NCSA

Key Aspects in 3D File Format Conversions

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Outline

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- Basic Archival Questions
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 - Can we quantify 3D noise introduced during conversions?
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 - Automation of File Format Conversions
 - Quality of File Format Conversions
 - Scalability with Volume
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- Live demonstration



Introduction



Introduction to 3D File Format Reality





Introduction: Our Survey about 3D Content

- Q: How Many 3D File Formats Exist?
- A: We have found more than 140 3D file formats. Many are proprietary file formats. Many are extremely complex (1,200 and more pages of specifications).
- Q: How Many Software Packages Support 3D File Format Import, Export and Display?
- A: We have documented about 16 software packages. There are many more. Most of them are proprietary/closed source code. Many contain incomplete support of file specifications.



Examples of Formats and Stored Content

Format		Geomet	ry		Appearance					Animation			
	Faceted	Parametric	CSG	B-Rep	Color	Material	Texture	Bump	Lights	Views	Trans.	Groups	
3ds	\checkmark	\checkmark			\checkmark								
igs	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark						\checkmark	\checkmark	
lwo	\checkmark	\checkmark			\checkmark	\checkmark	\checkmark	\checkmark					
obj	\checkmark	\checkmark			\checkmark	\checkmark	\checkmark	\checkmark				\checkmark	
ply	\checkmark				\checkmark	\checkmark	\checkmark	\checkmark					
stp	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark							\checkmark	
wrl	\checkmark	\checkmark			\checkmark								
u3d	\checkmark				\checkmark		\checkmark						
x3d	\checkmark	\checkmark			\checkmark								

• Some content may be more important than others

• The relative importance is situation dependent



Basic Archival Questions



Motivation

- Overall, the abundance of file formats makes it difficult to share 3D content
 - Depends on what applications the user has installed
- In terms of preservation/archiving:
 - Closed/Proprietary formats are a problem
 - If specification is not public then full access to the content is restricted to software from the vendor
 - Format may change over time with versions of the software
 - If vendor goes out of business future viewing of the content may be very difficult.
 - Difficult for users to view content



Basic Archival Questions

- Are the 3D formats well formed?
- Can we identify a minimal set of information to preserve?
- Is there an optimal format to convert to?
- Can we quantify 3D noise introduced during conversions?
- Can we quantify differences in renderings?



Is There an Optimal File Format to Convert to?

- **Definition of 'Optimal'?**
- Possible definition of 'Optimal File Format to Convert to':
 - The format that results in the least data loss when converted to by other formats.
- Finding 'optimal file format' requires a converter between the many available formats ...



Can We Quantify 3D Noise Introduced During Conversions?

- Definition and Measurements of Data Loss or 3D Conversion Noise?
 - Definition and measurements of data loss during conversions should be application dependent
- Quantifying 'data loss' needs a loader for both original format A and target format B so that we could load and compare the 3D content independent of how it is stored.



NCSA Polyglot to Support Archival Processes

-Conversions -Data Loss Evaluation During Conversions



Towards a Universal Converter

- Use what is available in 3rd party software to perform conversions
 - Document what formats can be opened/imported by each application
 - Document what formats can be saved/exported by each application
 - Automate the use of each application and combine their abilities to perform conversions over larger set of formats



Mapping Software Import and Export Functionality

	Ur	ntitle	ed	- Proje	ct Fol	der: C:	Documer	nts and Se	ettings Wonel	nenry\My D	ocuments\3dsr	nax - A	utodesk 3	ds Ma	x Design 20	09 E	
File	e 6	Edit	Tools	Group	Views	Create	Modifiers	Animation	Graph Editor:	Rendering	Lighting Analysis	Customize	MAXScript	Help	Tentacles		
$\ \langle$	P	3	> 🗣	- 70	R	All	•] 💽 😽	ש <mark>ו</mark>	View 💌	₽. <i>1</i> +	🥎 🕎	, ¢	%	{} []	reate Selection

