International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 1 Jan 2022, pp: 288-294 www.ijaem.net ISSN: 2395-5252

Potentials of Automation Process in Construction Industry: A Mini Review

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Submitted: 02-01-2022 Revised: 09-01-2022 Accepted: 12-01-2022

ABSTRACT
Road construction industry is labour and capital intensive and construction work is conducted in risky and dangerous situations. The importance of construction automation has grown rapidly in developed countries. In developing countries, the construction industries need automation technologies such as new machineries, electronic devices etc. The infrastructure project requires more numbers of skilled labour, good quality of work, increased productivity etc. The problems associated with construction work such as decreasing quality of work, labour shortages, safety of labour and working condition of projects. This will increase the constructional activities output and lower the labour cost to some level. By integrating gradualautomation to the construction industry, there can be a better improvement in construction productivity and cost reduction.The review finally concludes that road construction and maintenance tasks have a significant potential for gradual automation due to the repetitiveness and relatively moderate sensory requirements of many tasks.

Keywords: Automation, Robotics, Construction, Road, Infrastructure, Productivity.

I. INTRODUCTION

Road construction is a common project embarked upon in every part of the world. Construction industry is labor-intensive and construction works performed in dangerous or risky situations because of many problems associated with labours like education, skill, experience, human tendency, strike, etc[1]. Hence, the importance of construction automation has grown rapidly. Applications and activities of automation in this industry started in the early 90s aiming to optimize equipment operations, improve safety, enhance perception of workspace and furthermore, ensure quality environment for construction works.

Construction productivity on large projects, including road construction, has been constant or declining. This has been coupled with a dramatic increase in construction labor cost and shortage in funding for new road construction and maintenance. At the same time, highway construction costs have been increasing, even after correcting for general inflation[2]. One viable solutions is partial or full automation road construction material layout and machinery as described by figure 1[3][4].

The primary contribution of automation in construction is the development of a comprehensive, multidimensional analysis of costs and benefits associated with a specific automation application. Automation is particularly germane due to the relative simplicity, repetitiveness, and large volume of work involved with roadways. Since, today's construction projects are characterizing by short design and construction period, increased demands of quality and low cost. Theseproblems can be approached by a flexible automation using robots based on computer assisted planning, engineering and construction management. Particularly in high labor cost countries, automated and robotized construction technologies can compensate increasing demand on construction projects[5].

Automated and robotized construction process can reduce stress, fatigue, and time delay of working time through the year. Introduction of robotic technology would result in better workingenvironmentand health conditions, couple withadvanced mechatronics know how and skills. The reduction of construction and repair rehabilitation time would improve cost benefit analysis of construction project or critical

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maintenance activities likes in roads due to faster availability and return on investment.

In addition to any strictly financial benefits, an expected advantage of automated road construction equipment is improvement in work safety and health[6]. In some instances, laborers will be completely removed from the work loop and thus prevented from being run over by the working machine or other vehicles. In other cases, the health hazards associated with the worker's proximity to hazardous materials may be reduced.

New innovative technologies such as automation and roboticshas the potential to improve the quality, safety, and productivity of construction industry. In view of the fact that productivity isa key issue in the construction sector which needs to be improved, automation will improve not only the productivity but also take humanity into consideration and be harmless to the global environment. In recent times, the demanding construction requirements and shortage of skilled labours have made automation a viable alternative.

In developing countries, a lot of work load is dependent on the workers and labours. Also all these labours are not the skilled ones or trained properly, but still the construction activities are carried out by the old traditional ways. So, to mechanize the construction skilled labours with proper work training is necessary[7]. With the help of these skilled labours, the various construction activities may be performed with accuracy. When there are skilled labours, then the automated machineries can be utilized with full extent from design, implementation to construction, and maintenance [8][9].

