APPLICATIONS OF UAV TECHNOLOGY WITHIN THE CONSTRUCTION INDUSTRY

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Abstract

This paper shows how drones can help with construction inspection, which is currently costly in terms of the safety of workers and time. The paper depicts the use of drones to collect construction data with drone software that allows people to create 2D plans and 3D models. Moreover, the study explains how unmanned aerial vehicles, or UAVs, could improve job site safety and reduce material waste in the construction industry. Finally, this paper presents an exploratory study that identifies specific ways in which UAVs could improve safety at construction sites. Data collection of large construction projects uses surveyors' tape measures, laser rangefinders, total stations, and mapping software. However, these are time-consuming and costly methods that are impractical for measuring more significant amounts of space.

In contrast, the use of UAVs would enable the next level of data collection to occur more efficiently. Specific examples using 3D software will demonstrate the potential applications within the construction industry and the challenges that limit their implementation into the industry. A UAV can monitor worksites and equipment to provide information to those responsible for operations, health, and safety in a timely fashion. The footage creates inspection reports from a distance, thus reducing pressure on-site and providing accurate reports faster. UAVs for inspections will eliminate or reduce the need for risk assessments, supply chain audits, and quality control audits during construction.

Keywords

UAV, inspection, 3D models, safety

JEL Classification

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Introduction

The construction industry is one of the most extensive socio-economic activities globally. From building dams to skyscrapers, the construction industry has existed for centuries. Drones (UAVs) are recently being adopted by many industries, including the construction sector. The integration of UAVs in the construction industry is a critical emerging technology to improve quality, reduce overall costs and shorten construction durations. Moreover, the theory behind UAVs has been used in different fields where aerial camera images can increase efficiency and save costs. In construction, UAVs are already being tried with outstanding results. They are equipped with a camera and can also carry loads. Engineers can use drones for a variety of purposes in the construction industry. Utilizing drones, project managers, designers, and engineers can work better with less effort. Engineers can use drones to measure topographical features such as land elevation, water levels, and roads. Contractors could also take aerial images of construction sites or project progress. Engineers use drones for 3D modeling, site mapping, and analyzing project progress. Unmanned aerial vehicles (UAVs) or drones have been used primarily for military purposes for a long time. This paper investigates possible uses of drones within construction projects, how they may benefit the industry, why they need to do so and looks at what drone technology is currently available to businesses involved in this sector.

Construction Progress Monitoring

York et al. (2020) noted that the latest technological advancement in the construction industry is the emergence of drones used for monitoring progress, inspection, and analytics. The development of this technology offers contractors numerous benefits and opportunities. For example, some contractors now require drones because they are valuable and provide better solutions than other performance verification methods. Drones provide an aerial view of a site; this allows builders to measure distances and dimensions, track progress on a project, locate missing personnel and equipment, and monitor traffic patterns on-site. The use of drones can save time and money while increasing safety by reducing time spent walking around on-site. There are four main uses of drone technology within the construction industry: site surveying, aerial photography, monitoring traffic flow, and surveying sites. Drones can be used to create scaled maps of construction sites so that any changes made by workers or supervisors can easily be measured and tracked over time.

It is the most common early application of UAV technology; however, directly assessing the progress of construction projects and continually monitoring the site makes it possible to intervene at a stage in which repair costs are minimal. These "health checks" help increase the efficiency of projects by reducing delays and helping to avoid unplanned stoppages. It would also be possible to record risk levels on-site from a bird's-eye view, which people could then assess to help maintain safety and aid in planning for future events. Although various technological options are available to track and monitor construction projects, UAV services the needs more appropriately than any other technology. The use of UAVs in construction management offers many benefits, such as increased safety and saving time and money in monitoring and controlling the construction activity. One of the highest causes of construction site injuries is lack of visibility. Construction sites are large, and production demands are high, which translates to moving objects, creating dust and dirt, high amounts of noise. These factors all add up to low visibility and an increase in accidents. By utilizing autonomous aerial vehicles (drones) on construction sites, we can decrease incidents due to worker-related visibility issues by providing safe and direct views of the construction area from an aerial view while simultaneously monitoring other safety hazards such as the status of job transport routes. UAVs can be used for various tasks, including coordinating construction workers, improving the efficiency of construction operations, and monitoring the progress of construction operations.

