Automation And Robotics In Construction Industry

Rushabh Pravin Alandkar
Dept of Master of Technology, Construction Management
MIT-ADT University, Pune-412201, Maharashtra, India

Abstract- *Automation has the potential to make construction faster, safer, cheaper and more varied, resulting in smart construction. Automation of construction can be useful for the production of structures from enhanced homes to giant skyscrapers much more quickly and at much lesser cost and improved efficiency. This paper explores the vision in making of smart and innovative infrastructure efficiently. The study of Automation and Robotics and their implementation in construction field is illustrated in this paper. The article further emphasizes more on the futuristic demand and application of automation in construction industry. The paper is managed to be written as simple for easy understanding.*

Keywords- Civil Engineering, Construction Industry, Automation, Robotics, Off-site Construction.

I. INTRODUCTION

In an emerging country like India, the growth and development of infrastructure may require the construction industry to switch from traditional methods to modern ones in order to increase productivity and performance [1]. Higher productivity value can be handed over to the end users rightly at optimum cost without affecting the quality and safety aspects. Removal of human error can improve the performance of the structure, which itself is a legacy of construction. Construction industry is the less automated industry that mainly uses manual intensive worker as a primary source of productivity. Whether its new commercial construction, renovation or demolition, robots don't yet play a significant role in any step of buildings lifecycle.

The construction industry plays an important role in national and global economies. With the boom in urbanization, more people are continuously moving from the villages and different rural areas to the metropolis and consequently the infrastructure needs to be re-evaluated so as to accommodate the inflow [1]. The construction industry contributes about 10% of GDP in developed international locations and extra than 25% in growing nations. However, the degree of automation in construction is a long way much less than in other industries, inclusive of production. This consequences in both negative productiveness and volatile operating conditions. Automation and robotics applications are possibilities to resolve such troubles in construction industry. Because of the rapid improvement of computer hardware and software program within the beyond few decades, important upgrades may be found in robotic management, sensing vision, localisation, mapping and making plans modules [2].

Automation and Robotics in Construction

For a higher knowledge of the concept of robotics and automation and their relevance to the construction enterprise, there is a want for certain clarification of the phrases. However, the standards have been defined from popular attitude before concerning them to construction overall performance and the development enterprise [1]. Automation can be defined as the use of machines and technology to make processes run on their own without manpower [3].

Need of Automation and Robotics in Construction

Automation of construction addresses numerous and serious problems related to construction as an instance, low quality of final product, shortages of skilled worker, protection of labour, bad weather circumstance and short construction span which in recent times are features of project. If automation construction is practiced, construction work will be constant and consequently construction time span will decrease and this will provide large economic benefits. Moreover, construction automation increases safety of labours and improves quality of the work. In this study, the benefits and application of construction automation and robotics will be mentioned. Many branch of civil engineering, in consideration with design and construction processes can be benefited from this technology.

Automation and Robotics Techniques in Construction

This phase gives a short overview of the exceptional kinds of robot and automated structures used inside the construction industry. These structures are numerous, and there is no consensus regarding a defined categorisation. The lines between classes are continuously moved or blurred by way of new developments in technologies. The categorisation presented right here intends to facilitate the knowledge of a totally complicated and sundry technology landscape and to offer the reader with a quick review of the specific kinds of

structures. The categorisation supplied here is in partially based on the work [4].

The sorts of automation and robotic technologies for construction may be grouped in four trendy classes (see Table 1): (1) Off-site prefabrication systems, (2) On-site automatic and robot systems, (3) Drones and autonomous vehicles, and (4) Exoskeletons. The primary construction robots were developed in Japan to boom the quality of constructing components for modular homes. [5]. (Category 1: Off-field prefabrication systems). The adoption of these robots was the result of a hit use of robots inside the automotive production area in Japan.Later, construction robots started acting on construction sites, and automated construction sites structures have been evolved (class 2: On-site Automatic and robotic structures) [5]. The new developments have been robots and autonomous vehicles for inspection, tracking, maintenance, etc. (Class 3: Drones and Autonomous Vehicles). Ultimately, Exoskeletons are wearable mechanical devices that augment the abilities of the consumer. Observe, that Exoskeletons are not strictly a robotic gadget, due to the fact they augment the talents of the employee instead of changing it altogether. However, it turned into decided to include exoskeletons right here due to the fact this take a look at makes a speciality of all hardware technologies that improve construction activities. As an example, exoskeletons require an excessive degree of automation and a considerable ability exists on human-robot collaboration [6,7]. In this sense, before construction sites are entirely without human workers, it is able to be expected that robots, automatic systems and augmented people will work together seamlessly.

