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A Review on Automation and Robotic Technology in Construction Industry

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Abstract: ***Automation and robotics are the use of computers, control systems and information technology to manage various works, replacing manual labour and improving efficiency, speed, quality and performance. Multiple researchers have worked and are working in the construction field to implement robotics technology in construction industry. Growth in utilization of automation and robotics technology is more apparent in western world. Such technologies are developed due to reducing labor population, diminishing of skilled workers, to eliminate dangerous jobs for labors and to promote safety and security in construction. The aim and purpose of this review was to study and analyze the ongoing consciousness, desirability, usefulness, acceptability and adaptability of robotics and automation in the construction industry. The implementation of robotics has been used to a large extent on-site and mostly targeted low rise buildings. The general perception of the practicing construction industry professionals is that robotics and automation are considered to be similar and are beneficial and suitable for a developing country. A systematic search of IEEE, Web of Science, and Scopus was conducted. The systematic search shows that researchers in the USA played a main role on robotics and automation in construction industry, followed by Switzerland and Germany.***

Keywords: Robotics, Automation, Modern technology, Construction industry, Future of construction, Off-site construction, On-site construction, Exoskeletons, Autonomous vehicles, Drones.

1. Introduction

Robotics is the multidisciplinary section of science and engineering that incorporates various engineering branches like mechanical, computer science and electrical engineering. Robotics is a field dedicated to the development of autonomous devices, including manipulators and mobile vehicles. Robotics develop man-made mechanical devices that can move by themselves, whose motion must be modelled, planned, sensed, actuated and controlled, and whose motion behaviour can be influenced by “programming”. Robots are called “intelligent” if they succeed in moving in safe interaction with an unstructured environment, while autonomously achieving their specified tasks. Robotics involves design, construction, operation, and use of robots.

Automation is a formation of technologies and its function to command and observe the manufacturing and transporting of a variety of economic consumption. These technologies are used to establish machines that can replace humans and can copy human actions. In its abbreviated form “Robotics and Automation in Construction” is termed as RAC. In the construction industry the desire to establish robots and automation derive from the dangerous and unsafe environment of this industry. Even though implementation of RAC is observed in many construction projects, the global utilization of RAC is cramped due to advanced technology and unaffordable which make robots and automation commercially impracticable for many projects with lower scale.

A lot of building construction projects have the prospects to be carried out by implementing the robotic technologies, habituating fresh technologies requires a number of distinctive properties of excessive payload, loyalty, and vast workspace to be accomplished. In addition, number of robots works together performing same task, due to which path planning on construction site becomes hard and difficult.

Robotic technologies surely have the potential to enhance measures like its momentum and capability, also allowing construction in environment where it is hazardous for humans to work such as disaster areas, high regions, poor lightening areas etc. In this context, this review focuses on current studies in this field.

1.1 Objective

1) To analyze the aspects that opposes the implementation of robotics and automation construction industry.
2) To evaluate the consciousness of robotics and automation in construction industry.
3) To identify benefits of robotics and automation in construction industry.
4) To recognize the beneficial aspects that support implementation of robotics and automation in construction industry.
5) To determine safety and quality standards in construction.

1.2 Merits

Robotics and automation systems in construction industry can achieve the following advantages:

1) Enhancing working conditions as prevailing physical work is diminish to a minimum so the workers are relaxed from difficult and harsh working environment.
2) Reduction of labor costs.
3) Abolition of objections made by workers about works concerning noise and dust such as cleaning, removaland construction of surfaces.
4) Funds accumulated on welfare and well – being improvement of a worker.

5) Expanding productive capacity, performance and efficiency with reduced costs.
6) Saves a lot of time.
7) Consistent quality with higher precision than that offered by proficient workers.
8) Abundant safety for both workers and the public through implementing and installing machines for hazardous jobs
9) Four supportive factors supporting the utilization of robotics and automation in construction are given in Table no.1.

Table 1: Four supportive factors withdrawn

Factors Withdrawn	Supportive Factor Label	Containing Variables
Factor 1	Suitability (to construction projects)	Upgrade project status, convenient for repetitive works, lower danger to human life
Factor 2	User value-add & comfort	Helps to boost user satisfaction, put on usefulness to the building projects, assist to develop management professionals.
Factor 3	Savings and efficiency boosters	Expand productivity, saves time, lower labour demand, provide savings.
Factor 4	Viability (financial and commercial)	Readily accessible commercially, financially achievable, presently in use.

