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Automation in Construction Industry- LiDAR

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Abstract: ***The world of automation has been growing rapidly for the last few years and it is there is a huge demand from the users. Many companies have automated their manufacturing processes which have led improved productivity and quality improvements. In the construction industry innovation technology is extremely slowly and reluctant to adopt new strategies and low budget also contribute to the slow innovation rate. Because of these slow developments in the technological innovation automation is uncommon solution in the construction industry. Most construction company in India does not fully achieve to implement automation due to various constraints. The purpose of this thesis is to investigate existing and emerging solutions that could be used to automate on site operation.***

A literature study was conducted to gain knowledge about the overall implementations, challenges, opportunities, etc. of automation and robotics in the construction industry. After the literature study to incorporate some extra data interviews were conducted with companies using automation at present and companies which intent to implement automation but face some obstacles in its implementation. To get idea about the factors that are becoming an obstacle in the implementations a questionnaire was designed. With the help of this information research questions were formulated. The result findings were regarding what are the possibilities to use automation, what are the benefits that could be possible after implementations, and what are the requirements and the challenges faced if automation is implemented.

The data collected shows that the factors affecting depend on each site conditions. The study reveals that there are some challenges regarding the implementations of solution. This thesis provides knowledge of available technology (LiDAR) and if that can be used for automation on site as well as how to adopt new technology that can benefit the project in many ways. Here the benefits that can be expected from the successful implementations of such technology to increase the productivity, quality, time management with the help of automation are evaluated.

Keywords: Construction industry, Automation and Robotics, Barriers, Opportunity, LiDAR.

I. INTRODUCTION

The construction industry of India is an important sector from point of development as well as it creates investment opportunities for various related fields. The construction industry is divided with a handful of major companies which are involved in all types of construction activities that carry out any required segment of the construction, the middle companies are specialized in a particular type of work of the complete section and thus they carry out only the specific part of the construction work, the small company contractors work on the contractor basis and carry out the work. The construction industry plays a powerful role in the economic growth and also providing structural development. The construction industry is labour intensive and provides indirect employment. Construction industry is the 2nd largest employer and contributor in the economic sector 10% of the country's GDP depends on the construction activities.50% of the construction demands are the infrastructure project and the rest are the residential, industrial and other activities.

Construction industry is the one in which automation is practiced the least. In developing countries like India automation must be used to the most in construction industry. New machinery, equipment's, electronic devices, new methods, for tunnels for bridges these things requires automation. The recent developments in the field of computer science and technology when combined with the construction activities give a better and a productive output, it not only gives a better output but also saves the time and the human intervention in the process.

A. Construction Scenario in India

The key sectors in the Indian construction market are commercial construction, industrial construction, infrastructure construction, energy and utilities construction institutional construction, and residential construction. In 2022, the residential construction sector was followed by infrastructure construction. The construction process may vary from time to time day to day and in any other situation the construction of the structure may always not be according to the plan or as per the design process at such times the traditional method may become difficult to carry out the construction. In such tedious conditions or during the time of hardships automation is used which works according to the condition leaving harm to human life.

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Human efforts and risk to life are reduced; a better quality of product is the output if the technology is used in proper amount at the correct place and correct timing. The developed countries are using automation and increasing their output and economy thus developing countries like India must adopt automation and help in improving the country's economy. While development and adoption of automation technologies has evolved more slowly in construction than in manufacturing, the time is now ripe for automated construction technologies to play a major role in helping to bring construction's digital transformation into full bloom. The continued evolution of the construction industry will rely on automation in its many forms, from automated digital design and analyses processes to the automated creation of construction documentation and, ultimately, the act of construction.

B. What is Automation

Automation is the technology by which the process or the procedure which conventionally included maximum or more human intervention can now be done with minimal human assistance. Automation can be used from the smallest work to the most difficult or remote work where human network is impossible to reach. Automation is used for operating various equipment's such as machinery, fabrication processes, mixing process, cleaning processes, in case of construction industry. In construction industry there are a few times when it gets difficult to carry out a process in which human intervention is not possible or it may be risky for humans at this time automation is used.

