



Exploring the Benefits of 360-Degree Panoramas for Construction Project Monitoring and Control [†]

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Abstract: In the field of technological construction tools, 360-degree panorama provides a panoramic virtual reality capable of representing the construction environment in great detail. While there are many studies on their pedagogical and safety applications, few studies address the benefits of their use in construction monitoring and control. For this reason, the present research aims to explore its application and benefits for monitoring and control, the research for which begins with a literature review of the application of 360-degree panoramas in construction, where the authors identified the main benefits. In the second stage, the authors analyzed two case studies of its application: the first is based on the construction of a retail project, and the second is based on an infrastructure project. After the implementation, the researchers conducted interviews with the team members responsible for implementing 360-degree panorama. The main benefits of 360-degree panorama are as follows: a complete overview of the construction site situation, verification of the distribution of the space used, documentation of the current project situations, as well as progress control and quality control. These results will hopefully help to improve the understanding of this tool's current state of the art in the construction field and open the door to future investigations on cost-benefit analysis that facilitate the application of this tool in construction sites.

Keywords: 360-degree panorama; benefit; construction industry; control; digital



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1. Introduction

Construction projects are complex endeavors that are constantly evolving, with the monitoring and control stage being one in which technology has been invested in to improve it [1] because the information-gathering tasks inherent to this stage are often manual and arduous, supported by subjective photographic material that accumulates as waste in the project [2]. Currently, technologies used to monitor and control a project include Laser Scanning [3], Unmanned Aerial Vehicles [4], among others. However, these technologies are often time-consuming and expensive [5].

In this context, there are 360-degree panoramas that are used in construction by offering low computational, low-cost, easy-to-capture, non-computer, and true-to-reality virtual reality simulations to the user [6,7], allowing for reducing the non-value-added, costly, and time-consuming activities of the monitoring and control process [5,8].

Moreover, 360-degree panorama is a reality-capturing technique that creates a complete view of the whole region surrounding an observer, giving a “sense of presence, of being there” [9].

Panoramic videos and photos have been used in different areas of the construction industry. In the safety field, Jeelani et al. [10] employed 360-degree panoramic images to investigate the personalized engagement experience. Accident simulation was conducted within this panoramic vision platform, allowing workers to visualize potentially

dangerous situations. As a result of a pilot study, it was concluded that this simulation generated a remarkable sense of immersion among users. Eiris et al. [7] used augmented 360-degree panoramas to represent the construction site to improve trainees' skills in hazard identification, where trainees found this format to be very advantageous for learning this skill.

In the field of pedagogy, Gheisari et al. [11] applied 360-degree panoramas to teach students how to make free-body diagrams of real structural elements without the need to go to the field in person, demonstrating that this technology can provide the experience of visiting a construction job site without being physically present. Eiris et al. [12] propose the use of iVisit, a platform for interactive guided site tours using 360-degree panoramas and virtual human figures to address the obstacles of visiting the site in person. This approach was tested by visiting a masonry materials site with 10 students in introductory construction courses. The results revealed that, on average, 86% of the students found iVisit easy to use, while 68.4% perceived it to be realistic. Finally, Pham et al. [13] developed a platform with 360-degree panoramas of learning safety practices, where students observed and found hazards at the construction site. They made a comparison with face-to-face and 360-degree panoramas hazard identification, finding that there is no statistical difference between the two methods.

While the most common application of 360-degree interactive panorama is to create virtual tours of complex projects [14], the ultimate goal is to use it in project monitoring and control as a method of managing documentation and assets to visualize components, monitor progress, and document defects or problems [6]. This is because they possess the potential to optimize the flow of information in terms of communication, understanding, evaluation, and the implementation of corrective measures in the development of construction projects [8,15,16].

Examples in the literature include the study by Côté et al. [17], who used panoramic cameras to compare reality with a detailed 3D model of a building, obtaining results which showed that the system provides improved communication between the designer and builder, more accurate work planning, and a better understanding of the work to be completed. On the other hand, Eiris et al. [6] detail a workflow to create a virtual panoramic environment using 360-degree photographs. They then applied this technology to a construction site at the University of Florida campus, demonstrating the technical feasibility and practical utility of generating interactive panoramic scenes of a real construction project complete for asset management and documentation.

From the above, it is understood that there are not many studies which have focused on the direct application of this technology in the monitoring and control of a project. Therefore, this study explores the benefits of using this technology in the monitoring and control of construction work through the analysis of two case studies and interviews with the professionals involved.

2. Materials and Methods

The following research is composed of two stages. The first stage corresponds to a review of the benefits of 360-degree panoramas in the construction sector, and the second stage explores the benefits of monitoring and control in two construction projects.

In the first stage, a review was conducted in Google Scholar and SCOPUS, using the keywords "360-degree panoramas" and "construction", which is described in Table 1. SCOPUS was used because, in the construction industry, it has more comprehensive coverage than other databases [18].

In the second stage, the projects described in Table 2 were analyzed. Those in charge of implementation were asked about the benefits obtained during implementation.

Table 1. Benefits of 360-degree panoramas.

Benefits	References
Improve flow of communication	[8,15–17]
More accurate work planning	[17]
Better understanding of the work to be completed	[17]
Feeling of immersion in the construction site	[7,9,10]
Reduce monitoring activities	[5,8]
Low cost	[7]
True to reality	[7,12]
Visualize inaccessible places	[14]

Table 2. Projects considered in the research.

Project	Implementation Time	Used Camera
Construction of a retail store	6 months	Richo Theta 2
Infrastructure Project	8 months	Insta360/Modelo: One R

3. Results and Discussion

In the present section, the benefits obtained by 360-degree panorama will be shown, and these benefits will be discussed against the 360-degree panorama literature.

