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Revolutionizing Building Construction with Drone Technology – An Application Review in UAE

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Abstract **-** Drones have emerged as a highly efficient and cost-effective means of collecting and sharing data in the field of building construction. This article delves into the various applications of drones during the construction and maintenance stages in the United Arab Emirates (UAE). It begins by exploring the drone platform, detection, and surveying systems, before delving into specific examples of how drone technology is used in construction projects in the UAE. This highlights the numerous ways in which drones can be utilized in the building construction industry. While drones offer a plethora of advantages, they do pose certain challenges such as limited flight time, signal strength, post-data analysis, multi-drone collaboration, weather conditions, and potential traffic disruptions. Nevertheless, equipped with high-definition cameras and advanced detection equipment, drones can inspect infrastructure assets in hard-to-reach areas, survey landscapes for pre-construction insights, assist in construction management, and provide high-resolution images for future planning. Furthermore, drones play a crucial role in providing accurate and dynamic traffic information, which significantly contributes to the development of smart cities. By directly addressing these challenges and leveraging the myriad benefits of drones, this article aims to assist owners, designers, engineers, and architects in enhancing the efficiency and performance of the building industry development in the UAE.

Keywords**:** Buildings, construction, drones, survey, safety.

1. Introduction

The field of remote sensing involves gathering information about an object, region, or occurrence without direct physical contact [1]. This is accomplished through the analysis of data retrieved by a device. Photogrammetry utilizes the block bundle adjustment approach to solve unknowns by optimizing the process [2]. Each bundle of rays, or images, from the camera to ground points are reconstructed to fit each other on the ground [3]. To achieve this, ample input information is required about all parameters featured in the collinearity equations.

As drone technology continues to advance, more sophisticated and cost-effective automated flight systems are being introduced [4]. This makes drones cheaper and more portable, which could have a significant impact on several industries [5]. According to PricewaterhouseCoopers (PwC), drone solutions have the potential to reduce the current $127 billion business services and labor costs across multiple industries [6]. Drones could be especially useful in industries such as infrastructure, agriculture, and transportation [7]. They are already being used in agriculture, geography, construction, infrastructure, and inventory management to gather localized visual information quickly and cheaply. Infrastructure inspection is another area where drones could be incredibly useful. This involves evaluating the physical condition of civil structures like buildings, highways, bridges, sewer, and water pipelines [8].

Many civil infrastructure applications of drones require detecting or surveying systems, which often rely on a variety of camera types. Visual cameras with high resolution are frequently used due to their versatility, allowing them to monitor construction sites and inspect infrastructure. In cases where vision is limited, such as in poorly lit or inaccessible areas, thermal cameras are a popular choice [9]. Impulse thermography is a non-destructive method that works particularly well for detecting voids in concrete structures [10]. Compared to passive thermal heat flux collection, impulse infrared thermography from UAVs can provide more accurate information about structural degradation [11]. Additionally, drones equipped with RADAR and LiDAR offer alternative mapping methods. While metal detectors and X-ray cameras have primarily been used for military purposes in drones [12], they may also have potential commercial applications.

The present paper aims to provide an in-depth analysis of the potential uses of drones in the construction and maintenance phases of building structures. It showcases a number of informative applications from ongoing and completed projects in the UAE. The case studies illustrate how drones can be employed to enhance the efficiency, productivity, and accuracy of various housing-related tasks. Additionally, the paper sheds light on the most significant challenges that must be addressed to ensure the effective utilization of drone technology in building development. The outcome of this review article aims to analyze the potential of drone technology to enhance the projects undertaken by the Mohammed Bin Rashid Housing Establishment (MBRHE) in the UAE. The objective is to devise a comprehensive framework that integrates drone technology seamlessly into MBRHE's construction and maintenance operations, streamlining project efficiency and precision. The paper intends to investigate how drone technology can be tailored to cater to the specific requirements of MBRHE, delivering innovative solutions for urban development and housing projects in the UAE. The article seeks to aid owners, designers, engineers, and architects in elevating the efficacy and performance of the building industry's development in the UAE, primarily focusing on MBRHE projects.

2. Application of Drones in Construction Monitoring

In today's construction industry, monitoring projects throughout their lifespan can be a daunting task, with various challenges to overcome [13]. One significant obstacle that has been identified is the slow adoption of new technologies, which can lead to missed errors and mistakes. Such errors may result in deadline extensions, ineffective on-site asset management, and sluggish acquisition of volumetric and as-built data sets, further exacerbating inefficiencies [14]. However, with the emergence of drone technology, these challenges can be addressed. Drones have now become fast, secure, and highly accurate ways of collecting progress information during construction projects.

