Geometric Registration for Deformable Shapes

4.3 Practical Animation Reconstruction
Digitizing Dynamic Objects
Real-Time 3D Scanner
Geometry and Motion Reconstruction

Input 3D Scan Sequence

Space-time Reconstruction
State of the Art
Industry Standard

3D Scanning

Motion Capture

XYZRGB

[Park & Hodgins ’06]
Markerless Performance Capture

[de Aguiar et al. '08]

[Vlasic et al. '08]
Limitations

Jelly Effect

[Masic et al.'08]
Real-Time 3D Scanner

[Weise et al. '07]
Dense Space-Time Reconstruction

[Wand et al. '09]  [Süssmuth et al. '08]  [Scharf et al. '08]
Early Test – 34 Frames

Correspondence Issues
[Süssmuth et al. ’08]

Topology Issues
[Wand et al. ’09]
Bi-Resolution Approach
Deforming Subject
Partial Scans
Partial and Non-Rigid Registration
Partial and Non-Rigid Registration

Small-Scale Dynamics
Bi-Resolution Approach

Warping a *coarse* template
Bi-Resolution Approach

Warping a coarse template
Bi-Resolution Approach

Synthesizing small scale details
Reconstruction Framework

Input Scans

Coarse Template

detail estimation

non-rigid registration

detail estimation

Reconstruction Framework

- detail estimation
- non-rigid registration
- detail aggregation

Large-Scale Motion
Fine-Scale Dynamics
Non-Rigid ICP

Non-Linear Optimization

\[ E_{\text{tot}} = \alpha_{\text{fit}} E_{\text{fit}} + \alpha_{\text{rigid}} E_{\text{rigid}} + \alpha_{\text{smooth}} E_{\text{smooth}} \]

Too few nodes:
- inaccurate

Too many nodes:
- inefficient
- less robust

Extension of [Li et al. '08]
Adaptive Deformation Model

Non-Rigid ICP

$E_{\text{smooth}} > \sigma$?

no

yes

Refine Graph

Next Scan
Adaptive Deformation Model

Input Scans

Warped Template with Graph
Detail Aggregation

Single Frame Synthesis

Multi-Frame Aggregation
Detail Estimation

\[ E_{\text{detail}} = \sum_{i \in V} \|v_i + d_i n_i - c_i\|^2 + \beta \sum_{(i,j) \in \mathcal{E}} |d_i - d_j|^2 \]

Point Constraint

Regularization
Detail Estimation

\[ \mathbf{v}_i^j \leftarrow \mathbf{v}_i^j + d_i^j - 1 \mathbf{n}_i \]

\[ d_i^j \leftarrow (1 - \gamma)d_i^{j-1} + \gamma d_i^j \]

Detail Transfer

Exponentially Weighted Moving Average
Forward-Backward Propagation
Reconstruction Process
The Puppet
3D Acquisition – 100 Frames
Initial Registration

First Scan

Coarse Template
Template Warping

Input Scans

Warped Template
Final Reconstruction – 100 Frames

Input Scans

Reconstruction
Correspondence Visualization

Reconstruction

Textured Reconstruction
Detail-Coefficient Stability

Reconstruction

Detail Coefficients
Close-up Comparison

Input Scan

Warped Template

Reconstruction

Overlaid Scan
More Results
Crumpling Paper Bag – 85 Frames

Input Scans

Reconstruction

Textured Reconstruction
Facial Expressions – 200 Frames
Limitations

Self-Intersection

Large Motion

Varying Topology
What’s Next?

Multi-View and Textures

Complex Materials

Surface Segmentation

[Vlasic et al. ’09], Princeton, ICT

National Geographic

WordPress
www.hao-li.com