3D Visualization of Volcanic Disaster with Spatial Information Open Platform in Korea

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1996: Yonsei University (BS)
1998: Yonsei University (MS)
   (A Study on the Development of Digital Photogrammetry System Using CCD and GPS)
2006: Purdue University (Ph.D)
   (Urban Area Road Extraction from Aerial Imagery and LIDAR)
2007–2012: SAMSUNG SDS
   (Spatial Information Strategic Planning)
2012–current: Korea Institute of Civil Eng. & Building Technology
   (ICT Convergence and Integration)
Outline

I. Research Background

II. V–World
   (Spatial Information Open Platform in Korea)

III. 3D Visualization of Volcanic Disaster

IV. Conclusions & Further Study
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I. Research Background

Issue

- Mt. Baekdu is The highest mountain(2,750m) in Korea.
- In 969, there was a large volcanic eruption (VEI 7.0) that had a wide spread impact by 1,000km more than Hokkaido in Japan.
- Since 2002, volcanic earthquakes have been observed 10 to 15 times each month in Mt. Baekdu
- Mt. Baekdu currently is a classified as ‘a high-risk volcano’ (Fig 1)’
- Small-scale volcanic eruptions do not cause much damage. However, with a large volcanic eruption in 969 happening again, then we can encounter larger political and economical impact than before.

< Fig 1. Study area(right) and Location of magma/frequency of volcanic earthquake(left) >
I. Research Background

Volcanic Disaster Preparedness Research Center (2012–2015)

- Accordingly, Korea Ministry of Public Safety and Security (MPSS) and National Disaster Management Institute (NDMI) launched the “Volcanic Disaster Preparedness Research Center” to carry out R&D projects for disaster safety technologies.
- KICT consortium had executed “Development of Volcanic Disaster Repose System” project

4 R&D Topics
I. Research Background

Requirements & Objectives of the System

Volcanic Disaster Response System

Integration
Various disaster prediction technology (Volcanic ash, volcanic flood, lahars..)

2D/3D visualization
Based on 2D/3D GIS technologies (2D GIS, 3D GIS, Web GIS, Analysis..)

Damage estimation
Quantitative&Qualitative damage estimation using GIS analysis

Real time
Efficient process using Scenario based DB and real time process

High-Speeding
Mass data processing using parallel computing

Decesion support
Decision support system for volcanic disaster

Concept Of system
V-World Open API + Disaster prediction algorithm
I. Research Background

System Architecture

Volcanic Disaster Response System

<table>
<thead>
<tr>
<th>Monitoring</th>
<th>Prediction/Response</th>
<th>Manual</th>
<th>System management</th>
</tr>
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<tbody>
<tr>
<td>Real time monitoring for KMA observation information</td>
<td>Damage prediction</td>
<td>Query response criteria</td>
<td>Scenario</td>
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<td>Situation management</td>
<td>Response process</td>
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<td>Dissemination</td>
<td>User</td>
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<td>Reporting</td>
<td>System</td>
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Decision Support System

Disaster Prediction DB

<table>
<thead>
<tr>
<th>Infra</th>
<th>Common</th>
<th>Geospatial</th>
<th>Manual</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>User</td>
<td>Digital map</td>
<td>Response manual</td>
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<tr>
<td></td>
<td>Scenario</td>
<td>Satellite image</td>
<td>Criteria</td>
</tr>
<tr>
<td></td>
<td>Statistics</td>
<td>DEM</td>
<td></td>
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<td></td>
<td>Notice</td>
<td>Thematic map</td>
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</tbody>
</table>

Integrated Damage Prediction System

1. Damage prediction simulation based on scenario (Batch)
2. Real time damage prediction simulation (Volcanic ash: Auto/Semi auto simulation)

Calculation Server

KISTI Server

Observation information, Climate model, Satellite image

Prediction results and response methods

Minister of Public Safety and Security

NDMS Server
Disaster information dissemination system

Dissemination to related organization

Mass data processing parallel computing

Instrument of production for spatial information

Temporal renewal
I. Research Background

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II. V-World

History

- V-World is a spatial information open platform in Korea constructed by MOLIT (Ministry of Land, Infrastructure and Transport)

