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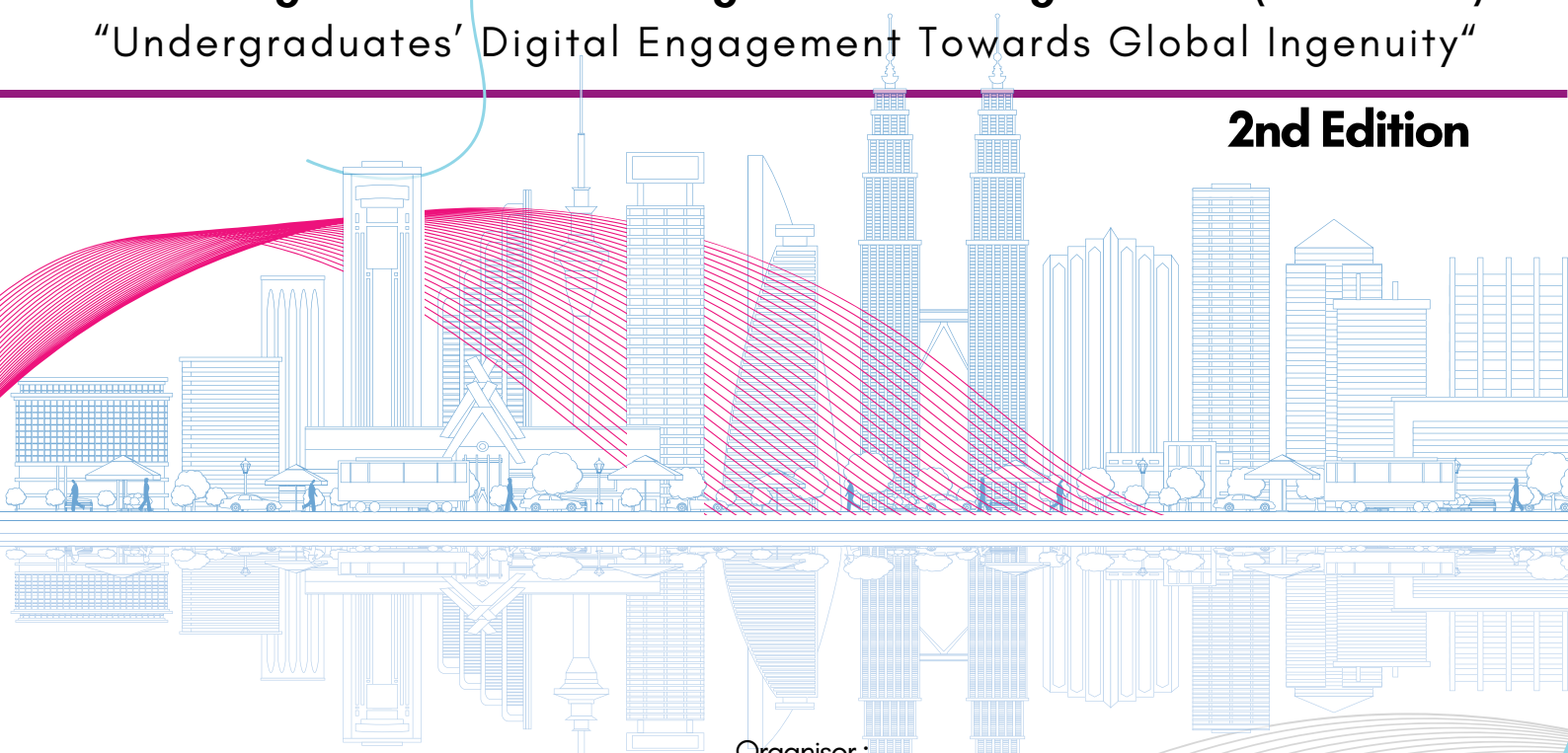
"Undergraduates' Digital Engagement Towards Global Ingenuity"

2nd Edition



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3D LASER SCANNER WITH PANORAMIC SYSTEM

