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Automation: A New Millennium Technology for Construction Industries

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ABSTRACT

Building and construction industries are one of the major industries around the world. In which Construction industry is a labour intensive. It is conducted in dangerous situations. So, the importance of construction robotics has grown rapidly. Applications and activities of robotics and automation in construction industry started in the early 90s aiming to optimize equipment operations, improve safety, enhance perception of workspace and furthermore, ensure quality environment for building occupants. Construction automation is a broadly defined planning and technical endeavor that includes in distinct areas .It is the development of programmable (i.e., robotic) hardware for the execution of construction work tasks; significant progress has been achieved in equipment navigation systems. It is also the development of computer-based tools for efficient and optimal planning, design, construction, and execution for construction. The main goal of this paper is to convince building designers and managers to incorporate robotic systems when managing modern buildings. This paper studies recent applications for robots and automation in the construction industry and sets opportunities and challenges through a new framework for better planning and control of construction equipment operation. In this paper, Studying recent applications and projects for using robots and automation in the construction industry, Setting opportunities and rapidly and also provides a new tool for addressing large-scale and complicated field problems.

KEYWORDS: Building automation, Robotics, Construction, Performance, Maintenance

INTRODUCTION

Automation is defined as a self-regulating process performed by using programmable machines to carry out series of tasks. Introducing the use of machines to a production process is called mechanization. Automation goes one step further and the process is not only supported by machines but these machines can work in accordance with a program that regulates the behavior of the machine. Construction automation has been described as the use of mechanical and electronic means in construction to achieve automatic operation or control to reduce potential exposure, time or effort while maintaining or improving quality.

The Development in the field of construction is being predominately characterized by increasing shortage of skilled labour. This shortage will have to compensated Building production is ultimately designed to improve performance and satisfy clients. It is always difficult to keep sight on the overall picture and the final goal. Developments of construction process result of changing circumstances and conditions that lead to improved performance for the client. Today's surveyors, civil engineers, and general contractors face tight timelines and even tighter budgets, especially in today's challenging economy. To finish heavy highway and site construction projects on time, within budget, and to specification, they need to work accurately, efficiently, and, all too often, around the clock. Fortunately, by combining the strengths of two recent industry developments—global positioning system (GPS) machine control and building information modeling (BIM)—engineers, contractors, and surveyors can automate much of the construction process, dramatically improve productivity and accuracy, and complete heavy highway and site construction projects faster and more profitably.

Construction phase is one of the important aspects of civil engineering structures. The success of a project depends on how well the construction phase is carried out. Efficient and economical construction is particularly important because of the increasing complexity of structures being built, the availability of improved materials and construction equipment. Typically in manufacturing field, robots are stationary and product moves along the assembly line. Automation is easier to incorporate because each product is identical with respective tasks done over and over. However, construction robots face with different demands than conventional industrial robots. They must move about the site, because buildings are stationary and of a large size. They require engines, batteries or motors and drive themselves. Construction robots also faced with changing site conditions and must be reprogrammed with each new condition. They must be able to function under adverse weather conditions including variations in humidity and temperature. Additionally, they are constantly exposed to dust and dirt on the site. Thus, there is a need to develop a robotic system for full scale experimentation for realistic assessment of automation in the construction industry.

OPPORTUNITIES AND CHALLENGES IN INDIA'S AUTOMOTIVE MARKET

There is a rapidly growing domestic market. Growth is also visible in automotive export markets. There are well trained, talented engineers and workers. Companies that aggressively adopt leading-edge technologies and standards will have a clear competitive advantage in the global automotive market. The importance of India and China as drivers of global growth is well documented. For instance, in 2009, India accounted for 2 per cent and China 4 per cent, which is projected to rise to 23 per cent for India and 18 per cent for China by 2030. India and China are also projected to have over 50 per cent of global middle class spending by 2050.

