

Drivers to the Adoption of Automation and Robotics in the Construction Industry

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Abstract

The Construction world is swiftly moving towards the simplification and computerization of virtually all construction processes. Automation and Robotics have been singled out by previous studies as a means of achieving this feat. A lot of countries have adopted these ideas to a large extent; however, some other regions are yet to do so. This study therefore seeks to identify and assess the drivers to aid the adoption of Automation and Robotics in the Ondo state construction industry. The review of literature was done briefly to identify some of these factors. Survey design was used in the Research Methodology and design; and questionnaires were administered to Built Environment Professionals (Architects, Civil Engineers, Quantity Surveyors) based on the number of samples drawn from the overall population of professionals present in Ondo State, Nigeria. Data was collected and using Statistical Package for Social Sciences (SPSS). Results showed that the biggest drivers to the adoption of Automation and Robotics were Size of firm, Performance Increment and Familiarity with the concepts of Automation and Robotics. It was recommended that construction firms should try embracing these concepts as the benefits are potentially limitless.

Keywords

Automation, Robotics, Construction, Ondo State, Drivers

1. Introduction

The increasing globalization market competition and advancement in technology in the 21st century have weighed in on the demand for the effective organisation, efficient construction processes and lastly, innovative construction techniques (Hasegawa, 2006). Previous researches and studies have been handy in suggesting and proving that Automation and Robotics can be a dignified option in achieving these innovative techniques, in terms of productivity, safety and quality. The various previous researches carried out on the subject matter indicated a trend that majored mostly of the software development aspect as touching the early design stage of construction projects; some additional works have been done on steelworks, vertical transportation, concreting, finishing works etc. However, not much rigorous works have been seen to be directed towards the adoption and implementation of these technological innovations for Construction site works and processes especially in Western Africa. Computer hardware has seen crucial and telling improvements in recent times in areas like mapping and planning modules, sensory modules, vision localization, robotic control etc. due to rapid developments in Information and Communication Technology (ICT) (Oke, Aigbavboa & Mbena, 2017)

Automation in the Construction atmosphere can be briefly depicted as the use of computerized and mechanized machines in performing some self-regulatory processes in construction (Oke, Aigbavboa & Mbena, 2017). Besides the process being supported by machines, these machines tend to be in sync and work in respect with a set of programs on a computer that dictates and regulates its behavior. The process is not only supported by machines but these machines can work in accordance with a program that regulates the behaviour of the machine. Further information and information about Automation is discussed under the literature review of this research.

In addition, Isaacs (2000) in his study suggested that Robotics is the investigation of the structure, assembling, and activity of robots, for example machines equipped for being modified to perform mechanical errands and to move via programmed control. Robots are utilized in industry to perform errands that are either tedious or in a risky domain; and as PCs create, robots are utilized for progressively increasingly multifaceted undertakings. In this research construction automation and robotics has been examined with its implementation to the on-going projects in Ondo state.

2. Review of Literatures

Computerization of development procedures is conceived to improve difficult work for unsafe and work escalated undertakings, for example, welding and high steel work; with development industry remotely organized by sensors and correspondences innovations to empower innovation and information empowered development laborers to play out their occupations rapidly and accurately (Fiatech, 2004). Past research had anticipated that development industry will turn out to be progressively astute and incorporated as materials, segments, apparatuses, gear and individuals become component of a completely detected and observed condition.

2.1 Automation

"Automation can be characterized as suitable utilization of machines, electronic gadgets and PC programming for the development work in other to achieve increment in the efficiency of development venture, decrease regarding the length, execute difficult work effortlessly, and realizes increment as far as development security. Besides, Development computerization has been depicted as the utilization of mechanical and electronic methods in development so as to accomplish programmed activity or control to decrease potential presentation, time or exertion while keeping up or improving quality (Paresh and Hiren, 2015). Research on the advanced work procedure demonstrates that robotization uproots, as opposed to replaces, human work and expertise, to upkeep, arranging, circulation and subordinate work. Robotization can in this manner be additionally characterized as an automatic procedure performed by utilizing programmable machines to do a progression of assignments. The procedure isn't just upheld by machines however these machines can work as per a program that manages the conduct of the machine.

