Advanced and traditional monitoring techniques for civil and environmental engineering

Lorenzo Brezzi

Program:

Environmental and structural monitoring plays a role of primary importance, both to guarantee an adaptive design to the site conditions, and to evaluate the its evolution over time. Traditional techniques, such as inclinometers, strain gauges, pressure sensors, but also topographic, GPS and laser scanner measurements are valid tools that are always up-to-date to help the engineer in his work. In addition, advanced and innovative techniques allow to estimate quantities that can be equally strategic. The optical fiber sensors are an example of innovative technology applicable to both environmental and structural areas that allows to obtain spatially dense and distributed measurements of deformations. Image analysis techniques are another important low-cost method capable of providing important information on the evolution of surface displacements. In this context, methods based on the correlation between successive frames are applicable to estimate the 2D and 3D motion field of a surface. Structure similarity algorithms, on the other hand, make it possible to detect almost instantaneous phenomena such as rapid collapses also quantifying the volumes involved. Finally, image segmentation techniques allow to obtain the automatic identification and measurement of objects present within the image.

The fields of application of the monitoring techniques are the most varied: from the small scale, in the laboratory, with collapse tests, deformation tests of resistant elements and photo interpretation of physical phenomena, to the real scale with monitoring of structures, unstable slopes and buildings. From the design phases of a new construction, to the analysis of the state of an existing work, from the design of the changes necessary to make a construction safe, to the confirmation of having reached a condition of safeness and stability.

The course will initially focus on traditional sensors, such as inclinometers and pressure sensors, examining the main characteristics, fields of application and obtainable results. A specific exercise will be held in the classroom for the management and interpretation of the results.

Next, the course will cover two innovative monitoring techniques. The fiber optic sensors for the measurement of deformations will be described in their operation and contextualized in different application scenarios. Some image analysis techniques will then be presented, in order to measure displacements in the image plane, three-dimensional displacements, evaluate evident changes in the scene following material collapses, segment the colorimetric contents to identify and measure the objects present in the image. Practical exercises using Matlab are also foreseen in this second part of the course.

References:

- Cola, S., Schenato, L., Brezzi, L., Tchamaleu Pangop, F. C., Palmieri, L., & Bisson, A. (2019). Composite anchors for slope stabilisation: Monitoring of their in-situ behaviour with optical fibre. Geosciences, 9(5), 240.
- Bado, M. F., & Casas, J. R. (2021). A review of recent distributed optical fiber sensors applications for civil engineering structural health monitoring. Sensors, 21(5), 1818.
- Stanier, S. A., Blaber, J., Take, W. A., & White, D. J. (2016). Improved image-based deformation measurement for geotechnical applications. Canadian Geotechnical Journal, 53(5), 727-739.

- Thielicke, W., & Sonntag, R. (2021). Particle Image Velocimetry for MATLAB: Accuracy and enhanced algorithms in PIVlab. Journal of Open Research Software, 9(1).
- Brezzi, L., Gabrieli, F., Cola, S., Lorenzetti, G., Spiezia, N., Bisson, A., & Allegrini, M. (2019, July). Digital Terrestrial Stereo-Photogrammetry for Monitoring Landslide Displacements: A Case Study in Recoaro Terme (VI). In National Conference of the Researchers of Geotechnical Engineering (pp. 155-163). Springer, Cham.
- Detert, M., & Weitbrecht, V. (2013). User guide to gravelometric image analysis by BASEGRAIN. Advances in Science and Research; Fukuoka, S., Nakagawa, H., Sumi, T., Zhang, H., Eds, 1789-1795.

Examination and grading:
Oral examination at the end of the course, checking on completeness and suitability of knowledge.

Course details:
The course will be held in person. The dates and the place will be defined and communicated once the number of students attending is known. There will be lectures, presentations of case studies and practical exercises in the classroom.