Monitoring of Historical Structures using Drones

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Abstract. The use of drones has been increased in recent years for surveying, facility management and other relevant fields. However, more recently, the technological progress in the design and navigation of low-weight and autonomous drones and UAVs have resulted in their more practical and cost-effective operation in the fields of construction management and monitoring. This study presents a framework for the development of a fully automated smart construction monitoring and reporting system based on real-time data obtained from drones and UAVs. The data in terms of drone images from multiple locations and point clouds (from 3D scanning of construction site) can be used to construct a 3D model using the photogrammetry techniques. This so-called "drone model" can be compared to BIM model at various construction stages to monitor the construction progress. Beside construction scheduling and costing, this comparison can be expanded to include real-time recording, reporting, billing, verification and planning. The system not only provides convenient and smart ways of site supervision and management but also results in better monitoring operations which are practically difficult by manual methods. The usability of this non-destructive method of damage detection is shown with practical example.

1. Introduction

Civil Engineering not only deals with construction of structures but also more on monitoring and maintenance of existing buildings [1]. An early detection of damages of cracks is required to avoid accidents. Crack detection is not only for industrial and residential buildings, but also in the field of monitoring of historical structures, which are in exposed conditions. Due to advancement in recent technology, the usage of drones is rapidly increasing in various fields.

Drones permits remote data acquisition in environments dangerous to human life or inaccessible to direct examination. The Drones provide potential for acquiring remote data more rapidly and at lower cost than manual data collection [2]. Due to advancement in recent technology, the usage of drones is rapidly increasing in various fields. In agriculture drones are introduced to know the status of their agricultural land regarding crops health, crop monitoring. Certainly, the construction industry can take the advantage of drone technologies in practical situation. Drones are used as a tool to visually monitor their construction projects. The application of drone in examination of structures helps in development of efficiency and quality of the structure.
The Drone may be of various sizes, shapes, and structures (miniature unmanned helicopter, rotary-wing UAV, quadcopter, drone, etc.) and they are qualified by their manifold characteristics. Previously, they were ordinary aircrafts under remote control, but recently autonomous Drone have been started to be used [3]. Modern Drone move according to the pre-programmed flight pathway or they can be operated with the help of a more complicated system of dynamic automation. A digital, calibrated, and integrated camera is installed in a Drone, the purpose of which is to acquire the Earth’s surface photographic images. The images made during the Drone flights can be investigated and processed by applying the methods of photogrammetry, with substantially lower costs to be incurred than they used to be in cases, when the images were taken from an airplane equipped with the complicated and rather expensive equipment, devices, and facilities [3].

Drones have become cheaper because many control functions can now be implemented in software rather than having to depend on expensive hardware. This has allowed single or multiple Drones to be employed for real-world applications. The Drones very often require a means of communication so that they can communicate with on-land computers, sensors or other Drones. As most of the research with Drones is still in its initial stages, there are a number of open questions that need solving, like mapping and localization schemes, route planning, coordination and task allocation and communication issues, among others [4]. Developed countries have already started use of Drones in their precision agriculture, photogrammetry and remote sensing.

This paper deals with the use of drones for monitoring of structure that are difficult to access.

2. Visual monitoring of structures

2.1. Purpose of using drones for monitoring

Elevating platforms or scaffolding on structure are high-priced products and cause high logistical efforts. Trained staff, like scaffolding, can get access to certain parts of the structure, but they can hardly evaluate the damage on these structures with accuracy. Consequently, they can only take photos or videos of the concerned part of the structures. Typically, visual monitoring of large structures like dams, bridges towers, historical monuments or elements of those structures, needs particular equipment’s and particularly trained staffs. Figure 1 shows structures that are hard to access and monitoring unit like industrial climber.

![Figure 1. Inspection of Tall structures with Man power](image-url)
2.2. **Drones - applications and limitations**

Drones can fly remotely which is controlled by a pilot from surface. In civil engineering field light weight drones are used, which has higher efficiency and are handy. These drones also can be provided with higher-resolution camera or with other sensors, which provides various application in the field of civil, agriculture, surveying, photography, disaster relief, meteorology and geology.

Agricultural application includes Agriculture land will be monitored by the drone from which the images of the land will be acquired. Once the images are processed, they can be fed into the app portal developed for the farmers. Through the portal farmer can know their complete 360 information about their crop details including current market price. That will facilitate the farmer to make decisions to combat any losses due to natural calamities. Drones have some drawbacks, due to the small payload, only light weight digital cameras can be used for photo and video capturing.

2.3. **System configuration**

The drone used here is DJI Mavic mini system made by SZ DJI Technology Co., Ltd., see Figure 2.

Table 1. Table with specifications of the drone

| Specifications | DJI Mavic mini |
|----------------|----------------|
| Resolution     | 12 MP          |
| Sensor         | 1/2.3" CMOS    |
| Lens           | Aperture: f/2.8 |
|                | Shooting Range: 1 m to ∞ |
| Video          | 2.7K at 30fps  |
|                | 1080p at 60fps |

*Figure 2. DJI Mavic mini*
3. Case study

3.1. Visual inspection of Water tank

Figure 3. Water tank

Figure 4. Flight path of drone

One of the important applications of drone is the visual inspection of structures like water tank, religious structures, monuments, signal towers, etc. Since structural safety is important, the building must be monitored visually; this monitorisation is done in short period, done by industrial climbers, which is quite expensive and risky. Mostly, essential parts like columns and water tank head have to be visually monitored. Manual inspection of those components constitutes a high risk for the individual.

The water tank is located at sangeethapatty village, vetrilai karanoor, kottagoundampatty post, omalur taluk. The water tank was monitored thoroughly. Due to regular loading and unloading of water, the main focus will on the column for the height of 10m and on the head of the tank. For data acquisition of unknown structure, it is necessary to have efficient flight strategy priorly. For this, manual piloting is suggested based on the wind speed, lighting conditions and obstacles around the building. Since the restriction of flight time depends upon battery it is highly important to get adequate information about the time to rise towards the head of the tank and return to home point, because the speed depends on the flight mode chosen by the pilot.

Two flight strategies can be used for collecting data. These strategies can be designed priorly for a GPS-based automatic flying and camera provoking. For strategy I the water tank was captured by drone in predetermined path at fixed distance from the building and vertically predetermined level from surface, while the drone camera is aligned towards the structure. The rate of camera capturing can also be increased on the path, so that there is enough overlapping of the images during a post-processing of images. The above concept of drone path is called point of interest (POI).

The hard part of the strategy I is that the drone pilot has to move along the drone for a continuous connection and for the drone to be in vision. Moreover, the lighting and speed of wind changes on the drone path around the water tank. Turbulences around the structures and irregular lighting will have
effects in the image quality. The main challenge was to get higher quality image for effective detection of the crack. This allows identification of fine cracks, see Figure 5.

![Figure 5](image.png)

**Figure 5.** 3D model of the water tank - visual colour (left) & thermal texture (right) – detection of finite cracks in the wall of the water tank

4. Summary

This paper deals with the application of drone for monitoring of water tank without difficulty and danger. The inspection and the results show the finite crack detected on the walls of the water tank. It is economical when compared with other conventional inspection units.

These platforms can be flown near the structure and one can get very good images from the wall and other inaccessible areas. The images, corrected and gathered can produce cartographic products (orthomosaics) or 3D models, which have metric properties: this means that one can measure lengths or can calculate areas. Then drone can also be used in other fields such as agriculture, survey etc.

5. Reference

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