- **2010**
  - 3D T/F & Research

- **2011년**
  - Pilot Project

- **2012**
  - Services Upgrading project 1

- **2013**
  - Services Upgrading project 2

- **2014**
  - Enhance Lineup of services

- **Enhancing platform Service**
  - Expanding 3D service area (130 km²)
  - Providing Mobile, Data API
  - Serving 3D map of Seoul, 6 Metropolitans
  - Providing User, 2/3D Map Service
  - Provide an Open Platform based on Spatial Information

<Source: SpaceN, 2015>
III. V-World

3D Information

**World**

- **World wide**
  - Satellite Image → 15m
  - Sea Image → 500m
  - DEM data → 90m

- **Oversea Area**
  - London, Sydney, Tokyo 3D Model
    - [London]
    - [Sydney]
    - [Tokyo]
  - Satellite Image → 0.5~1m
  - Mt. Baekdu → 500m
  - DEM data → 90m

- **North Korea**
  - Satellite Image → 0.5~1m
  - Mt. Baekdu → 500m
  - DEM data → 90m

**Nation**

- **South Korea**
  - Satellite Image → 25~50cm
  - DEM data → 5m

- **Precisonal Area**
  - Seoul (part Dist.), 6 Metropolitans Yeosu, Chuncheon cities
    - Ortho image → 25cm
    - DEM data → 1m

- **High Precisonal Area**
  - Myeong-dong, Hong-dae, Insa-dong etc
  - Seoul
    - [Myeong-dong]
    - [Hong-dae]

(Source: SpaceN, 2015)
Services

II. V-World

**Open API**
- 2D/3D/integration OpenAPI
- proper reference & common tools

**Portal**
- The core hub of V-World
- notifying Information, news about V-World service

**2D/3D map**
- 2D/3D map, integrated search service
- Searching and using high quality NSDI

**Developer center**
- apply & authorize Open API key
- support Open API developer

**Data center**
- Spatial Info, Metadata and list
- data error declaration

**3D Desktop service**
- An application like Google Earth
- utilizing Various 3D practical service

**Participation center**
- sharing user content
- participating POI marking and uploading 3Dmodel, user content

< Source: SpaceN, 2015>
Successful Application: Public

- Developed the new contents and better map service using the V-world.
  - Provided various supporting service of international events

- Yeosu Expo
  - Providing cyber tour and event information service

- G20 Seoul Nuclear Security Summit
  - Supporting security service of G20 summit leaders
  - Ex) Terror simulation

<Source: SpaceN, 2015>
Successful Application: Civilian

- have developed better system and enhanced solutions
  - have utilized 2D/3D map of V-world as background map
  - ex) business marketing, location based service and etc

Utilize for gCRM and place marketing

Utilize Vworld as background map of its solution

< Source: SpaceN, 2015>
Galleries - Domestic

<Gangnam Station>  <National Assembly Building>

<Gyeongbok Palace>  <63 Building with Han River>
Galleries – Overseas

<London>

<Sydney>

<Tokyo>
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System Concept for Predicting Volcanic Ash Dispersion

Goal for predicting volcanic ash dispersion

- Our goal is predicting hourly base volcanic ash dispersion after volcano eruption for preparedness

Before eruption

- So, we pre-calculated 1 year volcanic ash dispersion scenarios with various parameters and stored
- Pre-calculating uses historical average weather condition

After eruption

- When volcano erupting, the system choose most similar scenario at that time, and provides it
- However, weather condition would be different with historical average weather condition
- Therefore, the system continuously calculate the predicted volcanic ash dispersion reflecting the changed weather circumstances, and provides it
Calculating Volcanic Ash Position & Concentration

- WRF (Weather Research & Forecasting) model and modified Fall3D algorithm are used
- Obtaining 3D position & concentration for volcanic ash takes massive computation time
- Therefore, high speed parallel processing modules by using super computer were developed

