Integral control system for building works based on an Augmented Reality device

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1 Introduction

The construction sector is recognized as one of the sectors with the greatest impact on the country's economy. Production in the building construction sector is worth €74,532 million, which is equivalent to 6% of the PIB (PIB). Despite this, the works present a low profit margin (not exceeding 2% on average in Spain [1]. This is mainly due to three reasons:

- Lack of innovation, promoted by the sector's refusal to adopt new solutions and its resistance to change [2].
- This lack of digitization adds to the lack of coordination between the entities involved in a construction project [3].
- The lack of a good work pre-planning and its subsequent management [4].

After analysing the current situation, the need for a system capable of detecting construction errors and reducing the delays caused by the lack of automated work planning is detected.
Thus, detecting the opportunity of developing a system for monitoring building works with the ability to automatically detect construction errors in real time and automatically update the work plan based on the actual performance of the work by means of an AR device.

2 Methods

The main objective of this work is the development of an integrated management system for building works, which allows improving the efficiency, accuracy and automation of tasks related to construction supervision and control. This innovative system seeks to achieve three fundamental goals: detection of construction errors, real-time updating of the work plan according to the actual performance of the work, and automated partial measurements, counting

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of parts, execution approvals, as well as the preparation of monthly and final certifications of the work.
To achieve the complete development of the project, the first step is to obtain a hardware subsystem based on Augmented Reality (AR) technology. This subsystem will be in charge of acquiring with a high precision the characteristics of the elements of the work to be analysed.

For this purpose, an AR device will be developed, which will allow selecting the elements to be analysed and obtaining precise geometric information about them. It is important to highlight that this device will be robust, resistant, portable, and easy to use for the users involved in the supervision of the work. In addition, there will be a Data Acquisition Device (DAQ) that will compile all the records made with the AR device.

2.1 Hardware system

For the selection of the AR device, different options have been studied:

- **Virtual reality glasses:** providing an immersive and enriched experience. These glasses offer the ability to superimpose real-time digital information on the physical environment, allowing users to interact and visualize additional information in an intuitive and natural way.
    - Pupil labs
    - Eye Tracking
    - VRExpert

- **Tablets:** Their ability to scan the environment, visualize models, make annotations, update work plans, generate reports and facilitate collaborative communication makes them indispensable allies to boost efficiency, accuracy and productivity in the construction and construction management process.
    - Android tablets
    - Apple tablets

In selecting the most appropriate device, the following criteria have been taken into account:

1. Environment scanning capability: this scanning capability is essential for detecting construction errors, obtaining accurate measurements and superimposing virtual elements on the physical environment.
2. Integration of functionalities: allowing model visualization, annotation, report generation and collaborative communication.
3. Usability and accessibility: familiar and friendly interface and intuitive controls that facilitate its use. This guarantees greater usability and accessibility for the professionals involved in the project.
4. Cost: The economic analysis is a determining factor in the choice of the co-marketing product.

As a result of the multi-criteria analysis, the iPad has been selected as the most appropriate device for capturing augmented reality.

2.2 Software system

In order to create augmented reality and then implement it on our devices, Unity will be used.

Unity is a powerful software development engine and game creation platform widely used in the entertainment industry and beyond. With its versatile capabilities and focus on creating interactive and visually stunning experiences, Unity has become a fundamental tool for augmented reality (AR) application development.

A study has been conducted to select the most appropriate method for augmented reality integration, there are mainly three methods:

- Image target
- Unity AR+GPS Location
- Area target

Considering the different augmented reality integration methods, the Area Target approach stands out as the most suitable option for our application in this project. Unlike Image Target, which is limited to a specific reference image, Area Target allows us to use an environment reconstruction as a reference, which is beneficial in changing environments and large areas. Although GPS-based methods have their utility, they have limitations in terms of accuracy, stability and indoor performance.

Element generation: for the generation of elements *prefab* elements are used. The *prefab* elements are files that contain the information and configuration necessary to display virtual objects in augmented reality. They are created in Unity and placed in the construction environment using the spatial reference provided by the Target Area.

Elements to create interaction: To achieve an effective interaction between the virtual elements and the Target Area in an augmented reality application, it is necessary to use several key components, such as Box Colliders, Scripts, Tags and GameObjects. These elements play a fundamental role in collision detection, action execution and development state management in the virtual environment.

3 Results

Below is a scan made with the LiDAR of the iPad 14, over some offices of the Polytechnic University of Valencia:

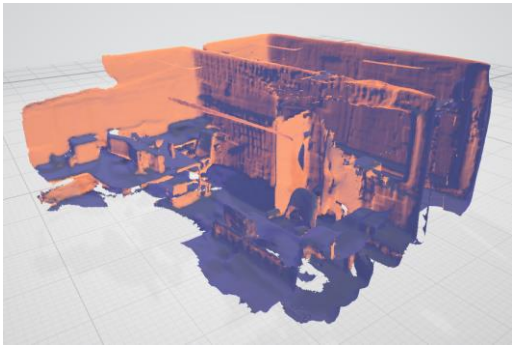

Figure 1. Three-dimensional capture from iPad 14 LiDAR. Source: self-made.

Models and designs loaded on the iPad 14 are accurately superimposed on the scanned environment by the cameras, with proper alignment and no significant deviations.

Figure 2. Model 3D. Source: self-made

The virtual elements are updated in real time in a smooth and uninterrupted manner, facilitating visualization and decision making at the construction site.

Figure 3. Modelo 3D with virtual element. Source: self-made

4 Conclusions

- The selection of the iPad Pro 14 as the main component of the hardware subsystem was the preferred choice, meeting the key criteria of scanning capability, functionality integration, usability and accessibility, and cost-effectiveness. Its LiDAR technology and versatility guarantee an efficient management of building works.
- The development and design of the software subsystem using Unity has allowed the successful integration of augmented reality, facilitating the identification and characterization of construction elements, as well as the comparison with the virtual model.
- The implementation of a neural network for the automatic update of the work plan based on the actual performance of the work has proven to be effective in optimizing efficiency and productivity.
- The communication subsystem based on the 4G technology of the iPad Pro 14 and the SCP protocol has shown a fluid, secure and versatile communication, being essential for collaboration and data transfer in real time.
- The development of the digital platform has begun, establishing the requirements of the server that will host it and initiating the integration with the communication system.
- Technological surveillance and patenting processes have been initiated, laying the groundwork for keeping up to date in the market and protecting the project's intellectual property.
- System verification tests have validated its optimal performance in terms of power-up, start-up time, processing, environment scanning, visualization, usability and security of transmitted data.
- The system has proven to improve efficiency, productivity and quality in the management of building works by providing an accurate and real-time view of projects through the use of BIM and augmented reality technologies.

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