Deterministic Uncertainty for Terrestrial Laser Scanning Observations Based on Intervals

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Abstract

Terrestrial laser scanners (TLS) are well-suited for conducting area-based deformation analysis of infrastructures. Unlike common point-based geodetic sensors, TLS can measure millions of points across the environment without requiring pre-defined, signalized measurement locations. However, TLS point clouds are affected by both random variations and residual systematic errors. These uncertainty components are often addressed using only probabilistic approaches, which may inadequately or overly optimistically represent the remaining systematic errors. To overcome these limitations, this study introduces an alternative framework based on interval mathematics to bound uncertainties arising from systematic errors. The proposed methodology includes a sensitivity analysis of TLS observation correction models, examining the variability of key input parameters. Unlike the quadratic approach for variance propagation, the interval-based method enables linear uncertainty propagation, effectively characterizing residual systematic uncertainties and their maximum effects. This paper details the methodology and presents typical interval values validated through simulations and real-data experiments. The findings highlight the potential of interval-based methods to enhance the TLS uncertainty model.

Keywords: Terrestrial Laser Scanners, Uncertainty Budget, Interval Mathematics

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