Remote monitoring of deformation using Terrestrial SAR Interferometry (TInSAR, GBInSAR)

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[Please refer to Mazzanti, GIN June 2011, pp 25-28 for more details. Ed.]

Principal of operation

Terrestrial Synthetic Aperture Radar Interferometry (TInSAR, also referred to as ground based SAR interferometry, GBInSAR) is a RADAR technique for the remote monitoring of displacements. By the movement of a RADAR sensor along a linear scanner (i.e. a rail that allows precise micrometric movements of the sensor), 2D SAR images are derived. By comparing the phase difference, i.e. interferometric technique, of each pixel between two or more SAR images acquired at different times, the displacements along the instrument line of sight (LOS) are derived. Thus, 2D color images of LOS displacement can be achieved as well as the displacement time series of each pixel (Figure 1). TInSAR monitoring can be performed by installing the equipment at a stable location in a panoramic position, and it does not require the installation of contact sensors or reflectors in the monitored area.

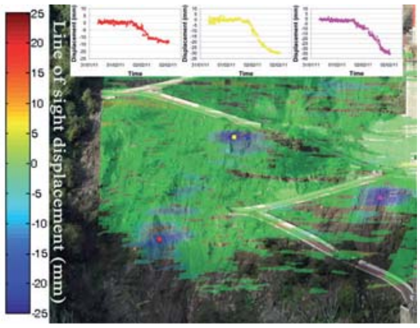

Figure 1. TInSAR displacement map overlaid on the slope picture and time series of displacement.

Main fields of application

The best application of TInSAR is the continuous monitoring of unstable slopes and dams. Other applications include linear infrastructures such as bridges, localized subsidence and buildings. TInSAR monitoring of buildings is quite challenging because although it is possible to collect highly accurate displacement data by a non-contacting technique, it is quite complex to detect vertical movements.

Accuracy and pixel resolution

The theoretical accuracy of TInSAR equipments is on the order of +/- 0.1 mm. However, both the precision and the accuracy are strongly reduced by the atmospheric noise. The precision ranges from few tenths of mm to a few mm, depending on the monitoring distance and the atmospheric conditions. The pixel resolution of a terrestrial SAR image ranges from few decimetres to several meters (depending on the equipment and on the monitoring distance). At a distance of 1 km, the most common commercial equipment has a resolution of about 0.5 x 4 m.

Main advantages

The main advantage of TInSAR is probably the ability to monitor displacements from a remote position without the installation of targets or sensors on the monitored ground or structure. Other advantages include applicability under any lighting and weather conditions, including rainfalls, clouds and fog; high data sampling rate (few minutes); long range efficacy (some km); high accuracy and spatial control.

Main limitations

The main limitation is the complex management, processing and interpretation of TInSAR data. Other limitations include: i) the size of commercial equipment (up to 3 metres long); ii) limited cone of view (some tenths of degrees in both the H and V planes); iii) unidirectional measure of displacement (along the instrument LOS) and iv) signal phase ambiguity (i.e displacement higher than 4.5 mm between two consequent images are not easily detectable).

Future challenges

- The increasing number of applications will contribute to improve both the technique and monitoring good practice.
- Cheaper and smaller hardware may improve the use of TInSAR, especially in urban areas.
- Advanced algorithms and software for the processing of data may improve the usability and effectiveness of TInSAR.

Commercial sources in North America

In the author's knowledge the following two companies are providing services with TInSAR: Olson Engineering Inc., Colorado (USA), http://olsonengineering.com.and C-Core, Kanata, Ontario (Canada), www.c-core.ca. European companies with longer expertise are listed in the article referred to above.

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