DAM MONITORING
(in collaboration with Milan Polytechnic-Surveying Dept.)

Introduction

Monitoring of structural movements (dams, historical buildings, towers) is an increasingly important task for today's construction engineers.

IBIS-L introduces a totally new solution in this field of application, providing many advantages over traditional instruments:

Fig. 1: IBIS-L

- Remote sensing of up to 4 km.
- Displacement accuracy up to 1/10 mm.
- Real-time two-dimensional mapping of simultaneous displacements over large areas (several km^2)
- Sampling of movements every 5 minutes
- Autonomous operation
- Day-night, all weather operation

This case study reports the results of a survey performed on a real-scale arch gravity dam in Alta Valtellina (Cancano, Sondrio) and are given as a typical example of dam monitoring. The experimental results consist of:

- visualisation of two dimensional radar image of the dam;
- visualisation of two dimensional displacement maps of the dam;
- visualisation of single pixel time histories.

Measurements were performed in collaboration with the Surveying Dept. of Politecnico di Milano (Regional Centre of Lecco) and in collaboration with AEM company, which IDS thanks for the logistical assistance.

Measurement description

In contrast to optical sensors, IBIS-L simultaneously measures the displacement of the entire scenario illuminated by the antenna beam, providing a continuous mapping of displacements of the entire area.

To exploit this key feature for dam monitoring, the best position to install the sensor is in front of the wall of the dam so that the IBIS-L antenna beam can cover the whole dam, as illustrated in **Fig. 2** and **Fig. 3**.

Fig. 2: installation site

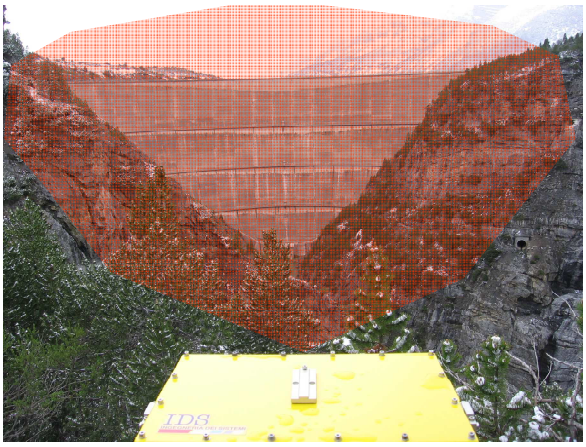

Fig. 3: IBIS-L coverage area

Measurements were carried out in the following operational conditions:

- dam-sensor distance: 400m
- range resolution: 50cm;
- angular resolution: 4.5mrad;
- operation mode: continuous.

The measurements lasted for two days (continuous day and night operation), sampling the scenario every 9 minutes. During the measurement period, the level of the dam water basin was increasing.

Results –Radar Image of the Dam

Fig. 4 shows the focalisation map of the dam produced by IBIS-L (the IBIS-L position is in (0,0) coordinates): the map provides the operator with information on the intensity of the backscattered signal received by IBIS-L and thus provides an estimation of the quality of the measurement for each pixel in the image.

A higher backscattered signal for the pixel means a more accurate displacement measurement.

The power image has been projected over a CAD map to geo-reference the scenario.

