Engineering Virtual Environments with X3D

Architecture
A case study of the application of X3D
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Tutorial outline

• Background – the challenges
• Could X3D meet these challenges?
• Relationship of X3D with XML
• Examples
The construction industry

- Architects
- How they handle data
- Current software options
  - What is being used
  - New developments

Architects and 3D visualisations

- Used to create walkthroughs
  - Use something like 3ds max
  - Create a video, avi file

- 3D realtime models
  - Turntool, 3ds max plugin
Architects and information

- 2 out of 3 firms use PDF to archive drawings and send drawings to contractors
- Over 50% use a variant of AutoCad as their main tool
  - Otherwise there is a wide range of other software being used
- 84% intend to move into 3D soon
  - Building Design 2004, UK survey

What does AutoCad produce?
The construction process

- The design
  - 2D, drawings, sheets or
  - 3D, a model
- The specification and quantities
  - A database
- Join these together and you have a BIM system

BIM

- Building Information Management
- Two-dimensional documents are replaced by 3D models, where each section of the building is linked with information regarding its real-world properties
AutoCad and Databases

- Data contained in an external database table linked with AutoCAD graphical objects
  - OLE, Object Linking and Embedding data
- Labels that display data from selected table fields as text objects in the drawing

AutoCad and the Web

- PDF, plotted to Distiller
- Saved as a raster image, JPEG or PNG
- DWF
  - The electronic drawing set is saved as a single multi-sheet
  - Can be password protected
  - Autodesk Express Viewer
    - Viewed or plotted by anyone with the freely distributed external viewer,
The problem

- 2 distinct data sources
- Proprietary solutions
  - AutoDesk’s Revit
- Open source solution
  - X3D?

AutoDesk’s Revit

- BIM system
- *Revit* uses parametric building model
- Information contained in a building database
- Every view (2D, 3D or schedule) is generated dynamically from the database
BIM Systems v. 2D

- 2D type packages, like AutoCAD, are dumb
  - Endless possibilities
- BIM systems can be limited by a finite number of possibilities
- May require workarounds
- Does allow the full scope of tasks
  - Hunt (2005)

Could X3D meet these challenges?

- X3D is an application of XML
Information Rich Virtual Environments

“...combine the power of VEs and information visualization, augmenting VEs with additional abstract information such as text, numbers, or graphs.”


– Hetherington et al 2005
X3D

- X3D to manage content
- Structure of the scene graph
- Embedding/linking of abstract data

X3D Scene graph

```xml
<?xml version="1.0" encoding="UTF-8"?>
<Scene>
  <Switch DEF="buildingElement" whichChoice="-1">
    <Group DEF="Foundation">
    </Group>
  </Switch>
  <Group DEF="FloorSlab">
    <MetadataSet>
      <MetadataString
        value="The type of concrete..."
        name="Specification" />
    </MetadataSet>
    <Shape DEF="Floor">
      <Appearance>
        <Material
          DEF="Concrete2_mat"
          diffuseColor="0.5 0.5 0.5" />
      </Appearance>
      <Box size="3.0 0.2 3.0" />
    </Shape>
    </Group>
  </Group>
  <Group DEF="BelowGroundWalls">
  </Group>
</Scene>
```
Structure

- Grouping is key to the method
- **Switch** controls the rendering of the building elements
- One to many relationship

Metadata types

1) `<MetadataSet name = "" value = "" reference = "" >
2)  `<MetadataString name="" value = "" reference = "" />
3)  `<MetadataDouble name="" value="" reference = "" />
4)  `<MetadataFloat name="" value = "" reference = "" />
5)  `<MetadataInteger name="" value="" reference = "" />

   </MetadataSet>

1) Container
2) Strings
3) Double-precision floating point numbers
4) Single-precision floating point numbers
5) Integers

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Web3D Symposium 2005  web 3D consortium
Metadata example

```xml
<MetadataSet>
  <MetadataString
    name="Specification"
    value="Lots of stuff about the type of concrete"
  />
  <MetadataString
    name="Supplier"
    value="Bloggs and Co"
  />
</MetadataSet>
```

Specification embed or link?