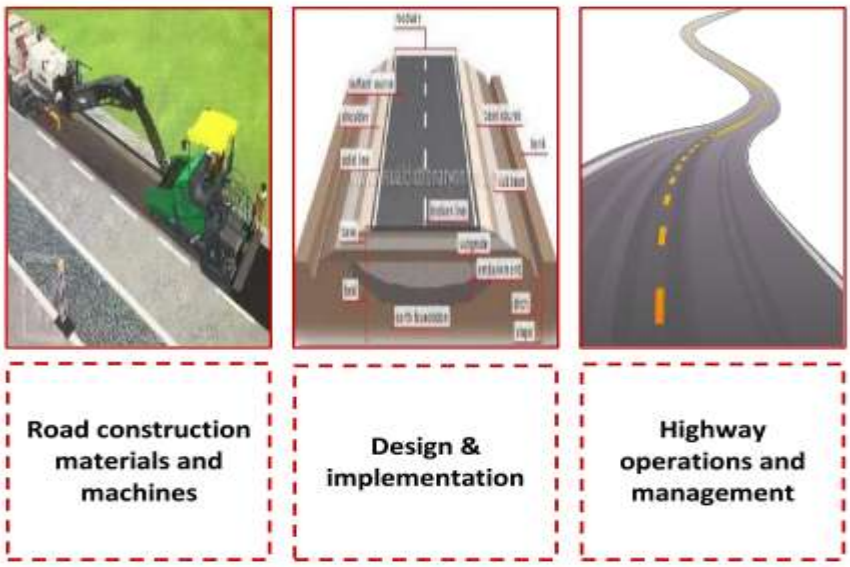

Figure 1: Road construction material layout and machinery

II. OVERVIEW OF AUTOMATION FOR CONSTRUCTION

For rapid construction with less risk and good quality there has been more and more use of machines as well as equipments in the construction industry. Human efforts and risks are reduced by using machines, robots, etc. at appropriate places. Automation is not replacements of the human-power but is an important supplement that caters to the need of mega-construction and fast-track construction[10][11].

Human power is replaced by new technologies of automation because of unskilled labours, they do not give good quality work as compared to automation. Automation increases the productivity of the construction project, reduces the duration and laborious work, and increases the construction safety, increases the quality of work as compared to unskilled workers[12].

The trend of single task automated machines is divided into two streams, one being the low cost teleoperated type. As construction work is less-repetitive, the alternative teach-playback type robot does not fit for construction applications. Another reason is that practically, low cost robots need to be developed. On the other hand, dramatic labour saving cannot be achieved by tele-operated type robots because these require operators. The second stream is the fully automated system. These machines has laser sensors and a CPU which

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enables teaching, less operation. The robot measures the portion to be worked on by its laser sensor and then goes on performing the work on its own under the guidance of the operator[13].

The project success from the project management's view point is achieved when the project is completed with the lowest possible cost, the highest quality, no accidents, etc. In other words, success means bringing each of the project performance indicators such as cost, schedule, quality, safety, labor productivity, materials consumption or waste, etc. to an optimum value. Applying automation and robotics in construction is addressed from the perspective of raising projects performance to serve the client and the environment[14][15]. Automation and robotics systems in construction industry may achieve the following advantages:

- Uniform quality with higher accuracy than that provided by skilled workers.
- Improving work environment as conventional manual work is reduced to a minimum, so the workers are relieved from uncomfortable work positions.
- Eliminating complaints about noise and dust concerning works such as removal, cleaning or preparation of surfaces.
- Increasing productivity and work efficiency with reduced costs.
- Higher safety for both workers and the public through developing and deploying machines for dangerous jobs.[16][17].

Excavation as performed by an excavator is the process of moving bulk material by digging, cutting and scooping, or a combination of them. The term robotic excavation implies the application of state of the art in robot motion control for automating excavating machinery, so that such a machine can accomplish excavation tasks by itself and without the continuous supervision and intervention of an operator[18]. The term excavation is a common activity that is often carried out in construction sites. This has attracted the focus of civil engineers and researchers on how to make excavations process autonomous through the use of robotics excavators.

