CAD2X3D Conversion and Visualization of Massive CAD data

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Case 1

• Size (CATIA) : 413 MB
• # of files : 1023

Requirements for visualization

1. Inside a Web-browser (MS Explorer)
2. Product Structure
3. Navigation/Viewing functions
4. Object selection

Additional conditions to the requirements
- The design is frequently changed and it should be reflected ASAP.
Motivation

- **CATIA V5 Hub_Assembly model**

CATIA Hub Assembly
(6 Files)
Motivation

- Visualization Requirements

1. Inside a Web-browser (MS Explorer)
2. Product Structure
3. Navigation/Viewing functions
4. Object selection
Motivation

- Visualization Requirements

1. Inside a Web-browser (MS Explorer) → Plug-in viewer
2. Product Structure → PS tree
3. Navigation/Viewing functions → zoom/panning/rotate/…
4. Object selection → selection/show/hide/find/…
Motivation:

- Visualization Requirements
  1. Inside a Web browser (MS Explorer) ➔ Plug-in viewer
  2. Product Structure ➔ PS tree
  3. Navigation/Viewing functions ➔ zoom/panning/rotate/…
  4. Object selection ➔ selection/show/hide/find/…
Proposed Solutions

A. Save as VRML/X3D and use any VRML/X3D plug-in viewer
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A. Save as VRML/X3D and use any VRML/X3D plug-in viewer (126KB)
B. Save as 3D-XML and use 3D-XML plug-in viewer (25KB)
Proposed Solutions

A. Save as VRML/X3D and use any VRML/X3D plug-in viewer (126KB)
B. Save as 3D-XML and use 3D-XML plug-in viewer (25KB)
C. Save as HOOPS and use HOOPS plug-in viewer (15KB)
Proposed Solutions

A. Save as VRML/X3D and use any VRML/X3D plug-in viewer (126KB)
B. Save as 3D-XML and use 3D-XML plug-in viewer (25KB)
C. Save as HOOPS and use HOOPS plug-in viewer (15KB)

Cannot be customized!

Loyalty! License!

3D-XML Viewer

Hoops Viewer
Proposed Solutions

- Save as VRML/X3D and use any VRML/X3D plug-in viewer

- CATIA to X3D conversion with Product Structure conserved

Extraction of product Structure information

Extraction of geometry in multiple files

Mesh reduction and data compression

Integration of Product Structure and geometry files
Engineering IT & VR solutions based on International Standards, PartDB

Extraction of product Structure information

- Extracting product structure information using CATIA API

```xml
<?xml version="1.0" encoding="utf-8"?>
<root>
  <PSRootProduct name="Hub_Assembly" transformMatrix="1,0,0,0,1,0,0,0,1,0,0,0" referenceFileId="" />
  <PSProduct name="sleeve_sub_assembly" transformMatrix="1,0,0,0,1,0,0,0,1,0,0,0" referenceFileId="" />
    <PSPart name="gasket" transformMatrix="1,0,0,0,1,0,0,0,1,0,0,0.50" referenceFileId="" />
    <PSPart name="cylinder" transformMatrix="1,0,0,0,1,0,0,0,1,0,0,0.85" referenceFileId="" />
  </PSProduct>
  <PSPart name="disc_with_holes" transformMatrix="1,0,0,0,1,0,0,0,1,0,0,0" referenceFileId="" />
  <PSPart name="cap" transformMatrix="1,0,0,0,1,0,0,0,1,0,0,0.30" referenceFileId="" />
</PSRootProduct>
<FileReference>
  <PartReference id="disc_with_holes" path="D:\@CAD\&VR_Models\Hub_Assembly\" originalFileId="" />
  <PartReference id="cap" path="D:\@CAD\&VR_Models\Hub_Assembly\" originalFileId="" />
  <ProductReference id="sleeve_sub_assembly" path="D:\@CAD\&VR_Models\Hub_Assembly\" originalFileId="" />
  <PartReference id="gasket" path="D:\@CAD\&VR_Models\Hub_Assembly\" originalFileId="" />
  <PartReference id="cylinder" path="D:\@CAD\&VR_Models\Hub_Assembly\" originalFileId="" />
</FileReference>
<PropertyInformation>
  <PropertySet id="disc_with_holes" />
  <PropertySet id="cap" />
  <PropertySet id="sleeve_sub_assembly" />
  <PropertySet id="gasket" />
  <PropertySet id="cylinder" />
</PropertyInformation>
</root>
```

Hub_Assembly.xml
Extraction of geometry in multiple files

- Saving part files as VRML using CATIA API

```
- cap.CATPart  51KB
- cylinder.CATPart  55KB
- disc_with_holes.CATPart  109KB
- gasket.CATPart  56KB
- Hub_Assembly.CATProduct  19KB
- sleeve_sub_assembly.CATProduct  14KB
- cap.wrl  12KB
- cylinder.wrl  13KB
- disc_with_holes.wrl  56KB
- gasket.wrl  16KB
```
Mesh reduction and data compression