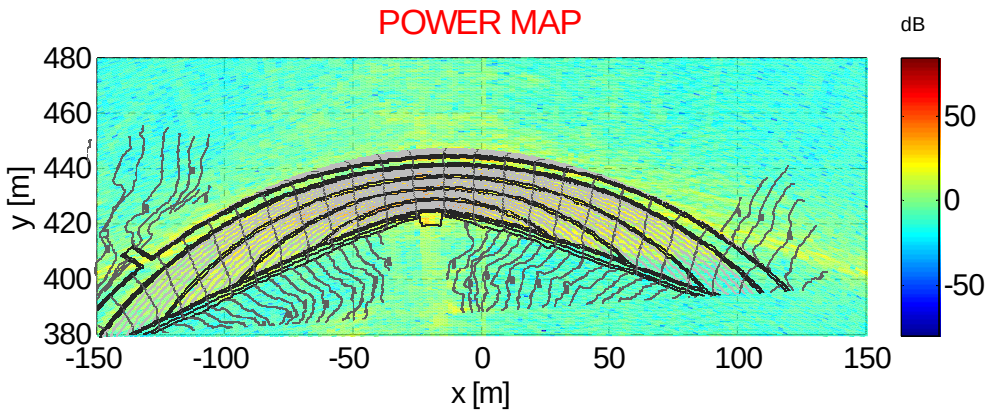

Fig. 4: power image projected over dam CAD map

Results – Dam Displacement Map

The following figures show three displacement maps obtained from processing IBIS-L data for three different observation periods reported in Tab. 1.

Period	Start	End	Duration
1	28/05/2007 at 19.13	29/05/2007 at 5.32	10h 19m
2	28/05/2007 at 19.13	30/05/2007 at 3.24	32h 11m
3	28/05/2007 at 19.13	30/05/2007 at 8.38	37h 35m

