Progressive Deforming Meshes based on Deformation Oriented Decimation and Dynamic Connectivity Updating

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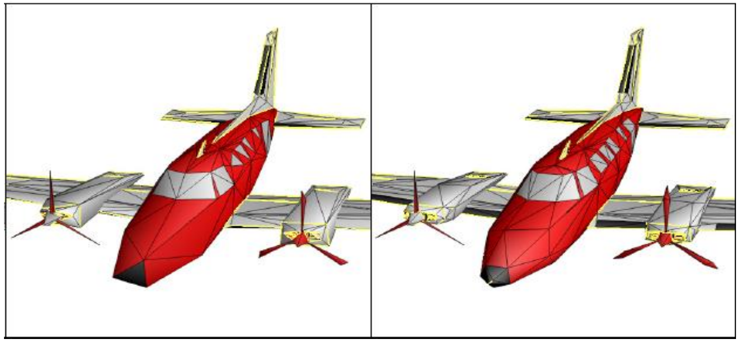
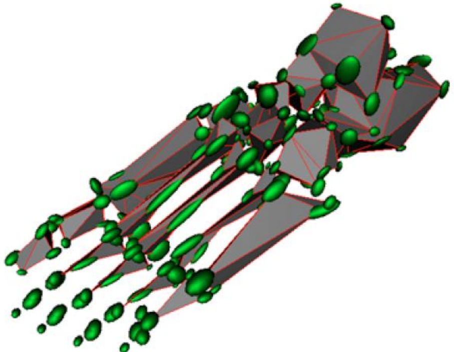
Goal - Level of Details

- Well-established for static mesh.

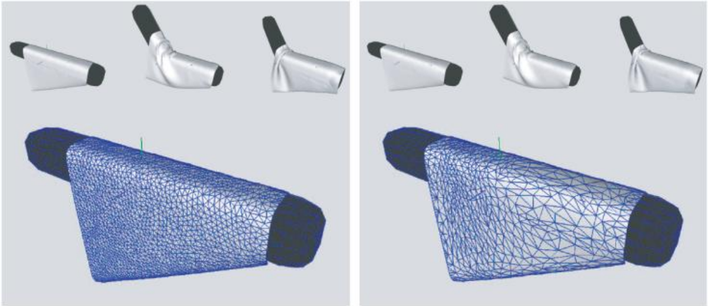


Hoppe ‘96

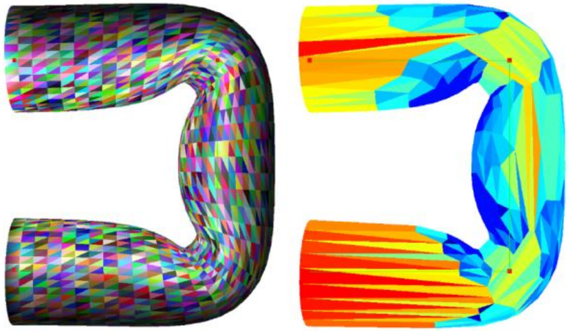


Garland & Heckbert ‘97

- Not for deforming meshes.



Mohr & Gleicher ‘03

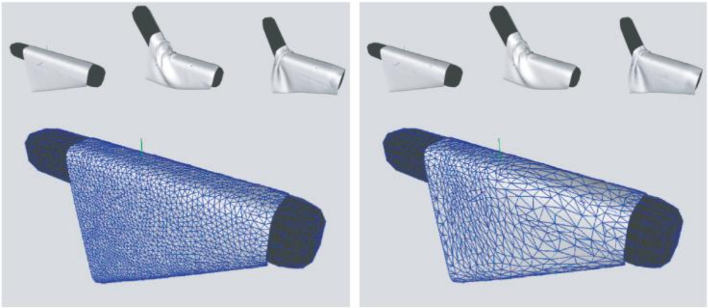


DeCoro & Rusinkiewicz ‘05

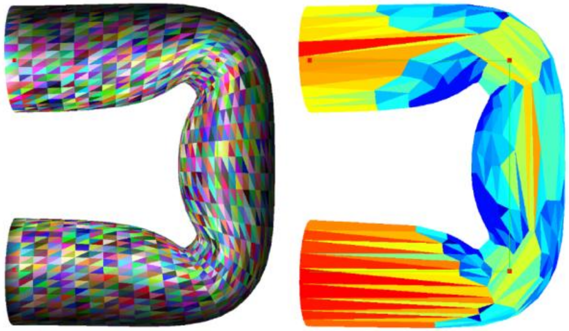
Main Idea - Deformation

- The key distinction.

