Closed-Form Modelling of Vertical Cylinder Quality in Support of Laser Scanner Network Design

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SUMMARY

Geometric network design has long been acknowledged as an important process for precise geodetic and photogrammetric measurement projects. Attention to the design of terrestrial laser scanner networks has increased in recent years. In this context, the configuration problem or first order design (FOD) is concerned with determining many factors including the instrument locations, scan overlap and target locations in order the meet project quality specifications. The quality of geometric features such as planes and lines derived from the laser scanner data is of particular interest in this work.

FOD design can be performed by simulating the environment to be measured and evaluating the suitability of candidate instrument locations. A built environment such as a complex structure or industrial facility generally comprises many key elements that can be modelled as geometric primitives such as planes (wall, floor and ceiling) and cylinders (pipes and columns). To evaluate the quality of geometric models of these features at the design stage, generation of simulated observations may be necessary. These data can be generated by ray casting, which can be a computationally expensive process. In order to avoid this computational load, model quality can instead by evaluated in closed form. With prior knowledge of the simulated feature location relative to the instrument and the instrument specifications for observation precision and angular sampling, the covariance matrix of model parameters can be evaluated without simulation of observations. It does so by modelling the geometric distribution of range observations in 2D angular space with a function that is introduced into the least-squares normal equations.

This paper presents the closed form modelling approach for vertical cylinders scanned with a terrestrial laser scanner. Results are presented from several real laser scanner datasets of cylinders having different radii and observed at different ranges. The closed-form model precision is

compared with the numerical estimates obtained from the parameter covariance matrix resulting from the least-squares estimation process.