

Earthwork Volumes Estimation in Asphalt Pavement Reconstruction Using a Mobile Laser Scanning System

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Abstract — This paper presents a novel method for estimating earthwork volumes in asphalt pavement reconstruction using a mobile laser scanning (MLS) system. First, based on the static targets, this method registers two point cloud datasets into the same coordinate system, which respectively are acquired in the reconstructing road before and after asphaltting. Next, road surface points are detected from each point cloud using a curb-based method, and further divided into a set of blocks. Afterwards, the blocks are perpendicularly partitioned into grids, where two surface features are extracted using the RANSAC. Finally, the volume of each grid is calculated according to these two surface features. The proposed algorithm has been tested on two sets of point clouds acquired by a RIEGL VMX-450 MLS system in the reconstructing road before and after asphaltting. The results demonstrate the accuracy and efficiency of the proposed algorithm in estimating earthwork volumes.

Index Terms — Mobile laser scanning, point cloud, earthwork volume estimation, asphalt pavement reconstruction, road surface detection

I. INTRODUCTION

Earthwork volumes based on which contractors are paid for highway construction are usually used in determining the economic distribution of earthwork [1]. It is one of the most important components in estimating highway construction costs. Accurate estimation of earthwork volumes is essential because disagreements on the estimated volumes often cause the owner and the contractor to look to courts for settlement [2]. Therefore, a good method for accurately estimating earthwork volumes is essential.

Many models for accurately estimating earthwork volumes have been intensively studied in literature. The average end area model and prismsoidal model [3] were commonly employed for estimating earthwork volumes. The prismsoidal model gave an exact volume for linear profiles, while the average end area model generally overestimated the volume. A mathematical model that provided the exact volume of curved roadways with linear profiles between stations was developed in [4]. Based on triple integration, this model assumed that the ground cross slope was constant between stations. In [5], a Monte Carlo based model was

proposed for estimating earthwork volumes of curved roadways. Using terrestrial laser scanning (TLS) technology, a detailed model before and after construction was created in [6], and earthwork quantities were calculated by comparing the triangular irregular network (TIN) of the original terrain to that of the accomplished project. 3D laser scanning and global positioning system (GPS) were used to acquire landslide data and to compute earthwork volumes in [7]. In this method, original 3D contour of the area and the landslide digital terrain model (DTM) were first obtained, and the DTM based on the base point was overlapped to the original contour at the same coordinate position and direction. Next, the volumes of collapse were estimated by the difference between the terrain features before and after landslide.

In recent years, the society has witnessed a rapid development of mobile laser scanning (MLS) systems which can acquire dense and accurate point cloud data with high pulse repetition rates. The MLS has been successfully used in many fields such as industries, arts, and engineering, due to its capability of acquiring data accurately and densely [8], [9]. The benefits of using laser scanners on construction field are the rapid raw data acquisition, easy levelling process, fewer human errors, and reliable reference for engineers. Therefore, MLS techniques are suitable for this study to compute earthwork volumes.

In this paper, we propose a novel method for estimating earthwork volumes from MLS point clouds. First, two point cloud datasets are respectively acquired by the RIEGL VMX-450 MLS system in the reconstructing road before and after asphaltting. For estimating the whole earthwork volumes, the two point clouds are then registered into the same coordinate system based on the static targets coexisting in both point clouds. Next, a curb-based method [10] is used to detect road surfaces for each point cloud and further divide them into blocks. Afterwards, each block is perpendicularly partitioned into a set of grids, where two surface features are extracted using the RANSAC [11]. Finally, the volume of each grid is calculated according to these two surface features. The experimental results demonstrate the accuracy and efficiency of the proposed

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