According to [19] automation of road excavation is a multidisciplinary task, encompassing a broad area of research and development such as planning, monitoring, environmental sensoring modelling and control. The work further demonstrated a fully autonomous execution of excavation tasks in common construction, such as loading a truck or digging a trench. The autonomous vehicle and environment sensors are fitted to the experimental robotic excavator. The hydraulic system is instrumented with transducers that measure the actuator pressures and the valve spool positions. Strain-gauge force sensors enable direct force measurement during digging. Sensing of the machine's external environment is essential for planning and controlling platform motion and autonomous digging operations and for monitoring progress towards task completion.

Figure 2: The robotic excavator in a trench-forming task[19].

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A work by [20]proposed the use of Intelligent compaction (IC), an equipment-based technology to improve quality control of compaction. IC vibratory rollers are equipped with a high precision global positioning system (GPS), infrared temperature sensors, an accelerometer-based measurement system, and an on- board color-coded display as discribed by figure 3. ICMV is a generic term for a calculated value based on accelerometer measurements on vibratory roller drums. These values are in different forms of metrics with various levels of correlation to compacted material's mechanical and physical properties

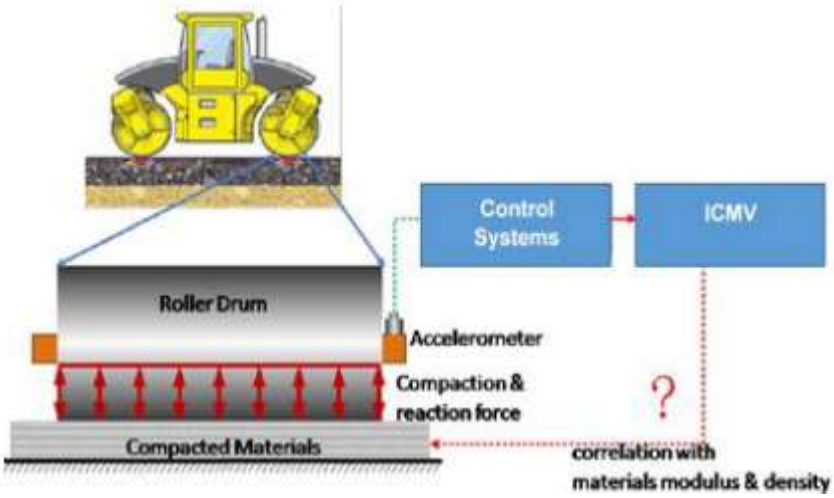

Figure 3:Illustration of ICMV measurement[20]

Similarly [21] discusses earthmoving construction automation using military machinery such as autonomous excavation and unmannedbulldozers with autonomous capabilities that can be used for extensive project as well as specialized tasks for military bridge construction, road blocks, building bases, and fortificationsearth moving, clearing terrain obstacles, opening routes, and detonating explosive charges. The study concludes that typical automated platforms shown in figure 4such asexcavators, bulldozersand front-end loaders can be integrated with internet of things (IoT),sensing and navigation devices to guide remotely controlled capabilities towards teleoperated, semi-autonomous, andautonomous military operations.

Figure 4: Robotic bulldozer for Military application[21]

Moreso, the work by [10] proposed a teleremote operation, where the operator is in a control room far away from the loading site but still performing all the tasks with the help of a remote and audio-video feedback from the machine as illustrated in figure. The operator assistance functions are tools for striving towards fullautonomy of the earth-moving process. In pure tele-remote operation, operator assistance functions can, for example, warn the operator before collision

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or alert them about inefficient and unsafe use. In assisted teleremote operation, these functions can mostly take over the operator. Examples of tele operator assistance functions illustrated by figure 5 are namelypath planning, collision detection, avoidance and navigation, preparing the boom and bucket for loading and dumping, loading algorithm and dumping algorithm.