1.3 Demerits

Robotics and automation systems in construction industry can achieve the following disadvantages:
1) Inaccessible locally and hard to acquire.
2) Not acknowledged and accepted by workers on construction field.
3) The shatter and crumbled nature of the market.
4) Complicated and difficult to access by the workers.
5) Initial cost is more and high financial obligations from owner.
6) High illiteracy of workers in new technologies.
7) Ongoing cost is more.
8) Always require an expertise to set them up.
9) Three resistance factors resisting the adaptation of robotics and automation in construction are given in Table No.2

Table 2: Three Repentance factors withdrawn

Factors Withdrawn	Resistance Factor Label	Containing Variables
Factor 1	Very little awareness	Very little technology, irreconcilable with present activities.
Factor 2	Suitability (to construction projects	Very extensive needs and demands, unsuitable, effects employment.
Factor 3	User disapproval	Unacceptable, expensive, absence of local commercial, unachievable

1.4 Applications

1) Robots and automation is used for-surveying, demolition, excavation, paving, earthmoving, concrete slab finishing and screeding, concrete distribution and transportation, positioning and welding of structural steel members, fire resisting and paint spraying.
2) Prototype machines have been evolved for fireproofing, shotcreting, concrete finishing, rebar placement, tunneling and positioning of structural members.
3) Robotics and automation in Concrete Works-laying, post laying leveling, final floor finishing, and removal of surface water.
4) Robotics and automation in Road Paving-asphalt receiving, spreading, conveyance, automatic control (start/stop) of all paving functions, remote controlled longitudinal crack sealing machine.
5) Robotics and automation in Finishing Works-window glass mounting, welding, indoor plastering, tile setting, block laying, surface finishing in tunneling.
6) Robots for structural works-concrete placing, steelwork lifting and positioning
7) Robots for finishing or completion works-wall or ceiling panel handling and positioning, exterior wall spraying.
8) Robots for inspection works-external wall inspection
9) Robots for maintenance works-window and floor cleaning

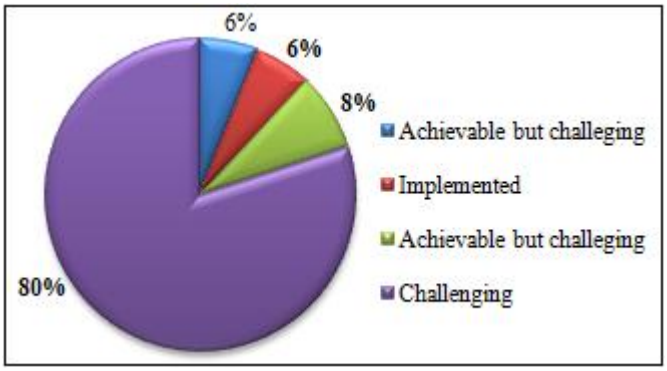

Figure 1: Implementation Robotics & automation in construction

1.5 Types of robotics and automation in construction industry

This segment gives a short and quick analysis of the different types of robotic and automated systems used in the construction industry. This can be classified in four general categories
a) Off-site prefabrication systems
b) On-site automated and robotic systems
c) Drones and autonomous vehicles
d) Exoskeletons

a) Off-Site Prefabrication Systems

This group incorporates numerous technologies that manufacture building elements at off-site locations in an automated fashion. The chief purpose of these systems was to enhance the features of prefabricated building elements and grasp creativity and inventiveness from the utilization of robots in other construction regions. These technologies embrace Building Component Manufacturing (BCM), which converts materials such as concrete, bricks, wood, steel, etc.

and low-level components into high-level building components. These technologies also include Large-Scale Prefabrication (LSP), which converts high-level building components into finished entire building modules such as bath or kitchen modules. This section also involves additive manufacturing techniques, also known as 3D printing. Additive manufacturing technologies have been developing swiftly, at present; it is feasible to print large scale construction elements.

b) On-Site Automated and Robotic Systems

This group incorporates automated and robotic systems that can be immediately used on the construction site to fashion buildings and structures. The single task construction robots (STCRs) is a type of system used earlier, which can perform a single task in a repetitive manner. The robotic arm used in automotive manufacturing is one of the best examples of this type of robots. These robotic arms are set up in movable platforms and are used to perform simple tasks on site. This system is too pliable as it could easily combine and bend with other traditional construction systems. No matter how, this system causes challenges such as the necessity for additional health & safety requirements, the struggle to accommodate and to correlate with human workers activities, and the absence of combination with downstream and upstream activities. On-site robotic factories have been established to deal with these challenges. Its primary aim is to combine self-sustaining STCRs into restrained environments that allow the execution of networked robot systems, in which numerous robots performs variety of tasks in an automated manner.

c) Drones and Autonomous Vehicles

This group incorporates nautical, aerial or terrestrial vehicles that can be controlled remotely, or which are independent i. e. no controller is required. These vehicles can performs different tasks including (1) surveying and monitoring tasks; (2) acquiring harsh and tough environments, thus abolishing human workers from high-risk area; and (3) automated demolition, transportation, and excavating of materials. Drones can be used to study extreme and dangerous sites. For example, drones have been evolved to obtain and observe mud volcano zones or even space investigation. A terrestrial drone can be utilized to self-operate visual survey, and also a vehicle that navigates and collects data for progress monitoring from construction sites. Excavators and drillers have been self-operated and self-regulated, and GPS-enabled driverless trucks carry away the excavated material to the specified destination. The clarity of mining functioning activities, in contrast with long-established construction tasks, has allowed the acceptance of these technologies. Nevertheless, there are yet a lot of challenges in the self-obtaining and self-regulating of earth-moving machines for traditional construction sites. As well as, there are various challenges to be considered and addressed in such a way that drones can be exploited adequately for construction, Which includes (i) low battery life; (ii) high initial costs; (iii) drones represent higher risks to health and safety; (iv) compound functioning of hardware and software, which needs additional training that leads to rise in expenditure; (v) incorrect recognition of rightness and forbearance, which leads to failure and accidents.

