Remote sensing image real-time processing for rapid disaster emergency response

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Outline

1、Major requirements in disaster emergency response

2、Main technical challenges

3、Conclusions

1、Big spatio-temporal gap between decision maker and actual disaster information

2008 Wenchuan earthquake

2012 Zhaotong earthquake

2013 Yaan earthquake

The rapid data acquisition and real-time processing of spatio-temporal data in disaster emergency response is seriously important

Sensor network is necessary for comprehensive disaster monitoring


InSAR


Optical


GNSS

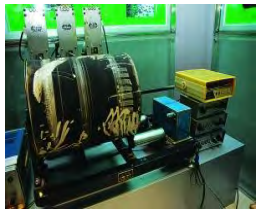

UAV


Airborne


Airplane


GBR


Meteorological station


Seismic Thumper

Space-based: wide range, low time resolution

Hundreds of satellites

Aerial-based : high time and space resolution, limited coverage

Thousands of aircrafts

Ground-based : high mobility, limited coverage and manual intervention

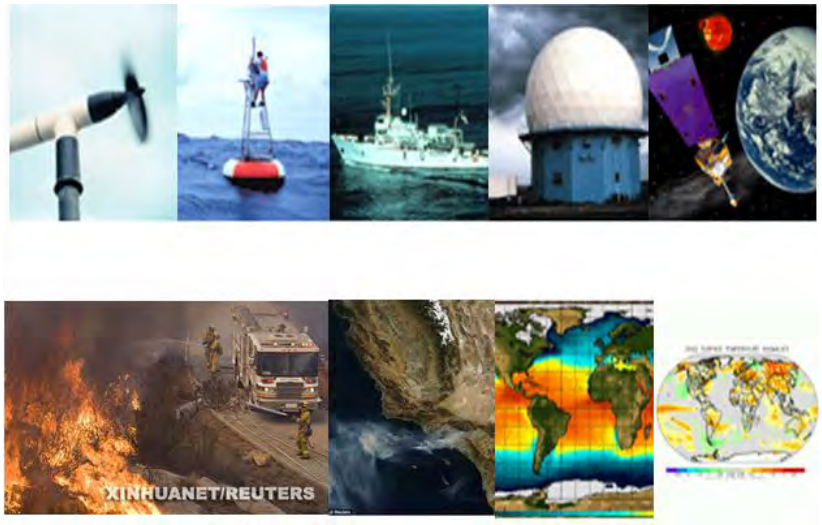
Millions of ground sensors

"Swimming in Sensors and Drowning in Data"

—David deptula, the U.S. air marshal

Rich data, Little information, Poor knowledge

For the limitations of rapid data processing, satellite data can be processed in time for less than 10%. How to timely, effectively and rationally integrate dispersed, massive and heterogeneous data is urgent and difficult problem



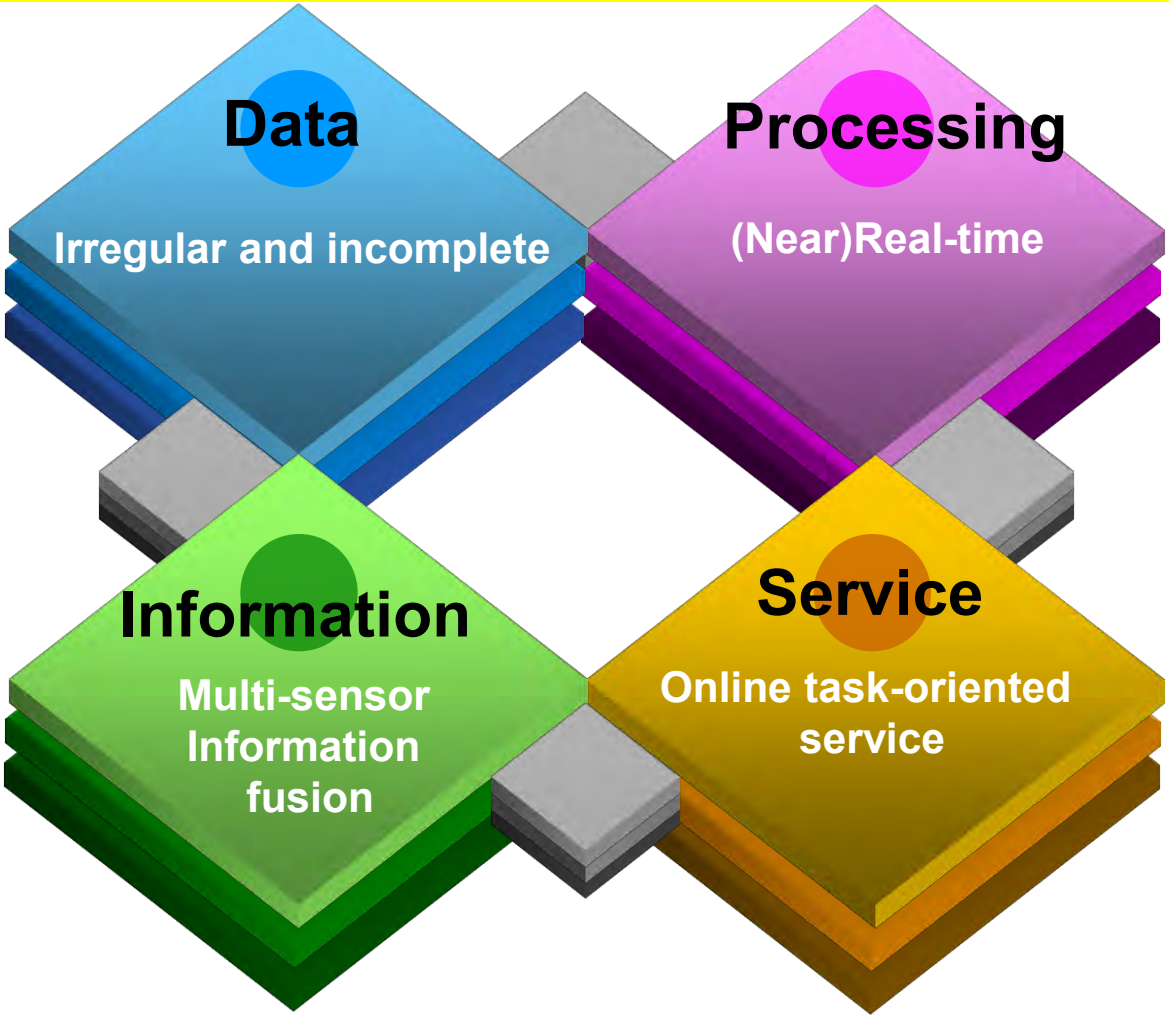
"Ingesting all of the data the agency requires remains a major challenge, regardless of how omnipotent an organization is perceived to be. And even once it is collected, analyzing it all in real-time is next to impossible. "

"To watch all the video that currently moves across the Internet in one minute would take five years to watch. And we can't ingest all that data at scale."

—Meyerriecks

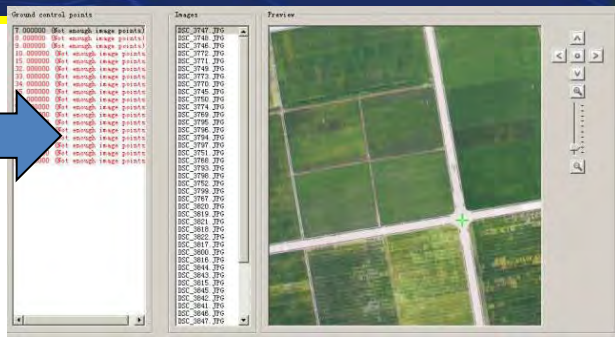
the Director of Central Intelligence Agency's Directorate of Science and Technology team

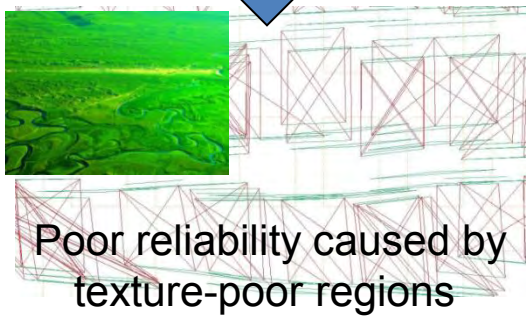
2、Main technical challenges



Core problem：Real-time continuous spatio-temporal Interpretation using discrete observation data

Challenge 1: Irregular and incomplete image data processing in emergency situations





