GeoGRID: integrated platform for applications of remote sensing

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FORMOSAT-2 Image Application and Distribution Center

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Outline

- Remote sensing
- Why GeoGRID?
- International GeoGRID project
- Taiwan GeoGRID
- FORMOSAT-2 Automatic Image Processing System
- Examples of applications
- Summary
Remote sensing

- **Definition**
- **Spaceborne remote sensing**
  - Sputnik (1957)
  - More than 8000 satellites have been launched so far
  - Play a more and more important role in our daily live
    - Resource investigation
    - Disaster mitigation and prevention
    - Environmental monitoring
    - National security
Remote sensing (cont.)

- **Development of Remote Sensing**
  - Data acquisition – rapid increase in resolutions
    - FORMOSAT-2 ~ 20GB/day (only Taiwan area)
    - ASTER ~ 70GB/day, a total of 150 TB collected from 2000 to 2008
    - ALOS ~ 1TB/day
  - Data analysis – complicated and computational demanding
    - Various methods/algorithms developed for various applications
    - Incorporation with geospatial data or models
  - Synergic operation
    - Rapid access and distribution
    - Protocol for various format/specification
  - Real-time applications
    - International Charter "Space and Major Disaster"
    - Site surveillance and environment monitoring
Remote sensing (cont.)

- Current situation of applications in Remote Sensing
  - A lot of time and effort are spent in image processing
  - Most of the research results are difficult to implement
  - The ratio of data utilization is embarrassingly low
  - No capability to access and analysis all data available

- Urgently need an integrated platform to solve the problems once for all
Why GeoGRID?

- General idea of GRID
  - A lot of computing
  - Advanced and important technique/knowledge
- GRID
  - Computing cluster grid
  - Data grid
  - Sensor grid
  - …
- An ideal solution for remote sensing
- International GeoGRID project
International GeoGRID project

- **AIST GeoGRID infrastructure**
- **GeoGRID features**
  - Gfarm file system replaces the tape-based traditional system for satellite data processing
    - Huge data sets can be immediately shared among international core researchers
    - High-performance data processing from raw data to the higher level products on demand
  - Certification Authority provides privileged users with secure access to the data
- **A big picture of GeoGRID**
- **Taiwan GeoGRID?**
Taiwan GeoGRID

- Disaster Prevention Research Center (DPRC), NCKU
  - FORMOSAT-2 Image Application and Distribution Center
  - ASTER
  - MODIS
- Collaboration between AIST and DPRC
- FORMOSAT-2
  - Specifications
  - Missions
  - Characteristics
  - Automatic Image Processing System
Specification of FORMOSAT-2

- Weight: 742 kg (with payload and fuel)
- Shape: Hexahedron, height 2.4 m, outer diameter about 1.6 m
- Orbit: 891 km, Sun-synchronous, 2 Passes over Taiwan Strait each day
- Panchromatic (PAN): 0.45~0.90 µm
- Multi-spectrum (MS):
  - 0.45~0.52 µm Blue
  - 0.52~0.60 µm Green
  - 0.63~0.69 µm Red
  - 0.76~0.90 µm Near Infrared
- Ground Sampling Distance (GSD):
  - 2 m for black and white images
  - 8 m for color images
- Swath: 24 km
- Mission Life: 5 years
- Launch Date: May 21, 2004 (Taipei Time)
Missions of FORMOSAT-2

- Natural Disaster Evaluation
- Agriculture and Forestry Prediction
- Land Usage Analysis
- Environmental Monitoring
- Coastal Search and Rescue
- Academic Research and Extension Education
Characteristics of FORMOSAT-2

- Daily revisit orbit
- High spatial resolution
- True color image
- Long strip of image acquisition
- Challenge of coregistration
FORMOSAT-2 AIPS
Automatic Image Processing System

- Level-1A and Level-2 products
- Band-to-band coregistration
- Multi-temporal matching
- Automatic orthorectification
- Time series analysis
- Change detection
Examples of applications

- Site surveillance at Kaohsiung International Airport and Kaohsiung Harbor using daily revisit imagery taken by FORMOSAT-2
- Illegal quarry mining of gravel on the riverbed
Summary

- GeoGRID would be able to provide an integrated platform that is ideal for applications of remote sensing
- FORMOSAT-2 IADC at DPRC, NCKU
  - All FORMOSAT-2 imagery
  - FORMOSAT-2 AIPS → core technology
  - Understand the needs and applications of remote sensing
  - Domain export in remote sensing for developing GeoDRID
- Team up for the Taiwan GeoGRID project
  - Resource of manpower, facility, travel, ...
  - Participate and contribute to the international GeoGRID project
  - 15 + 30 billion NT dollars
  - 15 + 15 years
Thank you for your attention
AIST GeoGRID infrastructure

Virtual Interface

User Interface

Application & Catalogue

Storage

Hardware

GEON Catalogue

Web Service

Portal

GSI

GeoGRID Catalogue

Application Service

DB

Gfarm filesystem

GeoGRID Cluster

ASC

210TB Gfarm filesystem
P4 3.5TB (raid5)/node x 60

AIST SUPER CLUSTER

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A big picture of GeoGRID

GeoScience platform

CCOP
Coordinating Committee for Geoscience Prj. in East and Southeast Asia

KIGAM
GSJ
GSI

USGS
KISTI
GTRC

IT Infrastructure enabled by GRID

GeoGRID: integrated platform for applications of remote sensing
Characteristics – Daily revisit orbit
Characteristics

