Robotics and Automation in Japanese Construction Industries

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1. Introduction

Although the Japanese industrial robot companies are proud of their number and sales of commercial industrial robots, the advanced research and developments are to look at the future robotics used in new applications. The term “Robot Technology (RT)” suggests rather broad meaning not limited to the conventional robot arm and its applications. It would include a wide spectrum of automation with the advancement of “Information Technology (IT)”. This is one of the features with the Japanese robotics R&D.

The construction industries have been facing to problems such as more efficiency, lower cost, less time, labor saving, etc. They have been trying to apply the RT key technologies more efficiently. Actually, they have developed lots of construction robots and automation systems. Some have been put into practical use, and others have been turned out their poor performance and high cost. However, the activities are still going to aim the modernization of and the technical innovations of production system in the Japanese construction industries. The keynote speech will introduce the latest activities and projects in Japan and will discuss the relevant R&D in the global aspect.

2. Overlook in Japanese Construction Robots

The feature of the Japanese construction industries is that they are clearly separated into the two categories, building construction and civil works. They are entirely separated in many aspects of academy, R&D, funding, supporting agency, etc. The current R&D can be also overlooked in this way.

Automated construction technologies have been developed and introduced in the Japanese construction industries since the 1980s. More than 150 construction robots have been developed in the field of building construction, and some of them were commercialized as in Figs.1. There are some factors for the success in practical use of robots; clear function and target, compact mechanism, easy operation, and repeated improvement. Of course, it is true that there are very few successful cases. According to the analysis of factors which obstruct the actual use of construction robot, the most important factor is the “lack of robot performance”. This suggests the working abilities of the past developed robots were insufficient for their practical use in building construction. In order to break down such an obstruction, advanced robot key technologies should be well investigated and surveyed [1].

On the other hand, when looking at the civil works, construction robots for public work such as remote-controlled backhoes, bulldozers and dump tracks for disaster recovery and fully-automatic controlled shield machines are positively applied to specific sites as shown in Fig.3. The existing construction technology with the use of robot technology will be generalized and the construction technology based on three dimensional spatial data and IT construction technology by

remote-controlled robots will be developed in the future [2].

The robot technology progresses quickly through the recent research and development activities. Particularly, key technologies, including motion generation, operation, control, sensing and image-processing, information processing/gathering, and remote control, will contribute to the development of advanced construction robots and to the creation of new life space.

The Japanese government has been also trying to boost up the potential of construction industries and has been spending a certain amount of money for R&D projects. The Ministry of Land, Infrastructure and Transport (MLIT) has been funding the General Technology Development Projects in the period of Fiscal 2003-2007 (5 years), where they promote the development of technology for earthquake disaster prevention in large metropolitan areas and the development of assessment methods for fire safety performance. From FY 1972, when the first national project started, to the end of FY 2004, 56 national projects have been completed.

The Ministry of Economy, Trade and Industries (METI) supports a lot of key technology projects including “Humanoid Robot Project” (Fig.4) and “NEDO EXPO Robot Project”. In these projects many applications have been tested and demonstrated for construction automation [3].

The Ministry of Education, Culture, Sports, Science and Technology (MEXT) launched the Special Project for Earthquake Disaster Mitigation in Urban Area in 2002 aiming at significant

Fig.1 Wall Panel Handling Robot commercialized by Kajima

Fig.2 Exterior wall spraying robot developed by Shimizu.

Fig.3 Actual use of remote controlled earth moving machines at Mt. Unzen-Fugen disaster site.

Fig.4 Vicarious Operation of excavation machine by remote control utilizing humanoid robot.

mitigation the earthquake disaster damage on the scale of the Great Hanshin Earthquake, in big city regions such as Tokyo metropolitan area and Keihanshin area. This research project also aims to establish a basis of science and technologies for earthquake disaster-prevention measures. Thirty-three groups from universities and institutes have been developing rescue robots, such as Rubble-Through Searching Robot, Snake-Type Robot (Fig.5), Robot for Gathering Information, Intelligent Data Carrier for Rescue, Intelligent Aero-Robot, Multi-Crawler Robot [4].