Poor reliability caused by texture-poor regions

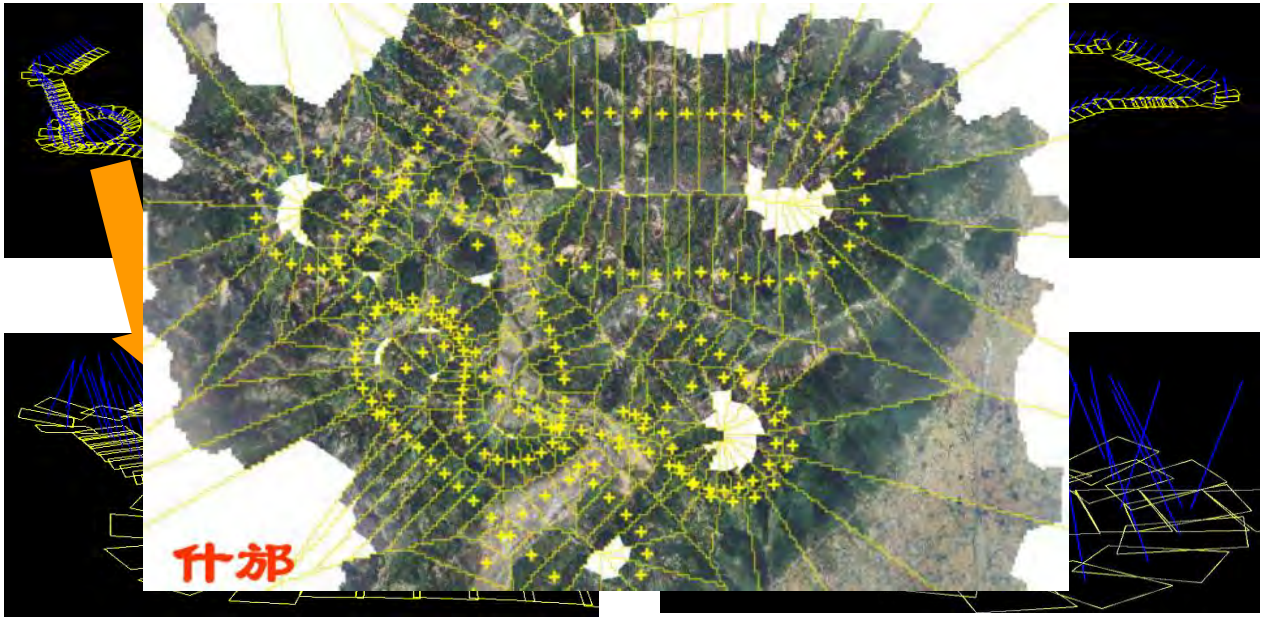
Difficulties:

- Incomplete fundamental data
- No (little) control points
- Irregular, incomplete and non-canonical UAV data processing caused by pose information instable and data errors.

Example 1: Irregular data processing

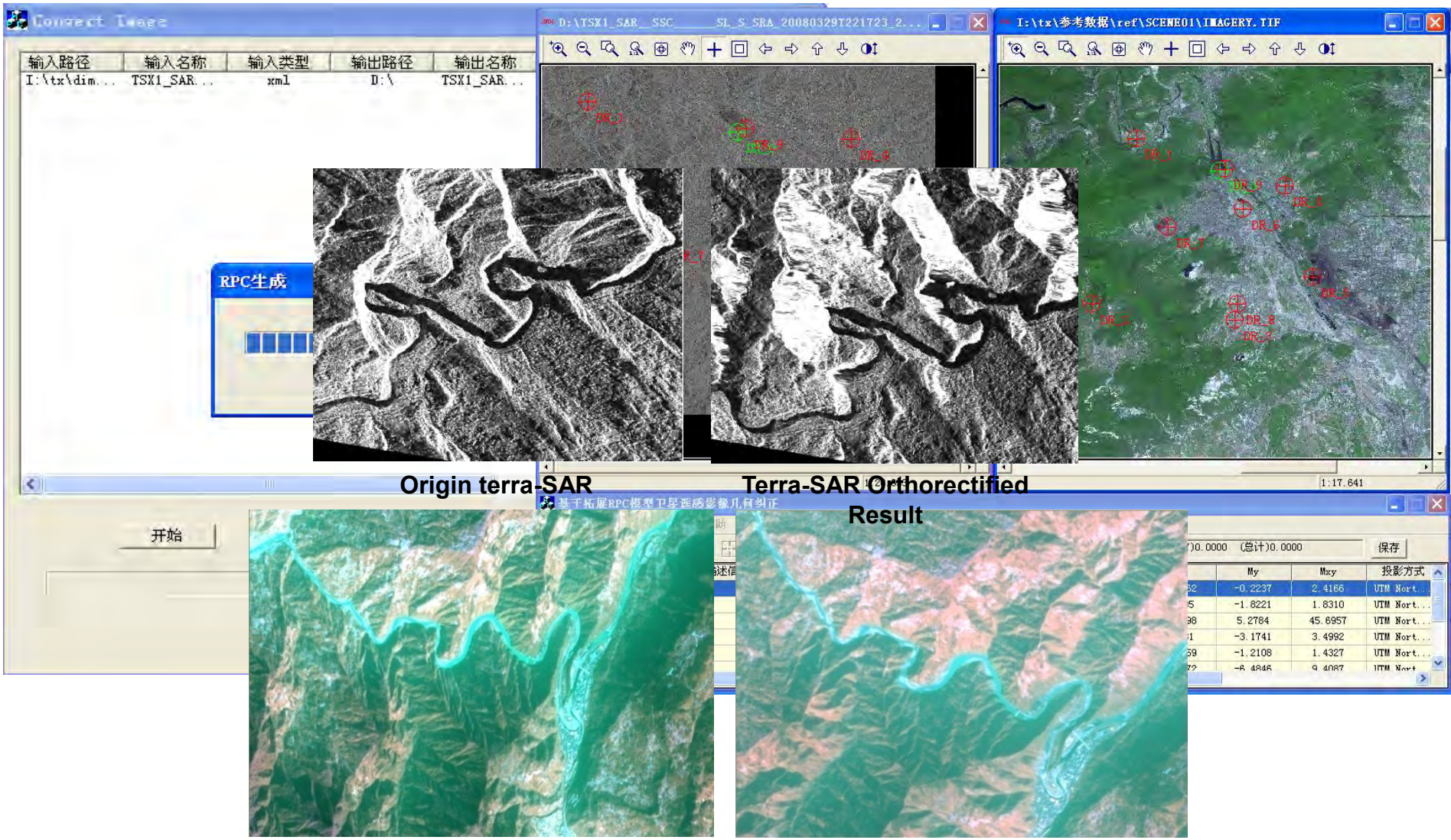
Breakthrough automatic image matching of unconventional aviation images in complex terrain and bad weather condition

Solve the problem of traditional operation mode's incapability of fast emergency response

