Ubiquitous Geoinformatics

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RS & GIS Field of Study
School of Engineering and Technology
AIT
Ubiquitous
- Exists Everywhere Next to You –
Computing / Network

Computers and Sensors, which exist everywhere like air and may not be seen, are communicating each other and support our life.

Mark Weiser’s home page, Ubiquitous computing
Ubiquitous Geo-informatics supports our life from global, local to personal phase. We can publish/access/utilize geospatial information from anywhere real time with other ubiquitous resources; Mobile Internet, PDA, Sensor, HPC and etc.
Research Framework


- RS: Local - Regional - Global
- Sensor Network
- Web GIS for Data Sharing
- Real Time Mapping
- Model Calibration
- HPC (GPGPU, Cluster, GRID)
- Scenario Simulation

Comparison of Satellite LAI and Simulated LAI

Model

Real Time
Contents

Topics

- Satellite Remote Sensing Overview
- Field Sensor Network
- Real Time Mapping
- Web GIS
- Modeling and Simulation, Data Assimilation
- High Performance Computing
Satellite Remote Sensing Overview

Acquiring Near Real Time Information on Earth
Polar Orbit Satellite and Geostationary Satellite

Courtesy: RESTEC
Several Important Numbers

• Radius of Earth
  • approx. 6,300km (a=6377, b=6356, Bessel)

• Altitude of Polar Orbit Satellite
  • 300km - 900km
  • Landsat 705km, JERS-1 568km, SPOT 822km, NOAA 833-870km

• Altitude of Geo-stationary Satellite
  • 35,800km

• Speed of light
  • 300,000km/sec

• Speed of Satellite (relative to the earth)
  • 6.5km/sec = 23,400km/hour, Jet Passenger Aircraft 900km/h
Very High Resolution Satellites  
(Better than 1m ground resolution)

Various Commercial Satellite Products are available  
Ideal to identify small objects, to create detail maps  
everywhere on the earth.

Ground Resolution (Data size of the ground)

<table>
<thead>
<tr>
<th>Satellite</th>
<th>Resolution (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IKONOS</td>
<td>100 (1m)</td>
</tr>
<tr>
<td>GeoEye-1</td>
<td>41</td>
</tr>
<tr>
<td>Quick Bird</td>
<td>60</td>
</tr>
<tr>
<td>World View-1,2</td>
<td>50</td>
</tr>
<tr>
<td>Preiades</td>
<td>50</td>
</tr>
</tbody>
</table>

Preiades Image  
Courtesy: SPOT IMAGE Home Page
This satellite image of a destroyed bridge in Taiwan was captured after Typhoon Morakot made landfall and produced as much as 109.3 inches of rain, triggering catastrophic mudslides.
Global 3D Data from Space
ASTER-GDEM, SRTM, PRISM, SPOT ....

PRISM on ALOS
3 Telescopes with 2.5m Resolution Create Accurate 3D Model of Earth Surface or Digital Elevation Model (DEM)

- ALOS: Japanese Satellite
- Courtesy: JAXA, ERSDAC
Low Resolution Satellite Data

- MODIS, NOAA, SPOT Vegetation
- Low Resolution; 250m to 1km, but
- High Multi-Temporal Data
  Observing everywhere on the earth 1 or 2 times a day
  with Wide View – 2,000km x 5,000km
- Ideal for
  - Global to Regional Monitoring of
  - Dynamic Phenomenon
    - Crop / Vegetation growth,
    Forest fire, Weather
  - Sea and Land surface
temperature and etc.

http://www.spotimage.fr/home/system/introsat/payload/vegetati/vegetati.htm

MODIS Image
Courtesy: NASA
Field Sensor Network
Ubiquitous Field Sensor Network

- Small and Low-Cost Sensors
- New Field Platforms
- Mobile Internet
- Real-time field information from anywhere
- Disaster, Agriculture, Logistics, Security, etc.
- Monitoring Panel, Early Warning, Simulation

Low Cost Sensor
CO2: SenseAir

Field Platform
FieldServer: NARC

Mobile Internet
Ubiquitous Field Sensor Network
Standardization of Sensor Data -> Important for Data Integration

