The Progress of landslides monitoring in China

Chuanrong Li

Key Laboratory of Quantitative Remote Sensing Information Technology, Academy of Opto-Electronics (AOE), Chinese Academy of Sciences (CAS)
1. Landslides pilot in China

China is a country with frequent landslide disasters. The characteristics of geology, geomorphology and climate determine the distribution pattern of landslides in China.

- The most severe region: Southwest China;
- Other regions: Northwest and Southeast China.

1. Landslides pilot in China

The quantity of landslides accounts for more than 70% among all the natural disasters, which has caused great losses of life and property.

<table>
<thead>
<tr>
<th>Year</th>
<th>Quantity</th>
<th>Proportion</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>10122</td>
<td>70.0%</td>
</tr>
<tr>
<td>2012</td>
<td>10888</td>
<td>74.8%</td>
</tr>
<tr>
<td>2013</td>
<td>9326</td>
<td>72.8%</td>
</tr>
<tr>
<td>2014</td>
<td>8128</td>
<td>74.5%</td>
</tr>
<tr>
<td>2015</td>
<td>5616</td>
<td>68.3%</td>
</tr>
<tr>
<td>2016</td>
<td>7403</td>
<td>76.2%</td>
</tr>
</tbody>
</table>

It is very urgent and meaningful to develop the technology to monitor the dynamic changes of landslides.
2. The development of topographic deformation monitor

Yansan Highway was blocked because of landslide.

Landslides often occur in the part of road, where soft rocks were retrogressive slided, and hard rocks were also collapsed.

The topographic deformation monitor was installed to observe the deformation and displacement of the high slopes real-timely.
2. The development of topographic deformation monitor

Construction site  Installment of topographic deformation monitor
2. The development of topographic deformation monitor

We developed a new topographic deformation monitor, based on the basic theory of photogrammetry, which has proven to be an effective tool to monitor the displacement and deformation caused by geological disasters.
2. The development of topographic deformation monitor

**System architecture**

- Digital images acquisition system
- Data pre-processing and remote transmission
- Data automatic analysis of the servers
- Remote control and alarm
2. The development of topographic deformation monitor

**Hardware and control system**

Camera structure design and machining

Thermo equipment

Camera control system

Night shot and alarm control system
2. The development of topographic deformation monitor

Camera calibration

- Optical lens correction was conducted at the panoramic calibration field, before collecting data.
2. The development of topographic deformation monitor

Camera calibration

- Night shot calibration

Night shot experiment
2. The development of topographic deformation monitor

Technical parameters of the instrument

- Continuous monitoring automatically in 24 hours;
- Monitoring distance is 5m to 1000m, with the displacement monitoring accuracy of 0.1mm when distance <10m;
- The operation temperature is -20°C to 60°C;
- The instrument power is very small, only from hundreds of watts to several watts;
- The efficiency of data transmission is very high, with 1M/10s;
- Monitoring frequency is 0.05HZ, 3 times per minute.
2. The development of topographic deformation monitor

**Data pre-processing and remote transmission**

- The digital images will be pre-processed after collecting, which includes numbering, classification and useful data selection.
- The data will be transferred to the servers by the network, and downloaded by users.
A new image matching method, i.e. all-pixels participated image matching algorithm, was proposed to process data. It takes all the pixels of the corresponding images to participate in the matching procedure and calculate the geometric parameters by least square criterion.

The principle of the algorithm includes:

- Gray corresponding equation;
- Information quantity equation;
- Procedure of least square solution.
2. The development of topographic deformation monitor

Data processing algorithm

Wavelet analysis

Multi-scale wavelet analysis results of images.

From the two figures, Signal to Noise Ratio (SNR) values of different scales were calculated.
2. The development of topographic deformation monitor

Data processing algorithm

<table>
<thead>
<tr>
<th>尺度</th>
<th>$\sigma_{G1}$</th>
<th>$\sigma_{G2}$</th>
<th>$\sigma_N$</th>
<th>mean $(\sigma_G^2/\sigma_N^2)$</th>
<th>log2 $(\sigma_G^2/\sigma_N^2)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>A5</td>
<td>0.2006</td>
<td>0.1937</td>
<td>0.0318</td>
<td>38.4414</td>
<td>5.2646</td>
</tr>
<tr>
<td>A4</td>
<td>0.2082</td>
<td>0.2020</td>
<td>0.0376</td>
<td>29.8209</td>
<td>4.8983</td>
</tr>
<tr>
<td>D4</td>
<td>0.0657</td>
<td>0.0672</td>
<td>0.0435</td>
<td>2.3357</td>
<td>1.2239</td>
</tr>
<tr>
<td>D3</td>
<td>0.0722</td>
<td>0.0730</td>
<td>0.0545</td>
<td>1.7731</td>
<td>0.8263</td>
</tr>
<tr>
<td>D2</td>
<td>0.0683</td>
<td>0.0652</td>
<td>0.0473</td>
<td>1.9898</td>
<td>0.9926</td>
</tr>
<tr>
<td>D1</td>
<td>0.0419</td>
<td>0.0471</td>
<td>0.0380</td>
<td>1.3751</td>
<td>0.4595</td>
</tr>
<tr>
<td>A0</td>
<td>0.2437</td>
<td>0.2392</td>
<td>0.0998</td>
<td>5.8530</td>
<td>2.5492</td>
</tr>
</tbody>
</table>

- The higher the resolution, the lower the SNR values, especially for D1, D2 and D3, which might lead to some errors in the image matching.
- However, A4 and A5 had higher SNR and log2 values than the original signal $A_0$, indicating that the algorithm can greatly improve the accuracy of high resolution images matching.
3. Landslide monitoring with the new instrument – a case at Yansan Highway

Data collection

• Data collection at daytime
  (From 6am to 16:30pm)
3. Landslide monitoring with the new instrument – a case at Yansan Highway

Data collection

- Data collection at night
  (From 16:29pm to 6:16am)

![Image of data collection files]

![Image of landslide monitoring]
3. Landslide monitoring with the new instrument – a case at Yansan Highway

Monitoring results

The changes of targets per hour can be observed from 4 directions.

The instrument has been working for about 7 months, from July, 2018.
4. The next steps

♦ The experiment on site will be continued to collect more data.
♦ Efforts will be done on finding out relation between displacement and landslide, including refining interpretation model and pre-warning threshold.
Thank you!