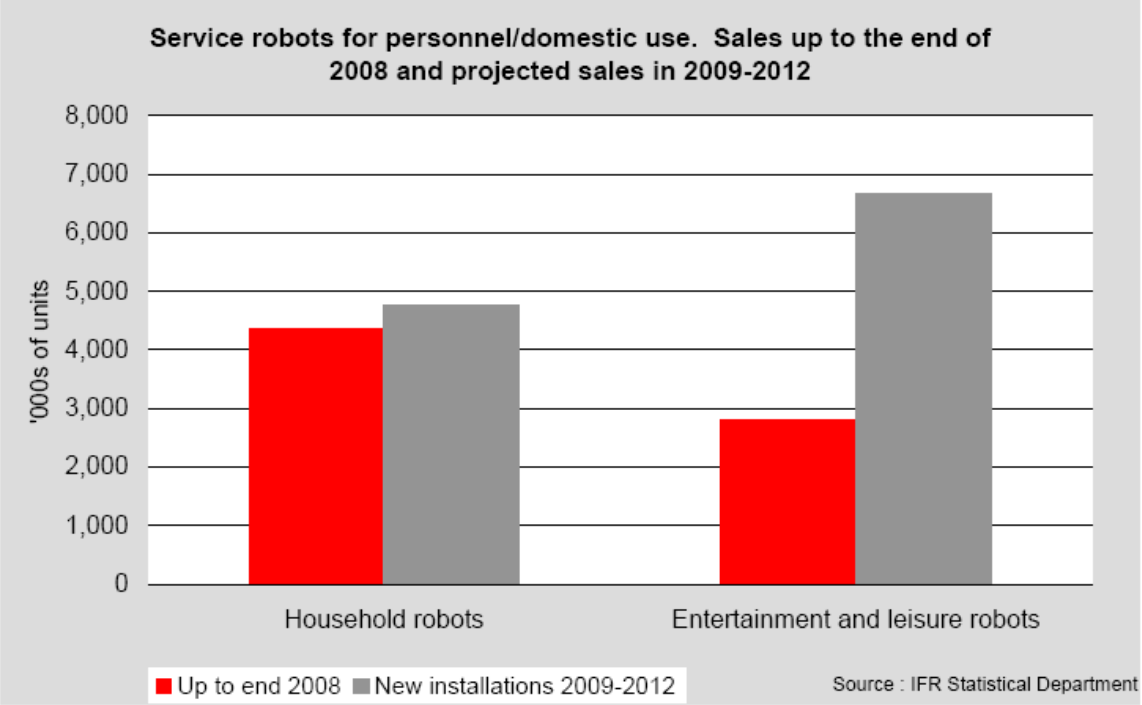

Figure 3 Service robots for domestic use (*Source: dtto IFR S. D.t)*

THE USE OF ROBOTS IN CONSTRUCTION

The robots used in construction are so-called service robots. As Fig. 2, *The implementation of robots in 2007 and 2008 in individual branches*, shows, the construction sector is the Cinderella of robotization as it did not even deserve a separate item in the chart. Still, there are manufacturers who supply service robots for construction. Their use, however, as my research to-date has confirmed, is solely limited to the production of building materials, packing and palletization. The greatest suppliers of such robots are the KUKA and MOTOMAN companies. A major producer of pallet loading systems is also the Kawasaki Robotics – Vanderloo B.V group.

Using robots in formwork production

Three KUKA robots in Werzalit AG + Co KG perform important tasks in the manufacturing process of formwork elements. In addition to windowsills, Werzalit AG + Co KG also produces plywood, veneers, shaped industrial parts and formwork elements for the residential and industrial building sector. The last of these products, in particular, is manufactured with the participation of KUKA KR 60 robots. The formwork is pressed from woodchips mixed with glue. The robotic solution chosen allowed enhancing the production quality at a low price.

Solution

KUKA robots pick up the workpiece and guide it to the tools which, unlike manual processing, does not need changing tools and thus saves time. The formwork elements are removed from the press with the aid of two linear units and moved to a table where the elements are weighed. The parts that are too light are discarded by the KR 60 robot. Good-quality formwork elements are moved to a grinding machine by the robot where they are deburred on four sides. Then, in another station, fungicide is sprayed onto the underside. Finally, the robot stacks the finished formwork elements on a pallet. Two different formwork types are produced in each system. The KR 60 robot is able to distinguish between them on the basis of their position on the table and sorts them onto two different pallets.

Results

Each system produces 70 elements per hour. The efficiency of the system helps to support other, less lucrative plants of the company. Thus, Werzalit AG + Co KG is able, for example, to make special built-to-order products which otherwise, without using robots, would not be economically viable.

Handling roof tiles

The CREATON Company was looking for a solution to modernize the production line for its "MAGNUM" series of mega-sized roof tiles for one of its plants, Autenried II, near Günzburg, Germany. The installed line can produce up to 60 tonnes of clay roof tiles per minute. Previously, this handling involved manual operations. At that time, each operator had to lift roof tiles weighing a total of 1.5 tonnes per day. Therefore, it was decided to automate this task. Today, the work is carried out by five KUKA KR 125/3 six-axis robots. One of the robots unloads four dried roof tiles at a time from dry-item carriers and puts them onto a conveyer. Then, another KR 125/3 places four roof tiles per cycle into the same number of H-shaped trays in which they are transported into the kiln and fired at 1.055 ^{o}C. After that, the third robot grips the four fired tiles and loads them onto a conveyer. The conveyer transports the tiles to the fourth and the fifth robot, who work as a pair for optimal performance. Each of the robots picks up two roof tiles, stacks them and places them onto a conveyer. Working together, the two robots stack four tiles into minipackages, which are then automatically palletized. If, instead of roof tiles, the line is producing fitting elements, the KR 125/3 robots always handle only one part per cycle. The operator may select the appropriate programme quickly and easily by means of the control panel of the KUKA robot controller operating on a human/machine interface similar to Windows.

Results of robot configurations

a) Flexibility – the entire system may be reconfigured within 15 minutes. For the robots themselves, even less time would be required.

b) High repeatability – the repeatability of the robots is high enough so that they can carry out positioning to within a millimetre when loading roof tiles on the trays.

c) More worker-friendly environment – less manual work – employees no longer have to manually lift loads weighing 1.5 tonnes per day.

d) High cost-effectiveness – the capital investment enables the company to produce higher-quality products at lower costs.

On 30th September 2009 at 7 p.m., a new exhibition-exposition was opened in New-York (USA) **Storefront for Art and Architecture**. Part of the exhibition was the presentation of three-year work of the Swiss research centre (ETH Zurich, architects Gramazio and Kohler) - Exploitation of industrial robots in construction.

Figure 4: Concrete Jet Robo**t**

Figure 5: Concrete Jet Robot

Figure 6: R/O/B/ - robot for placing bricks and blocks

Figure 7: At the same time, the first architectural project in the United States was launched in Pike St. (NYC) to be built exclusively with the aid of industrial robots.

OUTLOOK FOR CONSTRUCTION

Enhanced robotization in construction is conditioned on the use of robots during the very erection of structures (Fig. 4 – 7). Such research and verification are already in progress. These perspectives are of great significance with a view to the continuously spreading poor workmanship in the performance of individual building processes resulting from the still more acute shortage of qualified workers on the construction job market (Note: resulting mostly from the nearly dying vocational education and training in the Czech Republic).

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