- Technique by previous work



Mohr & Gleicher '03

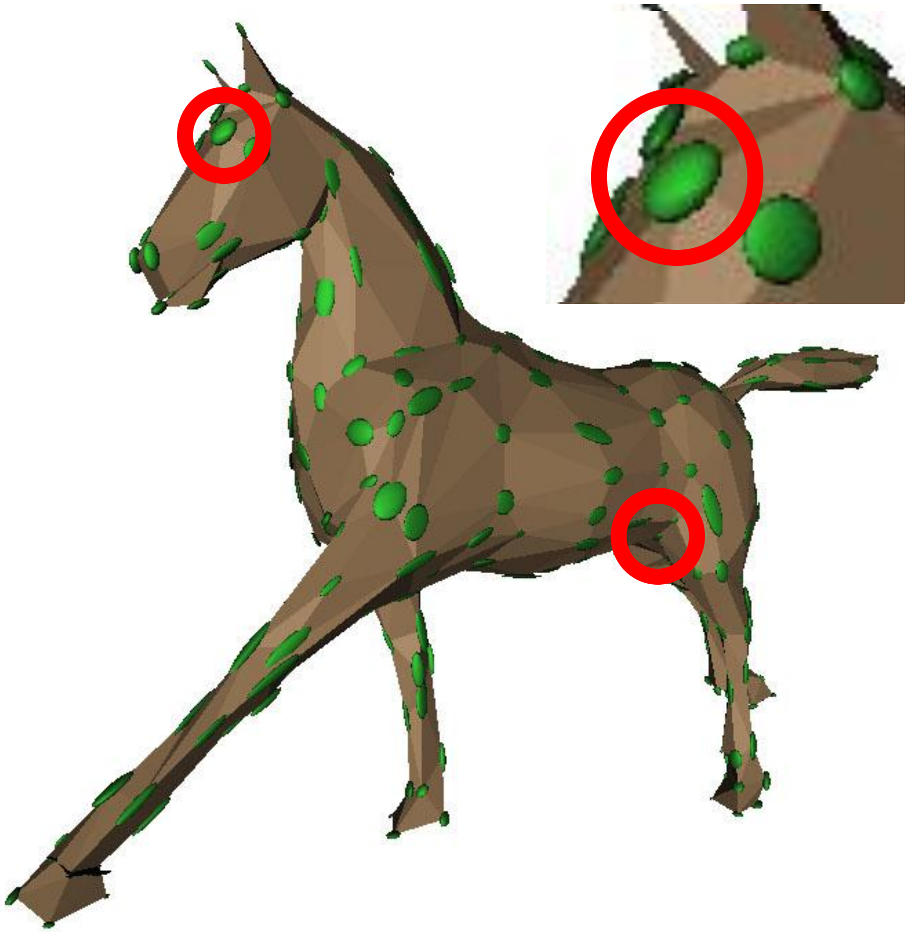


DeCoro & Rusinkiewicz '05

Agenda

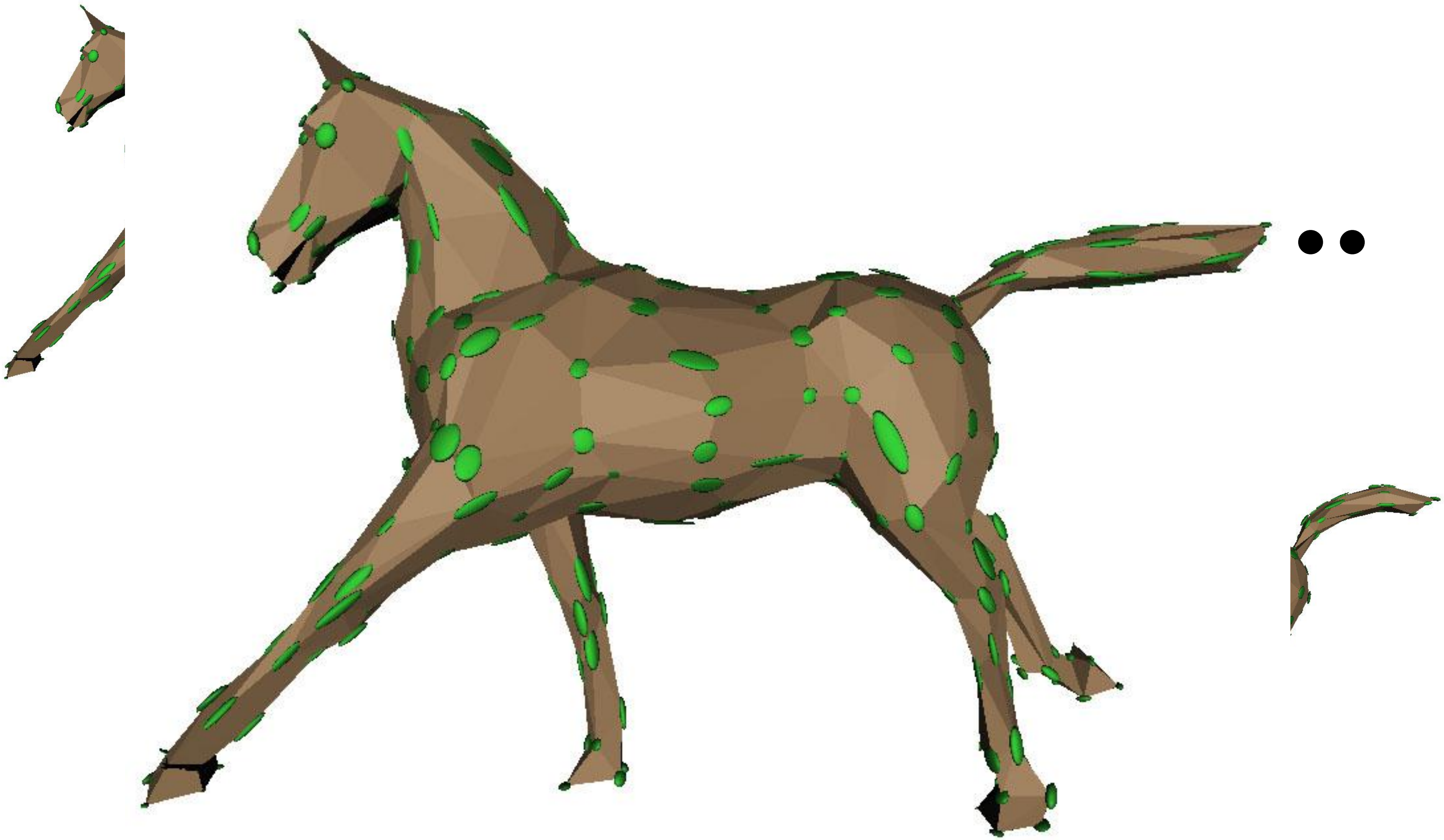
- Static Connectivity
  - Quadric Error Metric (QEM)
  - Deformation Sensitive Decimation (DSD)
  - Deformation Oriented Decimation (DOD)
- Dynamic Connectivity
  - Vertex Tree (View Dependent Simplification)
  - Dynamic Connectivity Updating (DCU)