Automation is the simplest form of controlling a work as the controller compares a process and sets desired values and procedure there are some set rules to follow automation which once set do not allow any kind of disturbance to disrupt the system. Once the set of designs are computed or set in particular machinery it follows the same procedure throughout and the final output is the result of the set procedure. Automation has been achieved by various means which include mechanical, computer technology, electrical equipment's mostly automation is the combination of all the technology working hand in hand with each other to give the best possible output. Automation can also be defined as the creation and application of technologies and controlling them till the final delivery and service of the product. Automation includes many elements of the system from planning, designing, manufacturing, transporting, utilities, installations, maintenance, management, demolition, and many more. Automation in itself is a different field which has brought transformation in the construction industry. Automation helps to maintain the increased demand in the construction.

C. Scope of the Project

1) To review the feasibility of application of automation on construction sites.
2) To investigate the factors those are affecting the implementation of automation at construction site.
3) We also analyze the benefits and the challenges faced when use of particular technology (LiDAR) and do they get the desires output.
4) Analysis for identifying the factors that significantly influence the safety and quality at site due to automation.
5) Propose specific improvement schemes based on the results.
6) Recommendations to help bring in new technology and efficiently incorporate it in daily practice.

II. TYPES OF AUTOMATION

Industrial automation systems are categorized based on their integration level and flexibility in the manufacturing processes and operation.

The automation system includes:

1) Fixed automation: Fixed automation systems are utilized in production of high volume products. This equipment's have a fixed set of operation sets and are designed to perform efficiently with the operation sets. This type of automation is used in mass production and continuously flow systems like conveyor belts.
2) Programmable automation: Programmable automation systems allow changing of operation sequence and machine configuration using electronic controls. Since the production process are not changed very often this programmable system are not much in trend.
3) Flexible automation: Flexible automation systems are utilized in computer controlled flexible manufacturing systems. Human operators enter commands in codes that are used to identify the work type. The instructions are used for the necessary processing of the product. Flexible automation is used in the batch processes and jobs.
4) Integrated automation : Integrated automation involves the complete work at manufacturing plants. The process functions under digital information. It comprises computer aided processes. Such technologies are utilized in computer integrated manufacturing and advanced process automation systems.

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A. Case Study for the Possible Applications of Automation

To summarize, the process of estimating the excavation required for a specimen road is complex and necessitates a comprehensive approach. It entails analysing the current site conditions, selecting the appropriate equipment, setting up the necessary sensors and accessories, establishing a benchmark, and scanning the sample road to collect accurate geospatial datasets.

B. Applications of Automation for Surveying

The Methodology for estimating the excavation required for a specimen road is a crucial aspect of road construction that demands a systematic approach comprising several well-defined steps. Firstly, one needs to carefully discern and analyze the current site conditions, taking into account both natural and human factors that might have an impact on the excavation requirements.

1) Conventional Method

Conventional methods have long been used in road surveying to gather information about the terrain and surrounding area. These methods typically involve using equipment such as measuring tapes, levels, theodolites, and total stations to measure distances, angles, and elevations. Surveyors would then use this data to create topographic maps, cross-sections, and profiles of the road and surrounding area. This process requires a high level of precision and accuracy, as any errors in measurement or placement of markers can have significant impacts on the road's design and construction. Conventional methods remain an essential part of road surveying, particularly in areas where newer technologies may not be accessible or suitable for the project's needs.

2) LiDAR Method

LiDAR (Light Detection and Ranging) technology is a remote sensing method used in civil engineering for creating high-resolution 3D maps of the environment. It works by sending out laser pulses and measuring the time it takes for the light to bounce back to the sensor. This enables the system to determine the distance to objects and create an accurate 3D map of the surrounding area.

There are two main types of LiDAR used in civil engineering: airborne LiDAR and terrestrial LiDAR. Airborne LiDAR involves mounting a LiDAR system on an aircraft to survey large areas quickly and efficiently, while terrestrial LiDAR is used for smaller-scale projects and involves mounting the LiDAR system on a tripod or vehicle

3) LiDAR Utilization

The utilization of LiDAR technology in various applications. LiDAR stands for Light Detection and Ranging, which is a remote sensing technology that uses laser pulses to generate precise measurements of the Earth's surface. LiDAR can also be known as Light Imaging Detection and Ranging, which refers to the extra capability of LiDAR to capture images through its collected data. LiDAR is widely used in survey applications to map the Earth’s surface. The technology provides high-resolution maps of the terrain, which can be used for various applications, such as urban planning, floodplain mapping, and coastal management. LiDAR data can accurately differentiate between types of vegetation and identify the locations of buildings and other structures. This information is crucial for designing accurate and detailed maps.