Advances in sensors, Real Time Kinematic (RTK) and Post Processed Kinematic (PPK) technologies have made drones capable of providing engineering-grade Geographic Information System (GIS) information, offering precise measurements, comparisons, building information modelling (BIM) integration, and progress reports. This provides a comprehensive understanding of the project as a whole and helps to identify potential issues or errors that may have been missed otherwise. The progress monitoring solutions are designed to provide quick and easy access to critical data, allowing project owners, managers, consultants, and contractors to ensure timely delivery, prevent revenue loss, and make informed decisions based on real-time information.

By incorporating drone technology, the construction industry can improve operational efficiency, reduce overall costs, and ensure a seamless construction process. Drones enable project managers to monitor progress in real-time, to identify potential problems early and proactively take corrective action. This also helps to minimize risks, reduce the need for manual inspections and enhance safety on job sites. Overall, the use of drone technology is proving to be a game-changer in the construction industry, paving the way for a more efficient, cost-effective, and sustainable future.

2.1.1 Project Progress Tracking

Utilizing images from predetermined locations can be an incredibly powerful tool for comparing changes when implemented correctly. As demonstrated by the images presented, the differences between them are distinctly and prominently highlighted, making them an ideal addition to project progress reports as evidence of progress in construction. Although these changes may only offer visual data, they can still prove to be a critical instrument in identifying even minor developments in project construction that might otherwise go unnoticed in the GIS data furnished in engineering progress reports. Figure 1 shows an example of monitoring project progress through drone technology.

Figure 1. Project progress tracking example using drone technology [15].

2.1.1.1. Virtual Site Walkthrough

Drone technology provides an innovative solution for capturing internal information of construction projects using virtual reality (VR) technology. Unlike drones, which are limited to capturing external data, VR cameras are attached to an engineer's helmet or a quadruped autonomous robot for internal data collection. The collected data is in the form of VR 360 videos that can be easily processed by a software platform. The platform can extract individual frames from the video and create a "Google Street View"-style command and control of the VR data.

To ensure accuracy, each walkthrough lane is determined and marked on the drawings by the draftsman before the project begins. These marked lanes are then overlaid onto the drawings file, providing precise geospatial information of any detected faults along individual walkthrough routes. This guarantees that the client receives a detailed report on the construction project's internal structure. Figure 2 shows an example of construction site walkthrough using drone technology.