Building Inspections

UAVs can be used to carry out a diverse range of construction inspection tasks. UAV-based building inspections can be implemented during the planning phase when there are still options concerning the course of action. These include comparing existing aerial images, surface scans, and historical data concerning construction progress and damage. Inspections are essential to construction because they help ensure construction is carried out as intended and help discover severe defects or deficiencies early on. Therefore, construction inspections need to be executed quickly and efficiently. In this paper, we describe the planning and implementation of an inspection system for a building structure by working with a mobile robot, an unmanned aerial vehicle operated by a pilot from the ground station, and the design of an inspection plan based on algorithms for localizing objects of interest (such as construction elements). Construction is a rather harsh industry. However, it is not just the labor-intensive work that presents challenges but also inspections of all facets of the structure. To this end, there is inventory and innovative methods of using unmanned aerial vehicles to perform building inspections. This technology will undoubtedly come into its own in the years to reduce costs and improve efficiency.

Figure 1: Drone mapping overlay with a design plan and as-built on-site progress (6)

Freimuth et al. (2017) concluded that an inspection task for a UAV could include different tasks such as object detection, tracking, and a detailed inspection. Robust motion planners and 3D detection are required to perform the task. The authors proved their point by providing a simulator for all kinds of UAV-based inspections of buildings by using the proposed archer device, which simulates all components of construction sites. The simulation includes multi-collision objects and virtual people. Simulation, a task execution tool, is implemented to allow planning and executing simulations on actual construction sites. It allows the automation of several operation steps and helps to improve process

times significantly. Rapid advances in unmanned aerial vehicles informatics and perceptions, such as low-cost, lightweight sensors and image processing, simplify implementing inspection tasks traditionally performed on construction sites by complex and expensive devices, such as laser scanners human-crewed helicopters. Due to this, UAVs' benefits in construction site inspections, challenges and current state of the art, and a method for designing a generic platform for carrying out site inspections with UAVs.

A building inspection is a prerequisite to assessing construction work, thus the need for the application of robots. It includes the verification of materials and components, the measurement of dimensions and documented defects, and the documentation of the current situation. However, building inspectors who inspect complex constructions on construction sites are faced with challenges that arise from a combination of complex spatial situations and danger to personnel and material. Unmanned aerial vehicles can be used for a building inspection to overcome these challenges: UAV can be operated at a safe distance from dangerous workplaces, do not require assistance, or protective clothing from humans can reach locations that are not possible for people, travel faster than humans and still make video recordings of high resolution.

