GIS based Flood Mitigation

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UBD|IBM Centre, Universiti Brunei Darussalam
• Launched in October 2011

• UBD and IBM Research Labs – India, Brazil, Australia, and USA

• Regional Climate and Weather Modelling, Energy Efficiency, Renewable Energy, and Hydrology
IBM BlueGene/P

High Quality Research Papers

13 Patent Applications in USA and Brunei

Training, and short courses
995 Emergency Calls

Flash Floods

13 November 2013
• BSB

19-26 Jan 2014
• Tutong

16 August 2014
• BSB
Basic Idea

GIS based Input → Processing → Web and GIS based Output
What is GIS?

• System for capturing, storing, checking, integrating, manipulating, analysing and displaying data which are spatially referenced to the Earth.

• Normally considered to involve a spatially referenced computer database and appropriate applications software
Why GIS?

• GIS handles **SPATIAL** information

• Information referenced by its **location in space**

• GIS makes **connections** between activities based on **spatial proximity**
GIS Components and its Cross-disciplinary nature

GIS

Spatial data

Computer hardware/software tools

Specific applications/decision making objectives

Spatial data

Data Base Management System

Digital Mapping

Computer Aided Design

Photogrammetry

Surveying

Remote Sensing

Databases
GIS Data Modeling

- Features in Figure 1
  - Buildings
  - Road
  - Lamp columns
  - Gas pipes

<table>
<thead>
<tr>
<th>Feature</th>
<th>Object:</th>
<th>Entity:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building</td>
<td>Polygon</td>
<td>PM office</td>
</tr>
</tbody>
</table>

Point
Line
Polygon

Name: Next
Address: 5 Market Place
Town: Kingston
Owner: Ms J Shore
Tel. No: 0181 547 1245
Floor space: 1300 sq m
Spatial data storage

Vector model
as geometric objects:
points, lines, polygons

Raster model
as image files composed of grid-cells (pixels)
Raster and Vector Data

• Raster Model
  – good for representing indistinct boundaries
    • information on soil types, soil moisture, vegetation, ground temperatures

• As satellites and aerial surveys use raster-based scanners, the information (i.e. scanned images) can be directly incorporated into GIS the higher the grid resolution, the larger the data file is going to be
GIS IN FLOOD MITIGATION
DATA ACQUISITION AND PROCESSING
Digital elevation model (DEM)

- 2-D grid describes elevation of the area of interest.
- Can be obtained with different quality and spatial resolution
  - 90 meters (Shuttle Radar Topography Mission, NASA)
  - 30 meters (ASTER, NASA + Japan's Ministry of Economy, Trade and Industry)
  - 1 meter (LiDAR, aerial or terrestrial survey)

Geotiff DEM file for tutong region of Brunei
Example of LiDAR data set
Brunei Domain

• Flood model in Brunei uses DEM of size 1688 x 1318 from global 90m SRTM data.

• The Domain has 1358 watershed basins.
Soil data

SRTM Soil data

High Resolution Soil data
Landuse: Vegetation and water bodies

OpenStreetMap + User-provided databases + Vegetation (8km) =

Source: UBD|IBM Centre, UBD
LandUse: Vegetation and water bodies

OpenStreetMap + User-provided databases + Richer vegetation data (15m-100m) =

UBD|IBM Centre, UBD
METHODOLOGY, MODELS AND IMPLEMENTATION USED FOR FLOOD MITIGATION
Basic idea

• Precipitation is mapped to the elevation data

• Vegetation data is used to intercept part of the precipitation

• Part of the precipitation infiltrates on soil

• Algorithms route the precipitation excess on surface
Inputs

- DEM
- MASK
- LANDUSE
- SOIL HYDROLOGIC CONDUCTIVITY
- SOIL PRESSURE HEAD
- SOIL EFFECTIVE POROSITY
- OUTLETS
- PRECIPITATION FILE
- NUMBER OF TIME STEPS
- TIME INTERVAL
Core algorithm

• For every iteration do the following:

  – Compute precipitation interception
  – Compute the new water height from remaining precipitation and overland routing
  – Soil infiltration, updating the water height
  – Overland routing
  – Update water depth at the outlets
Soil model

Non-saturated condition

- $S_{RZ}$: Root zone store
- $S_{UZ}$: Non-saturated zone store
- $S_{SZ}$: Saturated zone store expressed in deficit ($S_i$) or in depth ($Z'_i$)
- $q_b$: Sub-surface runoff in the saturated zone
- $q_v$: Sub-surface vertical runoff in the non-saturated zone

Saturated condition

- $q_{of}$: Surface runoff on saturation
- $r$: rainfall
- $a'$: cell area
- $b$: cell declivity (slope angle)
- $cl$: width of the cell's contour
- $h$: soil porosity
Basic Idea
Overland Routing
RESULTS AND FUTURE OBJECTIVES
Results and future objectives

Flood Forecasting Model on BG/P

Domain Decomposition
Overland Model for Tutong Basin
Integration with river model

• The overland model executes

• Transfer water from the river coordinates to the river model

• The river model executes

• Repeat from step 1 until the simulation is complete
River Model and Overland Model for Tutong
Overland Model

20 Jan 2014 - 08:00 BNT

mm

50 100 150 200 250 300 400 500 1000 1500 2000
OUTPUT: Overland and River Model
Next …

• Overland Model requires integration with Storm Water Management Model (SWMM)

• River Model requires integration with sensor network
Thank You