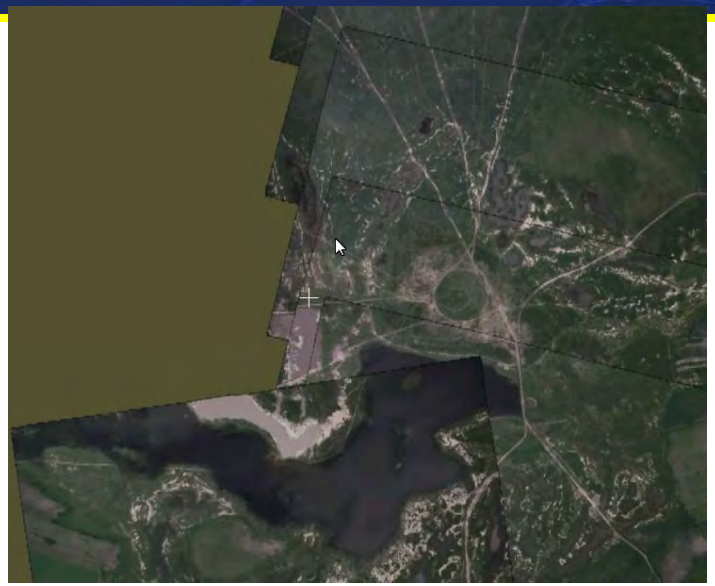


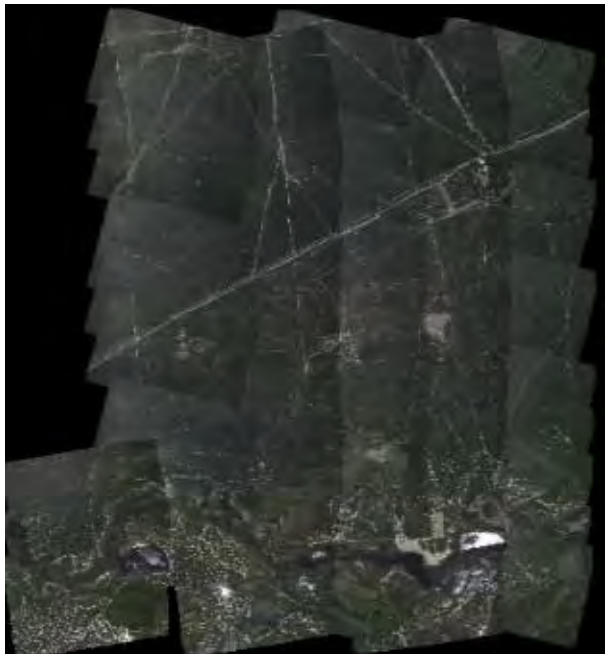
Simultaneous fly, view and imaging

Example 2: Ortho-rectification with few or without control points

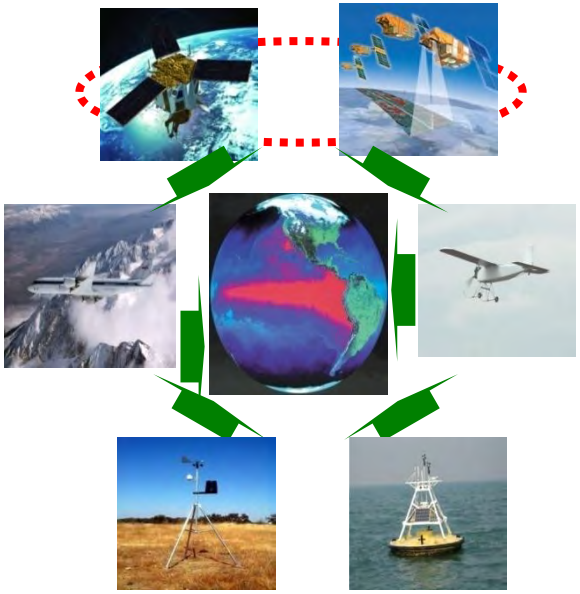


Example 3: Incomplete data caused by instable small UAV

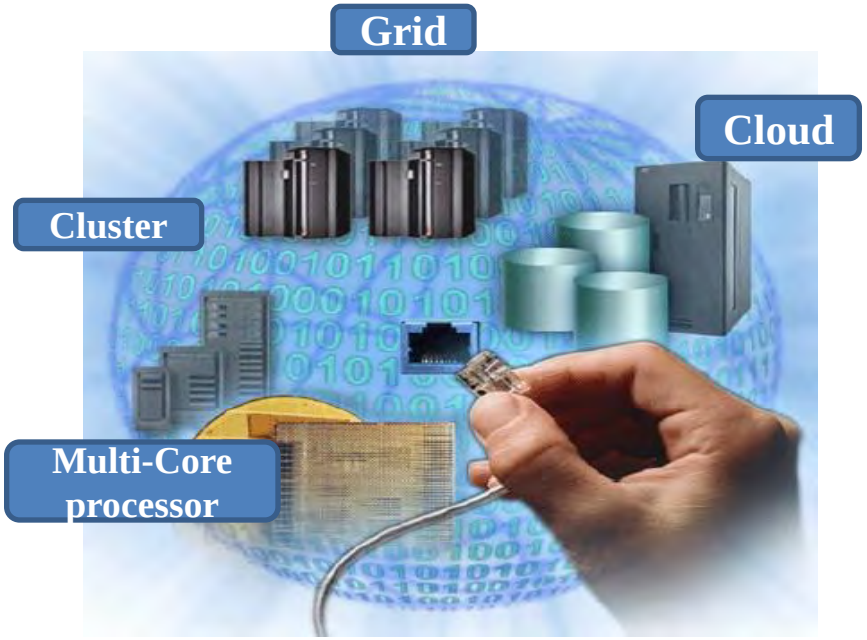




Challenge 2: Real-time processing of integrated space/aerial/ground sensor data



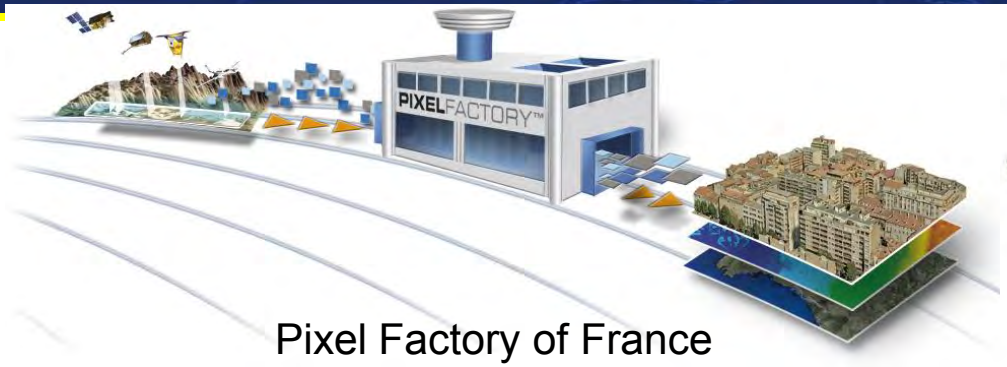
Real-time processing of integrated space/aerial/ground data is just the beginning



High-performance computing for Integrated hard/soft and big data

Difficulty: How to realize massive spatio-temporal data real-time high-performance computing?

Real-time processing is still a long way to go



Pixel Factory of France
（World-class remote sensing automatic processing system）

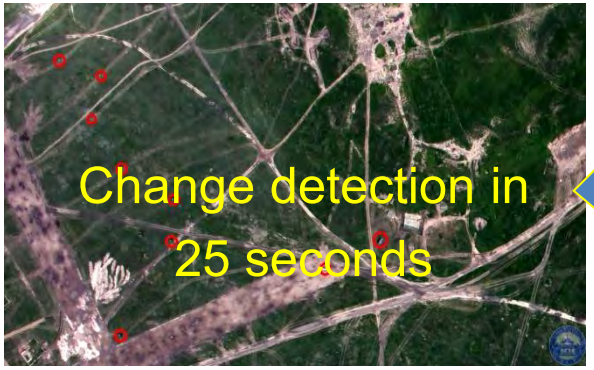
Pixel Factory of China
(DPGrid and PixelGrid)

“Building Rome in a Day”

Street Factory’s for 3D reconstruction
(Paris reconstruction in 2 days, 83%, 30%overlapping)

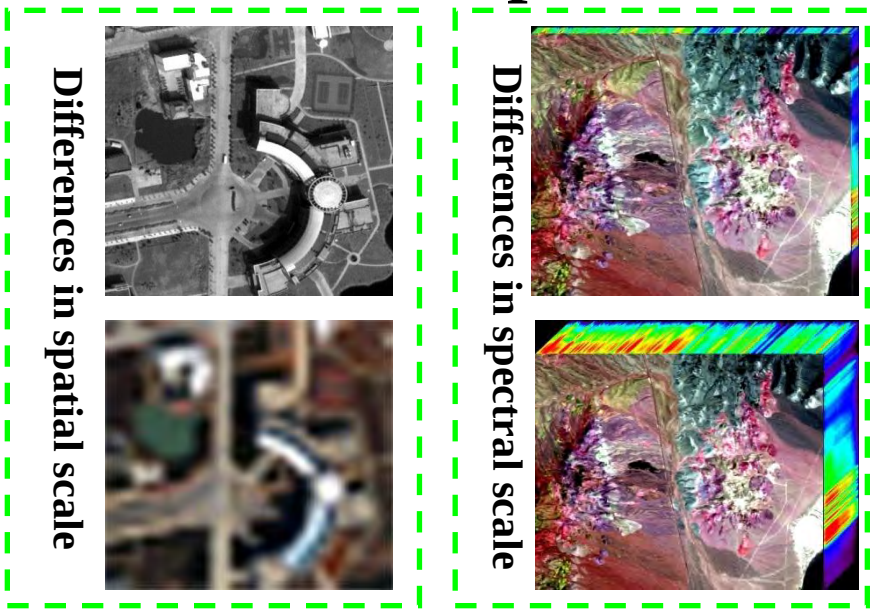
The batch processing techniques for satellite/aerial visible images has been very mature, and the 3D reconstruction of multi-angle camera images is gradually becoming practical.

Example : Real-time UAV image data products and change detection

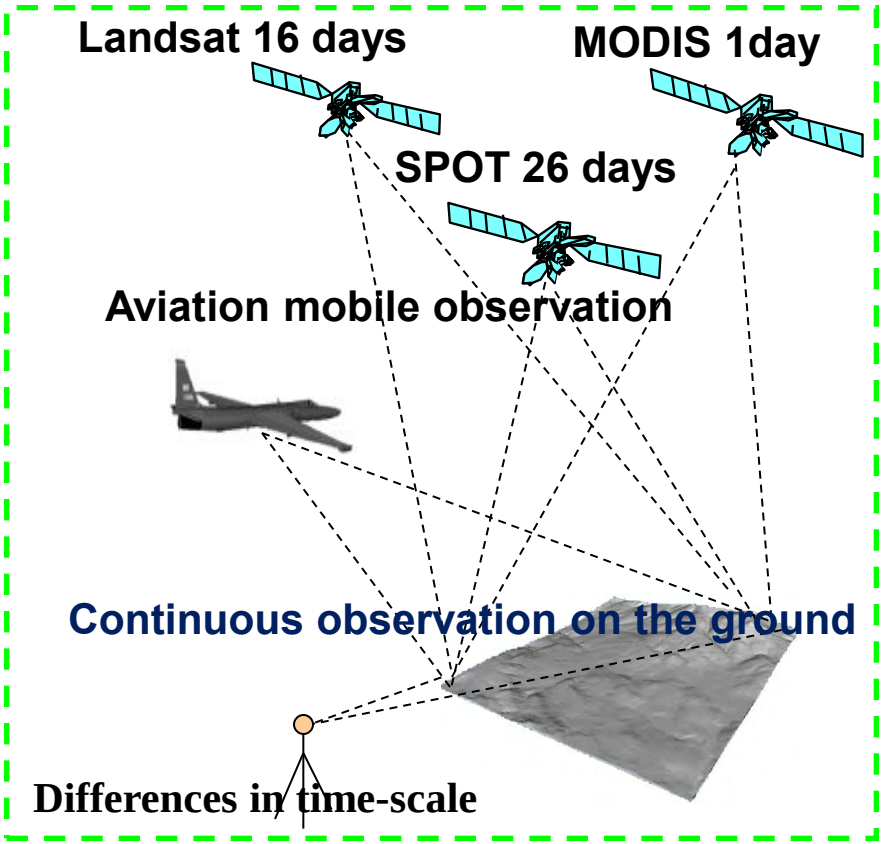


Challenge 3: Multi-sensor data assimilation and information collaborative computing

Problem description:

