FIRST RESULTS OF THE GEODETIC INTEGRATED MONITORING SYSTEM (GIMS) PROJECT

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The study of geodynamic processes, as well as the mitigation of natural risks such as those associated to landslides and subsiding ground affecting structures and infrastructures, often require to deploy monitoring systems. The observations provided by these monitoring systems allow in fact to mitigate the hazard effects in terms of economic costs and safety for the population, and to improve the knowledge on the causes and movements of the earth's crust. One of the possible approaches to monitor such processes consists in the continuous determination of the position (or displacement) of a network of points on the surface. In particular, depending on the movements to be monitored, different requirements can be defined in terms of temporal resolution (daily, monthly, etc.), of spatial resolution (number of points monitored in the target area) and in terms of accuracy of displacement estimates. Obviously the three requirements listed above are closely related to each other, since high accuracy in the measurements allows to observe smaller movements, and therefore it makes it even more interesting to have high resolutions both in the temporal and spatial domains.

To solve these problems, several geodetic techniques such as classic positioning, SAR or GPS / GNSS systems are now a common practice. Each of these techniques has peculiarities: for example SAR allows for high spatial resolution data, but has a temporal resolution limited by the satellite passages.

Classic positioning by total station instead, requires the presence of one or more operators, or the construction of expensive structures for the protection of automated total stations. In the first case, obviously the spatial resolution of the monitoring cannot be high, in the second case, instead, not only one must cope with high installation costs, but there is also the quite important limiting factor that only points seen from the total station can be monitored. Moreover, the accuracy of the measurements are strongly deteriorated by changes in atmospheric conditions, reaching worse than 1 cm accuracy for high distances between the total station and the point to be monitored, or even inhibiting the monitoring itself in case of dense fog.

The use of GPS / GNSS systems to monitor deformations is a common practice, typically performed by installing a network of geodetic-quality receivers that guarantee accuracy of the order of millimeters with a day of latency. However, the high cost of geodetic dual-frequency receivers generally limits the number of monitored points. In 2015, researchers from Geomatics Research & Developments s.r.l. (http://www.g-red.eu/), through a partnership with Softeco Sismat (https://www.softeco.it/), started a service called GeoGuard for the alternative use of low-cost GNSS devices, showing the possibility of obtaining results with accuracy of the order of 2.5 mm (standard deviation of position repeatability) with hourly resolution, which drops below 1 mm for daily updates. Currently this kind of low-cost GNSS monitoring is routinely performed by the GeoGuard service to remotely and continuously monitor more than 70 points in operational environments (e.g. landslides, dams, highway bridges, etc.). Several research centers and universities, such as Politecnico di Milano (Italy), Delft University of Technology (The Netherlands), the Research Institute of Sustainable Humanosphere (Japan), the Fukushima Renewable Energy Institute (Japan), also used the GeoGuard service within research projects to study displacement of points or even to infer information about the troposphere (e.g. amount of precipitable water vapor).

The Geodetic Integrated Monitoring System (GIMS) project, funded by European GNSS Agency (GSA) within the H2020 Programme, and led by GReD aims at developing, testing and commercializing an advanced low-cost system based on GNSS, Copernicus SAR and other in-situ sensors, like inertial measurement units, for monitoring ground deformations with a focus on landslides and subsidence. The advent of the Galileo and Sentinel satellites, and their integration with miniaturized in-situ sensors, enables new advanced monitoring solutions which are both cost-effective and highly accurate.

With the advent of Galileo, most of the limitation of GPS-only surveys can be softened because a larger number of visible satellites improves the geometry of the positioning, and consequently its precision, and because Galileo E5 signals are very promising in terms of both provision of a second civilian frequency and observation quality. Moreover, the availability of the Sentinel 1A and 1B data, which are provided with an open and free access policy, allows the usage of SAR images for ground monitoring purposes at lower cost and higher revisit time compared to few years ago. Finally, the miniaturization of sensors like accelerometers, inclinometers, etc. allows for the deployment of a large number of measuring devices provided that their observations, usually highly affected by severe noise, can be properly processed.

The observations of these three different monitoring techniques, namely GNSS, SAR and accelerometers, are complementary in time and space and can be integrated to obtain a better understanding of the monitored processes and a more complete knowledge of the deformation phenomena. In fact accelerometers are used for a real-time identification of sudden movements in terms of accelerations, GNSS receivers allow to identify pointwise shifts at the level of 1 mm per day or 2.5 mm per hour, and SAR images enable the identification of area deformation at level of few millimeters with a latency of few days thus giving a complete picture of the target ground deformations at all the required spatial and temporal scales.