Tab. 1: observation periods

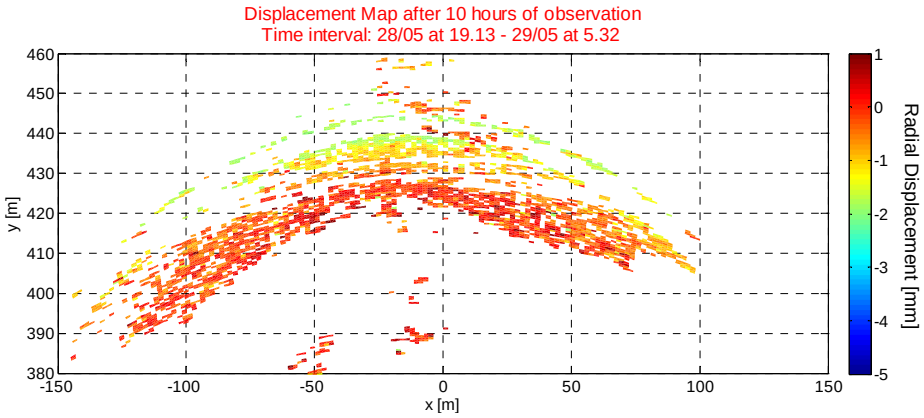

Fig. 5: dam displacement map after 10 hours of observation

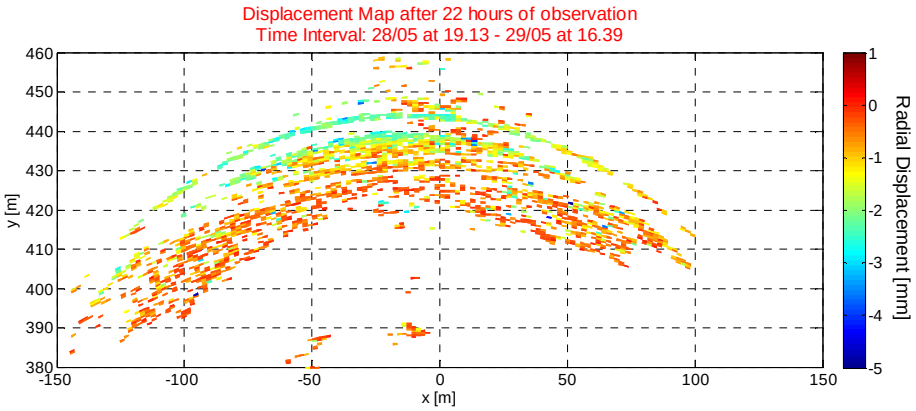

Fig. 6: dam displacement map after 22 hours of observation

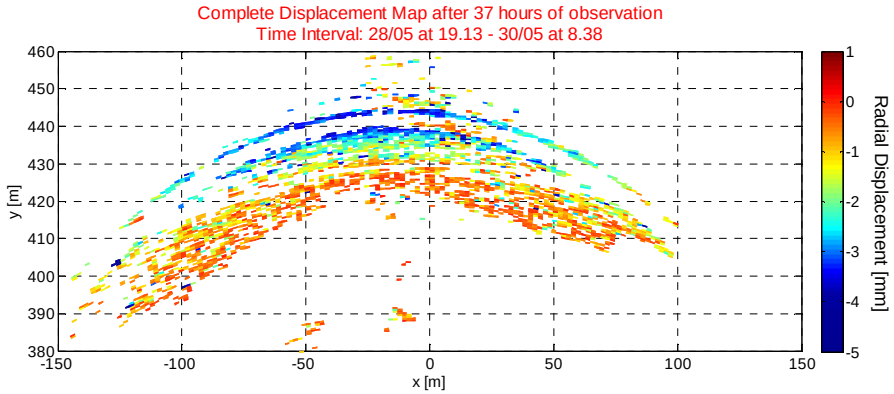

Fig. 7: dam complete displacement map after 40 hours of observation

Thanks to the possibility of viewing a 2-D displacement map, we can see the overall movement of the structure, showing the displacement of the dam caused by the filling of the water basin. Observing Figs. 7-9 we can see that the bottom part of the dam is almost steady (red colour) while the upper part moves about 4-5mm during the 37 hours of observation (blue colour).

The crowning displacement can also be retrieved by observing **Fig. 8**, which shows the time history of a point on the crown of the central section of the dam.

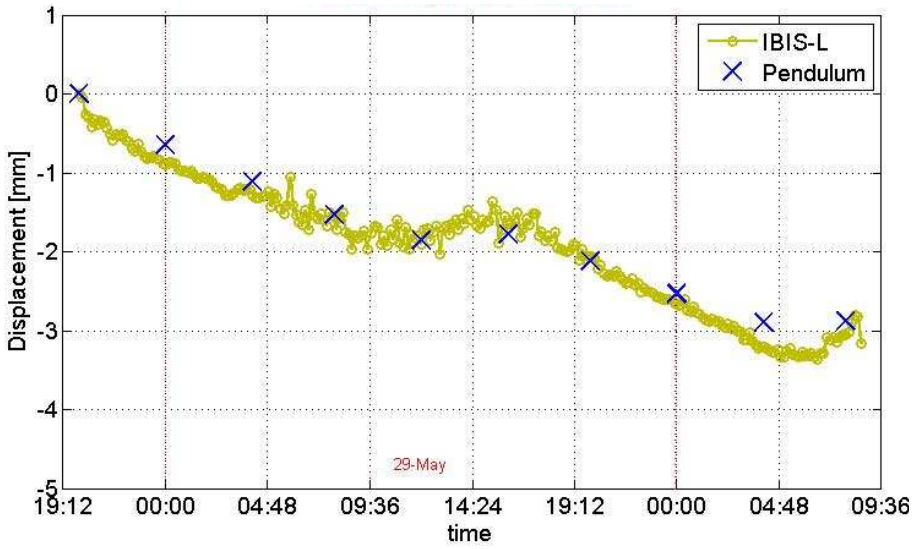

Fig. 8: IBIS-L single pixel displacement along the entire observation period compared with the pendulum data.

The point displacement was compared with the dam pendulum, and a good agreement was found.

Conclusions

This case study highlights the possibility of using IBIS-L as instrument to monitor the movement of a dam with an accuracy of tenths of a millimetre.

IBIS-L can be used to:

- Monitor the dam from a remote site, hundred of meters away from the structure;
- Monitor the structure without the need to access the dam because there is no the need to install sensors or reflectors on the structure;
- Monitor the entire wall of the dam at once;
- Monitor the dam in all weather conditions;
- Monitor the dam without the presence of an operator, since the system can be left working autonomously.

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