A Case Study on UAV-assisted Construction Surplus Soil Treatment Plant Management in Taiwan

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Abstract. Construction surplus soil tracking management has been the key management issue in Taiwan since 1991. This is mainly due to the construction surplus soils were often regarded as disposable waste and were disposed openly without any supervision, leading to environmental pollution. Even though the surplus soils were gradually being viewed as reusable resources, some unscrupulous enterprises still dump them freely for their own convenience. In order to dispose these surplus soils, site offices are required to confirm with the soil treatment plant regarding the approximate soil volume for hauling vehicle dispatch. However, the excavated soil volume will transform from bank volume to loose volume upon excavation, which may differ by a certain speculative coefficient (1.3), depending on the excavation site and geological condition. For managing and tracking the construction surplus soils, local government authorities frequently performed plant site spot check, but the lack of rapid assessment tools for soil volume estimation increased the evaluation difficulty for plant site inspectors. This study adopted unmanned aerial vehicle (UAV) in construction surplus soil tracking and rapidly acquired plant site photography and point cloud data, the excavated soil volume can be determined promptly after post-processing and interpretation, providing references to future surplus soil tracking management.

Introduction

Since 1991, Construction and Planning Agency of Ministry of the Interior, Taiwan has been performing the planning, setup, database establishment, personnel training, alert and circulation, system operation and maintenance of the “Construction Surplus Soil Information System”. Construction Surplus Soil Information Service Center was further established in year 2000, providing a platform for online declaration and data exchange for construction surplus soil across the nation, which is the current declaration and tracking system for construction surplus soil management. Currently the system maintenance and system update development is performed by Architectural Institute of Taiwan, which so far has provided more than 6 million registry lookup of declaration and inquiry services. The aforementioned system recorded the basic construction information of the construction surplus soils, soil handling and disposal site information, and monthly actual transported soil volumes, which greatly contributed to the overall tracking management of construction surplus soil in Taiwan.

Literature Review

Surplus Soil Tracking Management

In early days, the surplus soil originating from construction works is regarded and handled as waste in Taiwan. The tracking of surplus soil disposal is hence being strictly controlled and supervised, so in case a soil handling and disposal vehicle did not carry a valid certificate for the construction site and surplus soil treatment plant, the driver would be penalized in accordance with relevant laws and
regulations. Construction Surplus Soil Information Service Center (www.soilmove.tw) was also established for the tracking management of these construction surplus soils. Both the construction contractor and soil treatment facility are required to declare online regarding the generated volume of excavated soils and the actual received capacity, in order to verify the exact transported soil volume form construction site to surplus soil treatment plant in double audition. However, this surplus soil tracking system confirmed the excavated soil transportation only from the site declared information without further assessment tool. Many unscrupulous enterprises discovered loopholes in the hauling process and forged the declaration form to dispose the soil otherwise. Therefore, the management authority routinely performed on-site spot check to estimate the excavated soil volume and authenticate the actual disposed soil volume according to the monthly report. Up to now, on-site inspectors could not quickly determine the actual soil volumes at the excavated site and disposal plant. They could only wait for site measurement, signature verification and direct submission from the survey engineer at end of the year.

Thus, the demand for a rapid soil volume estimation method is rising, in order to assist the on-site inspectors in determining the in-situ excavated soil volume and verifying the declared amount on the declaration form, which would enhance the overall inspection quality.

**UAV Introduction**

An unmanned aerial vehicle (UAV), commonly known as a drone, is an aircraft without any human pilot aboard. UAVs are a component of an unmanned aircraft system (UAS); which include a UAV, a ground-based controller, and a system of communications between the two. The flight of UAVs may be operated with various degrees of autonomy: either under remote control by a human operator or autonomously by onboard computers.

**UAV Aerial Photography**

Most UAVs have a lower flight altitude than aircrafts. UAVs can capture ground images of high resolution and are less susceptible to photo quality degradation due to cloud obstruction. They can even obtain side-view images of buildings that are hard to be captured in general aerial surveying operations. This is of high application significance for the monitoring, investigation and recording of certain regional topographies. UAV aerial photography does not require aerial-photogrammetry-grade dedicated cameras and only requires common digital cameras. This is mainly due to the current digital camera and digital camcorders is highly advanced in terms of image resolution and sampling frequency and other specifications, in addition to the advancements of various measurement theories. Compared to the photogrammetry-dedicated cameras, the general, non-dedicated cameras have the following advantages: smaller sizes, lightweight, easy to be acquired, inexpensive, easy access to captured images, reusable memory cards and the captured images can be output directly in digital images for further modification on personal computers.