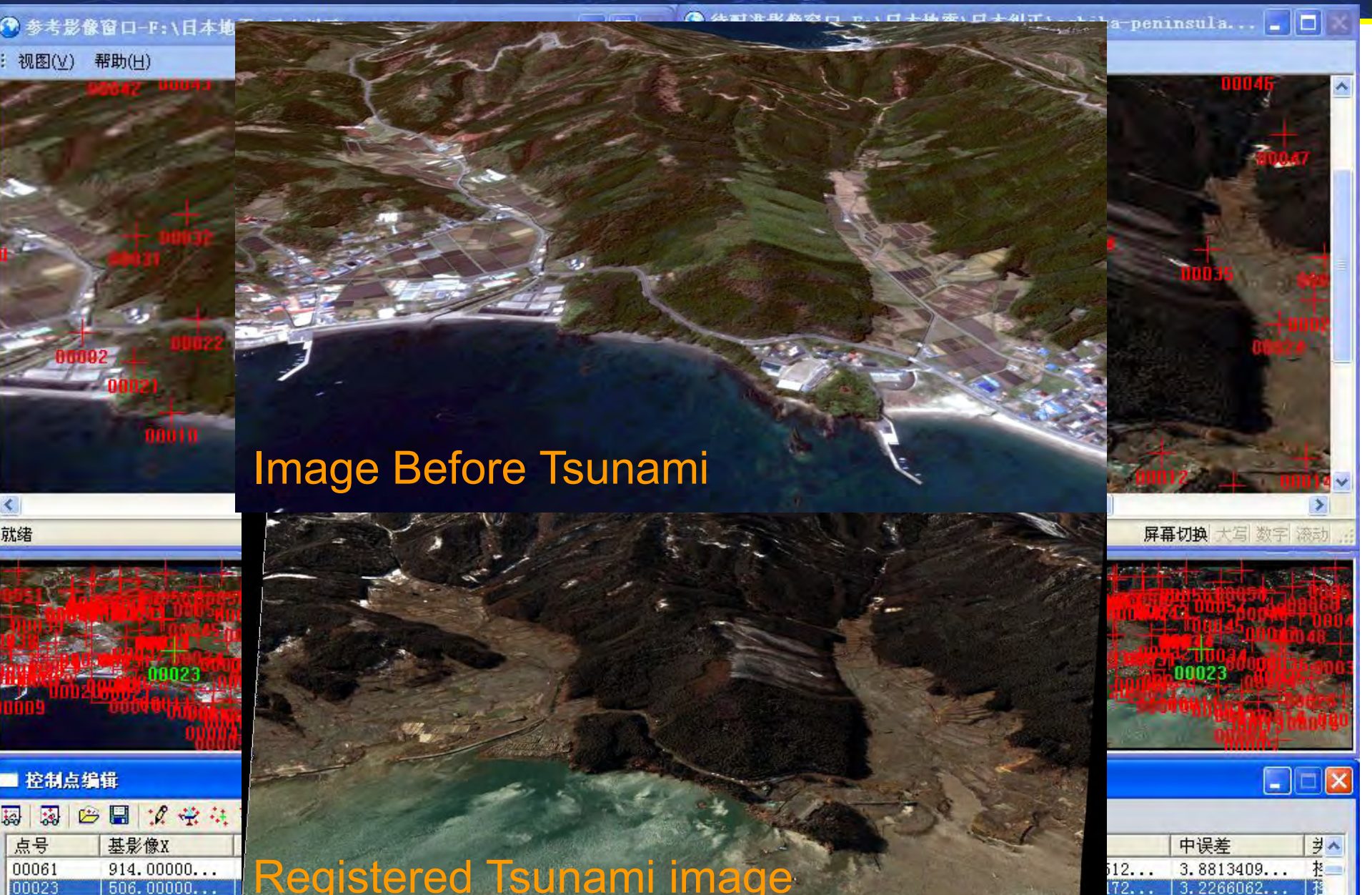


$$\hat{X} = \arg\max_{x} f[p_{spa}(X), p_{spe}(Y), p_{time}(Z), p_{All}(X,Y,Z)]$$

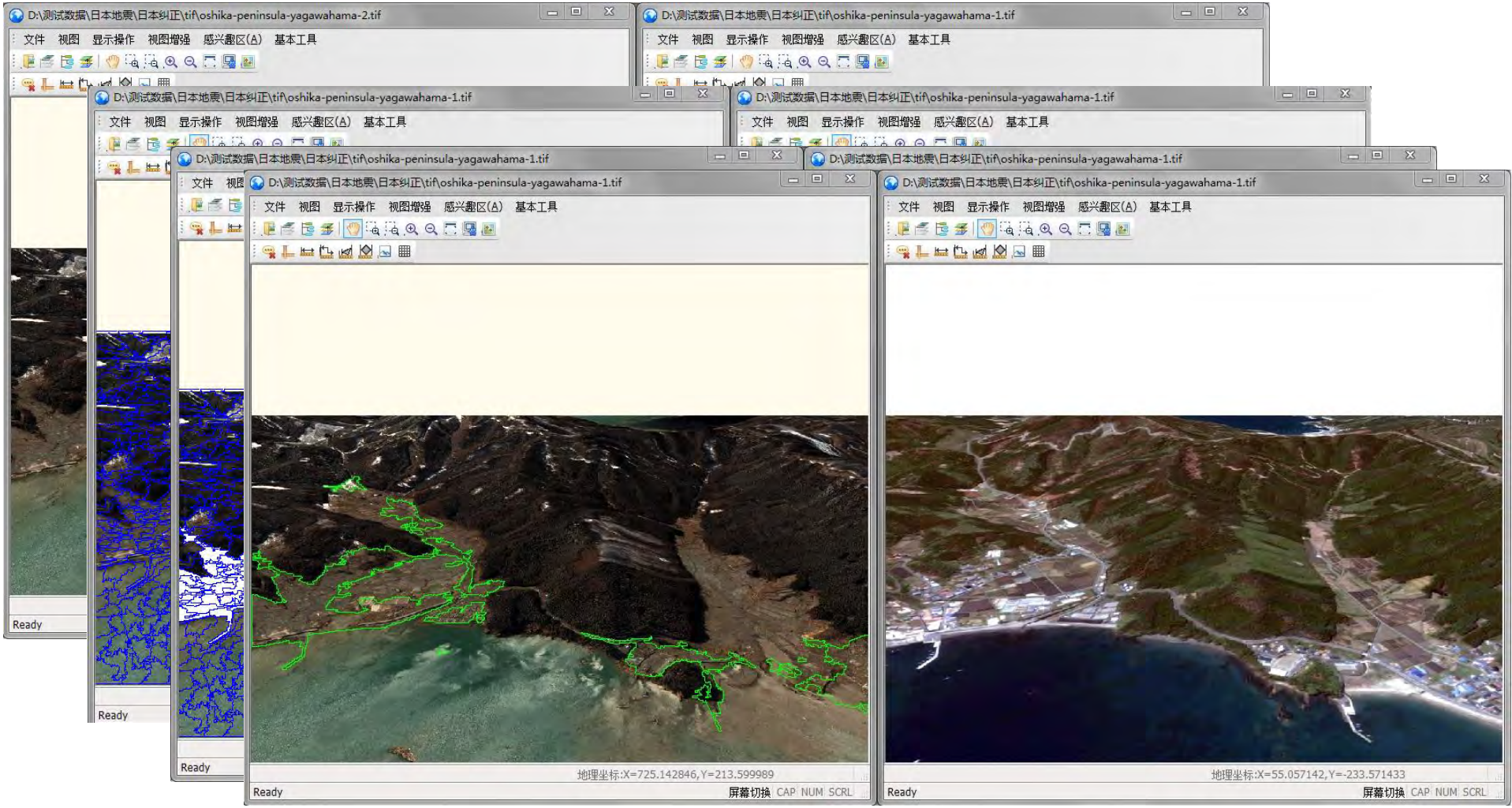


Difficulty: How to achieve assimilation and information fusion with multi-scale multi-temporal/spectral data?