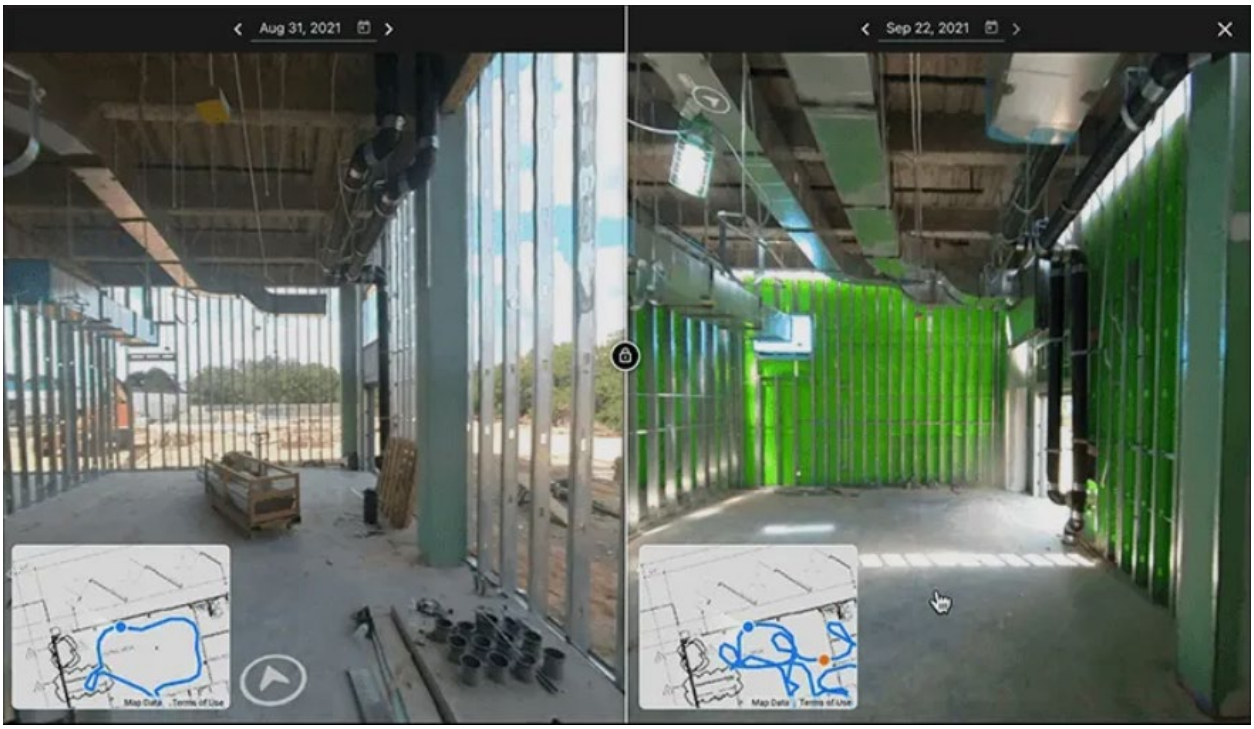

Figure 2. Example of virtual site walkthrough using drone technology [16].

2.1.1.2. Site Work Safety Monitoring

360-degree cameras are proving to be a valuable resource for Health, Safety, and Environment (HSE) teams in overseeing the workforce and detecting any potential safety hazards. These cameras, combined with virtual reality technology, allow users to experience a virtual walkthrough of the workplace. The application enables users to manipulate the camera, zoom in and out, and make notes and observations on any safety infractions. These annotations are tagged with location and time information, which makes it easy to pinpoint the exact location and time of the violation.

Once the data is annotated, the platform produces detailed reports that feature the location of the infractions, a snapshot of the data set, the timestamp, and the severity rating designated by safety professionals. The platform has the capability to detect a range of safety violations, including but not limited to, improper use of personal protective equipment, unsafe work practices, and potential hazards in the workplace.

In summary, the use of 360-degree cameras for virtual reality in combination with the virtual walkthrough application provides HSE teams with an effective tool for identifying, documenting, and reporting safety infractions. This technology helps to create a safer workplace environment by enabling safety professionals to take quick action to address any safety concerns. Figure 3 shows an example of work site safety monitoring using drone technology.

Figure 3. Example of construction site safety monitoring using drone technology [15].

2.1.2 Engineering Progress Monitoring

2.1.2.1. Materials Compare

To ensure timely and cost-effective project management, precise control over on-site materials and tracking earthwork progress for billable materials are essential. By utilizing drone technology to capture accurate GIS data and software that supports direct data comparisons and volume calculations, this process becomes effortless and can be achieved easily.

The state-of-the-art system provides GIS data with an impressive level of accuracy, with a precision of 1-2CM on the X and Y-axis and 3-5CM on the Z-axis. As a result, the volumetric surveys are typically 5-6% more accurate than traditional surveys conducted with a total station. Additionally, the volumetric survey solution significantly reduces the time needed to capture and process reports, cutting down from two days to just one hour, making it a crucial tool for multiple aggregate and construction companies to execute their year-end stock take. When combined with data compare feature, project owners and managers can generate a comprehensive volumetric project overview with just a few clicks. Figure 4 shows an example of materials volume changes monitoring using drone technology.