3ds Max

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Manufacturer	AutoDesk								
Version	2009 Educational, 11.0								
URL	http://www.autodesk.com								
Cost									
Opens	chr, drf, max	Adobe 31) Reviewer						
Saves	chr, max		Adobe 3D Reviewer						
Turn outs	3ds, ai, dae, ddf, dem, dwg, dxf	Manufacturer	Adobe						
imports	obj, prj, shp, stl, trc, vw, wrl, wr	Version	9, Trial						
Exports	3ds, ai, ase, atr, blk, dae, df, dw	URL	http://www.adobe.com						
Exports	obj, stl, vw, w3d, wrl	Cost							
Manufactu	rer Izware	Opens	3ds, 3dxml, arc, asm, bdl, catdrawing, catpart, catproduct, catshape, cgr, dae, dlv, exp, hgl, hp, hpgl, hpl, iam, ifc, igs, iges, ipt, jt, kmz, mf1, model, neu, obj, pd, par, pdf, pkg, plt, prc, prt, prw, psm, pwd, sab, sat, sda, sdac, sdp, sdpc, sds, sdsc, sdw, sdwc, ses, session, sldasm, sldlfp, sldprt, stl, step, stp, u3d, unv, wrl, vrml, x b, x t, xas, xpr, xmt, xmt txt, xv0, xv3						
Version	0.99.02								
URL	http://www.wings3d.com	Saves	prw						
Cost	Free		3ds, 3dxml, arc, asm, bdl, catdrawing, catpart, catproduct, catshape, cgr, dae, dlv, exp, hgl, hp, hpgl, hpl, iam, ifc, igs, iges, ipt, jt, kmz, mf1, model, neu, obj, pd, par, pdf, pkg, plt, prc, prt, prw, psm, pwd, sab, sat, sdae, sdae, sdae, sdae, sdae, sdaw, sdawe, see session, sldasm, sld1fn						
Opens	wings								
Saves	wings	Imports							
Imports	3ds, ai, fbx, lwo, lxo, ndo,		sldprt, stl, step, stp, u3d, unv, wrl, vrml, x b, x t, xas, xpr, xmt, xmt txt, xv0, xv3						
Exports	3ds, fbx, eps, lwo, lxo, nd								
	Q	Exports	igs, pdf, stl, stp, u3d, wrl, x t						



Input/Output Graphs





Input/Output Graphs





Input/Output Graphs





Building a Universal Converter

- The I/O-Graph stores the information needed to convert between the formats represented in the graph.
- In order to perform the conversion we must execute the conversion path found.
 - Many high end graphics programs are found on the windows platform
 - Those on other platforms, such as Linux, tend to have windows ports
 - Some are command line driven (usually small converter applications).
 - Many have only GUI interfaces
 - AutoHotKey: a scripting language for the Windows GUI.







NCSA Polyglot – Conversion Services

- Web interface: user can drag and drop files into upload area for conversion
- Java interface:

```
PolyglotRequest pgr;
pgr = new PolyglotRequest("http://???", "obj");
pgr.convertFile("file.wrl", "./");
```





NCSA Polyglot – Data Loss Measurement Services



stp -> (Adobe 3D Reviewer) -> igs -> (3ds Max) -> 3ds -> (Blender) -> x3d

Measuring Information Loss





Measuring 3D Model Similarity

- Surface Area
 - If a faceted surface simply sum up area of all faces
- Statistics
 - Mean, Standard deviation of vertices
- Spin Images [Johnson, 1999]
- Light Fields [Chen, 2003]
 - Compares silhouettes from various viewing angles around the objects



Geometry Based Content Retention



Conclusions

- We have designed a framework for 3D file format conversions and information loss evaluation with the key components
 - Input to output conversion graph
 - Automated conversions using 3rd party software
 - Conversion scripting and execution monitoring
 - 3D model comparison before & after conversions
 - Search for "optimal" path or file format



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- Project URL: <u>http://isda.ncsa.uiuc.edu/NARA/index.html</u> and http://isda.ncsa.uiuc.edu/CompTradeoffs/
- Publications see our URL at <u>http://isda.ncsa.uiuc.edu/publications</u>
- Peter Bajcsy; email: pbajcsy@ncsa.uiuc.edu



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