Practical Animation Reconstruction

Hao Li
Correspondence Problem Classification

How many meshes?
More than two: multi-view registration

Initial registration available?
Yes: Local optimization methods

Class of transformations?
Non-rigid deformations
Performance Capture

modeling → rigging → animation
Performance Capture

- surface reconstruction
- rigging
- animation
Performance Capture

Surface reconstruction → Rigging → Animation

[XYZRGB '09]
Performance Capture

- surface reconstruction
- automatic rigging
- animation

[XYZRGB '09]
Performance Capture

surface reconstruction \[\rightarrow\] automatic rigging \[\rightarrow\] animation

[XYZRGB '09] [Baran & Popović '07]
Performance Capture

- surface reconstruction
- automatic rigging
- motion capture

[XYZRGB '09] [Baran & Popović '07]
Performance Capture

- Surface reconstruction
- Automatic rigging
- Motion capture

[XYZRGB '09] [Baran & Popović '07] [Vicon '08]
Performance Capture

- surface reconstruction
- automatic rigging
- motion capture

[XYZRGB '09], [Baran & Popović '07], [Vicon '08]
Performance Capture

1. surface reconstruction
2. automatic rigging
3. motion capture
4. post processing

[XYZRGB '09] [Baran & Popović '07] [Vicon '08]
Performance Retargeting
Performance Retargeting

Local Shape Matching: Advanced Animation Reconstruction
Performance Retargeting
Markerless Performance Capture

[de Aguiar et al. '08]
Markerless Performance Capture

[de Aguiar et al. '08]
Markerless Performance Capture

[de Aguiar et al. ‘08]
Elastic Deformation

[Vlasic et al. ’08]
Elastic Deformation
Sparse Tracking

[Vlasic et al. ’08]
Elastic Deformation
Sparse Tracking
Baked-in Details

[VLasic et al. '08]
Jelly Effect

[Vlasic et al. '08]
Real-time Dense Acquisition

Structured Light Based on Phase-Shift Stereo [Weise et al. ’07]
Animation Reconstruction

- surface reconstruction
- automatic rigging
- motion capture
Animation Reconstruction

- Surface reconstruction
- Automatic rigging
- Motion capture
Local Shape Matching: Advanced Animation Reconstruction
Animation Reconstruction

dynamic shape reconstruction → automatic rigging → post processing
Animation Reconstruction

dynamic shape reconstruction  →  automatic rigging
Animation Reconstruction

dynamic shape reconstruction

automatic rigging
Objective

Input 3D Scan Sequence

Space-time Reconstruction

[Li et al. '09]
Challenges
Challenges
Challenges

Correspondence Issues

[Süßmuth et al. ’08]
Challenges

Correspondence Issues
[Süssmuth et al. ’08]

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

Large-Scale Motion
Partial and Non-Rigid Registration
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

Warping a coarse template
Bi-Resolution Approach

Warping a coarse template
Bi-Resolution Approach

Synthesizing small scale details
Reconstruction Framework
Reconstruction Framework
Reconstruction Framework

detail estimation

Local Shape Matching: Advanced Animation Reconstruction
Reconstruction Framework
Reconstruction Framework

Local Shape Matching: Advanced Animation Reconstruction
Reconstruction Framework

Local Shape Matching: Advanced Animation Reconstruction
Reconstruction Framework
Reconstruction Framework

Local Shape Matching: Advanced Animation Reconstruction
Reconstruction Framework

Large-Scale Motion

detail estimation

non-rigid registration
Reconstruction Framework

Large-Scale Motion
Reconstruction Framework

Local Shape Matching: Advanced Animation Reconstruction

Large-Scale Motion
Reconstruction Framework

Detail estimation

Large-Scale Motion

Detail estimation

Fine-Scale Dynamics

Detail aggregation

Local Shape Matching: Advanced Animation Reconstruction
Sequential Non-Rigid Registration

input data
Sequential Non-Rigid Registration

input data

template fitting

data provided by Stanford and MPI Saarbrücken
Adaptive Deformation Model

- Input Scans
- Warped Template with Graph
Detail Aggregation
Detail Aggregation
Detail Aggregation

Single Frame Synthesis
Detail Aggregation

Local Shape Matching: Advanced Animation Reconstruction
Forward-Backward Pass
Forward-Backward Pass
Forward-Backward Pass
Forward-Backward Pass
Super Resolution

Input Scan
Super Resolution

Input Scan

Warped Template
Super Resolution

Input Scan

Warped Template

Reconstruction
Super Resolution

Input Scan  |  Warped Template  |  Reconstruction  |  Overlaid Scan
Final Reconstruction – 100 Frames

Input Scans  Reconstruction  Textured Reconstruction
Crumpling Paper Bag – 85 Frames

Input Scans  Reconstruction  Textured Reconstruction
Facial Expressions – 200 Frames