2.2 Robotics

The word robot at first originated from a Czech play called Rossum's Widespread Robots, distributed in 1920 and debuted in Prague in 1921. The creator, Karel Capek (1890-1938), obtained the word robot from the Slavic *robota*, which means a constrained work (Freeman, 2017). Apply autonomy is a control covering computerized reasoning and mechanical building. It is worried about structure robots; which are programmable gadgets comprising of mechanical actuators and tangible organs that are connected to a PC. The mechanical structure may include controllers, as in modern apply autonomy, or might concern the development of the robots as a vehicle, as in versatile apply autonomy. Robots were designed to give help to individual, most particularly in high unsafe or dangerous circumstances. Among the issue experienced on building site where robotization and apply autonomy are connected is the issue of changing locales and reinventing of the Robot with each new destinations condition. Robot must most likely capacity under brutal climate conditions incorporating contrasts in temperature and mugginess (Kumar, Prasanti and Leena, 2008).

Isaac Asimov an author thought of the "Laws of Apply autonomy" (Critchlow and Arthur, 1985). The law was expressed as pursue;

- i. A robot may not harm an individual or through inaction, permit a person to come to hurt.
- ii. A robot must comply with the requests given to it by individuals aside from where such requests would strife with the primary law.
- iii. A robot must secure its very own reality as long all things considered assurance does not strife with the first and second laws.

2.3 Construction Automation and Robotics

Development computerization has been depicted as the utilization of mechanical and electronic methods in development to accomplish programmed activity or control to diminish potential introduction, time, or exertion while keeping up or improving the quality (Hewitt and Gambatese, 2002). Development robots are sharp machines that utilization smart control yet differ in modernity; and for the most part intended to expand speed and improve exactness of development field activities (Stein, Gotts and Lahidji, 2002). With customary issues encompassing the development business, there is consistently open door for development, and automated designing assumes a significant job in it. Quick increment in the advancement of robot innovation, control hypothesis and PC innovation will advance mechanization and inconceivably strengthen the importance of robots. The quick creating enthusiasm of development mechanization and mechanical autonomy by different development specialists prompts the use of robots and computerization in the divisions of structural building and auxiliary designing. As indicated by Zuzana, and Matej (2011) in development, the degree for robotization and mechanical technology advancements usage can be genuinely expansive, including all phases of the development life-cycle, from the underlying plan, through development of the structure nearby and building support or control after the structure has been finished to the possible destroying or annihilation of the structure. This would envelop the utilization of robotization and mechanical technology advances in all phases of development, from the computerization of the structure procedure using PC Helped Structure, the generation of cost gauges, development calendars and undertaking the executives using costing and arranging programming to real quick machines that utilization smart control during on location tasks.

2.4 Drivers for Adoption

Elements that decide the degree of usage are researched in connection to the essential kind of business and the parts of the structure and development industry in which organizations works; the size of the organization, including the gross yearly income and number of staff and whether they work locally or at a worldwide scale; and whether the advancements that the organizations use are created inside or obtained from outside. Level of utilization is likewise considered regarding zones of development, for example configuration, booking/arranging, costing, venture the executives and on location development (Alexander, Sebastian and St. Laurent, 2016).