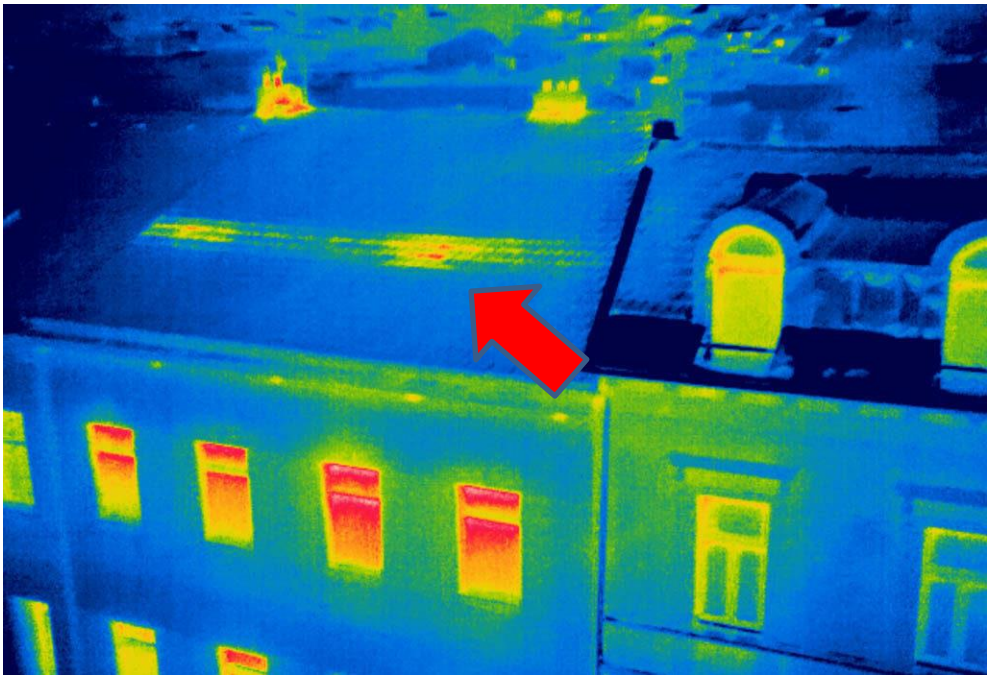

Figure 2: UAVs roof damage measurement caused by thermal bridges (8)

UAVs' application is becoming increasingly popular in construction site inspections for achieving high-quality 3D reconstructions for further analysis; engineers must achieve a complete and accurate reconstruction of the whole building. Also, the structure must be so that engineers can evaluate all-important visual and geometric characteristics. With the increasing use of drones in the construction field, a corresponding diversity of visualization presentations is required. Therefore, it is expected that innovative solutions arise that consider industry standards and requirements and are not restricted to specific databases or software solutions. Building inspections are done during the different stages of the construction of a building by gathering data on progress and quality and then creating pictures that show defects in the structure of the building. Architects and engineers can use this information to take action on what needs to be fixed before it worsens. For example, office or stand-alone buildings are usually inspected with a specially designed floor plan placed on the actual site. For maintaining the highest quality in these inspections, it is vital to plan and execute each measure as precisely as possible.

UAV technology and computer vision offer an alternative method for inspecting buildings which reduces the cost and workload of this process.

De Melo et al. (2017) did a study that evaluated the applicability of unmanned aerial system (UAS) technology to support safety inspection activities on construction sites, with a particular focus on steel structures. It is one of the first studies focusing on UAS technology in occupational safety and health and anticipates engineers will virtually integrate a future work scenario wherein UAS into standard safety inspection techniques. No construction site is too big or too small to be inspected with the information provided by an unmanned aerial system. Although this technology can save time, money, and lives by increasing safety, several issues need to be analyzed for further adaptation in this industry. First, the extensive use of UAVs allows for swift quantification of construction site safety. For instance, the rapid deployment of UAVs allows engineers to quickly fly over a construction site to identify potential dangers and provide practical solutions to worker safety issues. Second, the utilization of unmanned aerial systems in the industrial sector has increased in recent years, particularly in safety and inspections. Third, there is immense UAS application to develop effective strategies adopted on construction sites, based on extensive literature searches worldwide.

UAV technology offers an efficient solution to inspection tasks, particularly with complex objects such as construction sites. It could provide early notification of any missing or faulty elements and ensure smooth operation of the building construction process. While inspection activities are the first step towards preventing accidents on the construction site, recent data show that 95% of all accidents happen due to human error. Therefore, there is a need to reduce this percentage; however, traditional inspection methods are not suitable for all inspections in every construction site.