Quadric Error Metric (QEM)

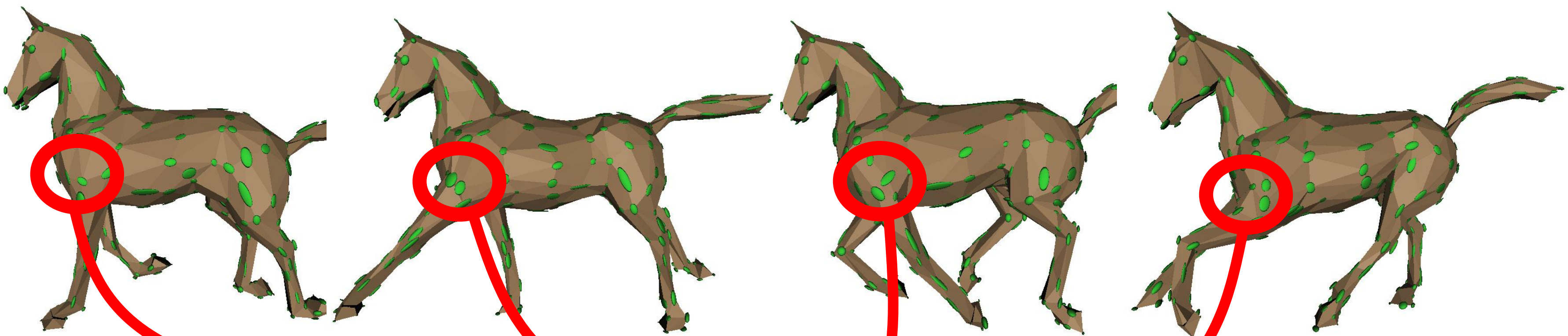


1. Prepare Q.
2. Select min.
3. Contract and re-compute
4. Repeat

Deformation Sensitive Decimation (DSD)



