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Title: **Development of terrestrial laser scanning data processing methodology in control measurements of engineering structures**

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In the modern world, security is given the utmost priority. Control measurements of engineering structures are part of this trend by providing precise, geometric information about the state of the structure. Due to their nature, they can be a component of Structural Health Monitoring, SHM, aiming to provide comprehensive security of the structure in both geometrical and physical aspect. In the last decade, terrestrial laser scanning (TLS) has been added to the measurement methods commonly applied in engineering geodesy. It provides quasi-continuous information about the geometry of the structure in the form of a three-dimensional point cloud (X, Y, Z coordinates) supplemented with information about the intensity of the laser beam reflection at individual points.

The possibilities of using spatial data in the form of TLS point clouds are very extensive, however, their proper use requires knowledge of a wide range of factors affecting the quality of data as well as of methods of properly processing it. This work focuses on the use of terrestrial laser scanning in measurements of concrete engineering structures.

As part of the research carried out during the preparation of this dissertation, factors considered significant in the context of the subject of the paper were analysed. In the work there was a division of factors due to the impact connected with: technical parameters of the instrument, angle of incidence of the laser beam, distance from the scanned surface, physical properties of the structure, i.e. colour, roughness, humidity and surface reflectivity, as well as atmospheric conditions. Literature and own research, including experimental work, was carried out for each group of factors.

In order to perform the analysis of the impact of the distribution of the angle of incidence of the laser beam and of the distance of points from the instrument on the quality of recorded data, it was necessary to develop own algorithms in Matlab software. Proprietary solutions allow not only to visualize the distribution of analysed quantities, but also to select points that meet defined ranges of values.

The dissertation examined the general principles of obtaining and processing TLS data in control measurements. The applied methods of point cloud orientation and algorithms used for their filtration and determining the mutual distance of point clouds were presented. A number of experiments were carried out using various concrete surfaces; these experiments showed the importance of proper selection of filtration algorithms and their parameters. The paper also presents the pros and cons of methods for determining the distance between point clouds and their qualitative assessment was performed, which indicated the highest reliability of the Multiscale Model to Model Cloud Comparison algorithm (M3C2).

Acquisition of TLS data of adequate quality is important both in terms of meeting the criterion of accuracy of the final product development and comparing data from subsequent measurement cycles. Based on the conducted tests, homogeneous area classes were defined, divided into the expected accuracy of surface mapping. A comprehensive proprietary methodology of using data from terrestrial laser scanning in control measurements of engineering structures was prepared. It covers all stages from acquisition to final processing of TLS data and was developed broken down into three groups for which the parameters of measurement are dependent on the expected accuracy of the final development.

In order to verify the methodology, point clouds of a diaphragm wall fragment of the Mennica Legacy Tower structure were acquired and processed. The data was obtained in accordance with the methodology described, the measurements were carried out in two measuring cycles with a two-month interval. Point clouds were limited in accordance with the proposed classes of homogeneous areas, and then their distance differences were determined using the M3C2 algorithm. The results of determining the distance differences based on point clouds processed in accordance with the proposed methodology and subjected only to filtration were compared. The comparison showed that improperly processed TLS data may indicate changes which do not occur on the structure. This is the effect of using for analysis data obtained at too large an angle of incidence of the laser beam, from too large a distance and with the wrong density. In order to independently verify the methodology, the obtained results were confronted with the predicted behavior of the structure. The magnitude of the determined and anticipated changes was confirmed, which attests to the correctness of the study. Additionally, an analysis of the possibilities of using archival data obtained for the water dam in Rożnów was carried out, and confirmed the need for proper data processing in order to obtain reliable results.

Based on the results of the conducted research, it was possible to formulate the thesis assuming that the use of terrestrial laser scanner technology in control measurements of engineering facilities, requires development of an appropriate methodology for obtaining and processing TLS data, including designing the network of instrument positions, taking into account the influence of geometric factors and physical properties of the measured surface, as well as the use of task-specific algorithms for processing and comparing point clouds. The proper way of analysing the results of control measurements allows to obtain reliable information about geometric changes occurring on the object.

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