Investigating the potential of stochastic relationships to model deformations

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Abstract

Terrestrial laser scanning (TLS) has proven to be an advanced method for areal deformation analysis, offering high-resolution, contactless data acquisition by capturing millions of data points on a structure's surface. To deterministically model deformations based on subsequently acquired point clouds, corresponding data points are usually required. In order to avoid the cumbersome construction of these corresponding points, this paper aims to enhance TLS-based deformation analysis by further developing a stochastic modeling approach. The main concept of the approach is to model the measured object by means of three components using a collocation-based approach: trend (undistorted object), signal (deformation), and noise (measurement noise). To demonstrate the ability of stochastic relationships to describe deformations, typical temporal deterministic deformation processes, like step, impulse, linear, and periodic responses are simulated by means of non-stationary stochastic processes in this contribution. To accurately model deformation patterns, different types of non-stationary Gaussian temporal processes such as locally stationary, piecewise stationary, and modulated stochastic processes are investigated with respect to their ability to represent typical deformation patterns. When modeling deformations in TLS point clouds as correlated stochastic processes, it is essential to distinguish the correlated deformation signal from the correlated measurement noise. Filtering techniques are employed to separate correlated noise from the deformation signal. Although the proposed method effectively separates signal and noise, the filtering results greatly influence the deformation model results. Future research will focus on alternative solutions for seperating correlated signal and noise and extending the methodology to spatio-temporal point clouds, enabling a more comprehensive analysis of deformations in complex structures across both temporal and spatial dimensions.

Keywords: Terrestrial Laser Scanning, Deformation Modeling, Separation of stochastic processes

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