**III. 3D Visualization of Volcanic Disaster**

- WRF (Weather Research & Forecasting) model and modified Fall3D algorithm are used
- Obtaining 3D position & concentration for volcanic ash takes massive computation time
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**Result data**

- Time reduction: 30% capacity improve.
- Divided Fall3D computation time: 4.5 min.
- First weather analysis for 3 hour takes 10 min.
- From second weather analysis, it takes 7.5 min.
- Total 112 min. before applying
- Total 71 min after applying
Applying ‘Cube in the air’ for particle concentration (gr/m³) 

- After calculating WRF model and Fall3D, grid type particle concentration file (NetCDF) is obtained.
- Each cell for grid has concentration and height value.
- Each cell is converted into cube, whose height is same with cell size, and is located at its coord.
- Color for cell presents particle concentration.

<Cube in the air (10km³)>
3D Visualization of Volcanic Ash

Applying ‘Dividing cube’ for particle concentration (gr/m³)

- Big cubes is not realistic when it is zoomed
- We can calculate small cubes when applying Fall3D, but it takes so much time
- For realistic visualization and time efficiency, we divide the cube in proportion to concentration
- After obtaining 6km³ cubes, divide the cube from a sixth (1/6) to a sixty fourth (1/64)
- Then, high-concentrating original cube has large number of small cubes
3D Visualization of Volcanic Ash

Applying ‘Dividing cube’ for particle concentration (gr/m³)
3D Visualization of Volcanic Ash

- Cube-expressed visualization has its viviparous limitation. Nobody think ash as cube.
- For visualizing volcanic ash as ‘fog’, we apply ‘Transparent plane’ method.
- After calculating WRF model and Fall3D, grid type particle concentration file (NetCDF) is obtained.
- Each file is converted into GIS layer, whose cell has its particle concentration.
- Remotely viewing layer has low transparency, and close range layer has high transparency.
- Each layer is located at its height.
3D Visualization of Volcanic Ash

Applying ‘Transparent plane’ for particle concentration (gr/m³)
3D Visualization of Volcanic Ash

Applying ‘Transparent plane’ for particle concentration (gr/m³)
3D Visualization of Volcanic Ash

Applying ‘Transparent plane’ for particle concentration (gr/m')
3D Visualization of Volcanic Ash

Overlaying airways in Korea

- Overlaying airway airways with volcanic ash in V-world, take-off and landing can be permitted or restricted
III. 3D Visualization of Volcanic Disaster

3D Visualization of Volcanic Ash

PM10 concentration at ground (gr/m³)
III. 3D Visualization of Volcanic Disaster

3D Visualization of Volcanic Ash

Particle ground deposit load (kg/m$^3$)
3D Visualization of Volcanic Ash

Particle ground deposit thickness (mm)
III. 3D Visualization of Volcanic Disaster

3D Visualization of Volcanic Flood

- For volcanic flood prediction, Flow2D algorithm is used
- Volcanic flooding basin is calculated every 6 hours during total 240 hours about four conditions
- The results are converted into shape file and visualized

<Volcanic Flood>
3D Visualization of Lahrs

- For Lahrs prediction, LahrZ is used
System Demo
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• KICT consortium had executed and developed ‘Volcanic Disaster Response System’ (2012~2015) funded by Korea Ministry of Public Safety and Safety

• The objectives of the system are 2D/3D visualization of predicted volcanic disaster, damage estimation, and supporting decision making

• Korea Ministry of of Land, Infrastructure and Transport have developed V-world which is a spatial information open platform

• ‘Volcanic Disaster Response System’ visualizes various volcanic disaster by using V-World open API

• Various volcanic disaster (i.e volcanic ash, volcanic flood, Lahrs etc ) prediction is 3D visualized at the system

• Now, MPSS have promoted “Volcanic Disaster Response System Ver. 2.0” since May 2015

• In this project, covered area will be expanded from Mt. Baekdu to 28 volcanoes located in far east asia area

• Also, various analysis models will be adopted for more accurate prediction
Thank You

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