TABLE 1
COMPARISON BETWEEN THE CONSTRUCTION AND THE AUTOMOBILE INDUSTRIES

Object	Construction	Automobile
Operation	Not standardized	Standardized
Design	Custom design	Manufacturers design
Production style	Item by item Non repetitious	Volume production Repetitious
Dimensional tolerance of parts	0.5 – 5 mm	0.01-0.1 mm
Work site	Mostly outdoors	Mostly indoors
Relocation of work site	Frequent	None

Source: Automation of building construction and building products industry state of art in Japan

TABLE 2
COMPANIES RELATED TO CONSTRUCTION AUTOMATION

Method	Classification	Function	Companies
Construction Automation at job site	Construction robot	Development & Use	General Constructors
	Assisting equipment	Manufacturing	Eagle Clamp Tokyo RI Yoshinaga Manufacturing
	Automated construction System	Development & Use	General Constructors

Precast method, Prefabrication method	Precast concrete column, beam, Precast curtain wall	Manufacturing	P. S. Mitsubishi Construction Oriental Construction Taisei U-LEC Takahashi Curtain Wall
	Steel frame fabrication	Fabricating	Kawada Industries Komai Tekko Tomoe Corporation Miyaji Engineering Group Yokogawa Bridge
	Welding robot	Manufacturing	Kobe Steel Komatsu Engineering Universal Shipbuilding
	Steel rods fabricate	Fabricating	Nohara Corporation Tokyo-Asahi Build

Source: Automation of building construction and building products industry state of art in Japan

CIVIL INFRASTRUCTURES

In the field of road construction, several projects had been developed over the last decade. They were mainly focused in the development of the new generation of semi-autonomous road pavers and asphalt compactors. The coordination of several machines in order to improve productivity, work completed in less time, reduce labour work etc. are also the objective of the project.

Fig.1. OSYRIS project sensor-based compactor
Source: Trends in Robotics and Automation in Construction by Carlos Balaguer and Mohamed Abderrahim

In the field of earthwork the research is centred in the introduction of new control techniques to existing machinery like excavators, bulldozers, draglines, etc. One of the major exponents of this research area is the control by CSIRO of the 100-m tall walking crane used in surface coal mining. The torque-force control during the excavation is also improving the productivity of the processes. The automated excavator that accounts for interaction forces in analysing the required bucket motion therefore seems promising. As the bucket comes in contact with its environment, the contact force must be regulated such that it remains within a specific range by using specific control strategy (Fig.2).

Fig.2. CSIRO's dragline project
Source: Trends in Robotics and Automation in Construction by Carlos Balaguer and Mohamed Abderrahim

Fig.3. the Automated excavator of the University of Sidney
Source: Trends in Robotics and Automation in Construction by Carlos Balaguer and Mohamed Abderrahim

The inspection and maintenance of the civil infrastructures periodically was another important research activity. It is necessary to inspect civil infrastructures to increase efficiency of machine and take maximum advantages from them. The inspection of building skeletons, complex roofs, off-shore platforms, bridges, etc. represents an extensive and valuable field of work.

HOUSE BUILDING

Interior-finishing operations in the building are very time consuming and requires high degree of accuracy. There are several mobile manipulators able to perform variety of operations like extend, compact and control the thickness of the floor concrete, painting and steel column fire protection spraying, assembly of interior walls and ceilings, etc. Most of these robots are teleported and perform only simple operations. The most representatives' robots of this type are Japanese ones. Three examples are presented: the "Mighty Hand" robot from Kajima (www.kajima.co.jp), which lifts heavy elements in construction as concrete walls, etc. (Fig.4), and the SurfRobo from Takenaka (www.takenaka.co.jp), which automatically compact the concrete floor by using two sets of rotary floats (Fig.5). These robots are used in several building construction sites where they succeeded in releasing workers from thousands of operations.

Fig.4. Kajima's interior wall assembly robot
Source: Trends in Robotics and Automation in Construction by Carlos Balaguer and Mohamed Abderrahim

Fig.5. Takenaka's concrete compactor robot
Source: Trends in Robotics and Automation in Construction by Carlos Balaguer and Mohamed Abderrahim

The last decade has witnessed the development of several robots for automatic assembly of buildings. An effort had been done in the brick laying masonry and the development of robotic prefabrication of façade and wall elements. The robot is equipped with auto-tracking laser telemeter in the tip in order to perform prices (up to 5 cm) brick assembly. The robot performs the assembly sequence obtained by the planning software and needs an initialization process in order to know the bricks pallet position (Fig. 6).

