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UAV-based construction progress monitoring: enhancing efficiency and safety

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Abstract

Unmanned Aerial Vehicles (UAVs) have gained significant attention for monitoring construction progress, offering real-time and accurate information for site management. This paper explores the advantages of utilizing UAVs in construction progress monitoring and highlights their contributions to decision-making, project coordination, data accuracy, and site safety. UAVs provide a comprehensive aerial view of the construction site, facilitating a better understanding of progress and spatial relationships. Regular monitoring at predetermined intervals enables time-lapse records, aiding in identifying changes and delays. Furthermore, UAVs enhance data accuracy through advanced processing techniques, enabling precise measurements and objective assessment of progress. They also improve safety by accessing hazardous areas and assisting in safety inspections. The study focuses on monitoring a new dormitory building at Harran University Osmanbey Campus using UAV flights at different times, providing insightful analyses for construction management. These findings contribute to the construction management field, benefiting project stakeholders and expanding our understanding of effective monitoring techniques. With advancing technology and evolving regulations, UAVs are expected to play an increasingly prevalent role in construction progress monitoring, enhancing project management practices.

Introduction

Monitoring construction progress using Unmanned Aerial Vehicles (UAVs) has gained substantial attention in recent years due to its potential to provide real-time and accurate information for construction site management. UAVs, equipped with cameras or sensors, have the capability to capture high-resolution images, videos, and data of construction sites from various angles and heights, thereby enabling detailed monitoring of construction progress [1].

The utilization of UAVs in construction progress monitoring offers several advantages over traditional manual methods [2]. Firstly, UAVs provide a comprehensive and holistic view of the construction site, allowing project managers and stakeholders to observe the entire project area simultaneously. This aerial perspective provides a better understanding of the overall progress and spatial relationships between different elements of the construction site, thereby enhancing decision-making and project coordination. Secondly, UAVs facilitate regular and consistent monitoring of construction progress by capturing data at frequent intervals. This temporal analysis facilitates the identification of changes, delays, or deviations from the planned schedule. Moreover, the use of UAVs in construction progress monitoring enhances data accuracy and reduces human error. The captured images and data can be processed using advanced photogrammetry and computer vision techniques, resulting in the generation of accurate three-dimensional (3D) models, point clouds, or orthomosaic maps of the construction site [3]. These digital representations provide precise quantitative measurements, such as volume calculations and area analysis. They enable effective comparison with as-planned models, facilitating objective assessment of construction progress and supporting quality control. UAV-based construction progress monitoring also contributes to improved safety on construction sites [4]. Rather than manually inspecting hazardous areas or relying on personnel to climb structures for visual inspections, UAVs can access hard-to-reach or dangerous locations, minimizing risks to personnel. The captured data can be used for safety inspections, identifying potential hazards, and ensuring compliance with safety regulations, thus enhancing overall site safety.

In the context of this study, the objective was to monitor the progress of the new dormitory building at Harran University Osmanbey Campus. This was accomplished through the implementation of UAV flights conducted at three different date, allowing for a comprehensive assessment and analysis of the construction progress. By employing UAVs as a monitoring tool, the researchers were able to closely observe the various stages of the construction process and present insightful analyses. The findings from this study contribute to the existing body of knowledge in effective construction site monitoring techniques.

Material and Method

UAV-based photogrammetry utilizes small onboard cameras to capture high-resolution imagery, enabling the generation of accurate 3D models, point clouds and orthophoto [5]. The process involves capturing multiple images from different perspectives and utilizing image processing techniques to extract spatial information. One commonly used technique in UAV-based photogrammetry is Structure from Motion (SFM), which leverages image overlap and feature matching to create photogrammetric products. SFM algorithms estimate camera positions, orientations, and calibration parameters, allowing for the reconstruction of the scene in three dimensions.

The process begins with an UAV flight conducted over the targeted area, capturing a series of overlapping aerial images using a digital camera. These images are then subjected to processing using the SfM technique, which is a computer vision method enabling the reconstruction of 3D information from a sequence of two-dimensional (2D) images [6]. The SfM algorithm analyzes common points or features present in multiple images and utilizes intrinsic and extrinsic camera parameters, such as focal length, distortion, principal point, camera position, and orientation, to compute the 3D coordinates of the points in the scene, resulting in the creation of a point cloud representing the scene's structure. SfM algorithms are rooted in the principles of photogrammetry, computer vision, and machine learning, representing state-of-the-art techniques widely accepted in the field [7-8]. As technology continues to advance, UAV-based photogrammetry is expected to play an increasingly significant role in the construction industry. Its ability to provide accurate and timely information for decision-making, along with its cost-effectiveness and versatility, make it a valuable tool for enhancing efficiency and productivity in construction projects.

Results

Both orthophoto and DEM were produced by flying the study area by UAV at three different times. For this purpose, the DJI Mavic 2 Pro, a UAV system was used to fly from a height of 50 m. The first flight was made on empty land. That is, it was carried out in the natural state before any work was done. The second flight was realized after the building foundations were completed and the construction progressed for a while. In this case, elements such as materials brought to the construction site, building columns, excavated foundations, construction equipment and soil heaps can be easily seen. The third and final flight was carried out at a time when the floors of the building were rising and its shape was well revealed. It is possible to say that there is more than one building and the construction will continue for a while.