Example 1: Oblique remote sensing image processing

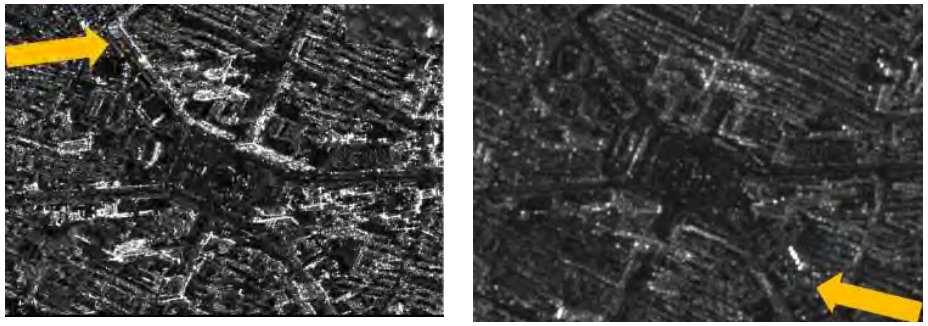


Building damage extraction based on object-level change detection

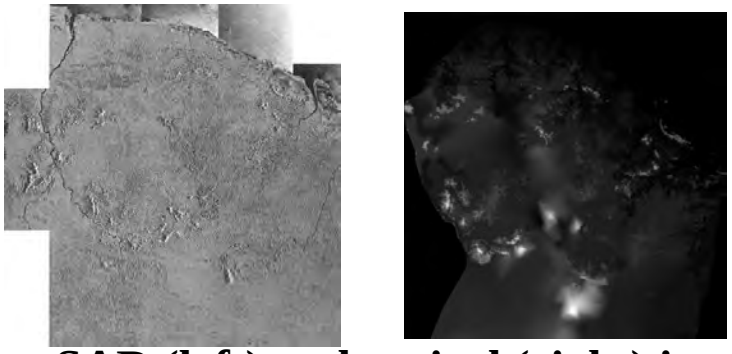


Object-oriented change detection results

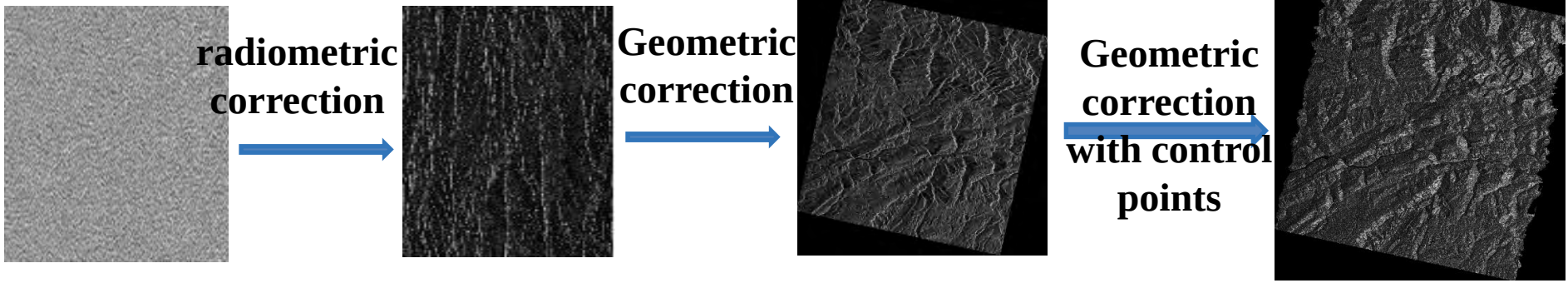
Example 2: Optical & SAR image registration



SAR images with same area and different side-looking

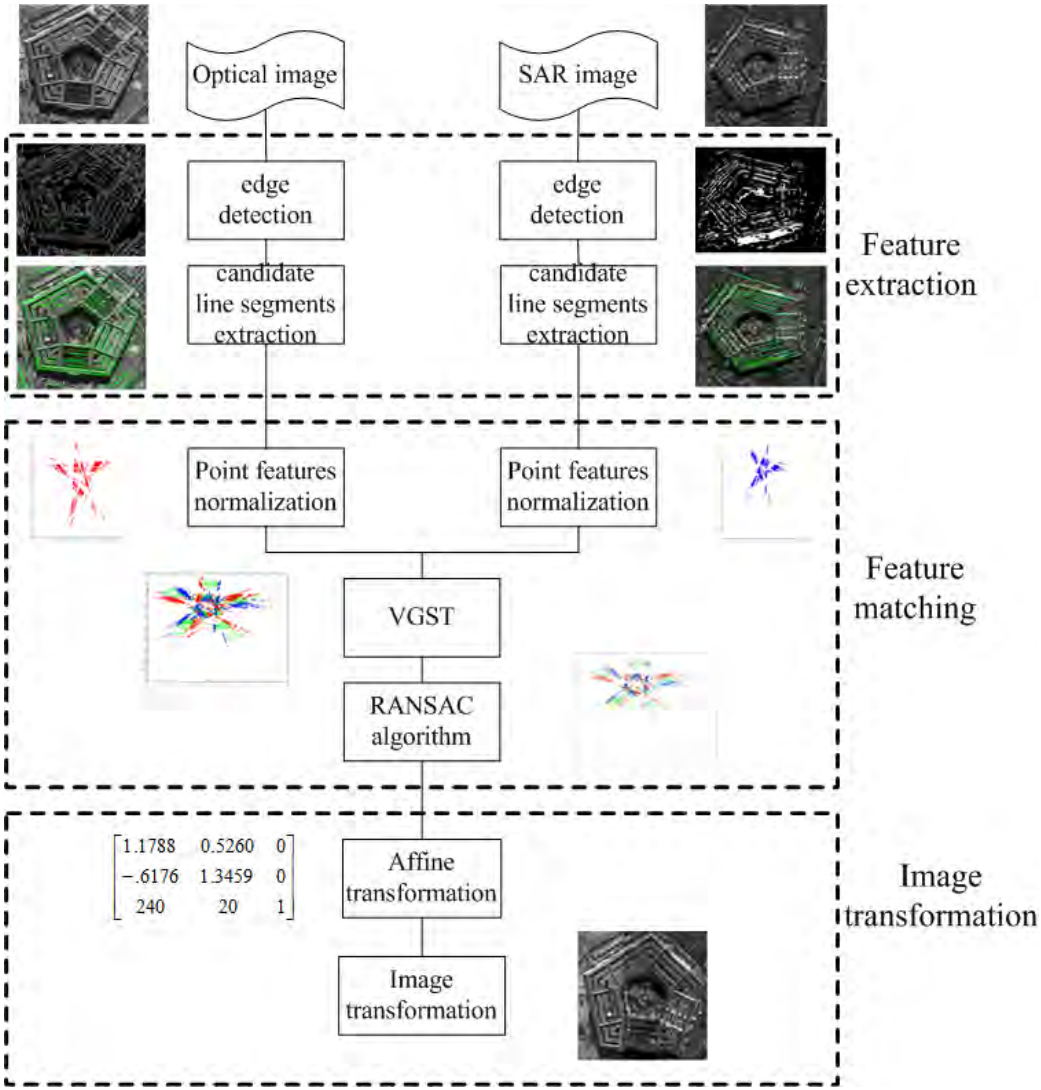


SAR (left) and optical (right) images with the same area



Difficulties: Different side-looking and resolution
Radiometric and geometric difference
Strong speckle noises *etc*.

An automatic optical and SAR image registration method based on VGST & line features



1) Most linear feature based methods use line segments or contours as matching primitive, however, we use line intersection as matching primitive so that conjugate line segment just needs to be collinear and several line segments can provide enough matching primitives.

2) As to matching point features, a new method called VSGT is introduced to improve the poor performance of traditional spectral graph theory (GST) based methods in sensitivity to local optimization.

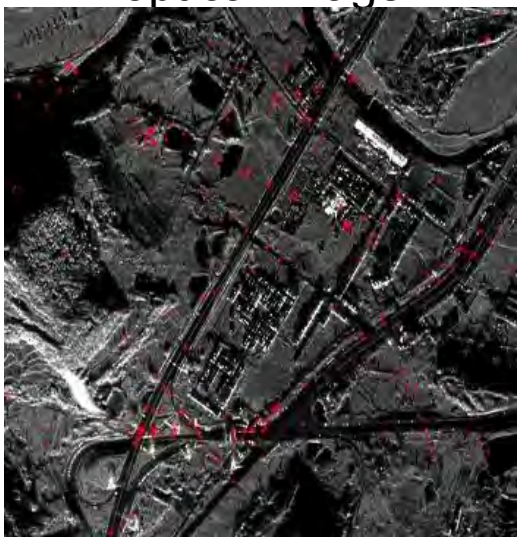
Optical image

Line detection of optical image

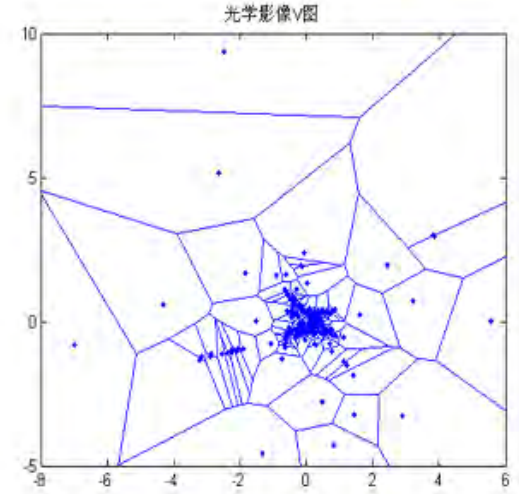
Line intersections of optical image

SAR image

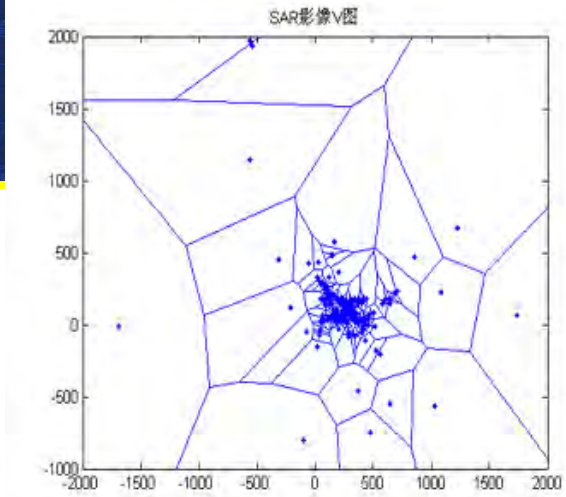
Line detection of SAR image



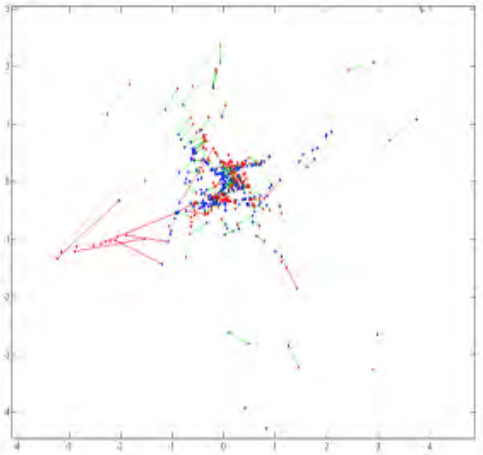
Line intersections of SAR image



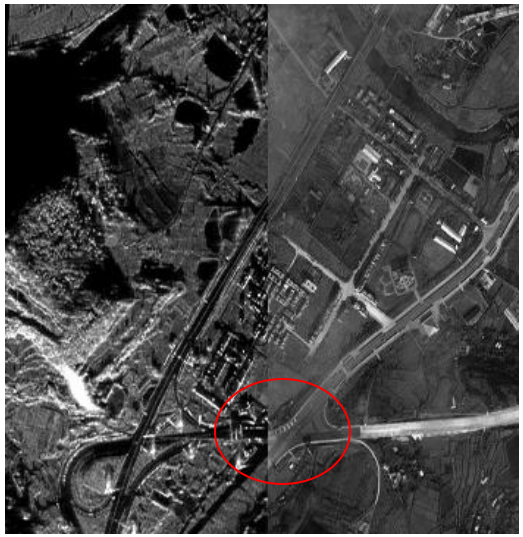
Voronoi diagram generated by points from optical image