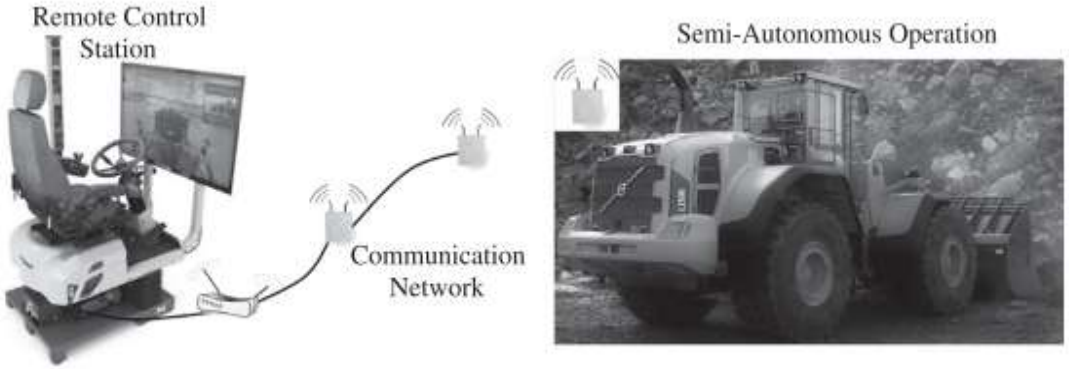

Figure 5:Tele-remote automation operation[10]

Similar automation process is discussed in figure 6[22] which proposed the use of two computer aided application software known asCIRCOM forground compaction and CIRPAVfor the asphalt pavers. The two automation software prototypes are comprises of three main sub-systems: the ground sub-system GSS, the on-board sub-system OB, and the positioning sub-system POS. The applications enable machine to machine automation aimed at data exchange from a ground station to different compaction machines working on a road construction site. The help to coordinate propermachine positioning and movement.

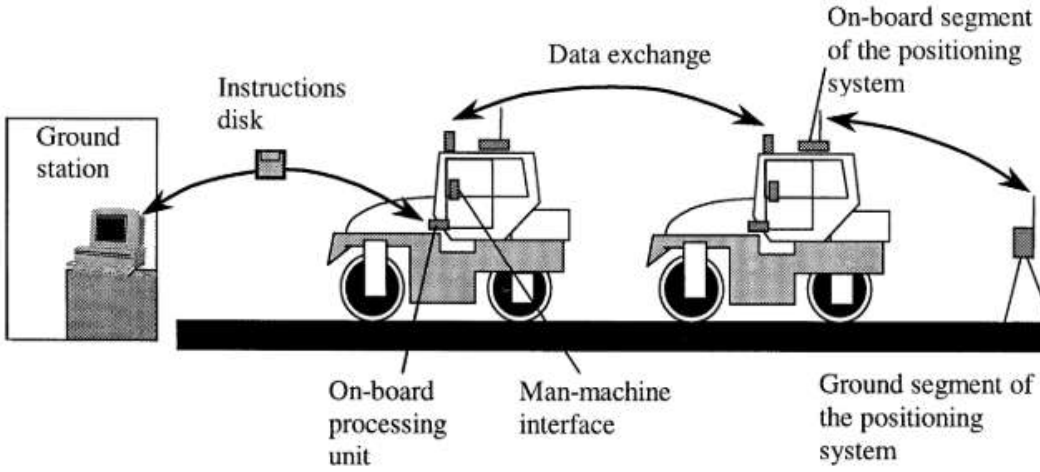

Figure 6 Global architecture of CIRCOM Automation [22]

III. CONCLUSIONS

The importance of implementing automation technologies is the need of today's infrastructure project and construction firms in order to increase the productivity and good quality of work. Both small and medium size firms require automation technologies partly or fully to implement in different sectors such as design, planning, on site construction etc. It is important to maintain the correct relationship between the speed of processing and the speed of material delivery, which is essential for automation in construction industry. The mini review has shown the feasibility of integrating automation and remote control strategies to road and general construction activities. Although the automation and robotics technology can benefit construction industry in many ways, it is not cheap, especially for application in the rugged outdoor environment.

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