Classical and New-Age Technology for Monitoring and Early Alarm-Systems

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SUMMARY

The evolution of the laser scanning and the classical surveying technology during the last decade offers a new possibility for surveying of large areas. During the last years the scanning technology and the robotic total stations became part of the monitoring of infrastructure and natural objects, which has always been of high priority for the engineering survey. The benefit of using such technology is the possibility for continuous and high dense data acquisition. The combination of sensor and data fusion for this measurement techniques as well as the application of the new age algorithms for data pre-and post-processing gives the possibility for near real-time high accurate structural deformation monitoring. Continues data recording, adjustment and transfer are crucial as they provide information at any time for different structure variations and complexities.

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1. INTRODUCITON

For the last ten years is observed fast development in the technology of combination between sensors within diverse common complex systems. The existence of such systems providing different accuracy levels offers the possibility for their usage in application areas of the engineering surveying, railway and automotive industry, land administration and for navigation purposes. The multi sensor integration and fusion is a comprehensive process where the input information from every sensor and further combination with special developed mathematical algorithms ensures the complete identification of the observed features.
Because of its flexibility and possibility for fast and continuous data measurement the multisensory integration and fusion rapidly evolved in various applications areas. The object of this paper is to provide an overview for the usage of new-age technology systems in the engineering surveying for monitoring.

1. MULTY SENSOR SYSTMES FOR DEFORMATION MONITORING

1.1 Geodetic instruments as complex sensor systems

The geodetic measurements for monitoring and displacements analysis of various engineering objects have always played an important role. The long term monitoring of structural objects like bridges, dam walls, building columns, wind power generators, and other constructions requires properly designed network schemes allowing the continuous and high accurate measurements. For such angular and length measurements in the mm area that have to be performed in a minute, hours or a day intervals the standard total stations are being replaced from the automated one (ATS) comprising precise servomotors, automatic target recognition sensor, electronic inclinometers, self-calibration control system and other sensors. The synchronized process of high accurate measurements (angular accuracy better than one second and distance accuracy better than one mm) and simultaneously adjustment software gives the possibility for real-time or post-processing deformation monitoring and analysis. This type of hardware and software combination is often used during the life cycle of a project for construction and reconstruction of structures and for a regular monitoring of the objects stability. (Staykova, Zill, 2015)
The application of the automated total stations technology is rapidly evolving in the recent years, primary for monitoring of big and complicated engineering construction works and during their exploitation, where a continuous measurement and mm accuracy is required. The automated total stations are equipped with tilt, geotechnical and meteorological sensors, self-check and calibration system which ensure the durational data acquisition neglecting the human presence and minimizing the surveyor errors. This systems are also able for combined geodetic measurements with total stations and GNSS, and a-posteriori combined adjustment of the acquired data.

The technology of ATS is successfully applied and proved in such tasks where hundreds of benchmarks should be measured in a 10 minutes to a day cycles. The intelligence of such systems allows the simultaneously data acquisition, record and transfer directly to computational center where an adjustment algorithm is applied. In this way the deformation analysis and statistics for multi-epoch monitoring can be received in almost real-time. This allows the safety construction and future monitoring of big underground or open sky structural objects.

2. LASER SCANNING TECHNOLOGY

2.1 Terrestrial Laser Scanning (TLS) for structural monitoring

Monitoring of the behavior of big aerial infrastructure objects such as landslides, dam walls, roads and highways, buildings' facade during reconstruction period has always been also of high priority for the engineering surveying. The needs or precise modeling and detailed geometrical characterization of the object requires high density of benchmarks. The development of the laser scanning technology introduces a new way for deformations monitoring. The high scanning speed, dense measurement of huge amount of points and high accuracy gives advantage of the TLS in comparison with other technologies used for structural monitoring. Compared with the technologies using single point monitoring approaches where the deformations detection is limed to specific benchmarks, the TLS provides high data redundancy. Combined with proper software products this technique offers the possibility for high accurate surface modeling and displacement detection in the millimeter area. As the TLS is a remote sensing measurement technology the impact over observed points and network is minimized (Milev and Staykova 2014).

A new approach for deformation measurement and a-posteriori analysis is developed. The measurement technique comprises in itself all advantages of the TLS, GNSS, geotechnical and meteo-sensors. Using the combination of scanning technology with prisms gives the possibility for wide area coverage, detailed surface monitoring and accuracy control. The solution is based on the combination between high density point cloud and accurate mathematical model for surface modeling and displacements detection.

