Object Surface Properties in TLS Measurements: an Approach Based on the Elementary Error Theory

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SUMMARY

The interaction between laser beams and backscattering object surfaces lies at the fundamental working principle of any Terrestrial Laser Scanning (TLS) system. The optical properties of object surfaces, like concrete, metals, wood, etc., are an important category of systematic and random TLS errors. In this contribution, an approach of quantifying the random errors caused by object surfaces is presented based on the elementary error theory. Two surface properties are addressed: surface roughness (as defined in the DIN EN ISO 4287) and surface reflectivity. The effects on TLS measurements are jointly modeled in form of a variance-covariance matrix, continuing a line of work for the TLS elementary error model. In contrast to other publications on the topic, the elementary errors of object properties are defined based on technical specifications of scanners and radiometric information of the studied surface. Covariances are computed with the help of estimated autocorrelation functions from empirical data.

The methodology is implemented for a scan of a concrete arch dam, which spans over 400 m, and has a height of 122 m from foundation to crest. The point cloud was acquired from a distance of 90 m. For each of the two surface properties, different types of correlation functions are estimated. The Gaussian function used for surface roughness, lead to correlation lengths of a few mm (~ 4 mm), and can be applied for all directions on the object surface in this case. Regarding surface reflectivity, a generalization is not recommended due to different values along the horizontal and vertical direction, fact caused by the surface properties of the dam. Nevertheless, retrieving correlation coefficients is possible with a lookup table, in which each cell contains the correlation coefficients of neighboring points along both directions in angular units.

Finally, a fully-populated variance-covariance matrix that considers the two object surface properties is obtained. Together with other groups of instrument and atmosphere elementary errors that have been treated in the past, it constitutes a stochastic model of TLS measurements, which is indispensable in area-wise deformation analysis.