Possibilities for building monitoring, using terrestrial radar interferometry

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Lately, the focus is on:

Equipping the constructions with sensors for monitoring deformations and displacements

- accelerometer arrays
- wireless and mobile technologies, combining several systems and measurement methods
- micro-electro-mechanical systems (MEMS)
- Terrestrial Laser Scanners (TLS)
- terrestrial radar interferometry systems - IBIS (Image by Interferometric Survey)
Measuring principle

\[ d = \frac{\lambda}{4\pi} \cdot \Delta \varphi \]

\[ d = \frac{d_p}{\sin \alpha} \Rightarrow \sin \alpha = \frac{h}{R} \Rightarrow d = d_p \cdot \frac{R}{h} \]
Choosing the observation position and setting the IBIS-FS instrument

The IBIS-FS system is suitable for static and dynamic monitoring of various types of structures (bridges, wind towers, high buildings, etc.), only 1D.

Main features:
- Fast movement measuring (up to 200 Hz).
- Accuracy: 0.01 mm.
- Long range: 1 km.
- Multi-point tracking, day&night.
- Easy and fast way to install and disassemble.

Using the IBIS Surveyor software on the field computer, the user goes through a series of steps to start the data acquisition.
- Static/dynamic acquisition selection
- Instrumental parameter setting
- Geometry configuration
- Mission selection
- Time management
- Measurements processing
IBIS-FS experiments in Bucharest

1) The tower building of the Institute of Atomic Physics (IFA) in Magurele

Choosing the reflection points with a SNR of over 40 dB, we can see their movements during the acquisition of interferometric information. There are grouped values that do not exceed 0.2 mm, which can be observed in a polar or cartesian representation.
IBIS-FS experiments in Bucharest

2) Tested the dynamic monitoring of the central deck of the cable bridge from the Bucharest bypass located in the area of Otopeni city.

We have positioned the instrument in the middle of the bridge deck, the transmission direction being vertical, we were able to detect the dynamical vertical evolution of the transverse beam when passing heavier vehicles. It can be observed the flexibility of the bridge structure, when passing a truck, determining a displacement of approx. -15 mm, but with a total return after a few.
Such beam variations of this bridge were also observed in real time on the graphical representations provided by the data acquisition software on the field computer.
IBIS-FS experiments in Bucharest

3) Determination of vibrations of the same cable bridge under heavy traffic.

We placed the instrument near the main pile that supports the cables and set the microwave beam direction relatively perpendicular to the central cable.

The oscillations of the cables, which are between +3 and -3 mm, relative to the observation direction of the instrument.
We can also simulate a dynamic evolution of the selected points (for 3 cables), generating a movie during the observation period.
Conclusions

- As a result of the tests carried out with these terrestrial radar interferometry systems are an alternative to the classical methods of determining the displacements of the building structures.
- It is possible real time analyzes which permit the calculation of vibrations velocities and accelerations of the investigated structure elements.
- Radar interferometry offers some advantages compared to traditional sensors used for this purpose, but also requires some special conditions (without obstructions between the instrument and the object investigated, no vibrations of the instrument, a clear geometry for the location of the instrument relative to the object, etc.) to obtain reliable data on the specified accuracy.
- Implementation of a national strategy to monitor construction objectives with different types of risks may be taken in consideration using this interferometric technique for monitoring displacements and deformations, especially because:
  - it is easy to mount outside the zone of influence of the objective,
  - it has very good precision of the determined values of the displacements,
  - it has the possibility of integration into a permanent monitoring system (for dams, for landslides, etc.),
  - and the possibility of triggering the alarm signals in case of imminent danger.
Thank you for your attention!

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