Voronoi diagram generated by points from SAR image



Marching result of Voronoi diagram



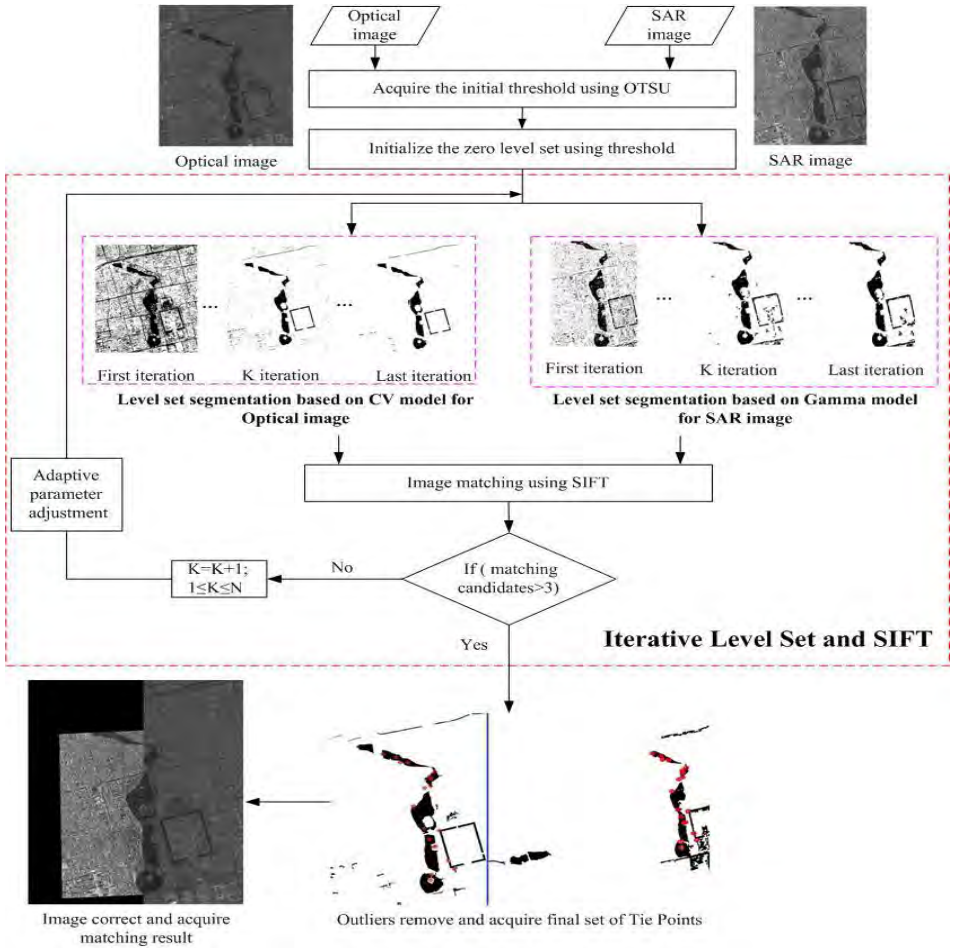
Registration result using MIOI (Chen *et al.,* 2003)

Registration result using MIHT (Suri and Reinartz, 2010)

Registration result using liner features and Voronoi diagram

A simultaneous image segmentation and registration method based on level set

- **Traditionally, segmentation and registration have been solved as two independent problems. However, if we use segmentation result for registration the segmentation methods become very important**
- **No matter which segmentation method we use ,it is almost impossible to obtain perfect registration result. So it is a good choice to integrate segmentation and registration simultaneously. And this is extremely important to real-time application**

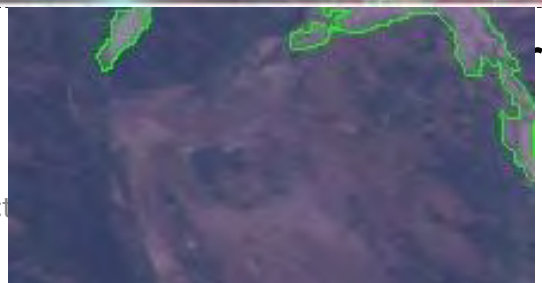


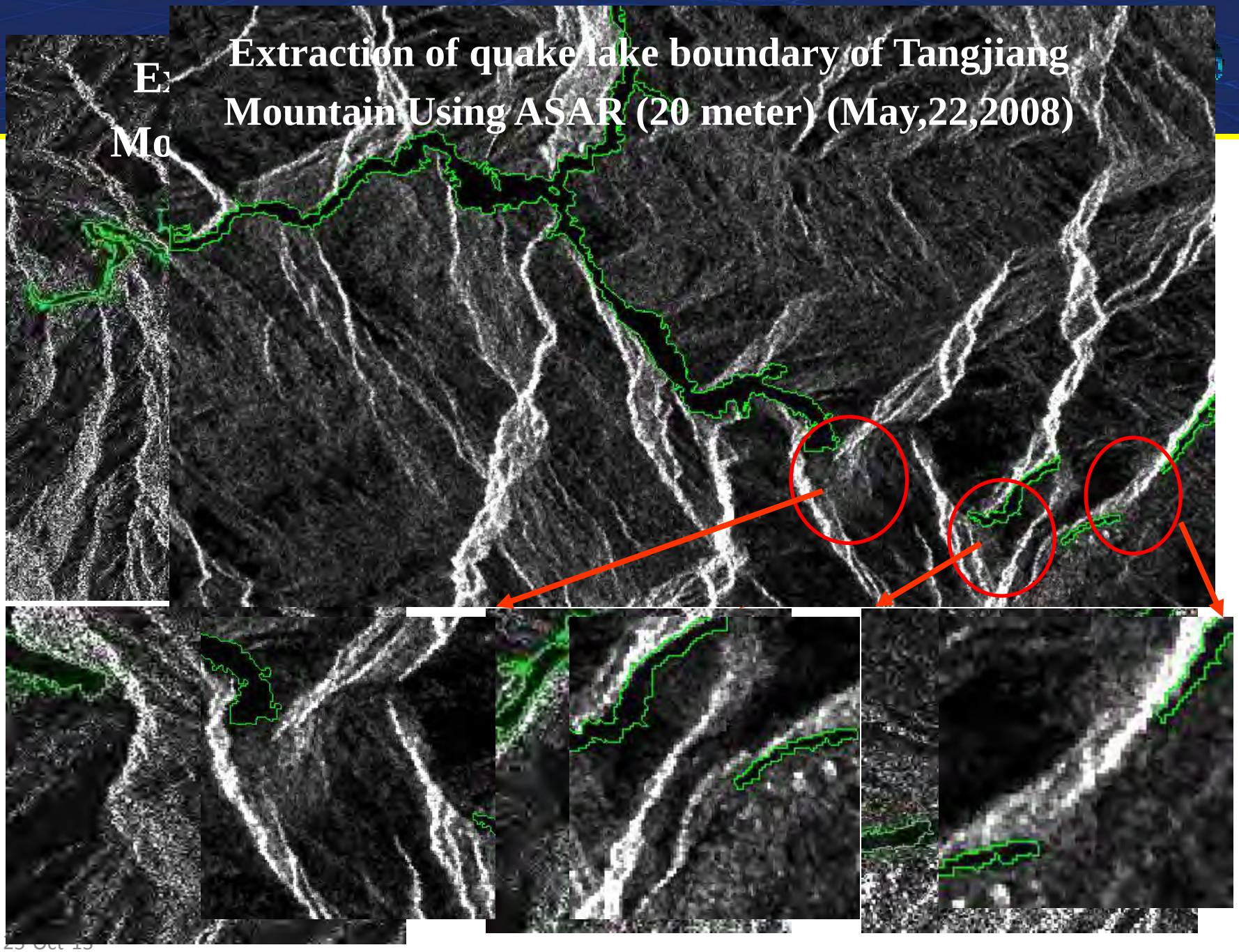
H. G. Sui, C. Xu, J. Y. Liu, K. M. Sun, C. F. Wen, 2012, "A novel multi-scale level set method for SAR image segmentation based on a statistical model" , *Int. J. Remote Sens.*, 33(17), pp.5600-5614.