2.4.1 Design Stage; This stage can just be portrayed to incorporate the calculated structure, for example the underlying phase of recognizing the need, delivering a plan brief and making starting structure ideas; the created plan for example building up the structure once the idea has been endorsed; and the development, generation, assembling of working illustrations (Hooker, 2004). There are diverse mechanization instruments or plan programming that can be utilized inside the various phases of the structure procedure, from the basic 2D portraying apparatuses with parametric controls through to completely incorporated 3D AutoCAD Interface (Hooker, 2004). The ideas of PC supported structure are not new in the development business, with the steady on-going advancement giving enhancements in the devices utilized. Computer aided design has likewise been promptly acknowledged by the development business, with most of originators from no matter how you look at it grasping innovation and utilizing it widely in their plan work. There have been various endeavors by analysts to extend the utilization of computer aided design; from the utilitarian instrument just supporting the creation of structure, to an increasingly intricate specialized apparatus ready to all the more likely sort out, team up and control the plan information (Hooker, 2004). Computer aided design capacities have expanded from a unimportant device used to impart and work together on configuration capacities, to envelop upgrades in the administration and control inside all parts of engineering rehearses (Hooker, 2004).

2.4.2 Planning, Scheduling, Estimating and Costing; Choice taking during the development procedure, starting at pre-contract organize and proceeding until the finish of the authoritative work, are ordinarily exposed to four limitations: time, cost the amount and the nature of the work required. While the quality and the amount of the work

are expressed in the undertaking illustrations and details, the contractual worker has more power over the time and cost of executing a venture (Laptali, Bouchlaghemand and Wild, 1997). There is various PC programming accessible to help development organizers, amount surveyors and temporary workers in the booking, arranging, evaluating and costing of development ventures. Models incorporate FastTrack Calendar 6.03 (AEC programming), Timetable Tracker 97 (Comprotex Programming), Achievements straightforwardness (KIDASA Programming), DataCAD Estimator (DataCAD LLC), WinEstimator Development Evaluating Programming (WinEstimator Inc.), Developer Data Frameworks for windows (BIS), and a lot more programming. Normally, development organizers carry understanding to structure documentation (2D or 3D illustrations and determinations) to create a development calendar comprising of a lot of exercises and consecutive connections. While development timetables impart time and the grouping of development exercises, venture members should rationally relate this calendar data as per the depiction of the physical structure. 4D-computer aided design evacuates this reflection by speaking to the relationship between calendar data and computer aided design data through a 4D motion picture that generally imparts the grouping of structure development. As such, computer aided design is utilized to create a visual portrayal of the development timetable and improves existing booking procedures. 4D-computer aided design innovation is progressing relentlessly and will greatly affect the procedures of current development the executives practice. With a reasonability arranging robotization incorporated with the present arranging and booking instruments, venture directors can attempt to further diminish in expense of undertaking and task spans (Laptali, Bouchlaghemand and Wild, 1997).

2.4.3 Project Management; Development venture the board is characterized as the arranging, coordination and control of a task from origination to fruition (counting authorizing) in the interest of a customer, requiring the ID of the customer's goals as far as utility, work, quality, time and cost; the foundation of connections between assets; incorporating, checking and controlling the supporters of the undertaking and their yield; and assessing and choosing options in quest for the customer's fulfillment with the undertaking result (Walker, 2015). The code of training for undertaking the board for development and advancement (Contracted Establishment of structure) depicts Task The executives as a new expert control which isolates the administration elements of a venture from the structures execution capacities and characterizes Undertaking the board as the general arranging, coordination and control of an undertaking from commencement to fulfillment went for gathering a customer's prerequisite so as to deliver a practically and monetarily reasonable undertaking that will be finished on time inside approved expense and to the required quality benchmarks. Anyway as indicated by Regal Organization of English Draftsmen (2017), the venture life cycle is isolated into various stages every one of which has doled out undertaking the practices and task and undertaking administrators with characterized duties. By and large, the accompanying stages are characterized: Origin, Achievability contemplates, Schematics structure, Generation Data, Bill of amounts, Offering, Venture Arranging, Development and undertaking Development.