d) Exo- Skeletons

Exoskeletons are automated devices, worn by the user, which boost work done by the workers. These are the wearable devices that cooperate with the wearer which is against a robot which carry out every activity independently rather than a worker. Exoskeletons can help in reducing the difficulties in the job of the construction workers and improves the efficiency by helping them to lift hefty loads, reduces tiredness, makes easy to use the tools in difficult times, etc. Exoskeletons also reduce injuries and carry on a healthier crew. Exoskeletons can be a clarification to the objections put up by an elderly construction crew, by allowing aged workers to carry out their work on-site and to carry out physically challenging tasks. Exoskeletons must be able to experience harsh conditions while being safe and comfortable to use. Yet, there are various challenges to be considered, including (i) Accessibility concerns, including performance, toughness, and adaptability; (ii) Health and safety concerns, as exoskeletons could increase catch, fall risks; and hygiene issues; (iii) The absence of combination with other personal protective equipment (PPE); (iv) The initial high costs, etc.

2. Achievements

The performance, techniques and applications of construction for the end result are on construction field and associated with the robotic technologies of automated building construction system, swarm robotics construction system, wire robots for automated construction, robotic construction crew, robotics for insulated walls, spraying roboticsand3D printers. These technologies have 57% targeted on low rise buildings, 35% targeted on low to medium rise buildings and only 8% could target the medium to high rise buildings. This signifies that implementation of such proposed technologies has resulted in a major restriction to target high rise building construction.

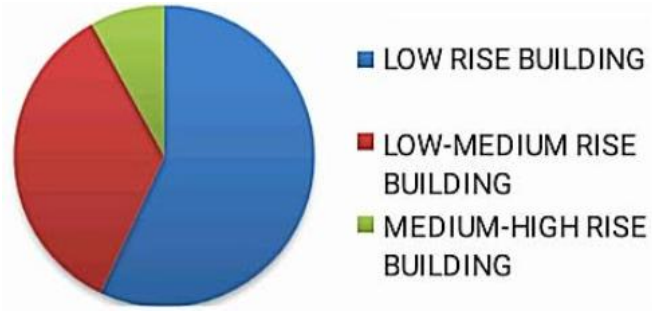

Figure 2: Robotic technology targeting buildings

Most of these robotic technologies were either under developed or imaginary. Their application on construction site, mostly in concrete building is challenging. Among these proposed robotic technologies only 10% were ranked as developed technologies, 6% is applicable in a construction site and only 8% is achievable.

3. Impacts

Robotics and automation are helping the construction industry in the manufacturing of construction products in the ready-made construction process (such as steel pylons, concrete panels, laminated wood members etc.) which

makes this technology more modern and advanced because machines are more correct and precise and help in planning to avoid unwanted materials. An exact amount of material that is essential to complete the product can be estimated by automated machines, thereby developing the working condition that has an impact on the health and safety of workers. A specification can be created with a computer by estimating the type of material and quality throughout the design process. By this the material specification and classification process at the planning stage of the construction project speeds up. Other impacts of automation and robotics in the construction industry are discussed below.

The most important direct construction activities such as steel rebar fixing, formwork fixing and striking, concrete pouring and curing could be replaced by the robotic technologies. The secondary construction tasks that could be abolished consist of ready-mix concrete conveyance to site, steel rebar fabrication, formwork fabrication, and material handling by manually and by cranes. This would have a major impact on the net productivity of the construction activities, and also on the complete capability and ability of the concrete building construction.

4. Conclusion

The review manifest that the robotic technologies in construction industry is in its inception, due to which it is identified as undeveloped and chiefly arduous to implement. The construction industry can initiate concerning better health, cost savings, safety and time. The robotics application and approach have been utilized to great extent on-site and targeted low-rise buildings. Finite novel structural design have been suggested by majority of papers, but lacked to initiate novel construction material. Although the direct and indirect construction works are connected to steel reinforcement, formwork, and concreting can be changed and can be abolished. Furthermore, one of the finest robotic design for the motive of building construction by using manipulator robot is found to be rapid prototyping. Whereas, the implementation of robotics in construction certainly have some drawbacks which need to be addressed and admitted. There is an extensive perceptivity that in spite of the fact that robotics and automation is appropriate for various construction activities, mostly it can be used for Earth work, Concreting and Finishing Works. There is an insight that robotics and automation are same and correlated and can be appropriate for developing countries. People may also deny the usage of robotics and automation because of complications and problems involved and absence of awareness amongst users. These components are essential for the robotics and automation industry to overcome resistance from the construction industry managers.

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