Application of Automation and Robotics in Construction

The following table exhibits the automated systems and robots category-wise and their relevant application areas in the field of construction industry.

Table 1. Examples of robotic, automated and autonomous systems in the construction industry.

Category	Description, Types and Application Areas
1. Off-field automated prefabrication systems	**Production of building components at off-field locations in an automated manner**
	Building component manufacturing (BCM)
	Large-scale prefabrication (LSP)
	Additive manufacturing (3D printing)
2. On-field automated and robotic systems	**Automated and robotic systems used directly on the construction field**
	Single task construction robots (STCRs) for bricklaying, steel-truss assembly, steel welding, facade installation, wall painting, concrete laying, etc.
	Roboticon-field factories
	Swarms and robots for building component assembly
3. Drones and Autonomous vehicles	**Terrestrial, aerial or nautical vehicles that can be piloted remotely or which are autonomous.**
	Access to extreme and dangerous environments
	Surveying, inspection and monitoring
	Automated drilling, excavation and earth moving
4. Exoskeletons	**Wearable devices that work together with the user as opposed to a robot which performs the task autonomously.**
	Improve workers productivity: lift heavy loads, reduce fatigue, and facilitate the use of tools in awkward positions.
	Reduce injuries

II. FUTURISTIC IMPLEMENTATION OF AUTOMATION AND ROBOTICS

1. Robot Industrialization: Automation And Robotic Technologies For Custom Designed Aspects, Module And Constructing Prefabrication:

For robotic revolution, standards, techniques, and tendencies in the field of building component production (BCM) primarily dependent on concrete, blockwork, timber and steel as constructing substances and large-scale prefabrication (LSP) holding the capacity to deliver complex components and products are main elements. BCM refers to the transformation of parts and low-degree components into higher stage additives by way of quite mechanized, automatic, or robot supported business settings, and it can be sincerely distinguished from the manufacturing of excessive-degree constructing blocks, along with constructing modules (prefabricated tub modules or help modules which can also be known as building sub-systems) and constructing devices (inclusive of the prefabrication of fully finished three-dimensional constructing sections, like Sekisui Heim, Pana home, etc.; see additionally Fig. 1). For relatively automatic prefabrication, according to the unique deviceproducer (OEM) version, component producers constitute Tier-1 or Tier-2 suppliers. Tier-1 providers might deliver additives at once to

corporations such as Sekisui Heim, whereas, Tier 2 providers would supply the suppliers of the bath or assistance units. For automated/robot on-field factories, component manufacturers again represent Tier-1 or Tier-2 providers. BCM and LSP industry can reduce on-field complexity and build the deliver spine in an aftermarket-like industry structure, which can be considered also as a prerequisite for the successful implementation of automated/robot on-site factories [11,23].

Fig. 1 The concept of Robotic Industrialization applied by the Japanese company Sekisui Heim to industrially personalize buildings on the assembly line (Image: courtesy of Sekisui Heim).

Fig. 2 Single-task construction robot (STCR) applied by the company Taisei to automatically coat and paint the facade of a high-rise building.

2. Site Automation: Automated/Robotic on-site factories:

The approach of setting up controlled, factory-like environments on the construction field within the form of computerized/robotic on-field factories (see Fig. 3) can be considered as a logical step forward in prefabrication strategies and STCRs generation. Thirty distinct field automation systems can be identified resulting in an application of automated/robotic on-field manufacturing unit era about 60 times. 13 classes of fieldautomation structures may be distinguished (10 categories for production and three classes for building disassembly [20]). One of the foremost thoughts for setting up automated on-field factories was to integrate stand by itself or (Single-task construction robot) STCR technology into controlled on-field environments to networked system structures and to improve agency, integration, and material flow on the construction site [20,21]. Research on the utilization of automated/robotic on-field factories for constructing disassembly is currently taken in addition in Japan, Korea, and Germany [22].

Fig. 3 Outside view of an automated/ robotic on-site factory (SMART) of the company Shimizu.

