Current and Future Status of 3D GIS in the UK

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Reader in Geographical Information Science

UCL/AGI Early Careers Network Career Fair

- 7th March from 3pm - 6pm at UCL, London
- Includes:
  - CV reviews
  - Mock interviews
  - Talks from professions about how they use GIS in their industry
  - Networking
- ECN also potentially interested in other locations in the UK!

University College London

- UCL
  - Founded in 1826
  - 30,000 students, 5000 staff
  - Ranked 8th in the world (QS 2014)
- Civil, Environmental and Geomatic Engineering (http://www.cege.ucl.ac.uk)
  - 50 academic staff, 150 researchers, 700 students
  - Specialist areas include
    - GIS
    - Citizen Science/Crowd Sourcing

About Me

- GIS consultant for 10 years in Malta, the Middle East, the UK and all over Europe
- Specialise in databases, software design, development and systems integration
- PhD in Geographical Information Science from UCL in 2007
- New Reader (Associate Professor) in Geographical Information Science
- Programme Director, MSc GIS @ UCL
- Research interests – GIS and technology
  - 3D GIS
    - Combining GIS and Building Information Modelling
    - GIS data quality and usability

Overview

- Introductions
- The Need for 3D GIS
- Current Status of 3D GIS
  - Data Capture
  - Data Management
  - Editing and Analysis
  - Presentation/Visualisation
- 3D Futures – Drivers for Change

Geographical Information Systems

- Traditionally when we think of GIS we might think of this
  - ESRI ArcGIS
**3D GIS**

- GIS is 2D because …
  - Historically maps are 2D

**3D GIS**

- GIS is 2D because …
  - Computer Screens are also 2D

**3D GIS**

- 3D GIS has been around a while
- But mainstream 3D GIS does not exist – why?
  - Applications?
  - Functionality?
    - Data Capture
    - Data Management
    - Editing and Analysis
    - Presentation

**What is 3D GIS?**

- Dimensions
  - 2.5D – x, y and 1 height value (z)
  - 3D – x, y and multiple height values for the same x, y points
  - 3D GIS deals with solid 3D objects – i.e. those that enclose a volume
  - NB: Talking about Vector GIS

- Operations
  - Data capture and edit
  - Data quality validation
  - Visualisation
  - Metric and topological analysis
  - Thematic mapping
  - Interpolation and statistical analysis
  - Proximity (buffer, distance)

*Integrating the 3D Geometry and the Information System*

**3D GIS**

- The first question to ask …
  - Do we really need 3D GIS?
  - Are there situations where:
    - 2D GIS really doesn’t provide the functionality we need
    - 2D GIS provides the functionality but with quite a bit of ‘fudging’

Some problems can’t be solved easily in 2D ..
3D Problems - Construction

http://www.agroupinternational.com/construction-2/construction-material/

3D Problems – Disaster Management

http://scientificallyspeaking.edublogs.org/2012/09/24/get-involved-young-ones/

3D Problems – Decommissioning Buildings


3D Problems - GNSS

Image courtesy of Dr. Paul Green – CNNP, UCL.

3D GIS – Applications - Research

- Economic Benefits of 3D GIS (UCL/EuroSDR)
- Review of:
  - the 3D value chain
  - potential 3D applications
  - the role of National Mapping Agencies in promoting 3D

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### 3D Data

**Data**
- Extrusion of 2D Datasets
- Manual Data Capture
- Point Cloud Sources
- LiDAR and Laser Scanning
- Computer Aided Design
- Photogrammetry

### 3D Data – Extrusion and Beyond

![3D Data - Extrusion and Beyond](image)

### 3D Data – Manual Capture - Sketch-Up and Google Earth

![3D Data – Manual Capture - Sketch-Up and Google Earth](image)

**Source:** 3D Models downloaded from Google Earth, February 2010

### 3D Data – Ordnance Survey

![3D Data – Ordnance Survey](image)

### 3D Data - Research

- Scan2BIM - Converting Point Clouds to Buildings @ UCL
- "City Doctor" project @ University of Stuttgart, Germany
- Completeness of Open Street Map 3D Buildings

![3D Data - Research](image)
3D Data - Research

- Using Google Glass to identify requirements for 3D City Models

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Data Management

- Can 3D datasets be stored using standard GIS approaches?
  - Databases?
  - Proprietary formats such as ArcGIS .shp?
- What exchange formats exist for data sharing?

3D Data

- Extrusion of 2D Datasets
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Data Management – Oracle Spatial, PostGIS, ArcGIS

- 3D Cadastral Systems (UCL/University of Coimbra)
Data Management – Exchanging Data

- FME
  - General GIS Data Exchange
  - Offers 3D import/export into Oracle Spatial, PostGIS, IFC, Shape
  - Also offers functionality such as extrusion
- CityGML
  - XML based exchange format for 3D city data
  - OGC standard in 2008
  - Models both 3D vector data and the attributes associated with the data

3D Data Management - Research

- How to efficiently transmit 3D data to mobile devices over low bandwidth
- How to best store 3D data to be efficient for visualisation and analysis

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3D Editing and Analysis

- Can the data be edited
  - In the database using SQL?
  - In the GIS using GUI tools?
  - What type of analysis functionality is available?