OGC (Open Geo-Spatial Consortium) Standards on SWE (Sensor Web Enablement)

- SOS (Sensor Observation Service)
- SPS (Sensor Planning Service)
- WNS (Web Notification Service)

Standard query/response by XML

- Sensor Metadata (Information on Sensor)
- Sensor Data

Interoperability

- Serve Data to SOS Compliant Applications
- Monitoring Panel, Early Warning, Simulation System

SSG provides SOS I/F and SOS Wrapper

- Cloud Platform for Sensor Back-end Service

Figure from http://52north.org
Sensor Back-end Cloud Service

Field Sensor

Sensor Back-end Cloud Service

Application

SOS Station
Water Station
Sensors

SOS Station
Water Station
Sensors

SOS Station
Water Station
Box
Sensors

Satellite

ADSL

GPRS

Internet

Agriculture

Environmennt

Consultant

Researcher

Engineer

Internet

Sensor Asia
Promoting Field Sensor Network
for Various Applications; Agriculture, Disaster, Environment, and etc.
Himalayan Glacier Lake Monitoring
Real Time Disaster Information under Extreme Condition

- Field Server at Imja Glacier Lake for GLOF (Glacier Lake Outburst Flood)
- WiFi to the Lake by 2 hops from Namche (longest segment is 28Km)
- Int’l Team (Nepal, Japan, Thai)

HP at NARC, Japan
Food Safety info. Direct to Consumers. Promoting Agriculture

Broadcast data in Univ. Tokyo Canteen

The station is set up at ChiangDao, Thailand

The project is organized by University of Tokyo, University COOP in Japan and Fujitsu Design Co., Ltd.

Foster Confidence in safety of food among consumers
Safety of Mountain Flights in the Himalaya

Prokara airport  Jomsom airport

A weather station and a camera were set at a ridge of Annapurna, Himalayas, Nepal

To provide air route weather and visibility information to air controller and pilot
SSG and SOS Station for Mobile CO2 Observation
Easy Deployment of Real Time Observation

workshop in Korea

Start of the workshop

CO2 in a running train in Japan
Full of people, but good air quality

Eee-PC SOS Station Syncing
CO2 data to SSG Server

Low Cost CO2 Sensor

More than 3,000ppm very high CO2

Full of people, but good air quality
Portable low-cost NO2 monitoring station
The station was set up at Siam square & Pintip
To measure NO2 concentration

This project is under cooperation with Dr. Ornprapa P. Robert from Sirapakorn
“Benefiting from earth Observation – bridging the data gap for Adaptation to climate change in the HKH region”

the Launch of

Real-Time Web Visualization

on Atmospheric Brown Cloud Observation

in Collaboration between ICIMOD and AIT (Honda Lab)

Powered by SSG Sensor Back-end Cloud Service
The system is used in Japan

UAV Landslide Surveying System

Information while flying to disaster managers, rescue teams

Collaboration with Dr. Nagai, University of Tokyo, Japan
Real Time Mapping
Volcano Real Time Mapping System
Continuously Create Orthophoto from Ground Digital Camera Image -> Real Time Decision Support

DEM

Skyline Matching

Landscape Image

2 min. for 1st image, 3 sec. from 2nd images
Orthophoto from Thermography Image
Night Time Monitoring is possible and effective

Real-time volcano activity mapping using ground-based digital imagery:
Kiyoshi Honda, Masahiko Nagai
Building Identification from a scenery images
Useful for security, disaster management

Aerial Scenery Photo

2D GIS data
Scenery Image  <>  2D Building GIS
Colored circles are linked to various information on 2D GIS such as name, facilities, number of people and etc.