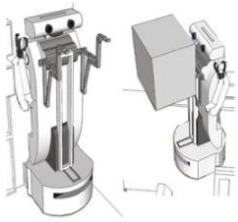
3. Ambient Robotics: Technologies For Maintenance, Assistance And Service:

Following the above distinctive principles and trends,it could currently be determined that CA generation, STCR processes, provider robot systems, and different microsystems era are merging with the built environment becoming inherent elements of homes, constructing additives,and constructing furniture. Absolutely, this tendency can be observed in the design of future care environments. By an inter disciplinary method, optimized care environments are developed in which service robotic systems are seamlessly interacting with the physical environment, embedded medicals sensors and subsystems, various sets of standardized and non-standardized processes, and human beings (care takers as well as care givers). This allows multidimensional help cell robot communicating with the wall, clever cabinets and assistance for dressing/undressing [30].

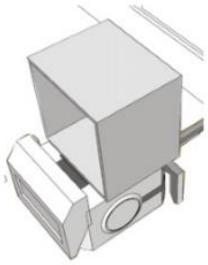
The simple idea consists of a allotted layered structure allowing omnipresent conversation, and a sophisticated human–device communique protocol [24]. The ambient intelligence (AmI, see for example [25]) paradigm units the standards to design a pervasive and obvious infrastructure ableto watching humans without interfering into their lives, adapting to the needs of the user. It ought to be cited though that populating a domestic environment with robot factors have to be achieved following a space-efficient usage scheme. Elderly human beings, and in particular, those the usage of assistive devices including wheelchairs and rollators, require increased barrier-free space for mobility purposes. Ambient robotics specializes in the co-variation and the introduction of compatibility (in a physical and

informational feel) of assistive environments and service robot systems [26].

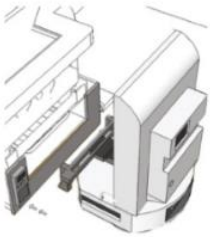
Subsystem 1: Telepresence Robot



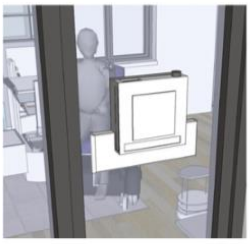
Subsystem 2: Humanoid Robot



Subsystem 3: Mobile Robot Platform



Subsystem 4: Heavy Duty Logistics



Subsystem 5: Window Cleaning Robot.

Subsystem 6: Floor Cleaning Robot

Fig. 4 Robots for inner-house mobility, logistics, and transfer assistance [26].

III. CONCLUSION

Numerous indicators (increase, performance, defect quotes, etc.) advise that traditional creation methodology has reached its limits. To overcome those limits, future construction could make use of what different manufacturing and carrier industries have already efficaciously carried out: consequent automation. Even though strategies of construction automation are nonetheless in an innovation or seed phase, it can be expected that with continued effort put into studies and development those approaches may quickly input into the boom phase and come upon adoption on a larger scale. Currently, it may already be invented that construction automation technology, Single Task Construction Robot techniques, provider robotic systems and distinct micro-systems era are merging with the built environment, becoming intrinsic elements of buildings, constructing components, and constructing furniture. It may be stated that it becomes ubiquitous and starts pervading our life on this planet and, mainly, built environments. Considering that this diffusion of robot era is in most instances strongly linked to the built environment, future interest fields for construction automation will derive from this.

The idea of the presented review paper revolves around the implementation of automation and robotics in building a smart and efficient infrastructure. It reveals the most need of application of this technology in the field of construction for renewable development. Variety of automation and robotics techniques and their applicable areas in construction of smart structure for building a smart city and setting a positive impact on environment have been discussed in this review paper. The article further emphasizes more on the futuristic implementation of automation and robotics and this paper concludes with a strategic plan on how civil engineering can be benefited with the implementation of automation and robotic systems resulting in construction of smart structures.

REFERENCES

[1] Ayodeji Oke1, Clinton Aigbavboa1, Siphiwe Mabena1 (2017) "Effects of Automation on Construction Industry Performance" ICMMSE 2017.

[2] Mi Jeong Kim, Hung-Lin Chi, Xiangyu Wang, Leiyun Ding (2015) "Automation and Robotics in Construction and Civil Engineering" DOI: 10.1007/s10846-015-0252-9.

[3] P. S. Mistri, H. A. Rathod (2015) "Remedies over Barriers of Automation and Robotics for Construction Industry" Int. J. Adv. Res. Eng. Sci. Manag.