2.4.4 On-Site Construction; the development of any structure incorporates various phases of development forms from earthworks, through development of structure (cementing, outlines gathering, walling ...) to completing works. Customarily, the connected development innovations inside these stages are known as work concentrated and led in different risky circumstances. Additionally, issues identifying with unsteadiness of work power supply and the expanding work expenses are surfacing in the development business (Thomas and Thomas, 2012). With regards to the scope of computerization and mechanical technology applications in building destinations, development robots and mechanization incorporate; three classifications: improvement to existing development plants and equipment's, task explicit robots, and wise or psychological machines. Upgrade to existing development plants and gear can be acknowledged through the connection of sensors and navigational guides, to give improved input to the employable. On location development work computerization was first presented through the advancement of development robots which was created at first to determine a portion of the troubles that are related with the development exercises. Development robots and mechanization are classified into 3 angles as indicated by the Global Relationship of Robotization and Mechanical technology in Development and they incorporates:

1. Task-explicit.
2. Enhancement to existing development plant and gear
3. Dedicated robots

2.4.5 Size of Company; The size of a specific firm or association is a genuine determinant to its reception of mechanization and applied autonomy; huge scale firms would like to embrace the utilization of this advanced advances in other to enable them to execute developments ventures effortlessly and less mistake likewise to have the option to convey a particular task in a decent quality. Bigger organizations working on a worldwide scale utilize the mechanization and apply autonomy innovations (Craftsmanship) more when contrasting with little organizations, the connection between the organization size (identifying with the quantity of representatives) and the use of robotization and mechanical technology advances in on location development larger part of huge endeavors actualized computerization and apply autonomy in its activity in the site though the advances utilization in little organizations isn't in consideration ever. This most likely relates with low attention to computerization and apply autonomy benefits inside little undertakings proprietors (Elattar, 2008).

2.4.6 Gross Annual Revenue; The income generated by an organization from carrying out project work can as well boost their interest in the adoption of development computerization and applied autonomy, the implantation of these technology will help yield increase in the firms' annual revenue (Thomas & Thomas, 2012).

2.4.7 Familiarity with Automation and Robotics; When an organization already has knowledge on how beneficial the adoption of automation and robotics is in the construction industry this will help in making them adopt the use of these technology so as to help their firm benefits from it (Maas & van Gassel, 2005).

2.4.8 Frequent use of Robots and Automated Machines; Putting these technologies into use in various constructions work would make a construction firms develop interest in the adoption of automation and robotics so as to help develop their firm technologically (Thomas & Thomas, 2012).

2.4.9 Time Management; Construction automation and robotics has been of various help in times of managing the construction duration, their adoption brings about fast delivery of construction projects and this is one thing each construction organization would like to possess (Kumar, Prasanthi, and Leena, 2008).

2.4.10 Performance Increment; Ngo and Schioler, (2006) said with the adoption of automation and robotics in construction work, this has brought about the issues for labourers requesting for increment according to the work being carried out by them. This factors help organization to consider the adoption of these technology so as to reduce the issues of labour demanding for increment.

2.4.11 Type of Company; The type of organization also determines the adoption of automation and robotics, a large scale firms that is involved in various construction work would prefer to put these modern technologies into adoption compared to a small construction firm. More massive organizations (particularly those with more branch workplaces) ordinarily have the money related ability to get the innovation, they can manage the related accrued cost (the purchasing costs, the expenses of refreshing and maintenance) as their benefit base is a lot more noteworthy contrasted with a littler organization (Elattar 2008).

2.4.12 Site Implementation of Automation and Robotics; On site implementation of automation and robotics is another factors that drives its adoption, putting these technologies into use in place of labours would surely increase its adoption by other construction firms (So & Chan, 2002).

2.4.13 Mass Production Using Prefabrication; Construction automation and robotics carries out prefabrication with ease and efficiently, as it's a difficult and stressful task for labour to carry out prefabrication, these modern technologies on the other produce as much as required with a good quality (Maas & van Gassel 2005).

2.4.14 Nature of Work; There are some works that are hazardous and risky to labours, the implementation of automation and robotics to carry out such task has helped in its adoption, robots are being designed to be able to work in various atmospheres and also hazardous area in which can subject labour to defects or loss of life (Fell, 2001).