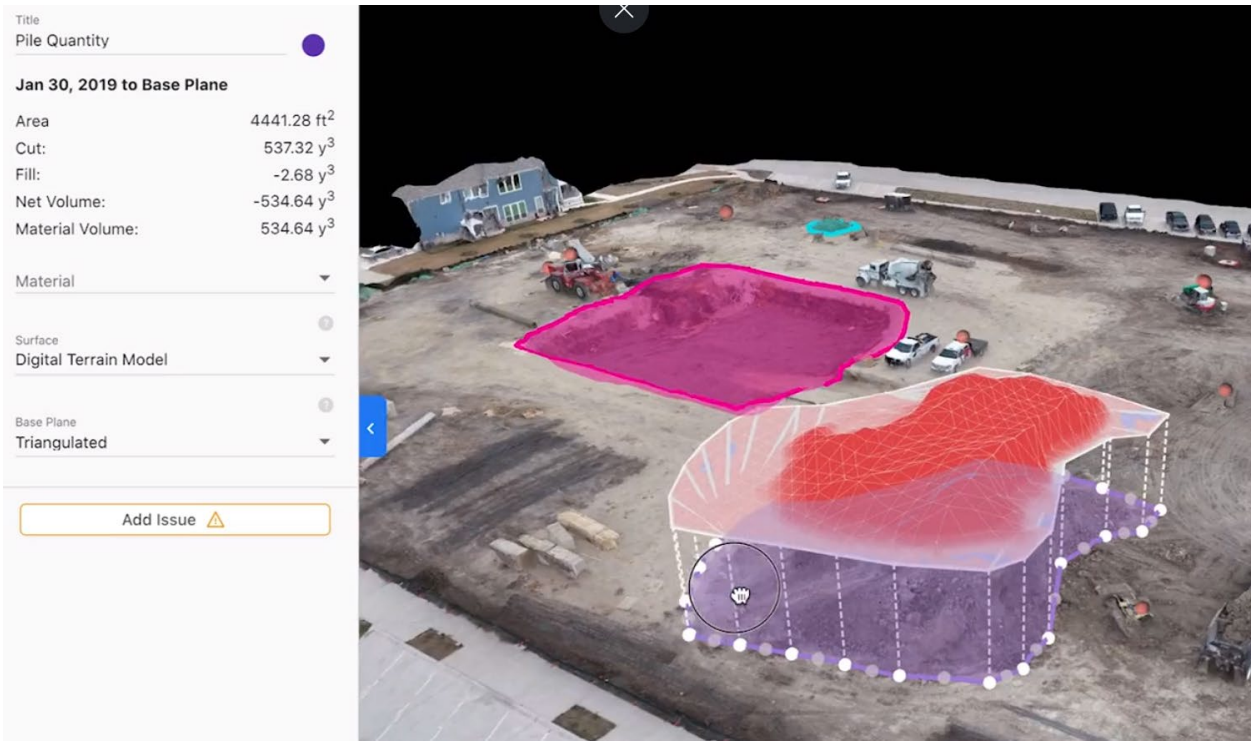

Figure 4. Example of materials volume monitoring using drone technology [16].

2.1.2.2. Verify Construction Accuracy

To ensure that construction is progressing according to the original plans, it is crucial to compare the current state construction with the original designs. Using the software technology, ZainTech captures precise GIS data sets, which be overlaid with a variety of data layers such as Autocad drawings on top of drone-based GIS maps, in combination with monuments (benchmarks) and PPK technology. By combining these datasets, we can achieve centimeter-level accuracy.

Having access to this data overlay, we can use measurement tools to confirm the accuracy of survey data versus drawings. We can verify the edges of the buildings to ensure compliance, double-check the road grades to ensure they match the original design, verify utility placement is as per design requirements, and much more. The best part is that all these measurements and verifications can happen quickly from the comfort of the office, without the need to send the survey team to collect data in the field. Figure 5 shows an example of construction accuracy verification using drone technology.

Figure 5. Construction accuracy verification using drone technology [15].

2.1.2.3. Sub-Contractor Monitoring

Construction projects often involve several subcontractors tasked with different aspects of the job. However, this can result in delays since there is no efficient way to oversee and manage each subcontractor's progress. That is where the drone data and cloud platform come in. By utilizing these tools, each segment of the project can be assigned to its respective subcontractor, providing granular control over work progress and real-time reporting that is entirely independent of reports from consultants and other subcontractors.

The data comparison feature enables project owners to swiftly generate data points essential for assessing the performance of individual subcontractors and identifying any potential issues in the construction process. These data sets are easily accessible, and reports can be tailored to the necessary output. This guarantees that the project is finished

on schedule, within budget, and to everyone's satisfaction. Figure 6 shows an example of subcontractor progress monitoring through volumes using drone technology.

Figure 6. Example of subcontractor progress monitoring using drone technology in road construction [17].

2.1.2.4. Compare Original Ground to Final Grade

When conducting earthworks for a project, it is essential to stay vigilant about any changes in the project's topography. To ensure the project's progress is accurate, it is important to be able to compare the design surface with the original topography and analyze both visual and quantifiable data. This innovative feature enables you to do precisely that, giving you a streamlined approach to monitoring any changes in the project topography. This approach provides you with a quick and efficient way to detect any potential issues, reducing the risk of construction errors that could lead to costly delays. By keeping a close eye on the project topography, you can ensure that the project stays on track and meets all necessary requirements. Figure 7 shows an example of monitoring earthworks progress through drone technology.