Example 3: Extraction of quake lake boundary using multi-temporal optical and SAR images

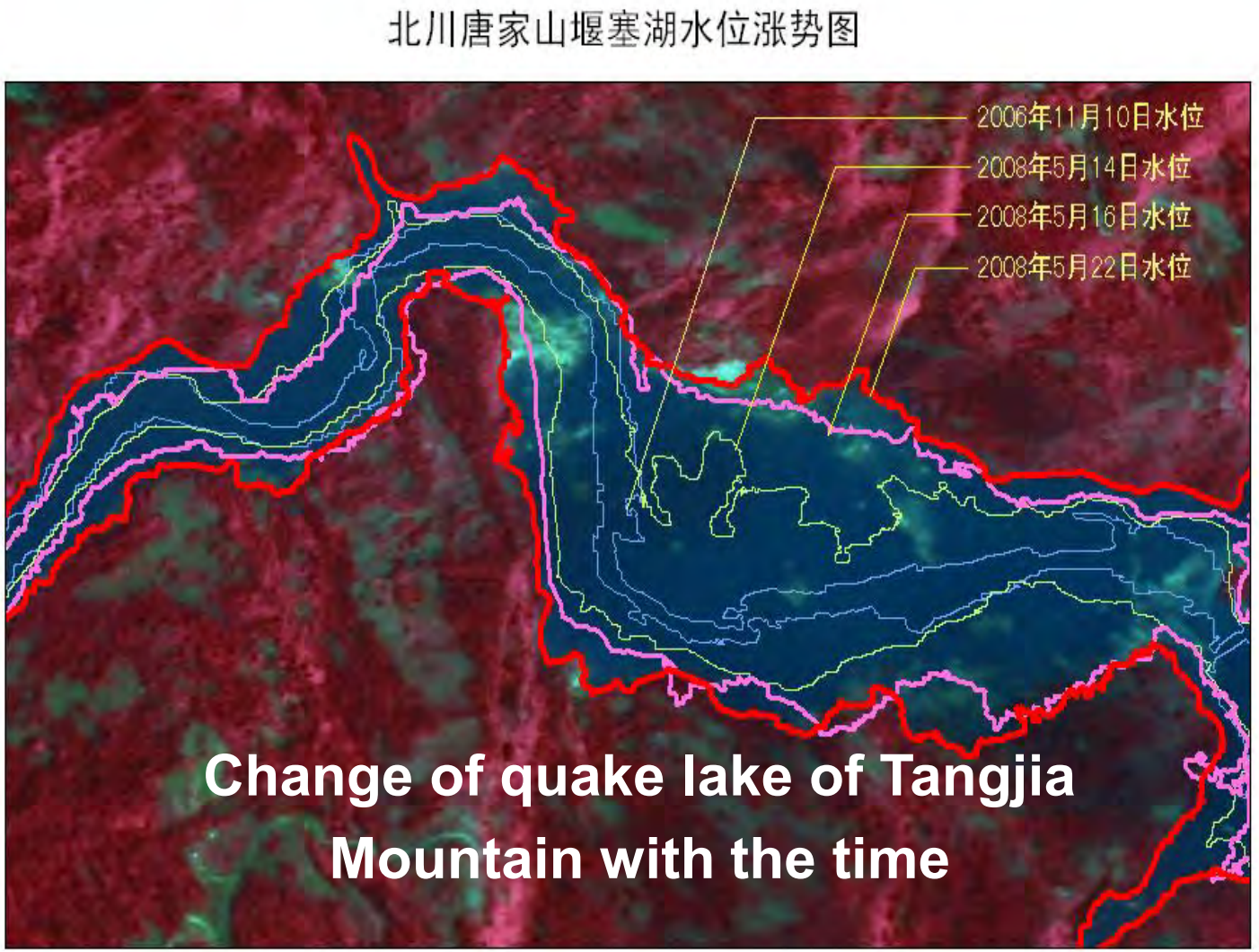
FW-2（2 meter）(May,14,2008)

Extraction of quake lake boundary of Tangjiang Mountain using SPOT5 (10meters) (May,16,2008)

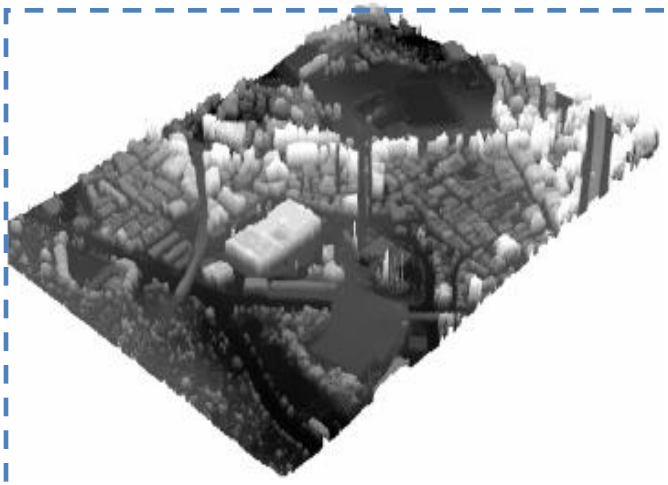



Extraction of quake lake boundary of Tangjiang Mountain Using ASAR (20 meter) (May,22,2008)