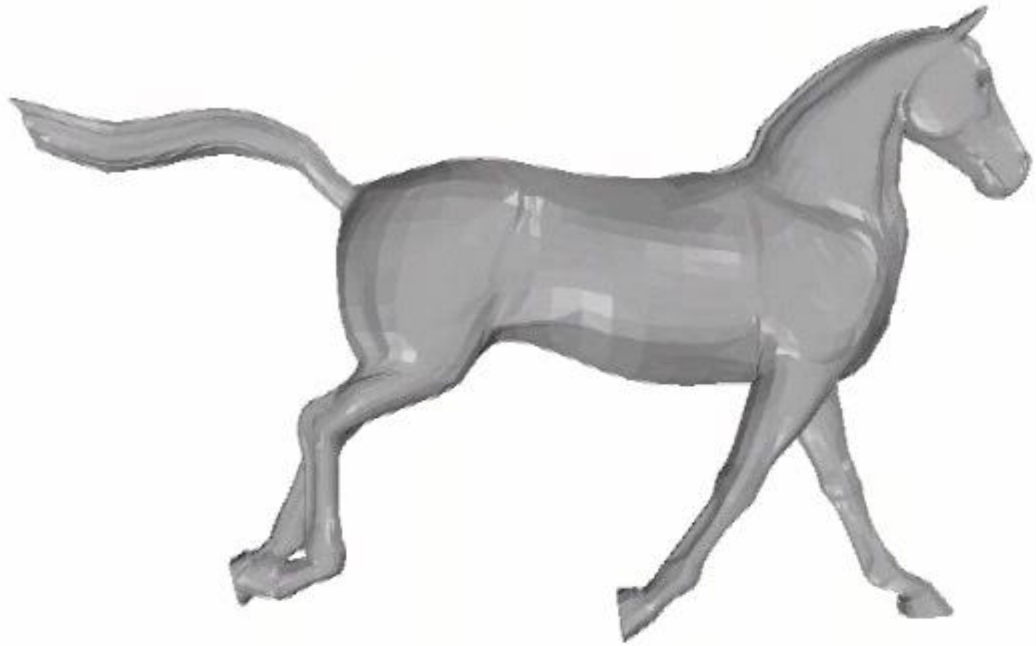
Deformation Sensitive Decimation (DSD)



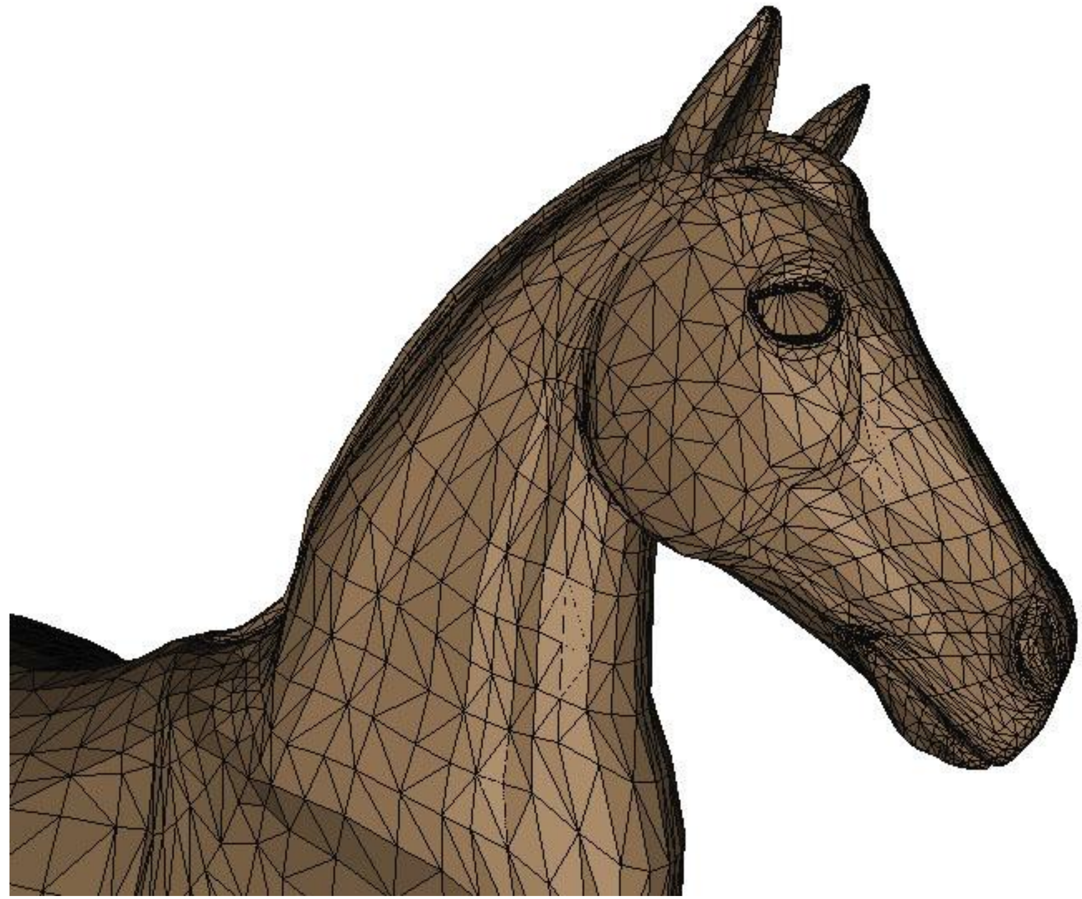
$$\text{Criteria} = \Sigma_t\, Q^t$$

Interpretation?