- A linked XML document to contain the specification?
  - A standard specification?
- Or one file that contains everything?
  - Embedded specification
XML and X3D

- XML technologies to provide usable information and displays
- XML technologies to extract, filter, display and calculate data
  - XSL
  - DOM
- Client side solutions
  - Real time interaction, SAI
- Server side solutions

XSL

- There are two components of XSL which work together to filter data:
  - XPath is a method for accessing parts of an XML document
  - XSLT is a method for transforming XML
Client side parsing

```javascript
var xmlDoc = new ActiveXObject("microsoft.xmlDOM");
xmlDoc.async = false;
xmlDoc.load("calculationModel.x3d");
```

- Use an ECMAScript function to load the XML/X3D file into the parser as an Active X Object
  - Must be Internet Explorer

XSL example calculation

```xml
<xsl:variable name="originalstrdimensions"
    select="/size"/>
<xsl:variable name="strdimensions"
    select="normalize-space($originalstrdimensions)"/>
<xsl:variable name="length"
    select="substring-before($strdimensions,'\')"/>
<xsl:variable name="breadth"
    select="substring-before(substring-after($strdimensions,'\'),')')"/>
<xsl:variable name="height"
    select="substring-after(substring-after($strdimensions,'\'),')')"/>
<xsl:variable name="volume"
    select="round($length * $breadth * $height)"/>
```
Client side XSL

- Is fine to filter data
- Stonehenge example
- Fine for simple calculations, XSL allows the creation of variables to hold data
- **But** these cannot be updated
  - for example to accumulate the total volumes of an indeterminate number of components

Client side DOM

- ECMAScript
- Walks through the document tree, creating a Array of various types of **Shapes** and **MetadataStrings**
- Writes the filtered/calculated data to the Webpage
DOM example

```javascript
if (shape[j].geometrytype == SHAPETYPE_BOX) {
    str = str + "<br>------- Box: ";
    dimx = shape[j].geometry.x;
    dimy = shape[j].geometry.y;
    dimz = shape[j].geometry.z;
    vol = dimx*dimy*dimz;
    totalGroupVol = totalGroupVol + vol;

    str = str + "x = " + dimx + ", y = " + dimy + ",
    z = " + dimz;
    str = str + " :: volume = " +
    Math.round(vol*1000)/1000;
}
```

What type of numerical data?

- Foundations
  - Volume of concrete
- Walls
  - Length of brickwork
- Roof
  - Area of tiling
Use of client side DOM

- Collecting useful data
- A number of functions to select different types of calculations
  - Volumes
  - Areas – more difficult
  - Specification
- Requires a strict hierarchy of the model file
- Correct ordering of Groups
- Yet to be tested on complex models
- Only uses boxes and extruded shapes

SAI

- Scene Authoring Interface is an application programming interface (API) for the X3D scene graph.
- SAI scripts work for Script nodes inside the scene, external applets outside the scene in a Web page, Java and EcmaScript
SAI diagram

Switch node

• SAI used to control the value of whichChoice
• Affects the rendering of the groups making up the model

```
<Switch DEF="buildingElement" whichChoice="-1">
  <Group DEF='Foundation'>
    :
  </Group>
  <Group DEF='FloorSlab'>
    :
  </Group>
</Switch>
```
SAI examples

• Stonehenge model
  – Shows the archaeological structure in its various stages of development
• Construction model
  – Shows the various stages of the construction process
  – Clickable model to show details of that component

Next steps Hope campus

• Temporal Modelling Research Group
• Model our campus over time
• Calculate footprints/coverage at different time periods
• Calculate volumes of different buildings
• Tell a history through the changing buildings on the site
Construction information

- Updating of data on the server side from the client, for example
  - Adding specification
  - Adding scheduling data
  - Providing costs for building elements

Client versus server side

**Client**
- May be browser specific
- Complete file is downloaded
  - Real time manipulation

**Server**
- Browser independent
- ‘Ready cooked’ solutions
- Or a time lag
- Greater control of data
Distribution of data, more challenges

- Ownership of designs and data
- Portable/mobile solutions
- Data transmissions
- Compression of data

Questions?
References


Links

- My webspace www.rochina.co.uk/x3d
- TurnTool www.turntool.com/
- Flux www.mediamachines.com/
- Revit www.autodesk.com/revit
- AutoCad www.autodesk.com/