3.1. Project 01: Construction of a Retail Store

In this project, the implementation of 360° cameras was achieved with the help of an Insta360/Model: one R camera and Google cloud storage. Figure 1 shows a photograph and the camera used in the implementation.



(a)



(b)

Figure 1. The figures show the implementation of the project: (a) 360° camera used in the project; (b) 360° photograph of construction.

The person responsible for implementation indicated that using 360° cameras for monitoring and control can have the following benefits:

- Firstly, 360-degree panoramas can help us better understand the situation's full context, unlike traditional photographs. Also, 360-degree panoramas have a wide range of views, allowing us to focus on different activities on the job site.
- Next, 360-degree panoramas help us to not take too many photos since a single photograph captures the whole environment, and it is difficult to lose the visualization of any part of the project. They also give us a complete overview of the project, which can be used for quality control verification of the space used.
- The camera can be attached to a selfie stick, making it possible to take pictures in hard-to-reach places.

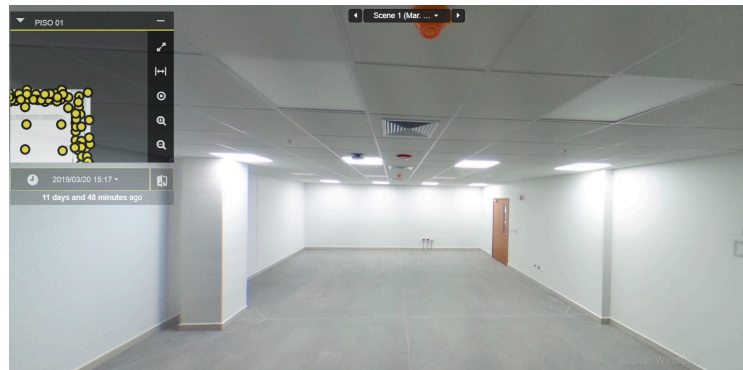
- Furthermore, 360-degree panoramas allow us to visualize the works that had been eliminated due to a change in the middle of the project. In addition, they allow us to visualize previous works, such as electrical installations behind walls, and compare them with different dates.
- Photographs can be shared with clients to reassure them of progress or alleviate their doubts without the need for field meetings.

3.2. Project 02: Infrastructure Project

In this project, the implementation of 360-degree panoramas was achieved with the help of an Insta360/Model: one R camera and Google Cloud storage. A photograph and the camera used in the implementation are shown in Figure 2.



(a)



(b)

Figure 2. The figures show the implementation of the project: (a) 360° photograph during construction; (b) 360° photograph at the end of construction.

For this project, 360-degree panoramas were used to monitor daily progress, allowing for information transparency. Furthermore, both the client and the general contractor had access to this information.

The photographs were used after the project for claims substantiation. The 360-degree photographs were considered to be evidence of the execution of activities and could show the project's progress, showing four to five parallel activities in a single image. This characteristic was significant in the claims stage because it was easy to locate which subcontractors had worked on a given date and to see if they had enough space and the conditions necessary to perform their activities.

Another significant benefit was that the 360-degree panoramas let all stakeholders be informed about the project's progress in a simple way, without the need for them to travel to the project. In the case of the infrastructure project, they had teams in different parts of the world, and by having access to the 360-degree photos and project progress, they could be informed of the project's performance simply.

Cameras also promote transparency of project progress information and help improve decision making. Occasionally, meetings were held with architectural or installation specialists away from the project. With the help of the cameras, they could access the site remotely and provide better solutions to the problems presented.

3.3. Discussion

One of the objectives of this paper is to show the application of 360-degree panoramas as a visual technological tool used in the monitoring and control stage of construction projects, as Eiris et al. [6] propose as future research. The two projects chosen are located in Peru, and as Eiris et al. [6] show, it is feasible to make use of this technology in the monitoring and control of projects, providing multiple benefits.

This review shows that the most common benefit of applying this technology is improved communication and transparency [8,15–17], which is also observed in both projects in this study.

Project 1 explains that it is possible to use 360-degree panoramas to visualize inaccessible areas, as mentioned by Eiris & Gheisari [14]. In addition, it is exposed that there is a greater understanding of projects due to the large capture range of the 360-degree panoramas compared to traditional cameras, which also results in not needing to capture a large number of images of the site, coinciding with what is exposed in the study of Subramanian & Gheisari [5], who also proposed that this point provides a reduction in the time spent on site to perform this activity.

The additional benefit found in this project is the ability to visualize progress over time of items through an orderly documentation of the photographs.

In project 2, there were many professionals involved in different parts of the world, so they could not physically be on the project. In this sense, the use of 360-degree panoramas allowed them to be informed of progress, as if they were physically present, thanks to the sense of immersion [7,9,10] and the resemblance to reality that this technology provides [7,12].

Additional benefits found in this project are improved decision making, the ability to show several activities in one photo, and the use of photos as evidence for claims.

4. Conclusions

This study presents a literature review of 360-degree panorama applications in construction and the benefits obtained in each project, followed by the analysis of two case studies in Peru, and the exploration of the benefits found in these cases.

This review demonstrates that the most common benefit of the application of this technology is improved communication and transparency. Additional benefits to those already outlined in the literature found in the present study are the ability to visualize progress over time of items through an orderly documentation of the photographs, improved decision making, the ability to show several activities in one photo, and the use of these photos as evidence for claims.

Thus, important issues need to be further explored in studies that address the monitoring of visual progress with the support of 360-degree panoramas. Among these, there is a need to determine through statistical tools the most important benefits of the application of this technology in Peru.

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