[4] T. Bock "The future of construction automation: Technological disruption and the upcoming ubiquity of robotics" Automation in .Construction 59 (2015) 113-121.

[5] Thomas Bock "Construction robotics" Automation Robots 22 (2007) 201–209.

[6] A. Ajoudani, A. M. Zanchettin, S. Ivaldi, A. Albu-Schäffer, K. Kosuge, O. Khatib, "Progress and prospects of the human–robot collaboration" Automation Robots 42 (2018) 957–975.

[7] G. Yang, J. Bellingham, P. Dupont, F. P, L. Floridi "The grand challenges of Science Robotics" Scientific Robot 3 (2018).

[8] T. Bock, T. Linner, "Robotic Industrialization: Automation and Robotic Technologies for Customized Component, Module, and Building Prefabrication" Cambridge University Press, 2016.

[9] L. Jaillon, C. S. Poon, "The evolution of prefabricated residential building systems in Hong Kong: are view of the public and the private sector" Automation Construction 18 (2009) 239–248.

[10] S. Lim, R. A. Buswell, T. T. Le, S. A. Austin, A. G. F. Gibb, T. Thorpe, "Developments in construction-scale additive manufacturing processes" Automation Construction 21 (2012) 262–268.

[11] T. Linner, T. Bock, "Evolution of large-scale industrialization and service innovation in Japanese prefabrication industry" Construction Innovation 12 (2012) 158–178.

[12] I. Perkins, M. Skit more, "Three-dimensional printing in the construction industry: a review" Int. J. Construction Management 15 (2015) 1–9.

[13] Y. W. D. Tay, B. Panda, S. C. Paul, N. A. Noor Mohamed, M. J. Tan, K. F. Leong "3D printing trends in building and construction industry" 12 (2017) 261–276.

[14] A. Więckowski, "JA-WA"-a wall construction system using unilateral material application with a mobile robot, Automation Construction 83 (2017) 19–28.

[15] A. Mirjan, F. Augugliaro, R. D'Andrea, F. Gramazio, M. Kohler, "Building a bridge with flying robots, Robotic Fabrication in Architecture, Art and Design" 2016, Springer International Publishing, Cham, 2016, pp.34–47.

[16] T. Bock, T. Linner, "Site Automation: Automated/Robotic On-Site Factories" Cambridge University Press, 2016.

[17] K. Asadi, H. Ramshankar, H. Pullagurla, A. Bhandare, S. Shanbhag, P. Mehta, S. Kundu, K. Han, E. Lobaton, T. Wu, "Vision-based integrated mobile robotic system for real-time applications in construction", Automation Construction 96 (2018) 470–482.

[18] C. Brown, "Autonomous vehicle technology in mining" Eng. Min. J. 213 (2012).

[19] T. Bock, T. Linner, W. Ikeda, "Exoskeleton and humanoid robotic technology in construction and built environment, The Future of Humanoid Robots- Research and Applications" In Tech, 2012.

[20] T. Linner, "Automated and Robotic Construction: Integrated Automated Construction Sites "Dr. Ing. Dissertation Technische University Munchen Munich, 2013.

[21] T. Bock, T. Linner, "Site Automation: Automated/Robotic On-site Factories" The Cambridge Handbooks in Construction Robotics, Cambridge, 2015.

[22] S.-K. Lee, W. Pan, T. Linner, T. Bock, "A framework for robot assisted deconstruction: process, sub-systems and modelling" Proceedings of the 32nd International Symposium on Automation and Robotics in Construction (ISARC), Oulu, Finland 2015, pp. 690–697.

[23] T. Bock, T. Linner, "Site Automation: Automated/ Robotic On-site Factories" Cambridge University Press / The Cambridge Handbooks in Construction Robotics, Cambridge, 2015.

[24] C. Georgoulas, T. Linner, T. Bock, "Towards a vision controlled robotic home environment" J. of Automation in Construction: Spec. Issue (ISSN:0926-5805) (2013).

[25] E. Aarts, H. Harwig, M. Schuurmans, "Ambient Intelligence: The Invisible Future" in J. Denning (Ed.) McGraw Hill, New York 2001, pp. 235–250.

[26] T. Linner, W. Pan, C. Georgoulas, B. Georgescu, J. Güttler, T. Bock, "Co-adaptation of robot systems, processes and in-house environments for professional care assistance in an ageing society" Procedia Eng. J. 85 (2014) 328–338.