INTRODUCTION

Interferometric Synthetic Aperture Radar (InSAR) is a radar technique used to monitor ground and infrastructure movements over potentially large areas at millimeter precision. Unlike optical imagery, this technique works at night and is not affected by cloud cover. InSAR compares radar satellite images over time, and is capable of measuring precise changes using interferometry.

Typical applications include proactive monitoring of watersheds, highways, railroad tracks, construction sites, and critical slopes and embankments - such as for hydro-dams and reservoirs - as well as mine pit walls and tailings dams. InSAR results have been validated by ground-source instruments many times, including GPS, ground based radar, and subsurface sensors, and complement such measurements by providing much wider area coverage and a finer mesh of data points, often tens of millions for a given area of interest.

Image acquisition depends on the availability of satellites with known orbits. A rapidly growing satellite network with high resolution cameras allows for greater area coverage than ever before. Typical scan frequencies currently range between 4 to 11 days, with up to 2 images being available per flyover (one ascending, one descending). Processed data is available within hours after each satellite image acquisition.

SOLUTIONS

Canary Systems and its partners are offering a fully integrated InSAR monitoring solution within MultiLogger Suite. Utilizing its built-in GIS engine, InSAR data can be overlaid as a georeferenced layer on new or existing Image Windows containing other detailed site maps and topographic information, as well as ground-based instrument data sources and sensors.

Key Capabilities

- **MILLIMETER PRECISION**
  Able to detect movements over time across large areas at millimeter precision

- **FINE DATA MESH**
  Provides fine mesh of data points, often tens of millions for an area of interest

- **WIDE AREA COVERAGE**
  Complements ground-source instruments by providing wider area coverage

- **INTEGRATION**
  Use MultiLogger Suite to integrate remote and ground based data within the same project views

- **VISUAL ANALYSIS**
  Display data as color-coded heatmaps or analyzed contours highlighting new or accelerating areas of motion

- **LIVE UPDATES**
  Connect to live GIS services updating project views automatically with the latest satellite image data
INSAR MONITORING

Visual information can be displayed as color-coded heatmaps or as pre-analyzed contours highlighting new or accelerating areas of motion. These RapidReports are processed and available within hours of the image acquisition.

InSAR data can be provided as a live link (URL) via ArcGIS service, or embedded as a static report or image. Live integration enables automatic updates of project views with the latest satellite radar imagery as soon as available.

Case Study - Dam Safety

Mosul Dam is an earth embankment dam in Iraq. Located on the Tigris river, it is the largest dam in Iraq, and the fourth largest dam in the Middle East. Built on a karst foundation, concerns over the dam’s instability have led to major remediation and rehabilitation efforts since 2003. Numerous sinkholes have formed downstream and to the east of the dam in the past years. In 2006, the United States Army Corps of Engineers ranked the dam as the “most dangerous dam in the world”. InSAR technology has been used to collect thousands of data points along the dam wall and nearby areas. The remote sensing technology allows for collection of data without extensive groundwork or even a presence on the ground. Using interferometric analysis, the data precisely shows where settlement and uplift movement is occurring.

Case Study - Tailings Dam

At a large copper mine in Arizona, a two mile long tailings dam wall with a known history of instability since construction has been subject to a combined monitoring effort by ground-based instrumentation and InSar. More than 15 million data points cover the complete mine site, as well as hundreds of sensors, including piezometers. On April 25, 2016, 0.5 cm of motion was detected on the tailings wall. Visual inspections were initiated immediately. Additional displacement and accelerating motion was observed again in May 2016. Structural modifications were made to the localized area, and no motion has been detected since June 2016.

InSAR Specifications

<table>
<thead>
<tr>
<th>Area of Coverage</th>
<th>Frequency</th>
<th>Post-scan analysis</th>
<th>Applications</th>
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<tbody>
<tr>
<td>30 miles x 18 miles in a single analysis</td>
<td>Every 4 – 11 days</td>
<td>Available within hours after image acquisition</td>
<td>Ground Motion:</td>
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<tr>
<td>Data Density: Tens of millions of data points per image</td>
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<td></td>
<td>Subsidence, Uplift, Slope creep</td>
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<td>Precision: Less than 0.2 inches (~3 millimeters)</td>
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<td>Marine mapping:</td>
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<td>Oil slicks, Platforms, Vessels</td>
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<td>Urban development:</td>
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<td>City planning, Economic indicators</td>
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