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Abstract

Inspection of Industrialized Building System (IBS) precast concrete components is vital for ensuring quality, safety, durability, compliance with industry standards, and the success of modern construction methodologies. Advanced technologies like 3D laser scanning enable precise detection of defects in precast components, but data management remains a major issue in their use in precast concrete inspection. Therefore, the aim of this innovation project is to develop an improvised 3D laser scanner by proposing the panoramic 3D laser scanner to improve the data management in precast concrete inspection. The objectives of this research are to identify the problems and issues of the existing 3D laser scanner in precast concrete inspection, to innovate the panoramic 3D laser scanner in improving the existing 3D laser scanner in precast concrete inspection using simulation and to suggest the marketability potential of the proposed panoramic 3D laser scanner in precast concrete inspection. The data was gathered through a literature review, utilizing academic articles from various internet sources. This innovation enhances accuracy, scanning range, speed, and workforce, thereby improving data management in the precast concrete inspection process.

Keywords: *IBS, inspection, panoramic 3D Laser Scanner, precast concrete*

1. INTRODUCTION

There were several problems of the existing 3D laser scanner that hindered its usage in precast concrete inspection such as high cost, the need for human intervention, efficiency, sensitive to occlusions and technical and range limitations (Wang & Kim, 2019). From these issues, the main issue of existing 3D laser scanner that seems the most crucial to be address is the technical and range limitations. Regular 3D laser scanner requires multiple scanning process and scan data for a single large precast concrete component which may result in complicated data management.The aim of this innovation project is to improvise the current inspection process for precast concrete. A panorama system is proposed to improve the current 3D laser scanner used to inspect precast concrete in manufacturing facility to overcome the range limitation of regular 3D laser scanner. The panoramic 3D laser scanner is proposed in the scope of achieving SDG 9 (industry, innovation, and infrastructure) providing efficient and accurate inspections, quality assurance, and reduction of rework and waste in precast concrete production.

The idea is derived from Design Thinking Framework. Design thinking is a methodology which provides a solution-based approach to solving problems. A simulation which includes computer-based modelling simulation software are made to simulates the features and performance of the panoramic 3D laser scanner to further understand its work process in precast concrete inspection works.The main result of this innovation project indicate that the panoramic 3D laser scanner offers a wider range of scans. Issues regarding data redundancy and limited data storage of regular 3D laser scanners due to repetitive scanning process needed to be done for a single large precast concrete component could potentially be solved.

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2. LITERATURE REVIEW

Precast concrete quality assessment is an essential aspect that influences overall construction quality. The current techniques used to measure precast concrete panels' dimensions, on the other hand, rely heavily on skilled inspectors and are time consuming. A 3D laser scanner is proposed as a dimensional measurement method for precast concrete in order to overcome these limitations (Kim et al., 2013). A new paradigm is needed to replace the manual inspection approach for precast concrete, which allows for instantaneous, human-free quality control. A 3D laser scanner that utilizes the unique features of the scan data was created in response to this need (Kim et al., 2013).

Positioned above the precast concrete's center, the 3D laser scanner covers the whole surface in a single scan. Precast concrete panels can undergo automated and quick dimensional inspection in only one scan. After the inspection is finished, the tolerance of the quality evaluation criteria is used to determine whether or not the sample is acceptable (Kim et al., 2013). In 2013, the method for the semi-automated inspection of dimensional quality of precast concrete slabs with a 3D laser scanner was introduced (Kim et al., 2014).

In addition, the 3D laser scanner can be utilized to inspect curved components. Because of its ability to acquire point clouds of component surfaces at high densities, the 3D laser scanner is particularly suited for the inspection of curved surfaces. It could also be used to inspect the dimensional quality of exterior connecting parts after casting (Ma et al., 2023). Because millimetric accuracy is required for dimensional quality inspection of precast concrete components, 3D laser scanners have become the most preferred inspection equipment in construction industry due to their great accuracy (Ma et al., 2023).