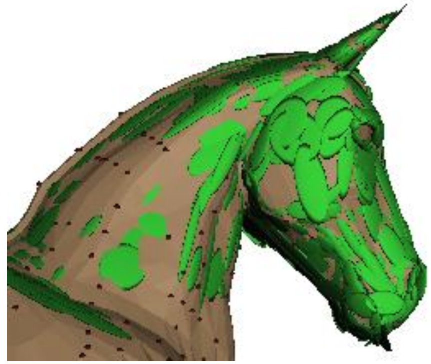
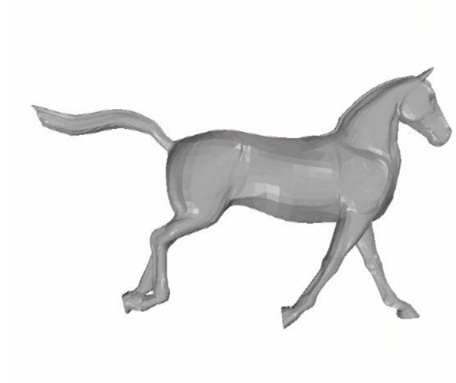
What we perceive in animation

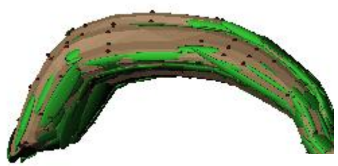


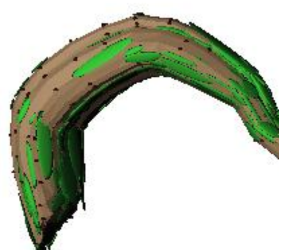
Problem with DSD



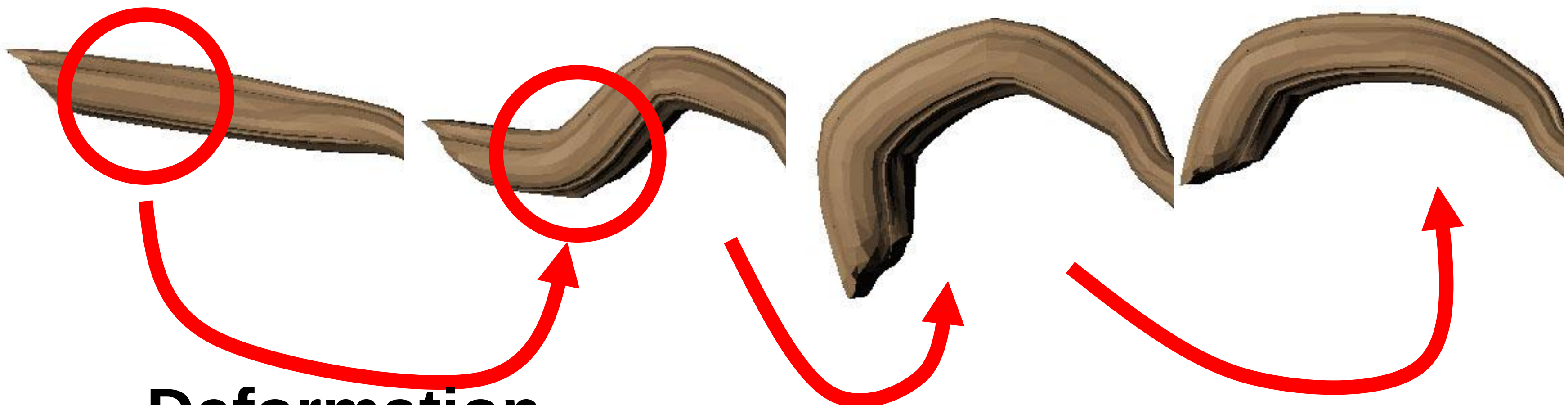
Problem with DSD

Cost =  x n 

Cost =  +  + 

\+  + ...

Deformation Oriented Decimation (DOD)