Members from 6 organizations, Japan Society of Civil Engineers (JSCE), Architectural Institute of Japan (AIJ), Robotics Society of Japan (RSJ), Advanced Construction Technology Center (ACTEC), Japan Construction Mechanization Association (JCMA), Japan Robot Association (JARA), join into the Council for Construction Robot Research. The council has been actively playing an important role to promote Japanese construction robotics and to organize domestic symposia and forums every year as well as organization of ISRACs since 1988.

3. Advanced Construction Technology with Remote Control Robot and Information Technology

The most advanced information technology and robot technology are introduced in the control of construction machines. These technologies improve the construction efficiency in sites, for example, disaster restoration. Based on their high compatibility, the conventional public construction methods are easily available by the low cost. While they are developed in the application of wide variety of work items, there are increasing needs for safety in construction sites. The improvement of construction business by introducing the information technology is rather delayed than in other industries, especially in the conventional public constructions. The development of the information technology is required in the construction business world to increase the efficiency and the cost of business and to improve its quality.

One of the General Technology Development Projects aims to develop the execution technology using remote control robots capable of construction works to remove dangers, pains or dulls from construction works (Figs.6 & 7). Moreover, the technology to utilize three-dimensional spatial data is developed, which is useful not only for remote control of robot but also for other tasks such as measurement, design and progress control in general construction sites.

4. NEDO Robot Project

The METI has spent 4.1 billion yen (30 million euro) to exhibit the advanced Japanese robotic technology at the Aichi EXPO in this year. Nine practical working robots are developed in cleaning, security, reception and care works. They are demonstrated and used practically in the actual site during the period of the EXPO. The cleaning robots are capable of avoiding humans and obstacles and determine their own location to carry out cleaning and brushing the ground in outdoor (Fig.8). The security robots are capable of detecting fires and suspicious objects, and recovering, transporting them by arms. It is an important fact that these robots are operated in the actual site with people and during the long term constantly and stably.

In addition, 65 prototype robots were developed. They challenged to demonstrate in the virtual

Fig.5 Snake-Type Robot "SORYU" developed by Tokyo Institute of Technology.

Fig.6 Excavation and loading by remote controlled excavators and crawler carriers.

Fig.7 Video showing an operator during remote operation.

Fig.8 Cleaning robot exhibited at Aichi EXPO.

town simulating a city of 2020 where people and robots coexist in harmony. Those 65 robots were screened and selected from over 200 proposals from universities, institutes, and leading companies. The virtual town was divided into street zone, house zone, park zone, consisting of shops, hospital, workshop, library, living and dinning rooms, garden, etc. There are some robots which can be applied in construction works, for examples, “Wall Walker” capable of traveling freely on walls and ceilings using suction cups, “Dr. Impact” traveling through a pipe, applying impact waves by tapping the inner walls with an impulse hammer and diagnosing, “Robot Suit” which can extend human powers in arms and legs, “6 Limb Robot” capable of traveling on ceilings, in narrow spaces as well as on rough terrains.

5. Domestic Symposium Held in 2004

There were 58 technical papers presented as well as 1 keynote speech in the 10th Symposium on Construction Robots in Japan held in July, 2004[5]. Five special sessions were organized in the topics of “Radio Frequency Identification”, “Humanoid Robots Applied in Construction”, “Robotic Systems for Safe Recovery”, “Unmanned Construction Using Automatic Earth Moving Machines”, and “Autonomous Locomotion and Autonomous Distributed Control in Construction”. In the technical sessions there were the topics on “Image Processing and VR”, “RT and IT for Underwater

Construction", "RT and IT for Tunnel Construction", and "RT and IT for Dam Construction". These topics are still expected in the coming ISARC2006.

6. Conclusions

The keynote surveys the current Japanese activities in construction robotics. The R&D for robot key technology is still active in industries as well as universities and institutes in Japan. The Japanese industries are also interested in exchange of their technologies, in collaboration with other countries. The author would expect more close international collaborations through the ISARC symposium and the activities of IAARC.

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