This technology can achieve efficient and accurate 3D point clouds generation without changing the position of the 3D laser scanner, which provides great convenience for the quality inspection of the components (Ma et al., 2023). Several types of 3D laser scanner had been used in assessing the quality of precast concrete (Wang et al., 2021). Some of them include Trimble X7, Artec Ray and Faro Focus S70. The use of 3D laser scanner in precast concrete production would contribute to the SDG 9 and IR 4.0 such as automated dimensional quality assurance of full-scale precast concrete components.

3. METHODOLOGY

A simulation is made as an attempt to model a real-life or hypothetical situation on a panoramic 3D laser scanner so that it can be studied to see how the system works. By changing variables in the simulation, predictions may be made about the behavior of the system. The simulation is made through 3D modelling software or SketchUp 2023 as a tool to virtually investigate the behavior of the system under study.

For the simulation of panoramic 3D laser scanner, there were several steps involved (Maria, 1997). The first step of developing the panoramic 3D laser scanner is identifying and formulating the problems. The problems related to the current technology of regular 3D laser scanner for precast concrete inspection were first identified and listed. The second step is to select an appropriate design. Selecting an appropriate design for a 3D laser scanner involves considering several criteria to ensure the device meets the desired specifications and application requirements.

The third step is to develop the model. Schematics and network diagrams of the panoramic 3D laser scanner are developed. Conceptual models are translated to simulation software acceptable form and the simulation model are verified to execute as intended. The fourth step is to perform simulation runs.

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The performance of the simulated panoramic 3D laser scanner against defined specifications and scenarios are evaluated in this stage. The last step is to document the model data for future use. Documenting the model data preserves critical knowledge and information about the design, specifications, simulation methodologies, and performance evaluation.

4. RESULT AND DISCUSSION

The previous section discussed the issues with the 3D laser scanner used for precast concrete inspection, with range limitation being a crucial issue that needs to be addressed. A panoramic 3D laser scanner captures detailed, comprehensive three-dimensional images of environments using laser technology and panoramic imaging, combining principles of scanning and photography for an all-encompassing view.

Unlike traditional laser scanners, a panoramic 3D laser scanner can capture data in a full 360-degree horizontal and vertical sweep. This capability ensures that no part of the environment is missed, providing a complete and continuous view. The device emits laser beams that bounce off surfaces and return to the scanner. The time it takes for the laser to return is measured to calculate the distance to various points in the environment. This process is repeated millions of times per second, generating a dense point cloud of data. The collection of data points represents the scanned environment. Based on the existing product, Faro Focus S70, the scanner is designed with high-speed scanning and high capture rate to reduce the time it takes to complete the scan.

With sub-millimeter accuracy such as Artec Ray scanner, the panoramic 3D laser scanner typically incorporates high-resolution panoramic cameras to capture detailed images of the scanned area. The panoramic 3D laser scanners are designed to be user-friendly and portable with minimal weight such as Faro Focus S70 scanner. It features intuitive interfaces, quick setup procedures, and robust designs that make it suitable for both indoor and outdoor use, ensuring it can be deployed in a variety of conditions and locations. The automatic calibration and self-levelling feature from Trimble X7 were incorporated into the panoramic 3D laser scanner for easy and fast setup.

The concept of the suggested innovation idea is transferred from a basic hand sketch into 3D model using 3D-modelling software to provide improved visual presentation of the innovation idea. The purpose of doing this is to give a clear understanding of what the project looks like and how it operates. Figure 4.1 shows the visualization of panoramic 3D laser scanner and Figure 4.2 shows the setup of panoramic 3D laser scanner in front of precast concrete.

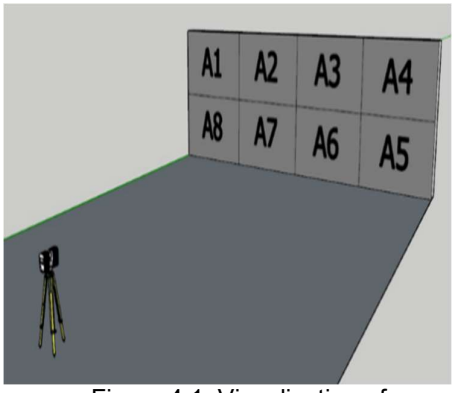

Figure 4.1: Visualization of panoramic 3D laser scanner.