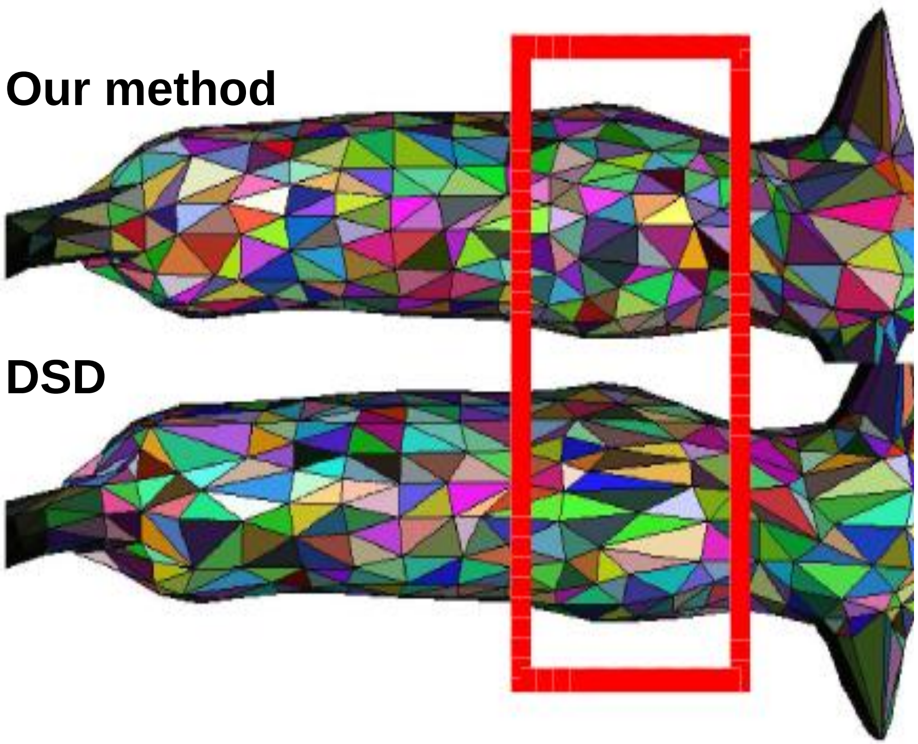
Deformation

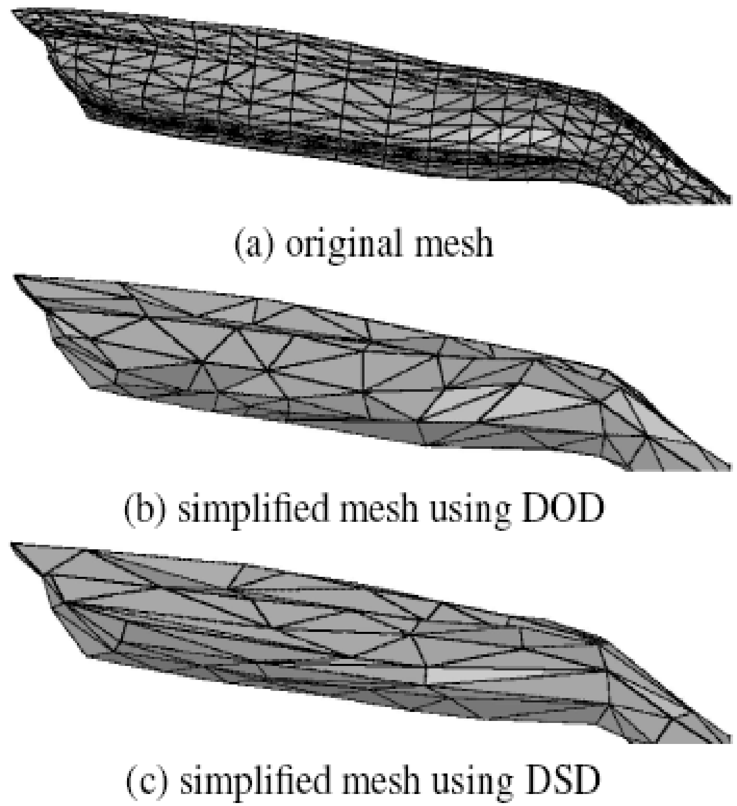
$=\Delta l^{t}$ Δl^{t+1} Δl^{t+2}

$$\text{Criteria} = \Sigma_t \left(Q^t + \underline{\text{weight} * \Delta l^{t}} \right)$$

SCA´06

Comparison





Agenda

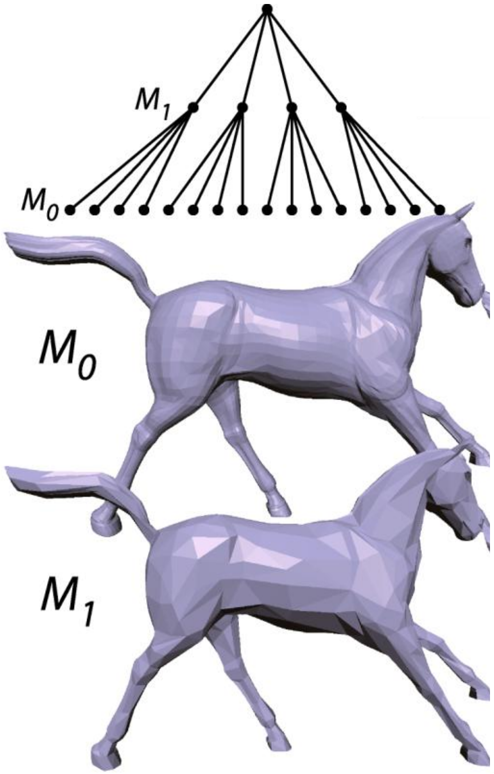
- Static Connectivity
  - QEM
  - Deformation Sensitive Decimation (DSD)
  - Deformation Oriented Decimation (DOD)
- Dynamic Connectivity
  - Vertex Tree (View Dependent Simplification)
  - Dynamic Connectivity Updating (DCU)