To calculate the distance of the object, the Lidar emits a pulse of light from its laser emitter towards the object in question. The beam travels at the speed of light, and when it hits the object, a small fraction of the beam is reflected back towards the Lidar sensor. The sensor records the travel time of the beam and uses it to determine the distance to the object based on the speed of light. The reflectivity or amount of the emitted pulse energy that returns the Lidar sensor back is then used to determine the reflectivity of the object. The sensor calculates the intensity of the returned light and uses it to determine the reflectivity or the amount of energy absorbed or scattered by the object. Once the sensor receives these measurements, it processes and maps them into a three- dimensional point cloud of the object, which provides an accurate representation of the object’s surfaces.

4) Problem Statement

To estimate the volume of earthwork required for the construction of a new road. To achieve this, we had to gather information regarding excavation, depth levels, and simple pothole measurements. However, we encountered difficulties due to the congested nature of the site, which posed a challenge for obtaining accurate measurements. The presence of many vehicles and pedestrians in poor condition made it further challenging to gather precise data. As a result, we were keen to find solutions to ensure we could achieve an accurate estimation without disrupting traffic and pedestrians. In order to effectively estimate the volume of earthwork required for the construction of a road it was decides to utilize a state-of-the-art technology known as the TF MINI-S LiDAR sensor. To further record and manage the data collected, the engineers used a Raspberry Pi 3B+ to record the measurements and create a database that could be utilized for further analysis and potential future use.

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The use of the TF MINI-S LiDAR sensor provided an innovative and effective solution to the challenges posed by the congested and dynamic road site. By optimizing the measurement process, the engineers were able to achieve a precise and comprehensive depiction of the road site, which is essential for successful construction projects

5) Calculations Requirements

Based on the output of the LiDAR sensor we would be calculating the depth of the ground surface of the road. For the calculation of output with respect to its position, the widely known principles to determine distance based on speed and time could be used. Formation level must be assumed so as to measure the excavation

The midsection formula is a commonly used method for estimating the volume of earthwork needed for road construction or other similar projects. The formula is based on the assumption that the cross-section of the road is composed of a series of trapezoids.

Here's how to use the midsection formula:

Measure the width of the road at regular intervals along the length of the proposed road. These measurements should be taken at equal distances, such as every 20 meters. Using these measurements, draw cross-sections of the road at these intervals. These cross-sections should be drawn to scale and should include the width of the road, the height of the embankment or cut, and the slope of the road.

Calculate the area of each trapezoidal cross-section by adding the area of the top and bottom rectangles and the area of the trapezoid in the middle.

Multiply the area of each cross-section by the distance between the sections to obtain the volume of earthwork needed for that section.

Add up the volumes for each section to obtain the total volume of earthwork needed for the entire length of the road.

III. CONCLUSIONS

The TF MINI-S LiDAR sensor is a highly versatile and valuable tool that can be leveraged for a multitude of applications, ranging from distance measurement and object detection to obstacle avoidance and environmental sensing. Particularly useful in construction projects, it offers a more efficient and streamlined method of gathering data that can be used to make significant progress. In this case study, the sensor was used to estimate the amount of work required for the construction of a road. The ability of the TF MINI-S LiDAR sensor to measure the distance between the road surface and the sensor was instrumental in providing the necessary data to generate a numeric model of the road construction site. By collecting this data and leveraging it to create a numerical model, the engineers were able to estimate the amount of work required for the project. This required careful planning and a sophisticated approach to utilizing the sensor to create an accurate picture of the road site, inclusive of all essential information such as depth levels, excavation requirements, and potential road obstacles.