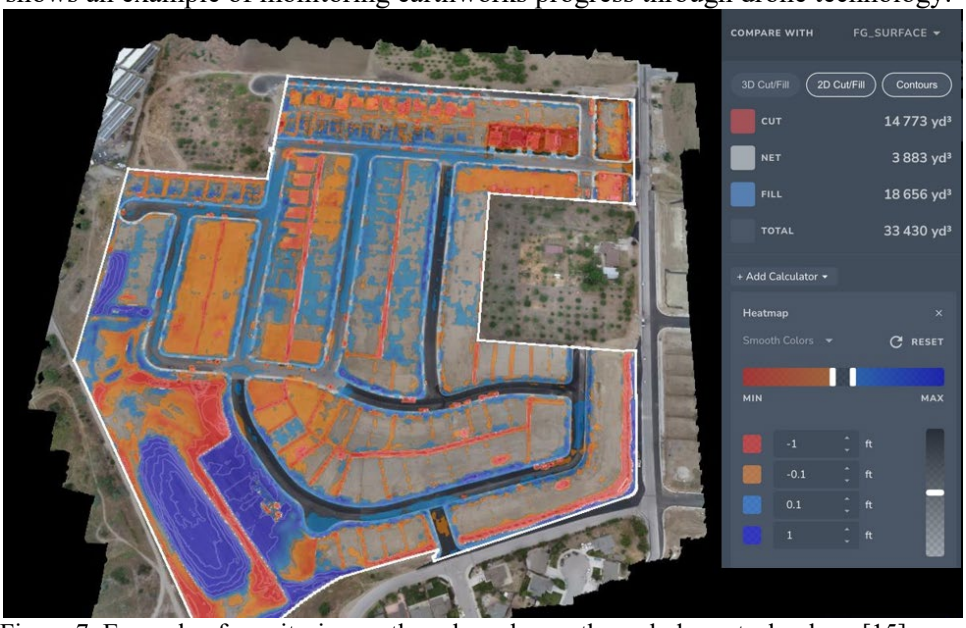

Figure 7. Example of monitoring earthworks volumes through drone technology [15].

3. Challenges

Drones have proven to be an innovative solution for many infrastructure projects. However, the flying time of limited, which means that some missions may require multiple flights. This can be time-consuming and expensive, for large-scale projects. Furthermore, drones have a limited payload capacity, which means that multiple drones may to collaborate to transport materials or equipment to the construction site, adding additional complexity to the project.

Operating drones also requires professional training, which can impact productivity. The Federal Aviation Administration (FAA) has strict regulations that limit drones from flying out of sight, which can be a restrictive barrier in some situations. Additionally, drones are vulnerable to adverse weather conditions such as heavy rain, snow, or strong winds, which can prevent them from operating effectively and safely.

While drones are beneficial for real-time traffic monitoring, they can also distract drivers and compromise traffic safety. Despite the availability of advanced algorithms, processing substantial amounts of data remains a significant challenge. Image sharpness and clarity are also critical obstacles that impede drones' further use in infrastructure projects.

Before drones' widespread use in infrastructure, it is crucial to have a good understanding of the input and output relationship, which can be challenging to comprehend and evaluate. Moreover, finding a balance between public concerns about safety and privacy and the advantages of drones poses a challenging issue. Therefore, it is essential to consider these factors when planning drone-related infrastructure projects to ensure that they are safe, efficient, and successful.

4. Conclusion

Incorporating drone technology equipped with advanced detection equipment can prove to be an invaluable asset in planning, designing, constructing, and maintaining civil infrastructure. Drones have the potential to significantly increase productivity and efficiency, while also reducing costs throughout all stages of the construction process. This comprehensive document provides an overview of the various types of drone platforms, detection equipment, and data-processing systems specifically designed for infrastructure projects. It also presents several case studies that demonstrate the benefits of incorporating drones in civil infrastructure projects, such as improved safety, reduced downtime, and enhanced accuracy in data collection.

Despite the benefits, there are still some challenges associated with incorporating drones in civil infrastructure projects, including regulations, data management, and privacy concerns. To overcome these challenges, future research should focus on applying research methods to measure the benefits and solve the challenges associated with drone use in civil infrastructure projects. This research can provide valuable insights into the effectiveness of drone technology in infrastructure projects and inform policymakers and project managers on how to best utilize this technology. Ultimately, integrating drones into civil infrastructure projects can offer significant advantages that can help streamline the construction process and lead to better outcomes for all stakeholders involved.

The use of drone technology has the potential to bring significant changes in the sustainable construction approach towards housing projects. By incorporating drones, contractors can carry out rapid surveys of vast project areas, monitor construction progress in real-time, and ensure environmental compliance, thereby promoting sustainability, reducing costs, and enhancing safety. However, to fully realize these benefits, it is crucial to improve drone technology by enhancing battery life, data processing capabilities, and data management systems while also addressing regulatory and privacy challenges. Future targeted research can help develop a tailored approach to optimizing drone usage in housing construction, aligning with the UAE's vision for smart, sustainable, and efficient urban development.

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