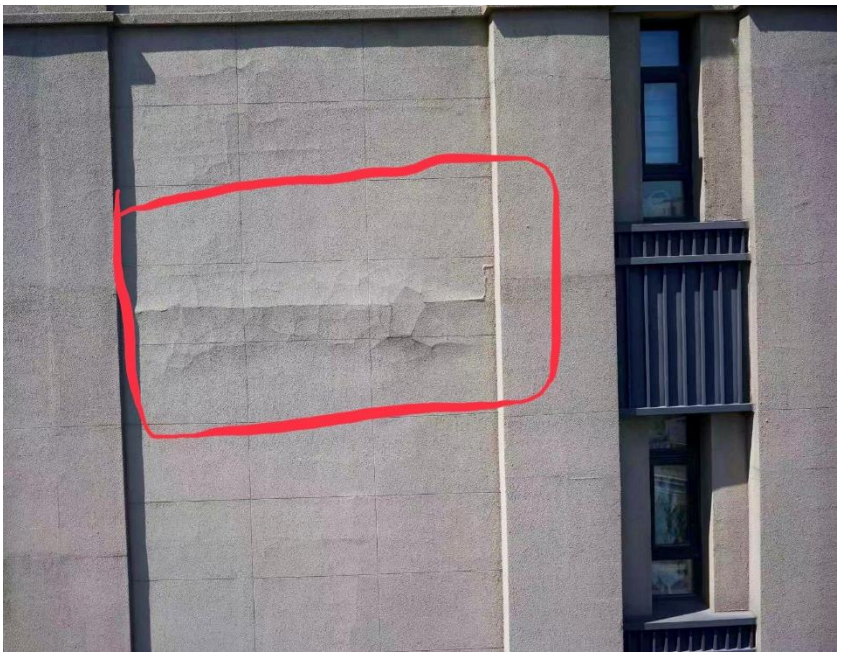

Figure 3: UAV photo of the façade destruction (10)

Unmanned aerial vehicles are becoming more viable as general-purpose solutions in the AEC+ industry and are now used throughout different aspects of the construction process. UAV inspection often attributes visual clarity to provide quality assurance to related building projects. UAV for building inspections is a step forward in construction technology. This technology enables us to reduce costs, minimize the number of on-site employees, and improve performance. The construction industry is transforming from the old world to the new. Unskilled labor and brute force methods have given new-age construction knowledge and innovative technology. Zero-hours, unskilled workers are more expensive than skilled, highly trained, professional workers who can modify their efforts based on the

construction progress. Although UAVs in a construction site are yet to be commonly used as most constructors are unaware of the rules and regulations, there is a consensus that the advent of these devices will have a significant impact on how building projects are completed.

The use of drones allows the façade to be analyzed with greater detail and accuracy than conventional methods. The analysis includes the assistance of advanced vision systems, sensors, and GPS to conduct routine structural inspections of high-rise buildings. This process is not limited to visual inspection and can also be used for various other applications such as energy modeling, thermal modeling, wind modeling. In addition, it significantly improves security in these buildings and can monitor any unauthorized access from areas that are typically dangerous for human beings (e.g., rooftops).

Drone Application in Construction to Save Money

Construction is one of the most labor-intensive industries, even though it accounts for 20 percent of global GDP. Until recently, construction has relied on human labor. In recent years this has been complemented by automated machine technology and, more recently, by autonomous robotic systems. The construction industry holds the potential for significant gains from automation due to its reliance on labor-intensive processes, immense data management requirements, and demand for real-time decision-making on the part of builders. Drones are ideal for such a process, given their ability to produce high-resolution imagery and other monitoring tasks at scale. There are many benefits of using drones in construction projects. There is no doubt that the adoption of this technology will change the way we build, but perhaps not as quickly as many believe. Though the joint study by Delgado et al. (2019) showed that most contractors have their drones, almost all of them feel that lack of education and data sharing is a major hindrance to the adoption of drone technology, causing them to keep drones as mere toys instead of using these drones for actual work.

Drones can be used to allow teams of workers who are remote from each other to connect in real-time, which saves time and money. The use of drones can reduce the cost of building monitoring by 50%. The construction industry is a multibillion-dollar industry with high-profit margins and huge growth potential. The construction industry is significant, and its impact on local, regional, and even national economies is significant. However, construction equipment costs have always been high compared to the revenue from new housing starts. This situation can be described as unfavorable economic conditions for employers and is, therefore, one way to address the issue of high equipment costs is to reduce machine numbers by implementing automation on vehicles that perform similar work. Recent advancements in technology have made it possible for unmanned aerial vehicles to replace routine tasks performed by human workers. Drones can be used at various stages in the building process to take over tedious and repetitive jobs. They are revolutionizing construction because drones provide an economical way to do complex tasks that people once did by hand or other means.