3D Editing and Analysis - SQL

```
INSERT INTO "OSBUILDINGS" (GEOM) VALUES
(ST_GEOMFROMTEXT('POINT(0 0 3).27700'));

INSERT INTO "OSBUILDINGS" (GEOM) VALUES
(ST_GEOMFROMTEXT('POLYHEDRAL_SURFACE(((0 0 0.0
1 0, 1 1 0, 1 0 0, 0 0 0)), ((0 0 0, 0 0 1, 0 1 1, 0 1 0, 0 0 0)),
(0 0 0, 1 0 0, 1 0 1, 0 0 0)), ((0 0 1, 1 0 1, 1 1 1, 0 1 1, 0 0 1)),
(1 0 0, 1 1 0, 1 1 1, 1 0 1, 1 0 0), ((1 1 0, 0 1 0, 0 1 1, 1 1
1, 1 1 0))'),.27700));
```
3D Editing and Analysis - SQL

SELECT ST_3DMAXDISTANCE(A.LOCATION, B.LOCATION)
FROM THREEDBUILDINGS A, THREEDBUILDINGS B
WHERE A.ID = 6 AND B.ID = 5;

SELECT ROUND(MIN(A.DATA AVERAGE), 2) AS MIN,
B_NAME
FROM 3D NOISE DATA A, CHADWICK IFCSPACE SOLID B
WHERE SDO INSIDE (A.GEOM, B.GEOM) = 'TRUE'
GROUP BY B_NAME
ORDER BY MIN ASC

3D Editing and Analysis – Desktop GIS

- Some good functionality in ESRI ArcScene and 3D Analyst (mostly 2.5D)
  - Size of a shadow cast by a building
  - Visibility analysis
- ArcGIS Pro Links 2D and 3D in one environment
- However can’t easily create new 3D geometry
  - Need to find a balance between the complex tools provided by CAD/BIM and usability

3D Editing and Analysis – Research

<table>
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<th>Room Number</th>
<th>Number of Noise Points</th>
<th>Minimum dB</th>
<th>Average dB</th>
<th>Maximum dB</th>
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<td>58.76</td>
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</tr>
</tbody>
</table>

3D Editing and Analysis - Research

Comparing Querying Data in 2D and 3D

Assessing suitability of 3D roof structures for Solar Panels

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Presentation

- Can 3D datasets be displayed in a useful manner?
- What interfaces/tools are offered?
- Do concepts similar to 2D GIS exist?
  - Info tools?
  - Layers/themes?
  - Thematic mapping of different features?
ESRI ArcScene

QGIS – Threejs Plug-In

3D PDF

Presentation – Research
- How to handle the different interaction paradigms:
  - Many 3D viewers have controls such as viewer position and lighting, observer location
  - These derive from 3D visualisation requirements
  - But are not familiar to users of 2D GIS
  - Walking through walls
  - Requirement for Standardised Controls

Presentation - Research
- Investigating Usability of 3D Building Models for Notaries @ University of Laval
- Investigating Performance and Usability of 3D PDF @ UCL

Presentation - Research
- More intricate ‘Levels of Detail’ @ Karlsruhe Institute of Technology, Germany
- 3D Generalisation and Performance @ UCL
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3D GIS - Futures

• Encouraging Signs - Growth in 3D GIS Functionality
  – C. 2005
    • Arc scene in ArcGIS 8.3, Virtual London
    • Oracle supported 3D indexing but not solid features
    • 3D GIS is visualisation only, no IS
    • 3D GIS was 2.5D (surfaces, TINS)
  – C. 2010
    • Oracle supports 3D solids + some 3D functionality
    • Bentley Map links to Oracle 3D solids
    • ArcGIS 10 will support 3D editing
    • ViDOS, City GML from OGC, Google Earth + Sketch-Up
  – C. 2015
    • MapInfo and Geomedia both have 3D Products
    • PostGIS supports 3D
    • ArcGIS + Oracle have extended their 3D functionality
    • OS establishing a 3D dataset

Why isn’t 3D GIS on our Desktops?

• But still to be done (1):
  – Applications
    • Legacy of 2D
    • Do we need a “killer app” for 3D GIS?
    • Review of what is required
  – Is it the lack of tools or data that is driving the lack of implemented applications, or vice-versa?

Why isn’t 3D GIS on our Desktops?

• But still to be done (2):
  – Data
    • Sourcing, quality, integration of G and IS, roof structures
    • Generalisation and Levels of Detail
  – Structuring
    • Detail versus performance on mobile devices
  – Editing and Analysis
    • Linking Information Systems for analysis and CAD for 3D geometry manipulation
    • Missing analytical functionality (topology)
  – Presentation
    • Paradigm shift from 2D to 3D
    • Standardisation of interfaces
    • Usability

Futures: Making Use of Graphics Processing Units

• GPUs on mobile phones becoming more powerful

Futures: Combining 3D GIS and Augmented Reality

http://www.port.ac.uk/mappingandgeoinformatics/3dGIS/3dGIS_30.jpg
http://www.port.ac.uk/mappingandgeoinformatics/3dGIS/3dGIS_28.jpg
Futures: Learning from 3D Gaming

Futures: Integration with BIM

Futures: Indoors, Outdoors and Bridging the Gap

Futures: From Desktop to Web - Web GL

Futures: Time, Sensors, Smart Cities and the Internet of Things

3D GIS – Special Interest Group (AGI)

- "3D Pilot UK" - starting this year
  - See: https://www.youtube.com/watch?v=PhijuAhQw8
- Join the LinkedIn Group to find out more:
http://tinyurl.com/uk3dgis
Thank You

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