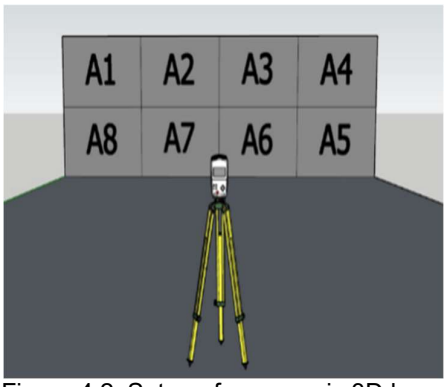

Figure 4.2: Setup of panoramic 3D laser in front of precast concrete.

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The components of the panoramic 3D laser scanner include lens and mirror, motorized rotating platform, display screen, control buttons, and light indicator. Apart from these components, the panoramic 3D laser scanner also comes with advanced control electronics. Microprocessors and microcontrollers process the data received from the sensors, control the rotation of the scanner, and manage other operations. Furthermore, the power sources of the scanner are from battery power and Alternating Current (AC) power. It is equipped with Lithium-Ion (Li-ion) battery due to its high energy density and long lifespan.

For the housing of the panoramic 3D laser scanner, aluminum was selected as the material as there are a few benefits of choosing this material and it seems to be the most appropriate. High-quality optical glass was used for lenses and mirrors of the panoramic 3D laser scanner, coated with anti-reflective coatings to minimize light loss and glare. Microprocessors and microcontrollers that made up the electronic components of the panoramic 3D laser scanner composed of silicon and other semiconductors and these components process the data collected by the scanner.

The panoramic 3D laser scanner is designed with sub-millimeter accuracy. This means that the margin of error or uncertainty in the measurement is smaller than one millimeter. The panoramic 3D laser scanner provides 360-degree panoramic views and can be used for large IBS components such as precast concrete walls or slabs. The panoramic 3D laser scanner can capture millions of points per second and process data in real-time, significantly enhancing productivity and efficiency. Advanced technological features, such as multi-laser systems and optimized algorithms, further improve scanning speed.

As the panoramic 3D laser scanner can scan large precast concrete components in a single scan, the workforce needed to arrange the scan result and the labor for auditing the data can be significantly reduced. The global 3D panoramic laser scanners market is expected to reach $5 billion by 2030, driven by rising demand in the construction and architecture industries for surveying and inspection purposes. The panoramic 3D laser scanner was designed with precast concrete manufacturers as target market to significantly enhance their production accuracy, efficiency, and overall competitiveness in the market.

5. CONCLUSION

As a conclusion, the dimensions of each precast concrete component at the manufacturing facility are crucial to be inspected for proper assembling of precast concrete components on construction sites. To overcome the range limitation of existing 3D laser scanners in precast concrete inspection, the panoramic 3D laser scanners are proposed.

With the concept similar to capturing panorama images through smartphones, panoramic 3D laser scanners work by providing a wider range of scans. Issues regarding data redundancy and limited data storage of regular 3D laser scanners due to repetitive scanning process needed to be done for a single large precast concrete component could potentially be solved.

To ensure the application of the panoramic 3D laser scanner in precast concrete inspection could be fully studied, it is recommended that a prototype model is made for research in the future. Moreover, the internal systems of the panoramic 3D laser scanners are not studied in this research as it requires specialized knowledge and expertise to understand and modify. Therefore, it is recommended to be studied in the future research to better understand the panoramic 3D laser scanner's system operational works.

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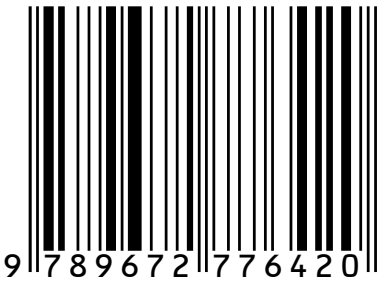

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