3D Timeline: Reverse Engineering of a Part-based Provenance from Consecutive 3D Models

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Disk Full of Models Problem

Temporal management of 3D assets
Understanding of legacy datasets
Provenance extraction and visualization
Our Aims

- Reverse engineer *plausible* editing history
- Summarise important high-level changes
- Provide a tractable solution
Target Operations
Additions and deletions of parts
Changes in polycount, size and transformations
Duplications, instancing and repeated copying
Related Work

Chronicle [Grossman et al. 2010]
MeshFlow [Denning et al. 2011]
Exploring Shape Variations [Jain et al. 2012]
MeshGit [Denning & Pellacini 2013]
Inverse Image Editing [Hu et al. 2013]
Overview
System Design

1. Independent *keyframe* pre-processing
2. Semantic analysis
3. Timeline visualisation
Pre-processing
Key Observations

Complex shapes are made up of parts
Modeling is often characterized by *massing*
Neighboring keyframes are highly related
Pre-processing
Hierarchical Face Clustering [Garland et al. 2001]
PCA-aligned bounding boxes [Jain et al. 2012]
Part-based hierarchy [Shapira et al. 2010]
Correspondence Estimation

\[ E_S := \| C_{\square}[w, h, d] - C'_{\square}[w', h', d'] \| \] (2)

\[ E_L := \| \| \vec{v} - \vec{v}_P \| - \| \vec{v}' - \vec{v}'_P \| \| \] (3)

\[ S_{ij} := \alpha E_S + (1 - \alpha) E_L \] (4)
A1: Correspondence Propagation

Greedy assignment based on affinity matrix
Proceeds from the last to the first keyframe
Uses majority vote for self-correction
$t_{i-1}$

$\cdots$

$\cdots$

$t_i$

$\cdots$

$\cdots$
Semantic Analysis
\[ \Phi_{m,n} = \begin{bmatrix} F_1 & \begin{bmatrix} t_1 & t_2 & \cdots & t_n \\ C_{1,1} & C_{1,2} & \cdots & C_{1,n} \\ C_{2,1} & C_{2,2} & \cdots & C_{2,n} \\ \vdots & \vdots & \ddots & \vdots \\ C_{m,1} & C_{m,2} & \cdots & C_{m,n} \end{bmatrix} & F_2 & \vdots & \vdots & \vdots & \vdots \end{bmatrix} \]
Addition
Deletion
Life-span
Duplication
Polycount increase
Polycount decrease

Size increase
Size decrease
Translation
Repeated copy
Instancing
Timeline Compression

Simplifies apparent complexity of matrix $\Phi$

Row-wise collapse

Column-wise collapse
A2: Repeated Copying Detection

Incremental duplication in a self-similar group
1-parameter regular structure [Pauly et al. 2008]
At least 3 components, their ordering and $T$
$C_S$
$C_s$

$2x$
Timeline Visualization
Evaluation
<table>
<thead>
<tr>
<th>Dataset</th>
<th>Frames</th>
<th>Polycount</th>
<th>Components</th>
<th>Corr. [ms]</th>
<th>Analysis [ms]</th>
<th>Total [s]</th>
<th>Throughput [C/s]</th>
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<td>Q2</td>
<td>Q3</td>
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<td>Q2</td>
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