Changes in the field such as excavated foundations, piles of earth and building constructions can be observed very easily from orthophoto. Additionally, the changes in the height of the land (rise of buildings) and volume calculations can be made easily by using DEM. At this point, it should me mentioned that, the digital photogrammetric products obtained through UAV-based monitoring offer versatile applications beyond safety and progress observation in construction sites. These products can be utilized for various engineering requirements, such as cross-section production, 3D model slope and aspect maps, and other essential analyses. The digital environment enables efficient extraction of valuable engineering information, contributing to enhanced decision-making and meeting diverse project needs. The integration of UAVs and photogrammetry provides a powerful toolset for comprehensive construction site management and supports effective engineering applications. The generated orthophoto and DEMs are given in the Figure 1.

Conclusion

In conclusion, UAVs for monitoring construction progress offers numerous advantages in the field of construction site management. The ability of UAVs to capture high-resolution images, videos, and data from various angles and heights provides real-time and accurate information for decision-making and project coordination. Through the implementation of UAV flights at three different times during the construction of the new dormitory building at Harran University Osmanbey Campus, this study successfully demonstrated the effectiveness of UAV-based monitoring. The comprehensive assessment and analysis of construction progress allowed for a closer observation of the various stages of the construction process, providing valuable insights for project managers. The generated orthophoto and DEMs proved to be valuable tools for monitoring changes in the construction site. The orthophotos provided a clear visual representation of excavated foundations, soil heaps, and building constructions, enabling easy identification of progress and deviations from the planned schedule. Meanwhile, the DEMs facilitated the analysis of height changes in the land and enabled volume calculations, contributing to efficient project management practices. Moreover, the integration of UAVs in construction progress monitoring enhances safety measures by reducing risks associated with manual inspections of hazardous areas.

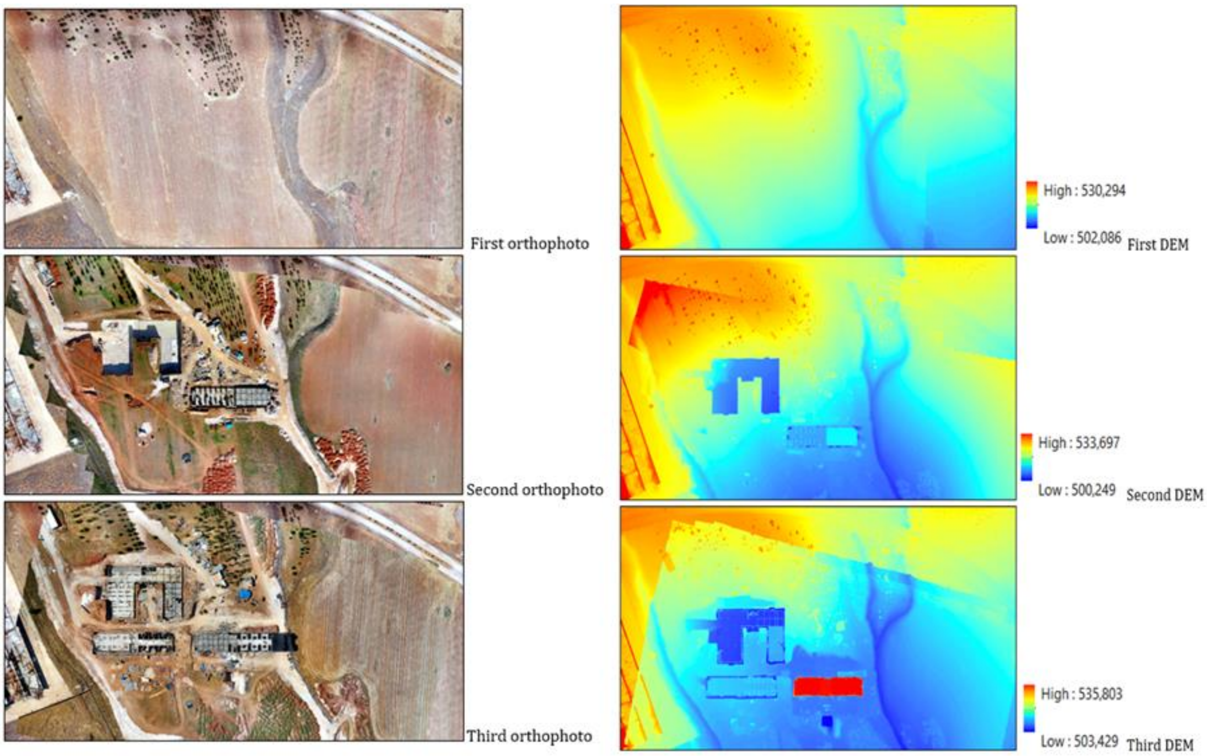

Figure 1. The produced orthophoto and DEMs

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