- WRL → X3D → X3DB using Xj3D

<table>
<thead>
<tr>
<th>Mesh</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>cap, wrl</td>
<td>12KB</td>
</tr>
<tr>
<td>cylinder, wrl</td>
<td>13KB</td>
</tr>
<tr>
<td>disc_with_holes, wrl</td>
<td>56KB</td>
</tr>
<tr>
<td>gasket, wrl</td>
<td>16KB</td>
</tr>
<tr>
<td>cap, x3d</td>
<td>12KB</td>
</tr>
<tr>
<td>cylinder, x3d</td>
<td>14KB</td>
</tr>
<tr>
<td>disc_with_holes, x3d</td>
<td>56KB</td>
</tr>
<tr>
<td>gasket, x3d</td>
<td>16KB</td>
</tr>
<tr>
<td>cap, x3db</td>
<td>3KB</td>
</tr>
<tr>
<td>cylinder, x3db</td>
<td>4KB</td>
</tr>
<tr>
<td>disk_with_holes, x3db</td>
<td>13KB</td>
</tr>
<tr>
<td>gasket, x3db</td>
<td>4KB</td>
</tr>
</tbody>
</table>
Mesh reduction and data compression

- Complex scene graph
- High-resolution mesh

Convert VRML into X3D

- Complex scene graph
- High-resolution mesh

Flatten the scene graph & Remeshing and simplification

- Simplified scene graph
- Simplified multi-resolution mesh

Remove non-essential node & Convert X3D into X3DB

- Simplified scene graph consists of essential node
- Simplified multi-resolution mesh

Faces: 6838

VRML File

X3D File

X3D Files

X3DB Files

Integration of P.S. and geometry files

- Extraction of product Structure information
- Extraction of geometry in multiple files
- Mesh reduction and data compression
- Integration of Product Structure and geometry files

Example XML structure:
```
<root>
  <Product name="Hub_Assembly" transformMatrix="1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1" ref=""/>
  <Product name="sleeve_sub_assembly" transformMatrix="1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1" ref=""/>
  <Product name="cylinder" transformMatrix="1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1" ref=""/>
  <Product name="disk_with_holes" transformMatrix="1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1" ref=""/>
  <Product name="gasket" transformMatrix="1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1" ref=""/>
  <Product name="cap" transformMatrix="1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1" ref=""/>
  <PropertyInfo>
    <PropertySet id="cs" />
    <PropertySet id="sleeve_sub_assembly" />
    <PropertySet id="cylinder" />
    <PropertySet id="disk_with_holes" />
    <PropertySet id="gasket" />
    <PropertySet id="cap" />
  </PropertyInfo>
</root>
```

Example file references:
```
<fileReference id="cap" path="D:\BMC\Revit\VR\Models\Hub_Assembly\" originalfile="cap.x3db"/>
<fileReference id="gasket" path="D:\BMC\Revit\VR\Models\Hub_Assembly\" originalfile="gasket.x3db"/>
<fileReference id="cylinder" path="D:\BMC\Revit\VR\Models\Hub_Assembly\" originalfile="cylinder.x3db"/>
<fileReference id="disk_with_holes" path="D:\BMC\Revit\VR\Models\Hub_Assembly\" originalfile="disk_with_holes.x3db"/>
```
Integration of P.S. and geometry files

- External referencing of geometry files

```xml
<ProtoDeclare name="CADGeometry">
    <ProtolInterface>
        <field type="MFString" accessType="inputOutput" name="url" value="" />
    </ProtolInterface>
    <ProtoBody>
        <Inline>
            <IS>
                <connect nodeField="url" protoField="url" />
            </IS>
        </Inline>
    </ProtoBody>
</ProtoDeclare>

<CADAssembly name='disc_with_holes'>
    <ProtolInstance name="CADGeometry">
        <fieldValue name="url" value=""disc_with_holes.x3db"" />
    </ProtolInstance>
</CADAssembly>
```
Case 1: Results

- Size (CATIA): 413 MB
- # of files: 1023

cf) Save as a Single VRML
- Size: 385.5 MB
- It couldn’t be loaded!

- Size (X3D/X3DB): 25 MB
- # of files: 905
Case 2

- Size (CATIA) : 1,154 MB
- # of files : 4054

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<thead>
<tr>
<th>Format</th>
<th># of files</th>
<th>Size (MB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3DXML</td>
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<td>136</td>
</tr>
<tr>
<td>HOOPS</td>
<td>1</td>
<td>105</td>
</tr>
<tr>
<td>VRML</td>
<td>1</td>
<td>1,136</td>
</tr>
<tr>
<td>VRML’s</td>
<td>3890</td>
<td>491</td>
</tr>
<tr>
<td>VRML’s (reduced)</td>
<td>3890</td>
<td>427</td>
</tr>
<tr>
<td>X3D’s</td>
<td>3890</td>
<td>455</td>
</tr>
<tr>
<td>X3DB’s</td>
<td>3890</td>
<td>65</td>
</tr>
<tr>
<td>IGES</td>
<td>1</td>
<td>1,934</td>
</tr>
<tr>
<td>STEP</td>
<td>1</td>
<td>1,287</td>
</tr>
</tbody>
</table>
Next Steps & Future Work

- To solve the current problems
  - Automation of the mesh reduction/simplification process
  - Limitation of the mesh-based representation
    => lightweight representation scheme based on NURBS/B-REP

- Code merging to Xj3D NPS codebase

- Sincerely hope X3DOM can cover the whole X3D specification!
Thank you!

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