3. Research Methodology

This study employed the use of Survey design which entails the development of instruments and methods of measurement, Collection of data, Modeling and analysis of the collected data. The target population chosen for the purpose of this research was the practicing construction professionals within Ondo state, Nigeria. Due to the limit in the usage of automation and robotics despite its numerous benefits which could help overcome the challenges associated with the common construction techniques, this study was conducted with the aim of assessing the implementation level of automation and robotics in Ondo state construction projects, this was achieved by a survey design carried out among construction professionals in the state. These construction professionals included the architects, quantity surveyors, engineers and builders. The sampling frame was gotten in accordance with the current list of registered members that are financially up to date with their respective regulatory bodies. Therefore, the sample size is calculated using the formula below;

Yamane’s theory

$$n = \frac{N}{1+N(e)^2}$$

Where n= the Sample size

N: the total population

e= the level of precision as = 0.15

Table 1. Sample Size of Respondents

Respondents Professional Body	Frame	Size
Quantity Surveyors	57	24
Architects	27	16
Builders	40	21
Engineers	180	35
Total	304	96

Source: NIQS, ARCON, COREN, ONDO STATE

The administration of study questionnaires constitutes the major instrument for primary data collection geared towards addressing the research problem and objectives which the research is anchored. Kothari and Garg (2014) opined that a questionnaire is a set of questions designed by the investigator to elicit some precise information on a particular matter. Data Analysis was carried out using Weighted Mean Score (WMS). It was determined as follows;

$$WMS = \frac{5n_5 + 4n_4 + 3n_3 + 2n_2 + 1n_1}{N} \dots \dots \dots (1)$$

Where n_2 = number of respondents who answered Agree

n_1 = number of respondents who answered disagree.

N = Total number of respondents

4. Data Presentation and Result

Table 2 Respondents' information

Factors	Variables	Frequency	Percent
Professionals	Architect	17	24.6
	Quantity Surveyor	23	33.3
	Engineer	17	24.6
	Builder	12	17.4
	Total	69	100
Type of firm	Consulting	26	37.68
	Contracting	43	63.32
	Total	69	100
Year of Experience	0-20	55	79.7
	20-40	11	15.9
	Above 40	3	4.3
	Total	69	100
Firm's Existence	0-5	25	36.2
	6-10	30	43.5
	11-15	8	11.6
	Above 15	6	8.7
	Total	69	100

Second factors from the table 2 shows the type of firm, 26 respondent of consultant representing 27.68% of the population and 43 respondents of contracting represent 63.32% of the population. Third factor in the table 4.1 which shows the years of experience,55 respondents has 0-20 years of experience representing 79.7% of the population, 11

respondents has 20-40 years of experience, representing 15.9% of the population while 3 respondents has above 40 years of experience representing 4.3% of the population. The fourth factors shows the firm existence of the respondents and 25 respondent has 0-5 years of firm existence representing 36.2% of the population, 30 respondents has 6-10 years of firm existence representing 43.5% of the population, 8 respondents has 11-15 years of firm existence representing 11.6% of the population while 6 respondents has above 15years of firm existence representing 8.7% of the population.

Table 3 indicates that the size of a particular firm is the most critical factors that drives the adoption of automation and robotics in construction. Also performance increment seems to be another factor that serves as a good driver to construction automation and robotics, on the other hand according to the collected data type of company was said to be the least factors that drives the implementation of this technology within the on-going projects in Ondo state.

