GEotechnical and Patrimonial Archives Toolbox for ARchitectural conservation in Belgium

GEPATAR

Contract - BR/132/A6/GEPATAR

SUMMARY

Context:

In Belgium, the federal collection of built heritage is one of the largest and most diverse in Europe and is visited every year by millions of people. This built heritage is of exceptional cultural and economic importance for the country and its protection is a priority at federal and regional levels. Due to heavy industrial and urban development, cultural heritage buildings suffer from physical, mechanical, chemical, and biochemical pathologies throughout their history. Furthermore, external human activities such as groundwater extraction, digging of underground galleries and temporary excavations all contribute to structural instability of the buildings. An adequate protection and preservation of the built patrimony requires the integration and the analysis of environmental, architectural and historical parameters.

Objectives:

The GEPATAR project aims at creating an online interactive geoinformation tool (the GEPATAR toolbox) that allows the user to view and to be informed about the Belgian heritage buildings at risk due to differential ground movements. Specifically, the project built a framework to assess the potential damage caused by ground settlement for masonry, infilled and bare frame structures using Persistent Scatterer Interferometry (PS-InSAR). This spaceborne based Synthetic Aperture Radar (SAR) method has been proven as a unique remote-sensing tool for low cost and precise (1 mm) ground surface deformation measurements.

Methodology:

Radar interferometry is one of the main tools used in this project to monitor the intensity and the spatio temporal behaviour of the ground deformation in Belgium and its impact on the stability of the patrimonial buildings. A PS-InSAR processing chain that was developed by CSL needed to fit the technical requirements of the satellite data hold by RBINS and to handle the new data format of the Sentinel 1 mission Three datasets of SAR images (ERS 1/2, ENVISAT and Sentinel 1), each covering the entirety of Belgium were acquired and processed, spanning a total period of 26 years (1992–2018). Countrywide deformation maps were produced by applying the PS-InSAR technique. High-resolution deformation maps of selected urban centres were obtained by processing very high resolution SAR data (TerraSAR-X and CosmoSkyMed). Within the GEPATAR toolbox, the country-scale deformation maps are integrated with other geo-data layers such as geology, land-use and the location of the built heritage; feature-based data fusion techniques and decision rules based on geomechanical expertise are combined to create ground movement risk maps. At the local scale the fusion process is more complicated due to the inclusion of non-spatial

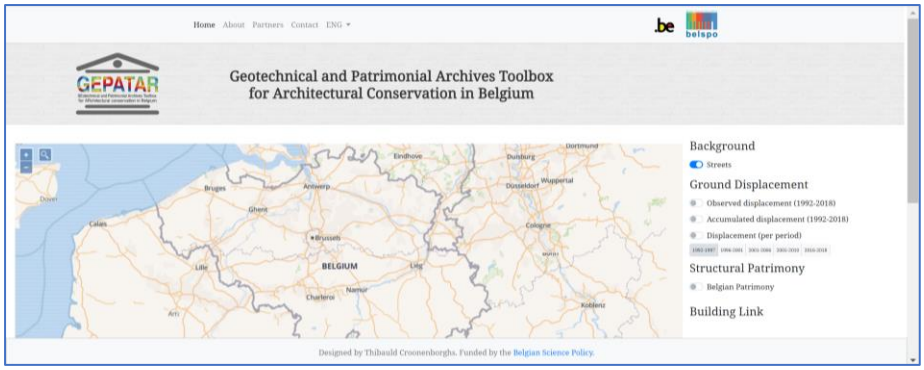
datasets, such as photographic and historical surveys, architectural and geotechnical data; at this scale decision rules are provided by engineering and architectural expertise. The output risk maps will be regularly updated with the availability of new SAR acquisitions. A methodology for damage assessment was developed, based on the restrictions that the algorithms were to be fully integrated in the GEPATAR Toolbox and analysis could run automatically with inputs provided from queries made by the GEPATAR Toolbox into other data sources, such as patrimonial archives and ground deformation maps.

The developed methodology consisted of following steps:

- defining the inputs: ground deformation data and patrimonial data
- calculation of ground deformation curve
- calculation of related building deformation
- calculation of potential damage and definition of cumulative damage level

Results:

The PS-InSAR processing results permitted to highlight subsidence or uplift that can be interpreted and followed through years with a millimetric precision. The processing realised on different satellites allowed to follow the evolution of the ground movements at different epoch since 1992 up to now. Seven moving areas were particularly highlighted: 1. Merchtem, 2. Antwerp, 3. Brussels, 4. Limburg, coal mines, 5. West-Flanders/Kortrijk, 6. Hainaut, coal mines, 7. Liège, coal mines. The developed damage model was directly implemented in the GEPATAR toolbox. Overall, it was found that distinguishing between movement due to structural changes, such as alterations in the roof, and movement due to ground settlement and uplift is not straightforward. The effects of the former are smeared out over the 10-meter interpolation grid and thus do not affect the velocity threshold criterion. However, they may affect the potential damage calculation in the absence of prominent PS caused by actual ground movement. The GEPATAR toolbox including the integration of the heritage data, the PS-InSAR data, the damage model, is available in three languages under the domain http://gepatar.kikirpa.be/.



Keywords: Structural monitoring, differential settlement, heritage building, InSAR, remote sensing