- True color imagery

Song-He Community
**Characteristics – long strip**

- Remote sensing instrument (RSI)
  - Build by EADS Astrium SAS, France
  - high electro-optical performance
  - no need to enlarge the integration or the imaging time
  - can take a much longer strip of image
  - meet high accuracy imaging requirements for earth observation systems
Characteristics – long strip

Reprint from Liu et al. 2005
Challenges

- Band-to-band misregistration
  - Example: Bulgaria (from SPOT Image)
- Pan-to-ms misregistration
  - Example: Dong-Sha Atoll (from NSPO)
F-2 AIPS – level-1A and level-2

- FORMOSAT-2 terminal (F2T)
  - Basic image processing system
  - Level-1A product
    - Basic radiometric calibration applied
    - Geometrically distorted
    - Lacks of georeference information
  - Level-2 product
    - Using the ephemeris data on-board
    - Projecting the raw image onto a spheroid
    - Standard deviation of geometric accuracy
      - \( \sim 150m \) (Liu et al. 2004)
    - Geometric shapes of ground features retained
F-2 AIPS – level-1A and level-2
F-2 AIPS – level-1A and level-2

NSPO Procedure

1. Take Image from target area
2. Original data archive
3. Original data check and deliver

NCKU IDAC Procedure

1. Import GERALD field
2. Build up PROJECT
3. Search associated image
4. Check image property
5. Level 1A product orders
6. Level 2 product orders
7. Products archive
F-2 AIPS – coregistration

- Not a unique problem of FORMOSAT-2
  - Any sensor with multiple telescopes → have the same problem to a certain extent
- ASTER solution (Iwasaki and Fujisada 2005)
  - Pre-flight period: Collimator data → preliminary geometric database
    - LOS vectors, cross-track pointing axis vectors that are both expressed toward the navigation base reference
  - Initial checkout period: acquired image + GCPs → fine tune-up the geometric database
  - Normal operation period: the image matching technique → compensate a dynamic part of the pointing stability + tune-up the geometric database
- FORMOSAT-2 solution: FNCC image matching technique (Liu 2006, in revision)
  - Correlation: pan~ms > VNIR~SWIR~TIR
  - Pointing range: FORMOSAT-2 >> ASTER, while orbit stability: FORMOSAT-2 << ASTER
  - Automatic
  - Multi-temporal images matching
- Example: 3 September 2005, Hsin-Chu, Wu-Fon County
- Application: Formosat-2 Pan-sharpened image of high quality
F-2 AIPS – multi-temporal matching

- Level-2 product
  - projecting the raw image onto a spheroid using the ephemeris data on-board to correct the satellite orbit and altitude
- Level-2 product of FORMOSAT-2 imagery
  - Viewing the same site with the same angles at the same time everyday
  - Lighting conditions and the shadows are nearly the same
  - The geometrics of ground features are retained well
  - Highly correlated
- Example: 2, 3 and 4 July 2005, Kaohsiung, FORMOSAT-2 daily image
- Challenge
  - Cloud conditions are different
  - Land covers change dramatically in some locations
- Application: Fast and accurate site surveillance
F-2 AIPS – Automatic orthorectification

- Level-4 product
  - GCPs + Satellite model + DEM → rigorous orthorectification
  - Correct geo-coordinate
  - Fundamental and crucial data product for GeoGRID

- Semi-automatic generation of Level-4 product
  - Base image → orthorectified image
  - Image matching and filtering
  - Output CPs to ERDAS LPS®
  - Input satellite altitude and DEM to ERDAS LPS®

- Example: 12 November 2004, Hsin-Chu, Wu-Fon County

- Validation

- Application: image map
福衛二號多頻譜影像各波段間的錯位問題
全色態與多頻譜影像間錯位問題
（錯位修正前） (錯位修正後)

全色態與多頻譜影像間錯位問題（錯位修正前）（錯位修正後）
全色態與多頻譜影像間錯位問題
（錯位修正前） （錯位修正後）

PAN未對準
全色態與多頻譜影像間錯位修正
錯位修正後之彩色融合影像
错位修正後之彩色融合影像
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正射影像自動產製

SPOT-5
FORMOSAT-2

Level-2

Level-4
GeoGRID: integrated platform for applications of remote sensing

正射影像自動產生

SPOT-5
 FORMOSAT-2

SPOT-5 正射影像
 FORMOSAT-2 Level-2影像
SPOT-5 正射影像
自動產製之FORMOSAT-2 正射融合影像
GeoGRID: integrated platform for applications of remote sensing
正射影像自動產製
GeoGRID: integrated platform for applications of remote sensing
GeoGRID: integrated platform for applications of remote sensing
彩色合成影像：
蓝 2/7 、
绿 3/7 、
红 4/7
Illegal quarry mining of gravel on the riverbed

- A unique and serious problem in Taiwan
  - Taiwan – one of the highest erosion rates in the world
  - The lofty Central Mountain Range formed by the slow collision of the Asian continental and Philippine plate
  - The heavy rainfall of the subtropical island during the raining season
  - Valuated: 300,000,000 US dollars per year
  - A tremendous amount of gravel washed into the rivers is an ideal source of construction materials
  - Only 1% of quarry mining is legal

- Why restrict?
  - Excavating gravels from the riverbed modifies the topography and changes the pattern of river flow
  - An unpredictable transportation of sediment frequently arises to reach a new status of balance
  - Devastating impacts on piers or other structures rooted in the riverbed

- General approach of monitoring – send patrolmen
  - Requires a considerable manpower
  - Jobbery: several scandals of corruption in public office were reported in the past
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研究區時序列影像

真實自然色

標準假彩色
研究區時序列影像

指數合成假彩色影像

NDGI

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