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Review Article

Drone Integration with BIM: A Review

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Abstract

Unmanned aerial vehicles, also known as drones, have been increasingly integrated with building information modeling (BIM) and construction automation. Small, light drones attached to advanced technology cameras and with infrared radiation have revolutionized and expedited the construction process. The use of drones for site surveying, building inspection, audit, and building energy modeling has made them vital to the construction industry. This article reviews the state-of-the-art drone integration with BIM and the digitalization of the construction process.

Keywords: Drone; Unmanned aerial vehicle (UAV); Building information modeling (BIM)

Introduction

Unmanned or uncrewed aerial vehicle (UAV), also known as drone, is an aircraft without a human pilot on board. The term "drone" was coined for a remotely flown aircraft utilized for practice firing of a battleship in 1920 [1]. Drones have been utilized in the military field and have considerably evolved over the past decade, becoming an important tool in the construction industry. The use of drones as robots in construction automation reflects a crucial aspect of building information modeling (BIM), which is a digital representation of physical and functional characteristics of a facility [2]. The combination of BIM with point clouds obtained from drones and other types of robots will further revolutionize the building automation process [3]. Drones act similar to flying cameras, which capture beneficial digital data and images from different aspects. Figure 1 illustrates the metaphorical integration of drone with BIM in clouds (Figure 1).

Figure 1: Metaphorical integration of drone with BIM in clouds.

The data obtained by drones are utilized to create 3D models, point clouds, or digital terrain models used for generation of 3D rendering of any locations, setting the scene for the BIM process. Drones facilitate the collection of construction site data, which must be shared across the entire project team through BIM-integrated software, such as BIM 360 glue [4]. Drone mapping, including site survey, design, volume and elevation measurements, are time-efficient and cost-saving. In conclusion, drones enhance the BIM process by providing highly accurate point cloud scanning and replacing the workforce for construction inspection. Moreover, drones ensure ongoing safety across the project by taking and recording aerial photographs. Drones also expedite data gathering during regulatory visits of authorities for audit purposes. Drone scanning tool captures site data, which are utilized in all BIM phases: (1) pre-construction for design purposes, (2) during the actual construction for progress tracking, and (3) post-construction for inspection and maintenance purposes. The drone flight post-processing creates a comprehensive image of audit results by considering altitude, quality, timing, and spectrum. This process overcomes the traditional challenges (such as time-consuming and labor-intensive) and considerably enhances the BIM process. 3D photogrammetry and 3D building modeling compatible with BIM-integrated software, such as Autodesk Revit, accentuate the crucial role of drones in BIM process enhancement. However, the implementation of drone flight post-processing lacks global

standards [5]. A protocol for thermography procedures using drones with infrared cameras was recently outlined on the basis of several experimental flights [6]. The current issues and benefits of drones in the construction industry are highlighted below.

Drone flight path

This aspect has been mathematically and geometrically researched by considering camera technology and drone battery life as well as its flight speed and distance from the target [7,8]. The most promising optimized drone path is either vertical or horizontal strips in a zig-zag pattern over the site area [9,10]. Computerized path planning is fundamental for autonomous drones. An algorithm has been developed to achieve the safest, shortest, and cheapest flight path in which the minimal distance from the obstacles is set according to the size of the drone [11].

Drone flight timing

Timing varies depending on the purpose of flight. The time before sunrise and after sunset is suitable for acquiring thermal imagery to avoid false positives due to direct radiation [12]. By contrast, daytime is recommended for inspection of mechanical and electrical systems [13].

Drone assists in thermography

The thermal patterns obtained by infrared cameras attached to drones can be converted to 3D models and used in BIM-integrated software, such as Autodesk Revit. A case study detected that heat transfer and air leak account for 40% of energy loss in a residential building [14]. Heat transfer imaging using drones is inexpensive, thereby addressing the issue of investment return for building energy retrofitting [15]. Infrared energy is absorbed and emitted by most of materials, thereby reflecting the temperature of an object. Infrared visualization provides immediate awareness of object conditions that deviate from the norm. Drones used for building surveys are currently integrated with infrared sensors as today's technology provides small and light sensors [16]. The construction sustainability, as the 6th dimension of the BIM [17], is enhanced through accuracy of energy audits resulted from thermal cameras attached to drones. A survey conducted on 92 publications regarding the use of thermography in the construction industry revealed that 10% of publications focused on BIM. This result indicates the contribution of thermography in the BIM process, which is dramatically increasing due to the usage of drones [5].

Drone assists building inspection

Drone-based surveying expedites auditing at minimal time, cost, and human effort while providing more accessibility to objects compared with that of human surveying. A case study in Molise, South Italy revealed that drone was a cost- and time-efficient tool for documenting and managing the archeology of fragmented Mediterranean landscapes [18]. The nondestructive and non-contacted inspection method using a drone with an infrared camera is highly suitable for assessing the construction defects and degradation of historical building and areas affected by catastrophic disasters [16]. In a case study, cracks and flawed areas caused by earthquake in a historic building were discovered and located by a drone infrared camera [16]. The use of drones with infrared cameras is a considerable improvement on traditional auditing techniques, particularly with respect to issues on global climate changes [19].

Drones as a delivery service provider

Drones are rapid, inexpensive, and eco-friendly vehicles. The pilot tests on drone delivery service conducted by Google and Amazon verified the high potential of drone for commercial uses [20].

Drone assists building assemblies

Construction automation has undergone the advanced techniques of delivery; therefore, manufacturing of real-scale buildings using drone has been tested. Drones, along with other kinds of robots, assist in building assembly on a fully or partly automated process; it can systematically transport and lay loads in buildings and constructions [3].

Conclusion

Recent developments in the robotization and automation of construction process along with continually evolving BIM methods have progressed the realization of building digitalization, and drones are a crucial part of this revolution. Drones integrated with BIM have a prominent role in pre-, during, and post-construction process in terms of digital documentation, site surveying, inspection, safety, thermography, energy modeling, and delivery. However, setting standards and regulations regarding these processes is necessary.

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Conflict of Interest

There is no conflict of interest.

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