Findings and Results

UAVs, or unmanned Aerial Vehicles, are an upcoming technology in construction site monitoring. UAVs provide sequential real-time data collected using high-resolution cameras and sensors. This data can then be applied in the following regions: 3D scanning of the construction site, progress assessment, and measurements of volumes. UAVs provide a highly flexible imaging platform to implement various image processing algorithms and create 3D maps of the construction regions. These maps can be used for various purposes, e.g., for determining the progress of the construction projects. The application of UAVs for construction monitoring enables the creation of highly accurate 3D models of complex structures and effective survey systems compared to any other alternative monitoring technique. Construction UAVs can be deployed in three main ways: aerial photography, progress assessment, and

measurements of volumes. These provide a holistic view of the physical state of a construction site and enable data to be collected that otherwise would require numerous human resources.

The Federal Ministry of Transport and Digital Infrastructure in the U.S. supports the use of UAVs within the construction industry often because it will reduce costs and other risks on construction sites. 18 months after starting the drone pilot project in the construction sector, the findings of BMVI point towards a positive overall economic effect. The cost savings achieved via UAV inspection stand at around 10% compared to conventional methods, while around 70% of firms said they were willing to continue using drones. It is a startling fact that construction site accidents kill more than 1,000 Americans each year. Given this, it is understandable to see why the U.S. Federal Aviation Administration has taken a firm stance in regulating the use of unmanned aerial vehicles for the inspection of construction sites and other operations that pose safety risks for workers and other members of the public. This case study has proved that unmanned aerial vehicles allow for real-time monitoring of the progress of a construction project. A UAV can safely monitor the advancement of a construction task allowing engineers and planners to track its production schedule and cost more accurately. The innovative technology of unmanned aerial vehicles is only being implemented due to its relatively fast development.

Nevertheless, drones' cost-efficient and time-saving potential attract interest from construction managers and SMEs. A regularly unmanned aerial vehicle flight over a specific area can provide an accurate 3D model with associated textures and metadata. Using an onboard camera fixed to the UAV, high-resolution orthomosaic views of the scene could be generated for other manual or automatic interpretation by experienced specialists.

The significant findings of the study could be categorized into two explanations. The first explanation focuses on the potential applications of UAVs in the service industry and will briefly summarize how UAVs can be helpful and their limitations in different applications. The second explanation explains some challenges that limit the implementation of UAVs for business use. As described in this review, UAVs offer exciting new opportunities for the construction industry. Although significant research and development are still required, several potential applications have been identified. Preliminary results from the study indicate that the commercial use of UAVs on construction sites can significantly improve the safety and productivity of workers. In particular, the ability to conduct inspections and quality control measurements quickly, at a relatively low cost, could provide benefits for firms that perform large numbers of small projects with high levels of quality control.

Conclusion and discussion details

Unmanned aerial vehicles can be instrumental in the building industry. They can use high-resolution cameras to take images of high-rise buildings and make them available to people on the ground. UAVs have several uses on a construction site, making it easier to get information about what is there. Implementing drone technology in the global construction industry would significantly bring advanced technologies into the building sector. Moreover, there is a new way of completing challenging jobs. In a word, the solution is drones or unmanned aerial vehicles. It may be a bit awkward to first hear from someone that UAVs are the answers to problems in construction; however, operations can be managed more efficiently using this technology. The development of this technology has taken off in the last few years, and now some drones can shoot H.D. movies, create 3D maps, conduct surveillance, and even deliver packages. There are several applications for this kind of technology inside the construction industry. Companies can use drones to help them operate more efficiently, streamline their services, save money, and improve safety. The findings indicate that commercially available UAVs have significant limitations operating in temperature extremes, navigating the congested and dynamic environment of the construction site, and autonomous landing. More generally, the vehicles' limited flight time and

weight capacity preclude their implementation into the construction industry. Also, the knowledge and situation circumstances associated with commercial usages of UAVs present a major challenge for researchers and practitioners to overcome.

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