A Case Study Application of Unmanned Aerial Systems (UAS) on Highway Construction Projects

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Abstract. Earthwork operations are often one of the major cost items on infrastructure construction projects. Precise estimates of actual earthwork volumes are important for both transportation agencies and contractors alike to ensure appropriate payments are made. Recently, unmanned aerial systems (UAS) have become popular for numerous surveying applications because they require less cost and time consumption compared with other common estimate approaches relying on drawings, equipment activity or a few survey points. In this study, UAS and digital photogrammetry technology are adopted to estimate earthwork volumes of a highway extension project. Two 3D point cloud models are generated to track the earthwork volume changes during construction. The resulting vertical and horizontal accuracy and its dependent factors including the use of ground control points are explained and discussed. The test results in this project prove the robust capabilities of UAS in earthwork volume measurement.

1. Introduction

Earthwork is engineering works created through the moving of massive quantities of soil or rock. The purpose is to reconfigure the topography of a construction site to meet the design requirements (Nunnally, 2004). As an important mission of a construction project, the earthwork operation is mainly executed in the early stage of the construction process. This means the earthwork progress controls the overall project schedule. Besides, earthwork is often one of the major cost items on most construction projects because of the long operation time and cost uncertainties caused by unstable geographical conditions and construction organization plans. It is essential to make the best possible measurement of the quantity of earthwork materials that has been excavated and placed. An accurate estimation of earthwork quantity not only enables contractors to present an accurate bid, assign construction assets reasonably, and formulate a project schedule but also helps owners make correct payments. Therefore, the selection of a proper measurement method is the prerequisite to accurate estimations and cost control.

In recent years, the surveying industry has seen significant changes with the development of modern technologies. However, the implementation of advanced survey techniques in construction is still in the early stages. According to the latest standard specifications published by the Department of Transportation (DOT) of each state, most states are predominantly using conventional methods such as tape and manual calculation methods based on the blueprints to collect data and calculate quantities for payments in the earthwork process. As shown in Figure 1, 68% of states measure the roadway excavation in its original position by taking cross sections and computing the volume by the average-end-area method. The cross-section method involves plotting cross sections of the existing and proposed levels at certain intervals across the construction site (Hintz and Vonderohe, 2011). The accuracy largely relies on the selected distance between the sections. Closer sections improve the estimation accuracy but require much longer time. A balance has to be made between accuracy and efficiency, which could result in various levels of errors. The average-end-area method is usually applied to estimate the earthwork volume involved in large and complex areas (Epps and Marion, 1990). The area is divided into a grid indicating the depth of cut or fill at each grid intersection. The method