Deformation Monitoring with Terrestrial SAR Interferometry

Michele Crosetto
Institute of Geomatics
Castelldefels (Barcelona)
michele.crosetto@ideg.es

Content

- Introduction:
  - Satellite-based SAR interferometry

- Ground-based SAR:
  - Fundamentals
  - Data acquisition characteristics

- Examples of monitoring campaigns

- Real-aperture-radar
Satellite-based SAR interferometry

- If $S = M$:
  \[
  \Delta \Phi_{int} = \Phi_S - \Phi_M = \Phi_{Mov}
  \]

- If $S \neq M$:
  \[
  \Delta \Phi_{int} = \Phi_S - \Phi_M = \Phi_{Topo} + \Phi_{Mov}
  \]
### Satellite-based SAR: TerraSAR-X

- Range resolution
- Cross-range resolution - SAR
- Coherent radar
- Interferometric capabilities

### Ground-based SAR

- Key characteristics:
  - It's a radar-based imaging sensor
  - Range resolution
  - Cross-range resolution - SAR
  - Coherent radar
  - Interferometric capabilities
GBSAR: range resolution

Range profile, where the targets are resolved with a given range resolution

Cross-range resolution: SAR

- The Synthetic Aperture Radar technique enables us to get high cross-range resolution exploiting the movement of the antenna.

- The SAR processing of the data collected during the sensor movement of 2 m allows the system to get a cross-resolution of:

\[ \Delta \varphi = \frac{\lambda}{2 \cdot L} = 4.3 \text{mrad} \]
We exploit the phase of the signal.

In particular, we exploit the difference of phase measured in two or more acquisitions.

\[ d = -\frac{\lambda}{4\pi} (\varphi_2 - \varphi_1) \]
Hardware: example of IBIS-L

GB-SAR – data acquisition

- Robust, day/night, all weather. High degree of automation
- Range capabilities: 3-4 km
- Intrinsically precise: mm, sub-mm
- Resolution:
  - ex. Ku-band: \( \Delta \text{range} = 0.5 \text{ m}; \quad \Delta \text{cross-range} = 0.0044 \text{ rad} \)
- Nominal coverage:
  - ex. Ku-band: 30-40\(^\circ\)
- Line-of-sight measurement
- Heavy instrument
Deformation monitoring example:
Formigal landslide (Pyrenees)
Formigal landslide (Spanish Pyrenees)

- 3 TLS campaigns: July 06, October 06, June 07
- 1 continuous GBSAR campaign: October-November 06
- Several topographic campaigns: total station & D-GPS

TLS data coverage: Formigal Test Site

July scan intensity image (4-07-2006)
TLS data coverage: Formigal Test Site

July scan intensity image (4-07-2006)

Good point = 60% of total

TLS data coverage: Formigal Test Site

October scan intensity image (5-10-2006)
TLS data coverage: Formigal Test Site

October scan intensity image (5-10-2006)

Good point = 36% of total

GB-SAR

Line-of-sight displacements:
5 October - 21 November 06; Max distance = 1950 m
GB-SAR

Point @ distance = 550 m

Technical issues
coherence over time
GBSAR – coherence

Continuous GBSAR acquisition

5 October – 21 November 2006
Coherence threshold = 0.9

The spatial sampling density and coverage are reduced

The monitoring feasibility has to be assessed on each site
Artificial Reflectors

Reflector artificial (triedre)
Technical issue: validation
Validation

Sensor to target distance = 44 m

Measurements not corrected for (linear) atmospheric effects
Real Aperture Radar (RAR)
RAR

RAR: Cadore bridge

Cadore Bridge (Belluno)

Length: 128m

Radar position
RAR: Cadore bridge

Spectral analysis

First resonance frequency