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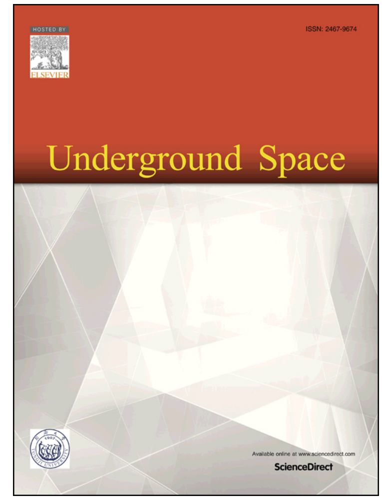

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Development of a 3D Modeling Algorithm for Tunnel Deformation Monitoring Based on Terrestrial Laser Scanning

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Abstract:

Deformation monitoring is vital for tunnel engineering. Traditional monitoring techniques measure only a few data points, which is insufficient to understand the deformation of the entire tunnel. Terrestrial Laser Scanning (TLS) is a newly developed technique that can collect thousands of data points in a few minutes, with promising applications to tunnel deformation monitoring. The raw point cloud collected from TLS cannot display tunnel deformation; therefore, a new 3D modeling algorithm was developed for this purpose. The 3D modeling algorithm includes modules for preprocessing the point cloud, extracting the tunnel axis, performing coordinate transformations, performing noise reduction and generating the 3D model. Measurement results from TLS were compared to the results of total station and numerical simulation, confirming the reliability of TLS for tunnel deformation monitoring. Finally, a case study of the Shanghai West Changjiang Road tunnel is introduced, where TLS was applied to measure shield tunnel deformation over multiple sections. Settlement, segment dislocation and cross section convergence were measured and visualized using the proposed 3D modeling algorithm.

Keywords: terrestrial laser scanning, tunnel, deformation monitoring, point cloud, 3D modeling

1. Introduction

Tunnel deformation monitoring is critical for engineers to evaluate tunnel safety and verify the design parameters against the measured results. Traditional monitoring techniques, such as tape extensometer (Kolymbas, 2005; Pells et al., 1981), Bassett Convergence System (Bassett et al., 1999) and total station (Hope and Chuaqui, 2008; Yang et al., 2005; Yang et al., 2006), fail to measure the deformation of an entire section due to a limited number of measured points. In recent years, some new technologies have been applied to tunnel deformation monitoring to improve performance.

Terrestrial Laser Scanning (TLS), also known as LiDAR, is an innovative technology that can acquire the 3D coordinates of millions of points at very high speed using laser ranging (Reshetyuk, 2006). TLS overcomes the limitation of traditional monitoring techniques and obtains complete information about tunnel deformation (Lindenbergh et al., 2005). To date, TLS has been widely used in topographic surveys, civil engineering, industrial measurement, historical heritage preservation (Lemmens, 2011), and other applications. Some researchers have