Duong Van Hieu, Honda K.
Web GIS

- Effective for Data Sharing, Data Update and Data Integration
  - RS Data, GIS data, Sensor Data
Sharing Tsunami Disaster information on Web GIS
IKONOS 1m Resolution in KhaoLak
Overlaid with Infrastructure Data (Hotels)
Multi WMS Server Implementation
Integrated Data Visualization from AIT, NASA, USGS on a Server in Canada

RS Images from AIT WMS Server

RS Images from NASA

Epicenter Data from USGS
Modeling and Simulation
Multi-Temporal RS data (SPOT VI) to identify Irrigated/Non-Irrigated, Number of Cultivation

Non-Irrigated Rice

Irrigated rice 2 crops/year (Homogeneous)

Irrigated rice 3 crops/year (Heterogeneous field)
Dynamic Monitoring of Cropping Activity Contributing to Food Security

Number of Rice Cultivation in Suphanburi, Thailand

1999

2000

2001

Non-Irrigated Rice

Irrigated Rice: 2 crops/year

Irrigated Rice: 3 crops/year

Poor Irrigated Rice: 1 crop/year

Others

Unclassified

Provincial boundary

Irrigation zone

Kamthonkiet D., Honda K. et.al.
Crop Model Parameter Identification through RS Data Assimilation

Evolve RS Monitoring (Snap Shot) to RS based Modeling and Simulation for Scenario Evaluation, Prediction and Decision Support
Soil-Water-Atmosphere-Plant Model (SWAP)

Adopted from Van Dam et al. (1997)
Drawn by Teerayut Horanont (AIT)
SWAP Model Parameter Determination Scheme
- Data Assimilation using RS and GA -

RS Observation

LAI, Evapotranspiration

Assimilation by finding Optimized parameters
By GA

SWAP Input Parameters
sowing date, soil property, Water management, and etc.

SWAP Crop Growth Model
LAI, Evapotranspiration

Fitting

RS Observation Graph

Day Of Year

Evapotranspiration LAI

0 45 90 135 180 225 270 315 360

Day Of Year

Evapotranspiration LAI

0 45 90 135 180 225 270 315 360
- Suphanburi Province Test Field
- Identify SWAP Crop Model Parameters by Data Assimilation
- Scenario Evaluation
- Decision Support

Comparison of Satellite LAI and Simulated LAI

![Comparison Graph]
Draught Monitoring in Thailand

- Model Identification for simulating impact of draught.
- Big damage to agriculture
- Dynamic Water Balance
  - Flux Observation
  - Soil Moisture
- Access to Data through SOS
- Funded by Thai Research Fund
Simulating Draught Impact

- The lowest rainfall appeared in 2003 but the most serious impact on rice yield was found in 2004.
- October Rainfall
  - 2003: 43.6mm
  - 2004: 3.3mm
- Calibrated model has proven dry spell in October has serious impact.

Charoenhrunyingyos S, Kamthonkiat D, Honda K. et.al.
High Performance Computing

- Accelerate heavy RS data processing, Simulation
- Cluster
  - SWAP-GA-RS Data Assimilation
- GRID
  - XGRID for LMF (Cloud Removal)
- GPGPU
  - General Purpose Graphic Processing Unit
  - 500 USD -> 480 CPU in one card
  - Low-Cost and High Performance
  - Super Computers in Top 10 effectively connect thousands of GPU
- Utilize GPU to accelerate RS data processing
GPGPU Computing

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IBM Smart HPC, 8th July, 2010
Intercontinental Hotel

Courtesy of:
http://gpulab.imm.dtu.dk
LMF Cloud Removal Algorithm


Lengthy Calculation:
2 weeks by single CPU for SE Asia Dataset
CPU vs GPU
Accelerate 35 times by single GPU

Aksaranugraha S., Honda K., Aoki T. et al.
GPGPU Workshop

- 26th, 27th January 2011
- Jointly Organized by
  - AIT
  - Kasetsart
  - Tokyo Institute of Technology
- 26th: Research Presentation
- 27th: Tutorial
Conclusion

- Ubiquitous Geo-Informatics
  - Integration of Geo-informatics and ICT
    - Remote Sensing
    - Field Sensor Network
    - Real Time Mapping
    - Web GIS
    - Modeling Simulation
    - High Performance Computing

- Contribute to the better life

- Exciting Research and Development in AIT
Thank you

honda@ait.ac.th
http://www.rsgis.ait.ac.th/~honda

Mr. Aadit Shrestha working peacefully in Chiang Mai Spinach Field for Sensor Network
If you would like to highlight your research activities do send in your inputs to scpo@ait.ac.th