This new-age technology as combined hardware and software solution brings all processes from data acquisition, to point cloud processing, deformation detection and documentation into one synchronized system. The single scans from the reference epoch are filtered for non-surface scans features (ghosts) and are merged together to create a common null scan with the highest possible accuracy. Each single point coordinate in the merged cloud is corrected to the optimal adjusted position. The advantage of this process is a mathematic description of the scanned surface. Based on the mathematical model the point cloud of the scanned area can be separated into different parts which best fit and describe the body form. Through comparison of the normal vectors of the points from the current epoch and the reference one are determined the deformations and their direction, and the volume changes of the observed object. The so calculated movements are documented and as color-coded deformation maps. (Leica Geosystems).

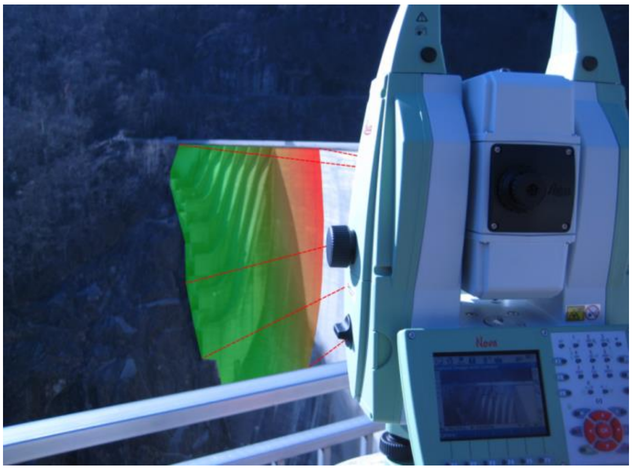

Fig.1.1. Scanned area of interest
(©Leica Geosystems)

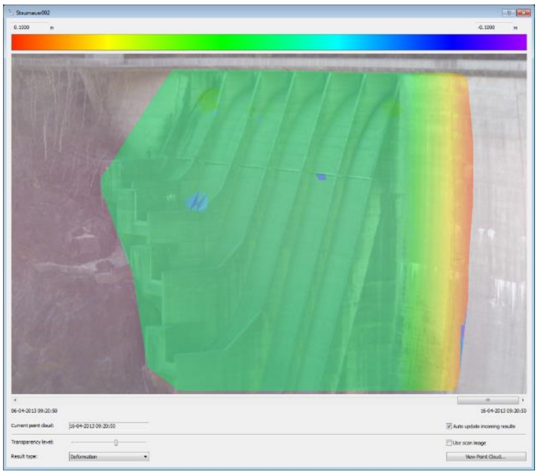

Fig.1.2 Color-coded deformation map
(©Leica Geosystems)

2.2 Application of the Mobile Laser Scanning (MLS) technology

For monitoring and investigation of wide areas the static measuring methods are being replaced form a mobile measuring complexes combination of variety of sensors (high-end and low-cost) which ensure fast, continuous and accurate data acquisition. The continuous way of data acquisition and processing minimizes the operator errors, reduces significantly the time for performance of the surveying work and the a-posteriori data analysis. The advantages of the MLS technique for fast, high accurate and complete scanning of the surroundings make it a substantial part for monitoring, for deformation analysis, and documentation of the as-built road and railway network and the correspondent infrastructure objects.
The maintenance of the road infrastructure objects and the road surface is one of the major tasks of the engineering geodesy. Fort detection the street surface deformation during constructive works below the road structure (such as building a tunnel, water channels, cables, pipes and etc.) the standard surveying methods and the TLS are proved to be time consuming, techniques with not enough dense representation of the as-built object. The usage of the MLS technique in combination with intelligent mathematical algorithms are proved to ensure a high accurate data acquisition, post-processing and analysis. The extraction and adjustment of the as-build rail and road geometry form the point cloud with SiRailScan and SiRoadScan is further used for clearance detection and documentation, surface settlements, signals position and any changes in current situation.

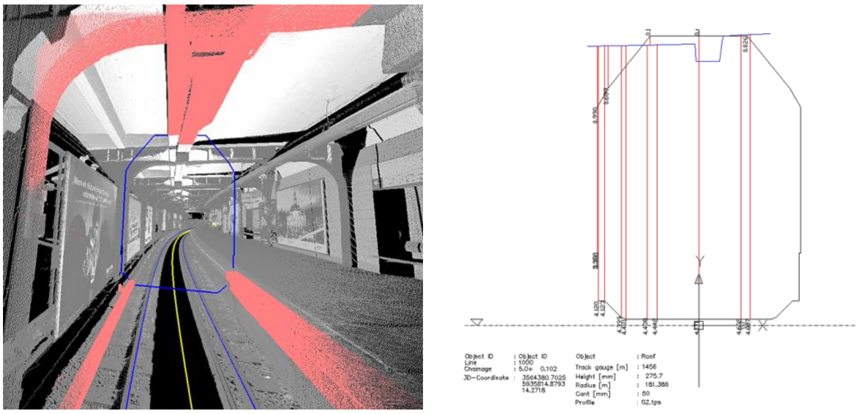

Fig.2.Adjusted as-built rail geometry with SiRailScan used as basis for performance of clearance analysis and documentation in chainage based railway system (© technet-rail 2010)