The need for dynamic connectivity

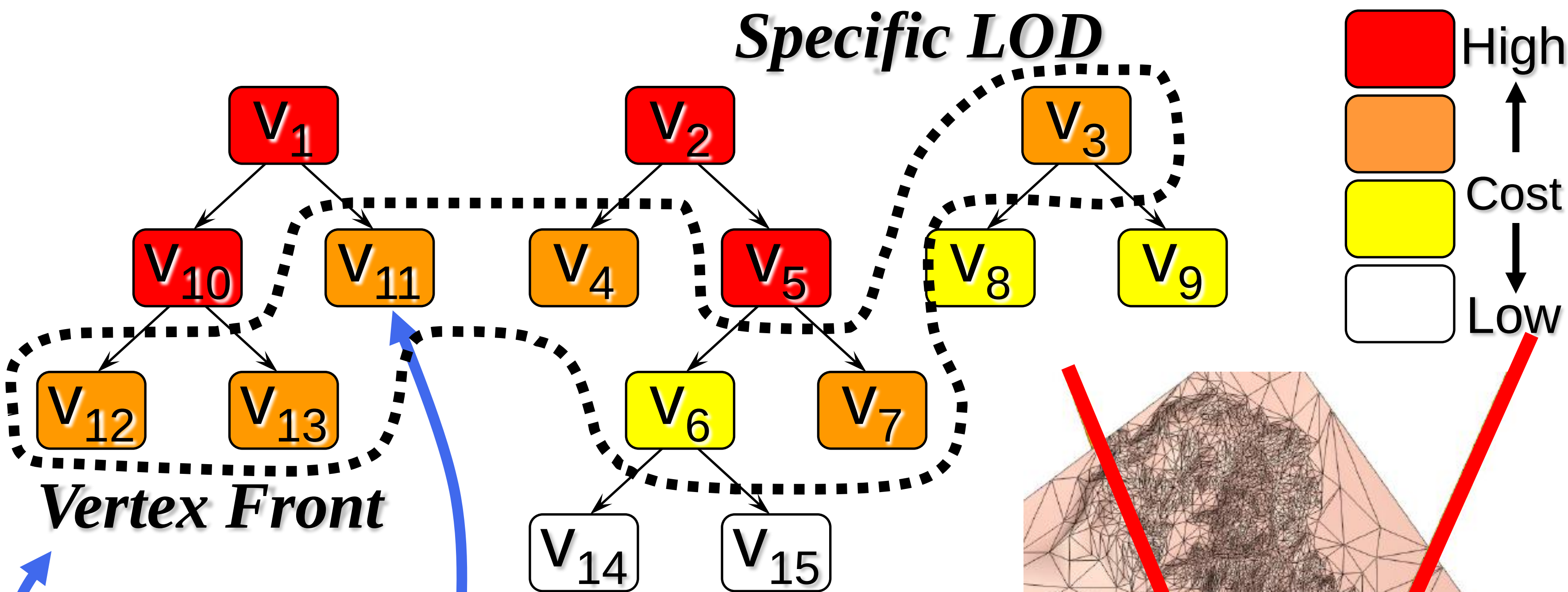
- Extreme deformation or 3D morphing

Previous Approach – Dynamic Connectivity

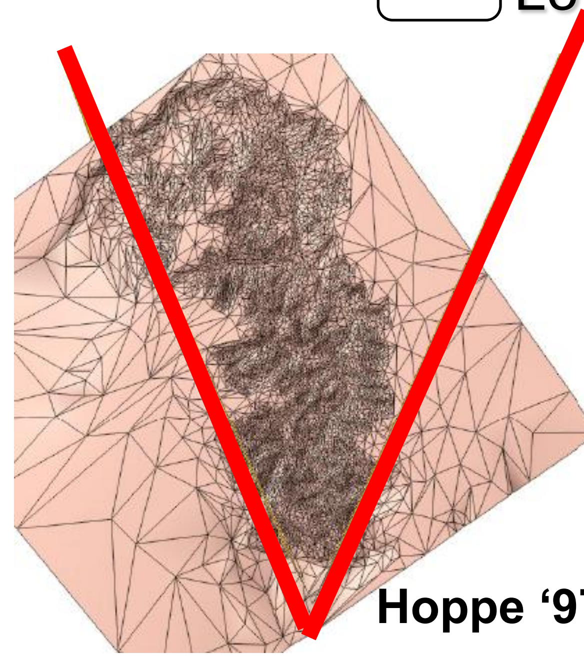
- Progressive Multiresolution Meshes for Deforming Surfaces
  - by Kircher and Garland, SCA 2005



Vertex Tree (View Dependent Simplification)