Fig.6. ROCCO project brick assembly robot
Source: Trends in Robotics and Automation in Construction by Carlos Balaguer and Mohamed Abderrahim

The assembly of steel-based buildings is performing by welding, such as column-to-column and column-to-beam joints. The Japanese WR mobile robot performs a variety of column-to column welding (Fig. 7). The steel columns of up to 100 mm thickness can be round-, square-, or H-shaped, as well as box-sectional members.

Fig.7 WR mobile robot for column welding.
Source: Trends in Robotics and Automation in Construction by Carlos Balaguer and Mohamed Abderrahim

ADVANTAGES AND DISADVANTAGES OF AUTOMATION

Advantages commonly attributed to automation include higher production rates and increased productivity, more efficient use of materials, better product quality, improved safety, shorter workweeks for labour, and reduced factory lead times. Higher output and increased productivity have been two of the biggest reasons in justifying the use of automation. Despite the claims of high quality from good workmanship by humans, automated systems typically perform the manufacturing process with less variability than human workers, resulting in greater control and consistency of product quality. Also, increased process control makes more efficient use of materials, resulting in less scrap.

Worker safety is an important reason for automating an industrial operation. Automated systems often remove workers from the workplace, thus safeguarding them against the hazards of the factory environment. In the United States the occupational safety and health act of 1970 (OSHA) was enacted with the national objective of making work safer and protecting the physical well-being of the worker. OSHA has had the effect of promoting the use of automation and robotics in the factory.

Another benefit of automation is the reduction in the number of hours worked on average per week by factory workers. About 1900 the average workweek was approximately 70 hours. This has gradually been reduced to a standard workweek in the United States of about 40 hours. Mechanization and automation have played a significant role in this reduction. Finally, the time required to process a typical production order through the factory is generally reduced with automation.

A main disadvantage often associated with automation, worker displacement, has been discussed above. Despite the social benefits that might result from retraining displaced workers for other jobs, in almost all cases the worker whose job has been taken over by a machine undergoes a period of emotional stress. In addition to displacement from work, the worker may be displaced geographically. In order to find other work, an individual may have to relocate, which is another source of stress.

Other disadvantages of automated equipment include the high capital expenditure required to invest in automation (an automated system can cost millions of dollars to design, fabricate, and install), a higher level of maintenance needed than with a manually operated machine, and a generally lower degree of flexibility in terms of the possible products as compared with a manual system (even flexible automation is less flexible than humans, the most versatile machines of all).

Also there are potential risks that automation technology will ultimately subjugate rather than serve humankind. The risks include the possibility that workers will become slaves to automated machines, that the privacy of humans will be invaded by vast computer data networks, that human error in the management of technology will somehow endanger civilization, and that society will become dependent on automation for its economic well-being.

These dangers aside, automation technology, if used wisely and effectively, can yield substantial opportunities for the future. There is an opportunity to relieve humans from repetitive, hazardous, and unpleasant labour in all forms. And there is an opportunity for future automation technologies to provide a growing social and economic environment in which humans can enjoy a higher standard of living and a better way of life.

CONCLUSION

In this paper, robotics and automation in construction focusing on the new robots developments and machine automation. This area of robot development was very strong during 90s. However actual research and development in the RAC is more focused on new emerging technologies and mainly based on software and IT technologies. This is based on the software integration, simulation and Virtual Reality environments, sensor-based monitoring and tracking, part-oriented construction, etc. These examples are the most representatives but are not exclusive of others. The research in RAC' focus on software and IT technologies does not mean that construction robotics development from the hardware point of view has seen a cessation, but their development is actually slow. Integration and coordination of both hard and soft areas is the Objective of the long-term research in the field of RAC. It is important to note that this research focus strategically appeared in several national and regional research programs.

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