Input Scans

Reconstruction

Overlaid Scans
Limitations: Drift

dynamic shape reconstruction → automatic rigging
Limitations: Drift

- Training
- Dynamic shape reconstruction
- Automatic rigging
Limitations: Drift

- training
- dynamic shape reconstruction
- automatic rigging
Facial Animation

[Weise et al. ’09]
System Overview
System Overview

scans

textures
System Overview

template construction

scans
textures
System Overview

- Template construction
- Texture mapping

Scans

Textures
System Overview

- Template construction
- Texture mapping
- Offline tracking

Scans -> Textures
System Overview

- Template construction
- Texture mapping
- Offline tracking

Scans

Textures
System Overview

scans

textures

template construction

offline tracking

dimension reduction

texture mapping
System Overview

- Template construction
- Texture mapping
- Offline tracking
- Dimension reduction
- Online tracking

Scans
Textures
System Overview

- Template construction
- Offline tracking
- Dimension reduction
- Online tracking
- Texture mapping

Scans
Textures
System Overview

- Template construction
- Texture mapping
- Offline tracking
- Dimension reduction
- Online tracking
- Retargeting

Scans
Textures
System Overview

- Template construction
- Texture mapping
- Offline tracking
- Dimension reduction
- Online tracking
- Retargeting

Scans
Textures
Dimension Reduction
Dimension Reduction
Dimension Reduction

Principal Component Analysis
Dimension Reduction

Principal Component Analysis
Dimension Reduction

Principal Component Analysis

Local Shape Matching: Advanced Animation Reconstruction
Dimension Reduction

Principal Component Analysis

$+ w_1 + w_2 + w_3 + w_4$
Dimension Reduction

Local Shape Matching: Advanced Animation Reconstruction

Principal Component Analysis

\[ \sum_{i=1}^{n} w_i \]

...
Limitations: Varying Topology
Temporal Coherent Shape Completion [Li et al. ’11]

partial data  reconstruction  partial data  reconstruction
Temporally Coherent Shape Completion

[Li et al. '11]
Temporally Coherent Shape Completion

[Li et al. '11]

partial data
reconstruction
partial data
reconstruction

Local Shape Matching: Advanced Animation Reconstruction
Light Stage 6 Capture

Lightstage 6 (USC-ICT)

[Vlasic et al. ‘09]
Light Stage 6 Capture

Lightstage 6 (USC-ICT) 8 Normal Maps / Frame

[Vlasic et al. ’09]

Local Shape Matching: Advanced Animation Reconstruction
Reconstruction

per view reconstruction
Reconstruction

per view reconstruction  non-rigid registration
Reconstruction

per view reconstruction → non-rigid registration → poisson reconstruction
Reconstruction

Capture
Reconstruction

Capture → Integration
Reconstruction

Capture → Integration → Matching
Reconstruction

Capture → Integration → Matching → Merging
Reconstruction

Capture → Integration → Matching → Merging

input scans
Naive Shape Completion

hole filled
Dynamic Shape Completion

input scan
Dynamic Shape Completion

input scan  visual hull hole filling
Dynamic Shape Completion

- input scan
- visual hull hole filling
- space-time filtering
Dynamic Shape Completion

input scan → visual hull hole filling → space-time filtering → detail re-synthesis
Temporal Filtering

\[ n-1 \quad n \quad n+1 \]

frame
Temporal Filtering

current frame
Temporal Filtering

$n-1$ $n$ $n+1$ frame

current frame
Temporal Filtering

n-1  n  n+1

frame

current frame
Temporal Filtering

n-1  n  n+1

frame

current frame
Temporal Filtering

frame

n-1

n

n+1

current frame

Local Shape Matching: Advanced Animation Reconstruction
Temporal Filtering

Frame n-1 \rightarrow n \rightarrow n+1

w=100

n-1 n n+1

frame

current frame
Temporal Filtering

- w=10
- w=100
- w=10

n-1  n  n+1

frame

current frame
Temporal Filtering

- w=10
- w=100
- w=10

n-1  n  n+1

frame

current frame
Temporal Filtering

w=10  w=100  w=10

w=1  w=2  w=1

n-1  n  n+1

current frame

Local Shape Matching: Advanced Animation Reconstruction
Short Range Correspondences
Short Range Correspondences

course-scale alignment
+ graph prediction
+ surf/optical flow
Short Range Correspondences

coarse-scale alignment
+ graph prediction
+ surf/optical flow

fine-scale registration
Short Range Correspondences

course-scale alignment + graph prediction + surf/optical flow

fine-scale registration

distance to target (cm)

0 1
Short Range Correspondences

coarse-scale alignment
+ graph prediction
+ surf/optical flow

fine-scale registration

distance to target (cm)
0 1

Coarse Registration

Fine Registration
Short Range Correspondences

coarse-scale alignment  
+ graph prediction  
+ surf/optical flow

fine-scale registration

Coarse Registration

Fine Registration

Merging
Short Range Correspondences

coarse-scale alignment
+ graph prediction
+ surf/optical flow

fine-scale registration

distance to target (cm)

Coarse Registration

Fine Registration

Merging

Local Shape Matching: Advanced Animation Reconstruction
Free-Viewpoint Video

[Li et al. '11]
Free-Viewpoint Video

[Li et al. ’11]
www.hao-li.com