Airborne Monitoring Tangjiashan Quake Lake
Dam of Tangjiashan Quake Lake



Example 4: 3D change detection using optical image and LIDAR data

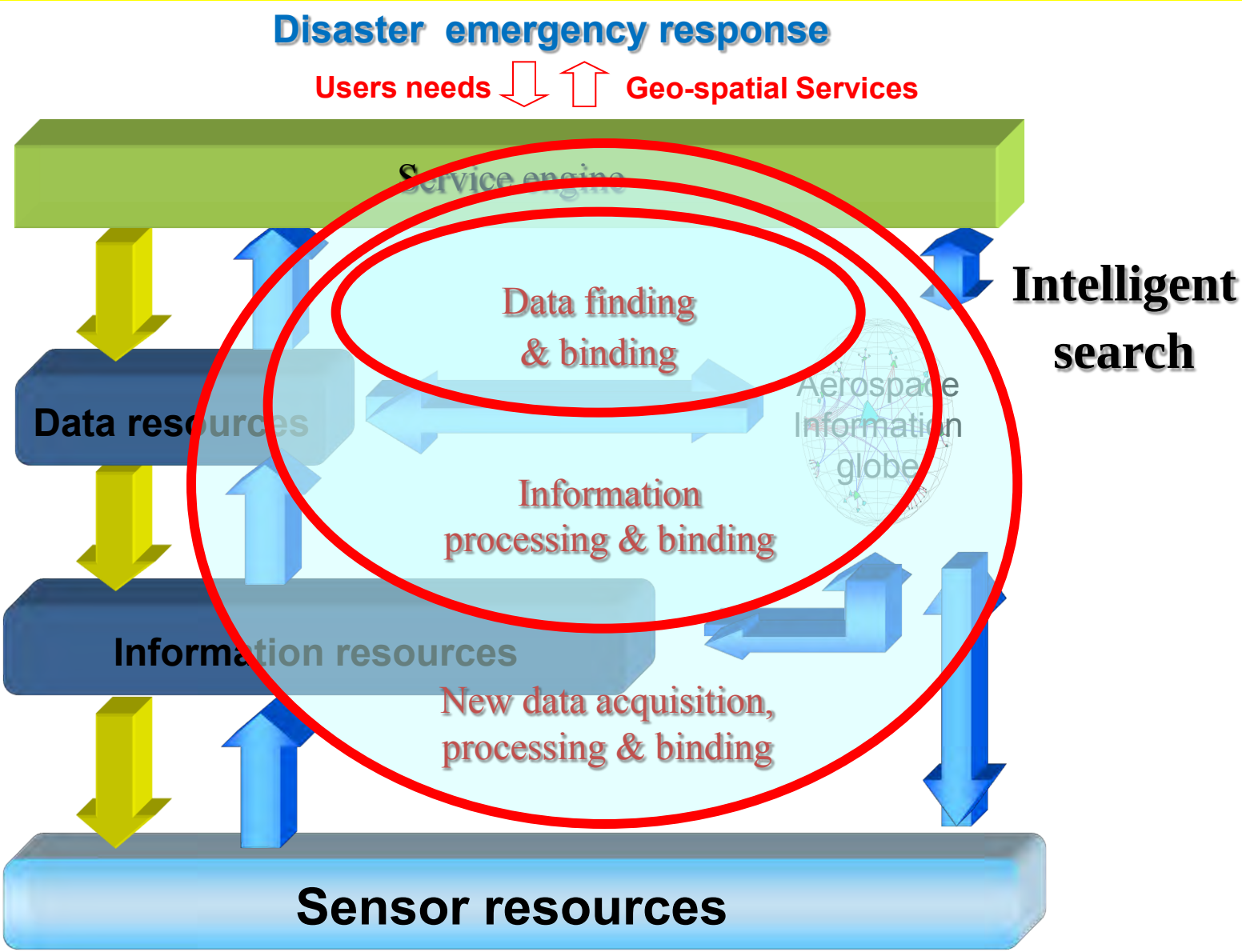


LIDAR data

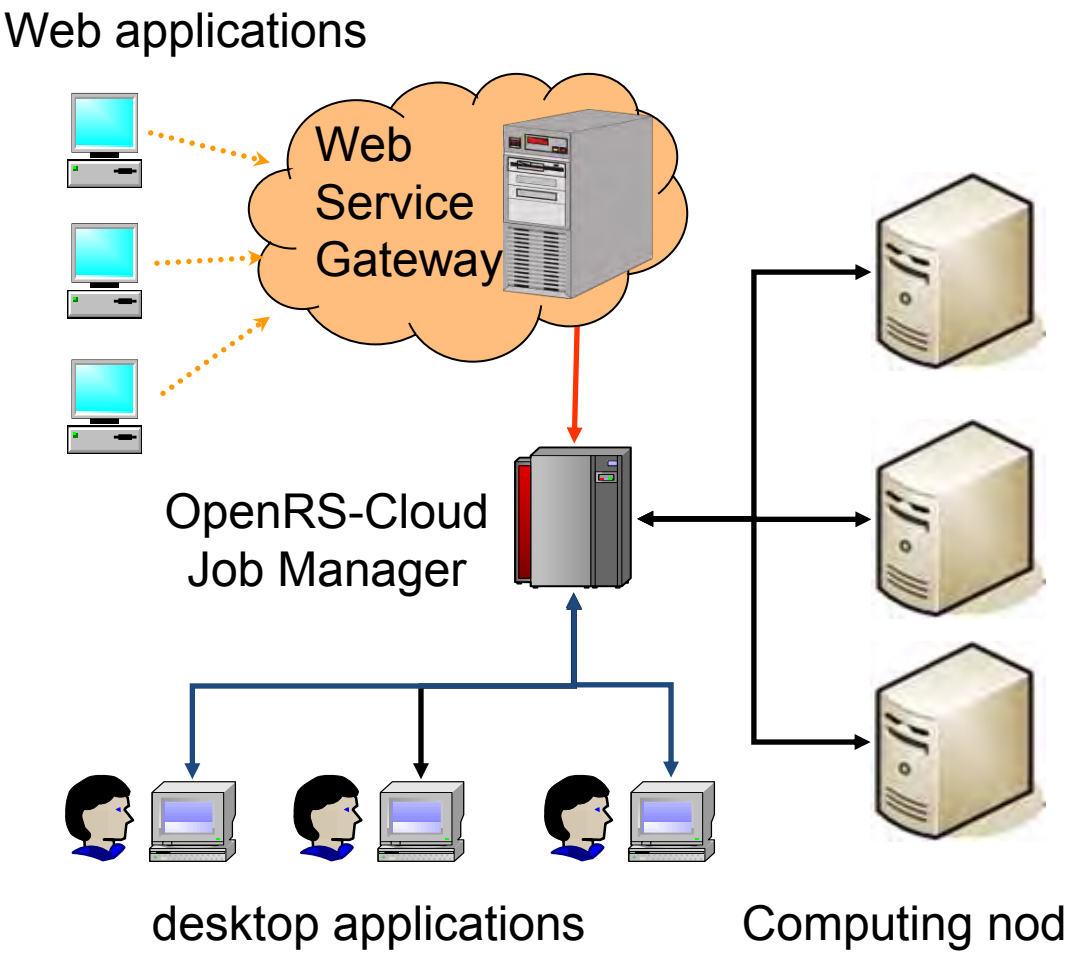
New 3D model generated using UAV images

3D change detection result

Challenge 4: Online task-oriented service



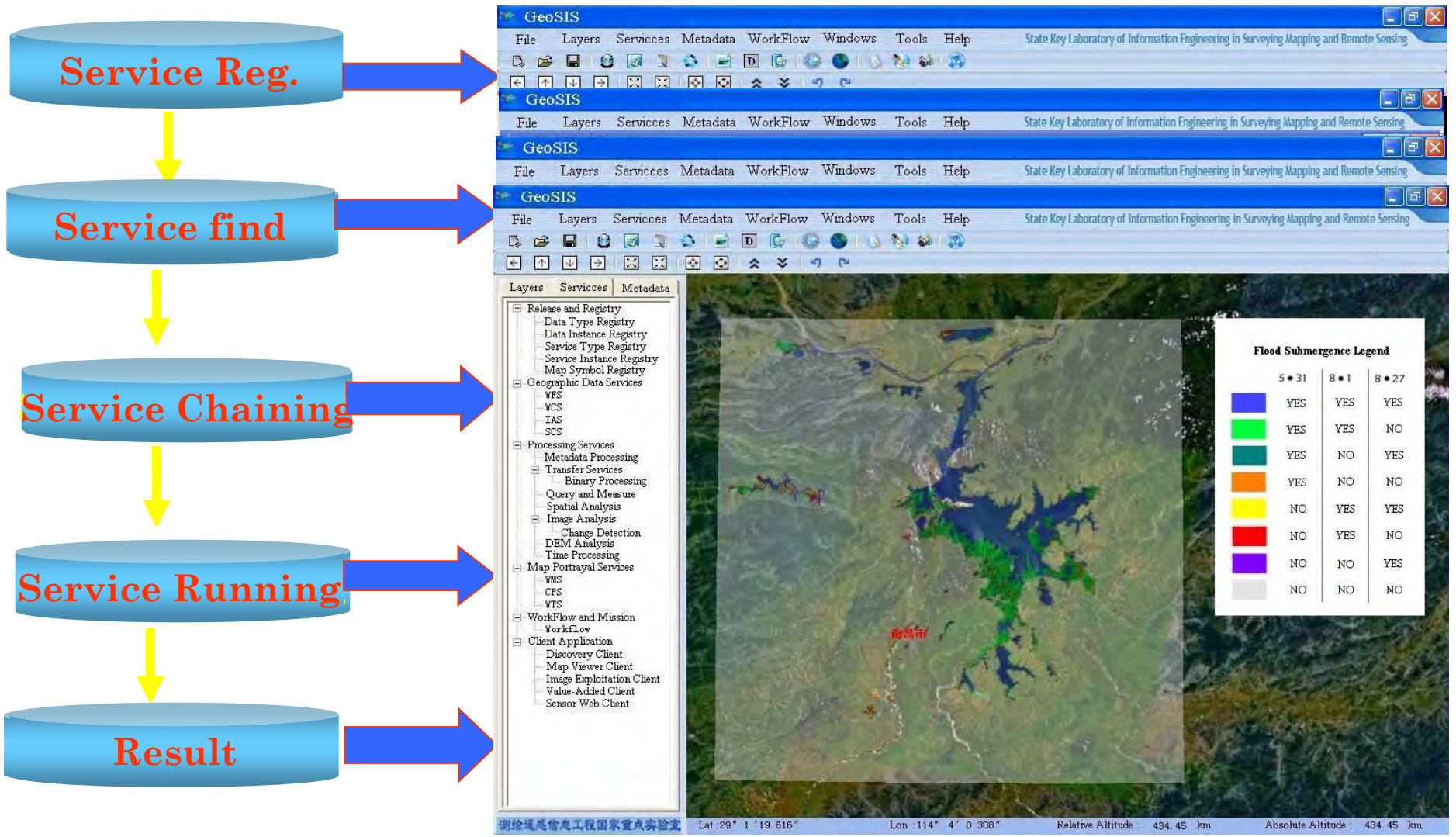
OpenRS: Remotely sensed cloud platform



Provide opening architecture for desktop processing, distributed and parallel processing, network service processing.

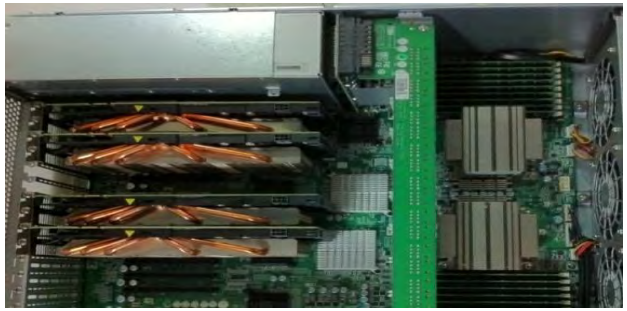
http://www.openrs.org

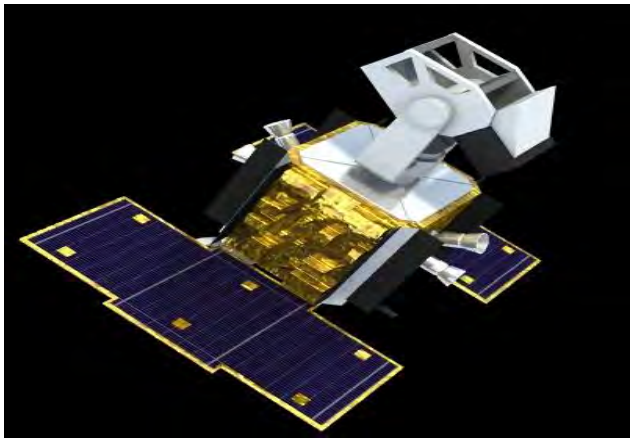
Example :Online flood disaster monitoring service



Visualizing of geoprocessing result in GeoGlobe

Challenge 5: Onboard real-time processing





Onboard processing are mainly concentrated in some data preprocessing algorithms, automatic advanced products generation and information extraction are still very difficult

3、Conclusions

4R service

（At the right time and right place to deliver the right information to the right people)

5R real-time service

（At the right time and right place to real-time deliver the right information to the right people）

“The world is changing very fast. Big will not beat small anymore. It will be the fast beating the slow.”

— Rupert Murdoch

“By 2012, 70% of Global. 1000 organizations will load detailed data into memory as the primary method to optimize BI application performance.”

- Gartner


Thank you !
Welcome to Wuhan University!