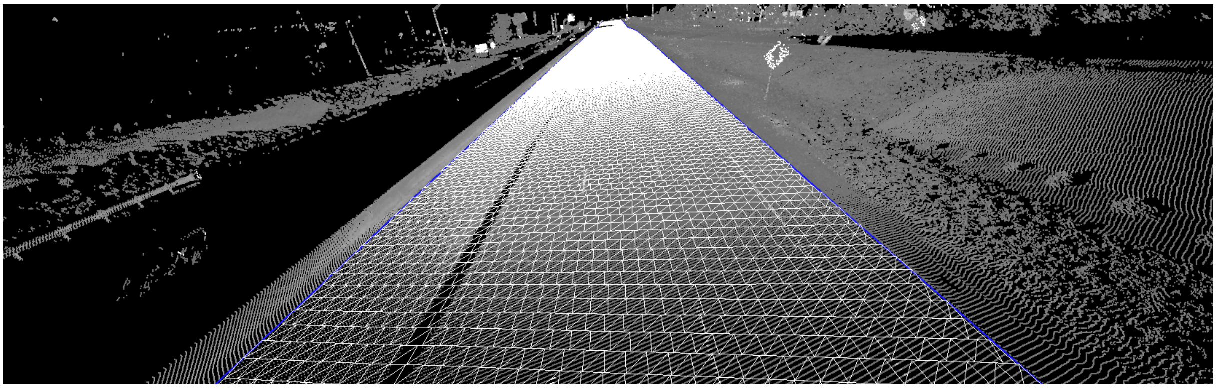

Fig.3. Adjusted with SiRoadScan road border lines and calculated model of the road surface.. (© technet-rail 2010)

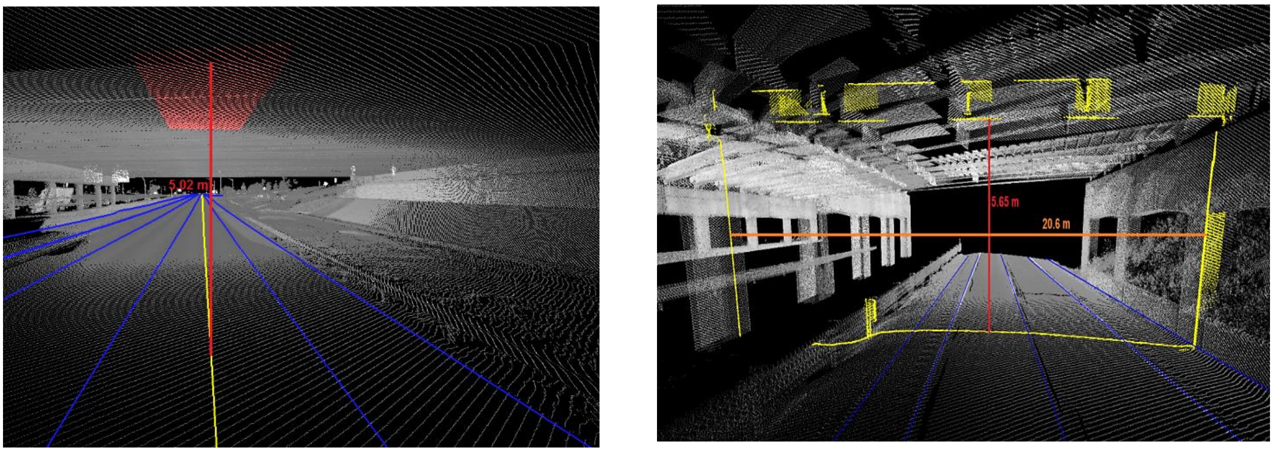

Fig.4. SiRoadScan detected clearances and documenred as-built measurements from road surefcae to the sinfrastructure object (© technet-rail 2010)

3. CONCLUSIONS

The continuous development of the standard measurement and processing technology from hour-wise to complete automated continuous process gives the possibility for near real-time monitoring of the natural and human built structures behavior. The existence and usage of such spatial monitoring technology gives the possibility for high-accurate and fast data analysis leading to converting this technology into reliable early alarm systems for damage prevention.

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