**Methodology**

This study mainly utilized the UAV-captured images from different flight paths and various camera angles, by stacking these multiple images in software to generate point cloud data, in order to compute the volume of these dense point clouds. The implementation of UAV in construction surplus soil tracking consisted of three procedures: (1) Point cloud generation through Agisoft PhotoScan using the aerial photographs, (2) File conversion of point cloud data using Autodesk Recap, (3) Excavated soil estimation using Autodesk Civil 3D, as shown in Figure 2. Upon the completion of the data preprocessing in the first step, in order to enhance the accuracy and reliability of the overall dataset. On the other hand, considering the delineation of excavated soil mass requires manual observation and identification, multiple delineation computation is performed in the third step before soil volume estimation. By implementing statistical method to discard deviated values, better estimation of construction surplus soil volume can be achieved.
Sometimes, there may be other disturbances on the site, such as weeds, canopies or pits, which affect the quantity calculation. Therefore, we must use other methods to modify the existing point cloud model for higher accuracy. Due to the small feature points of the water accumulated in the pit, it is difficult to calculate the correct 3D measurement results and cause many errors. The final measurement results of this project have been technically processed for the part of the pithole water image feature point that is difficult to calculate the correct 3D measurement results, so that the final result water surface height is close to the real water surface height and the calculation error is reduced.

Case Study and Results

The address, flight information and related settings of the measurement site of this land farm are shown in Table 1. The flight paths, simulated landscapes and final calculation results of each site are described in sequence.

The Figure 1 shown the three plant in PengHu county. The Figure 2 shown the flight path and the cloud point model. The Figure 3 shown the revision model of the pit. The Figure 4, 5 and 6 are the point cloud model of those 3 plant.

Figure 1. The three plant in PengHu county.

Figure 2. Flight path and the point cloud model.

Figure 3. The revision model of the pit.
Table 1. The location, flight information and related settings of this project.

| #  | Plant Name      | Altitude Baseline |
|----|-----------------|-------------------|
| 1  | Suo Gang plant  | 49.80m            |
| 2  | Hu Xi plant     | 66.00m            |
| 3  | Chi Kan plant   | 60.20m            |
There is a certain interference factor in the site measurement project of construction surplus soil treatment plant in Penghu County. The main interference factor is that the weed or tree canopy covered on the surface in the measurement range. The factor will increases the volume of the excavation, and the area of the water pit in the measurement range will reduce the volume of the fill.

Conclusions and Suggestions

Using UAV to perform aerial missions and calculation of the volume of soil in the treatment plant, if the area of the area is not large, compared with regular measurements, it does reduce costs, flexibility, and reduce the risk of manpower. The UAV camera can also has higher resolution in the camera. It is easier to obtain, and the access to the image is simple, and the advantages of the shooting result can be immediately examined.

In the project, due to the interference of analysis caused by some factors, including the error of the ground control point, etc., in the aerial photography process, if you want to find the feature points that can be used as image control points, you need to pay attention to and utilize 1. Right angle at the junction of the color 2. Not obscured by the obstacle 3. Not too close to the building 4. Not covered by the shadow 5. Land that is difficult to move 6. The terrain is flat, in addition, there is part of the water in the plan With a pothole, the non-UAV below the pothole can be photographed, so it is also a limitation of the aerial shooting results.

It has been found that the ground control point can be added to the lifting accuracy and only take about one day to generation and calculate the model quantity. The operating rate has its significant advantages. However, the acquisition of the ground control point must be considered officially released or self-measured.

The results of this project are summarized as follows. After measuring the area and the cadastral drawings, the measured area of each place is shown in Table 2. There is little difference in area measurement. But the area of Hu-Xi site is different from the one on the website. It is recommended to confirm with the land administration unit.

Table 2. Final calculation of 3 soil treatment plants.

| #  | Plant name  | Altitude Baseline | Area      | Remaining volume | Cut volume  |
|----|-------------|-------------------|-----------|------------------|------------|
| 1  | Suo Gang plant | 49.80m           | 37724.39m² | 8763.79m³       | 65879.60m³ |
| 2  | Hu Xi plant  | 66.00m           | 13851.04m² | 920.72m³        | 41872.58m³ |
| 3  | Chi Kan plant| 60.20m           | 7885.47m²  | 1316.32m³       | 19338.75m³ |

Due to the current legislative limitations of UAV flight in the world, such as the flight review of local governments in the no-flight zone, corresponding permits should still be applied through standard administrative procedures. Regarding the limitations of image overlapping due to noises above the soil heaps, Lidar is recommended a solution for the future studies. Lower flight altitude of UAV can also help the computation quicker and more accurate in point cloud data generation.

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