Satellite CT Scanning for Urban Infrastructural Health Diagnosis

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Contents

- Introduction
- Principles
- Case Works
- Future Research
Introduction - rapid urbanization

Rapid Urbanization in PRD Region
to be one of the largest bay areas
Mapping Impervious Surfaces with Satellite

Remote Sensing of Impervious Surfaces in Tropical and Subtropical Areas

Hongsheng Zhang, Hui Lin, Yuanzhi Zhang, & Chi-hao Wong

Building Height Retrieval for Urban Climate Research

Fusion of WorldView-2 Stereo and Multitemporal TernsAR-X Images for Building Height Extraction in Urban Areas

Yong Xu, Peilong Ma, Edward Ng, and Hai Lin, Senior Member, IEEE

Building height retrieval: The heights of buildings can be retrieved from WorldView-2 stereo images, which are typically acquired using multi-spectral and panchromatic sensors. The stereo pairs are processed using a structure from motion (SfM) approach to generate dense point clouds. The heights of buildings are estimated by comparing the point clouds with ground reference data. This approach allows for the retrieval of building heights at a high level of detail.

Sketch of an Urban Heat-Island Profile

Urban heat island effect: The urban heat island effect is a phenomenon where urban areas have higher temperatures than rural areas due to the presence of buildings and other urban infrastructure. This effect can be studied using satellite imagery to analyze the spatial distribution of temperatures in urban areas. The impact of the urban heat island effect on climate can be assessed using models that incorporate satellite data and other environmental factors.
Introduction - rapid urbanization

A Trend: Urban Underground Use
Asia's largest underground railway station opens in Shenzhen

A passenger buys ticket at the Putian underground railway station in Shenzhen, South China's Guangdong province, Dec. 30, 2015. Asia's largest underground railway station opened on Wednesday in the southern Chinese city of Shenzhen, slashing high-speed rail service between Guangzhou and Hong Kong and the new line slashes travel time between Guangzhou and Hong Kong to half an hour. [Photo/Xinhua]

Ground Surface Subsidence and Landslide

[Image: ground subsidence and landslide map]

(cm/yr)
Introduction - urban geo-hazards

2016年11月8日，日本福冈市出现大面积道路塌陷

福冈博多车站地陷1人伤
网民苦中作乐 改图想像哥斯拉襲擊
Conventional Engineering Methods

Leveling

GPS

Computed Tomography (CT)

X-Ray Computed Tomography. X-CT can help to generate the 3D images of our body or part of our body.

Regular CT Scanning for Health Checking
Principles

Data transmission and processing

SAR sensor

Ground station

downlink

Digitalization, data storing
Principles

The innovations of The Chinese University PS method

1. Develop a reliable network with adaptive densification to mitigate the atmospheric delay and avoid isolated areas
The innovations of The Chinese University PS method

2. Integrate SAR tomography with conventional PSInSAR in a unified processing chain (no need for spatiotemporal filtering to remove atmospheric delay) to resolve layover problems in complex built environments.

![Diagram showing PSInSAR and TomoSAR](image)

**PSInSAR**  
Layover problem  

**TomoSAR**

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The innovations of The Chinese University PS method

3. Employ ridge-estimator to improve the robustness of network adjustment

![Maps showing height, thermal amplitude, linear deformation velocities](image)

- LS-estimator result
- Ridge-estimator result
- Difference map
The innovations of The Chinese University PS method

4. Introduce seasonal temperature function to approximate thermal expansion and improve the monitoring capability for skyscrapers, bridges, railways and etc.

Red: linear fitting; Blue: linear and nonlinear fitting

Case Works - buildings
Case Works - buildings

Linear deformation velocity

Case Works - sinkhole

Jingzhou Building

Linear deformation velocity

Time series
Case Works - reclamation airport

Height

Case Works - reclamation airport

Mean settlement velocity
Generally, the difference is under 5 mm.

~100,000 measurement points per km²
~100,000 measurement points per km²

Case Works—shanghai subway

Mean settlement velocity
Case Works - highway

Linear deformation velocity

Case Works - bridge

Thermal amplitude

Linear deformation velocity
Case Works- dam

Summary

- We need to pay more attention to those hidden risks as the results of rapid urbanization
- The health of urban infrastructure should be regularly checked with efficient ways
- InSAR technology can help for building up the urban “CT” platform
- A Space/ground based integrated platform could provide a solution for monitoring the urban infrastructure health
Future Research

Key issues:

- How to standardize methodologies for engineering and scientific use
- How to construct multi-level (individual-, district-, city-, regional-, national-level) monitoring system
- How to establish an early-waning system for urban infrastructure diagnosis

Thanks!