IV. FUTURE SCOPE

This paper investigates about the current situation of the construction industry where the level of automation on the construction site is as compared to digitization is low and still unpracticed. After implementation of the technology like LiDAR in the various parts or procedures of construction the results can be checked if it gives a fruitful output. This level of automation has to bring into practice since it has much importance in improving the productivity, safe environment, security and safety on site, no dangerous working conditions, improvement in the quality and quantity, etc. but there are some factors which are affecting the implementation of automation on site according to the people working on site.. Thus after the analysis the future recommendations can be recommended.

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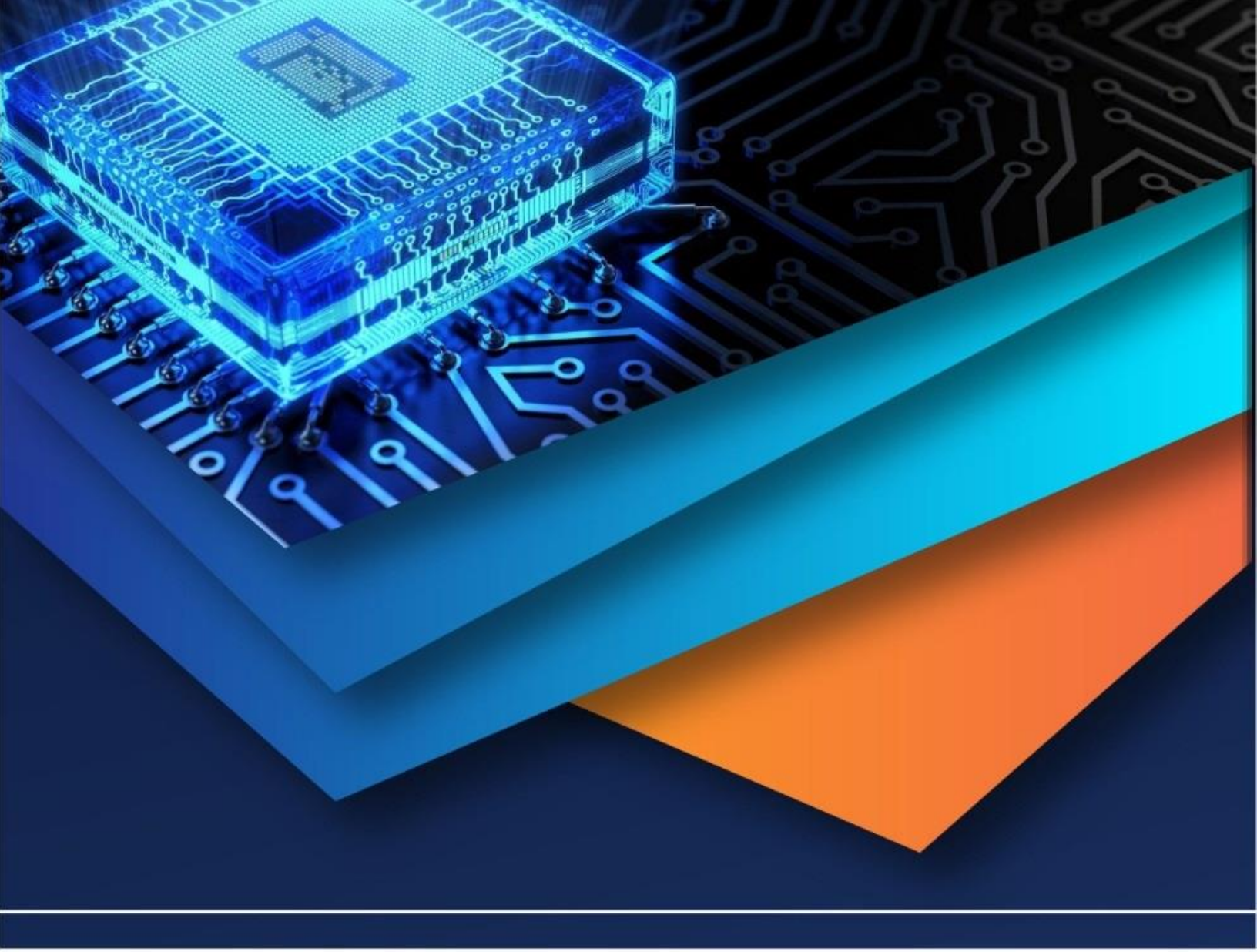

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