Real-time Facial Animation

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Template Personalization
Pair of 3D Scans
Non-Rigid Registration
The Recipe

detect overlap  correspond  deform
The Challenge

detect overlap → correspond → deform

deformation

ambiguity

incompleteness

?
The Challenge

- detect overlap
- correspond
- deform

incomplete correspondences
Observation

correspond

detect
overlap

deform

helps
helps
Global Optimization

correspond

detect overlap

deform
Non-Rigid ICP
Face Fitting
PCA Subspace

\[
\text{average} = \sum \omega_i \sum \text{PCA modes} + \omega_2 \sum \text{PCA modes} + \ldots
\]

Blanz & Vetter al. 99
Non-Rigid ICP + PCA
Expression Prior
Real-time Facial Tracking
Building Expression Space

tracked template

input scan
Building Expression Space

Principal Component Analysis

= \text{expression} = w_1 + w_2 + w_3 + w_4
Example-Based Facial Rigging
Blendshape Animation

\[ \text{laughing} = B_0 + \alpha_1 B_1 + \alpha_2 B_2 + \alpha_3 B_3 + \ldots \]

neutral face

blendshapes

blending weights
Blendshape Animation
Expression Transfer

prior blendshapes

[Noh & Neumann ’01]
[Sumner & Popovic ’04]

reconstructed blendshapes

...
Problems

prior  expression transfer  ground truth
Example-Based Facial Rigging

input face

input training poses

Facial Rigging

prior generic rig

blending weights

output blendshapes
Bilinear Problem

\[ B_0 + \sum_{i=1}^{n} \alpha_{ij} B_i \approx S_j \]

- input face
- input examples
- blending weights
- output blendshapes
Decoupled Optimization

\[ B_0 + \sum_{i=1}^{n} \alpha_{ij} B_i \approx S_j \]

Step A

Step B
Results

prior

without examples

whistle

with 6 examples

input example

surprise
Directable Facial Tracking
Blendshapes for Tracking
Probabilistic Animation Prior
Noisy Input

input scans

tracking

goal
Performance-Based Animation Pipeline

expression model

animation prior

input data

Stable Tracking

temporal coherence

expression parameters
N-Dim Expression Space
Animation Manifold

smile

mouth open

correction $\alpha^t$
Probabilistic Expression Prior
Probabilistic Animation Prior
Temporal Joint Probabilistic Distribution

\[ p(\alpha^t, \ldots, \alpha^{t-M}) = \sum_{k=1}^{K} \pi_k \mathcal{N}(\alpha^t, \ldots, \alpha^{t-M} | \mu_k, C_k C_k^T + \sigma_k^2 I). \]

MPPCA model
weights
mean
principal components
Gaussian noise
MAP Estimation

\[ \alpha^t = \arg \max_{\alpha} p(\alpha | D, \alpha^{t-1}, \ldots, \alpha^{t-M}) \]

\[ \approx \arg \max_{\alpha} \underbrace{p(D | \alpha)}_{\text{likelihood}} \underbrace{p(\alpha, \alpha^{t-1}, \ldots, \alpha^{t-M})}_{\text{prior}} \]

- **geometry**
  \[ p(G|x) = \prod_{i=1}^{V} k_{geo} \exp\left(-\frac{||n_i^T(v_i - v_i^*)||^2}{2\sigma_{geo}^2}\right) \]

- **texture**
  \[ p(I|x) = \prod_{i=1}^{V} k_{im} \exp\left(-\frac{||\nabla I_i^T(p_i - p_i^*)||^2}{2\sigma_{im}^2}\right) \]
Live Demo