Table 3 Drivers of Automation and Robotics

Drivers	Mean	Rank
Size of the Company	4.3088	1
Performance increment	4.2794	2
Familiarity with Automation and Robotics	4.2647	3
Time management	4.2059	4
Nature of work	4.1912	5
Economic feasibility studies	4.0896	6
Training and site implementation of automation	4.0882	7
Mass production prefabrication	4.0000	8
Gross Annual Revenue	3.9706	9
Globalization of the market	3.9559	10
Type of company	3.8529	11

5. Discussion of Findings

Hooker, (2004) observed that construction professionals are aware of how automation and robotics can be put into use in the construction stage which entails the Design stage and also the Construction work process. This study therefore revealed that the size of an organization is the most critical factor which leads to the adoption of construction automation and robotics (Elattar, 2008); a very large construction firm would prefer to adopt the use of technologies in other to bring about efficiency in its work, so also to enable them to handle various construction projects with ease and to also increase their productivity measures and time savings. The adoption of these measures would bring about uniformity and precision in the work of any organisation and this would therefore secure more projects for the organisation. Another very important factor following closely to “size of the company” is Performance increment. As depicted by Ngo and Schioler, (2006), the demand for increase in labour rates often influence a firm opting to make use of Automated innovations. Many firms will prefer to bring in machines that might seemingly be more expensive initially but ensure greater efficiency.

Furthermore, the level of familiarity and prior usage of Automation and Robotics by the workforce in a construction firm is another very important determinant of its adoption, as corroborated by Maas and van Gassel (2005). Literally, when firms have little or no knowledge about a concept, there is no way they can exhibit it; the only plausible option in cases such as this is hiring of automation specialists. The possibility and advantages of better time management is another cogent driver to the adoption of Automation and Robotics in any Construction Industry; and this in corroboration with Kumar, Prasanthi, and Leena (2008). Other drivers such as Nature of work, Economic feasibility studies and Training and site Implementation of Automation are also very important ; their respective Mean scores are relatively very high regardless of their actual ranking (Fell, 2001; So & Chan, 2002; Walker, 2015). Expansively, the type and complexity of a particular project goes a long way in attracting the usage of advanced technological innovations like Automation and Simulation. So, also the viability of the project; if the project indicates a very high profitability at the very inception due to comprehensive feasibility report; the management might decide to opt for Automation and Robotics out of the supposed revenue.

Lastly, the least dominant driver is the “type of company”. This simply indicates that the usage of Automation and Robotics is not jus limited to a particular sector or industry; any company is open to using it as its uses and possibilities are limitless.

4. Conclusion and Recommendation

The future patterns and open doors for the usage of robotization and apply autonomy advances in development ventures can be recorded and positioned from the most least noteworthy, there will be more noteworthy familiarity with mechanization and mechanical technology advances inside the development business network; the quantity of development organizations utilizing computerization and apply autonomy will altogether expand; mechanization and apply autonomy advances will be less expensive to obtain and work; there will be a fundamentally bigger scope of robotization and apply autonomy innovations accessible for use in development; the utilization of computerization and apply autonomy advances will empower firms to work all the more proficiently and intensely; the advances will be effectively accessible everywhere throughout the world; the advances would be promptly acknowledged by the laborers and the business; there would be a more noteworthy joining inside the development business as far as control and duty regarding structure and development.

Because of the high multifaceted nature of the development procedure and the development mechanical improvement robotization and apply autonomy selection is essential in other to propel development techniques. Draftsmen, amount surveyors, designers and every single other member of the development procedure must be coordinated in this adjustment procedure. The short-and long haul improvement of robotization will occur well-ordered and will be arranged to the individual application and necessities. It is additionally suggested that enormous estimated organizations that appear to as of now be up to date of Apply autonomy and Computerization ought to put more in Innovative work (Research and development) as the potential advantages are boundless.

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Biography

Olayinka Omole is a very passionate graduate student and an upcoming academic writer. He has shown interests in research works within and without his immediate environs; he is very much prepared to learn and further his progression in the academic sphere. Having graduated with a first class (hons) in his first degree from the department of Quantity Surveying, Federal University of Technology, Akure; he is well positioned in an environment yielding his rapid development as he proceeds in his graduate programme, ready to make a mark in the Built Environment and Academic world.