TLS and MLS for deformation monitoring

Monday, 07.04.2025, 15:15 - 17:15, Room Tulla

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Quality-controlled deformation analysis of the 26-m HartRAO radio telescope's main reflector: First results

Radio telescopes are pivotal in receiving radio frequencies from space. These telescopes, typically featuring parabolic dishes, focus radio waves onto a central receiving point to amplify the incoming signal. The stability of the telescope's main reflector's shape across various orientations is crucial, as deformations can distort the received signal. This study focuses on the 26-meter radio telescope at the Hartebeesthoek Radio Astronomy Observatory (HartRAO) in South Africa. A high-end laser scanner is employed to record the surface of the rotating paraboloid reflector in multiple orientations. The telescope is capable of moving through different declinations and hour angles requiring to measuring 88 different positions of the telescope, to provide a complete picture of the deformations. Fitting models are applied to estimate the shape of the rotating paraboloid from the raw data also considering calibration errors of the laser scanner used. First results for deformation patterns and, therefore, the local deformations of the main reflector are shown.

Keywords: Terrestrial Laser Scanning, Calibration, Misalignments, Systematic Errors, VLBI, Segmentation

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B. Riedel, O. Welke, M. Altmann, M. Gerke

A signalization-free coregistration approach of multiscale and multitemporal survey for structural monitoring

Infrastructure monitoring often calls for multi-scale and multi-epoch approaches: Quantifying and interpreting geometric deformation must be seen in conjunction with very local damages. For instance in the framework of so-called predictive maintenance, both, the quantification of load-depending deformation and the development of local damage, like cracks or spalling is necessary. Furthermore, the related observations must be made in several epochs, over months, years or even decades.
In our DFG-funded project "Optical 3D Bridge Inspection", which is part of

the DFG priority program "100+", we investigate the surface geometry and damage of prestressed concrete bridges with high-resolution optical measurement systems to support structural monitoring. For data acquisition, we aim to combine terrestrial laser scanning (TLS) and UAV-supported image blocks, as well as structured light scanning (SLS) and hand-held sensors (cameras, depth images). Our research questions therefore address efficient and signalization-free coregistration methods of multiscale and multitemporal survey and image information on large infrastructure structures.
This paper presents an approach for signalization-free positioning of TLS and SLS by tachymetric positioning. These coregistered point clouds and image data sets then form the basis for detailed analysis of surface deformation and the development of cracks and spalling areas.

Keywords: Signalization-free coregistration, Structural monitoring, TLS, SLS

N. C. Meyer, T. Medic, E. Friedli, R. Senti, A. Wieser

Investigation of different registration methods for TLS-based deformation analysis of hydroelectric dams – A case study

In this paper, we investigate various registration techniques for Terrestrial Laser Scanning (TLS) in the context of deformation analysis of hydroelectric dams. Accurate spatiotemporal registration of TLS data is particularly challenging in non-urban and mountainous environments due to the scarcity of unobstructed and geometrically well-defined surfaces. This is compounded by the presence of unknown changes over time in potentially large parts of the scanned scenes. These challenges complicate the establishment of suitable correspondences between the scans. Traditional registration methods often struggle under these conditions, leading to point cloud differences that may be misinterpreted and mask the actual deformations. We apply an approach utilizing optical flow, as well as Feature to Feature Supervoxel-based Spatial Smoothing (F2S3), to determine 3D vector fields between corresponding points and robustly estimate the registration parameters from these correspondences. We conduct a comparative analysis of the registration accuracies achieved using the above methods and those obtained from traditional registration methods, including the Iterative Closest Point (ICP) algorithm. Target-based registration results serve as a benchmark for this analysis. Additionally, we study the impact of the various registration approaches on the estimated deformations and compare the TLS-based results to those obtained from plumb line measurements within the dam. The pre-

sented investigation uses real measurements from the Santa Maria dam in the Swiss Alps, but the findings are transferable to other geomonitoring application cases in non-urban environments.

Keywords: Terrestrial laser scanning (TLS), Deformation analysis, Point cloud registration, Structural health monitoring, 3D vector fields

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F. Schill, M. Horn, Th. Moser, W. Lienhart

Investigating the precision of remote geodetic sensors for bridge monitoring: a large-scale field study

As infrastructure ages, monitoring is becoming increasingly important to ensure the safe operation of civil structures. Modern geodetic sensors can provide static and dynamic displacement data of these structures up to several hundred Hertz. As the measurements are made remotely, no direct access to the structure is required. While the precision of static geodetic measurements has been extensively studied, dynamic measurements have not been sufficiently investigated. To overcome this limitation, the dynamic capabilities of Robotic Total Stations (RTS) with respect to the precision of angle and distance measurements are investigated. The measurement systems were used in a large-scale load test on an Austrian motorway bridge. Several sensor systems such as RTS and Profile Laser Scanners (PLS) were used to monitor the structure and compare the capabilities of the sensors themselves. Controlled loading tests were carried out where two trucks, each weighing over 50 tonnes, passed the structure being monitored under controlled conditions. Additionally, static load tests were carried out. By comparing the two types of tests, it is possible to highlight the potential of dynamic tests. They offer advantages such as shorter closure times, which can increase the acceptance of load tests.

Keywords: Structural health monitoring, Sensor investigations, Precision, Dynamic bridge monitoring, Load testing

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M. Wagner, B. Jost, L. Klingbeil, H. Kuhlmann

Efficient and precise? – Evaluation of a mobile mapping system in the context of road surface monitoring

Deformations of the road surface due to high traffic load shorten the life span of the road and negatively influence the safety of the traffic participants. Usually, special sensor systems are used to monitor road conditions,

which are expensive and only built for one particular application. Mobile mapping systems, however, capture their close environment including the road surface. With the processed point cloud, multiple parameters can be derived. The major drawback of these systems is, that the uncertainty of the measured points and accordingly of the derived parameters is unknown and hard to derive. However, the uncertainty of the derived parameters is crucial for the interpretation. Within this study, we empirically evaluate the uncertainty of a mobile mapping system in the context of road surface monitoring. The considered parameters are the road cross fall and the rut depth. We repeatedly measure the road surface from both driving directions and extract the mentioned parameters for each pass at the same location from the point cloud data. Two data sets with different environmental conditions are considered, to evaluate the influence of the environmental conditions. This study demonstrates that the road cross fall is sensitive to remaining errors in the system calibration. The rut depth only depends on the uncertainty of the used profile laser scanner and on the used algorithm, especially the detection of the support points.

Keywords: Deformation monitoring, Mobile mapping, Uncertainty evaluation, Road parameters

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