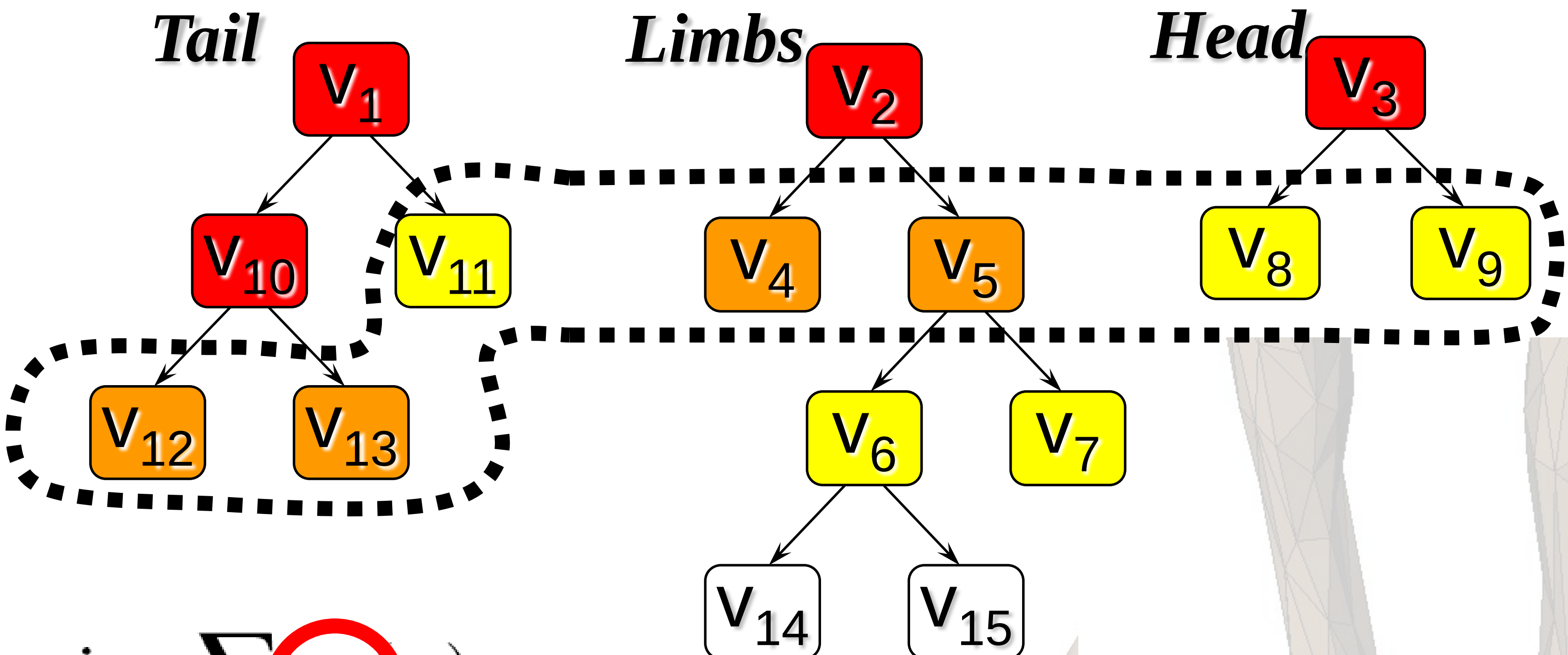


$$\min_{\mathbf{F}\in\Phi_m} \sum_{\mathbf{n}\in\mathbf{F}} \eta(\mathbf{n})$$



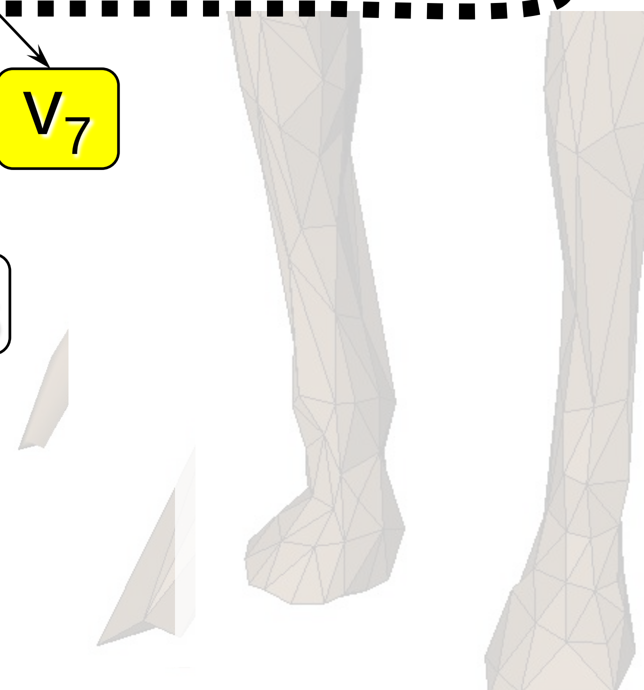
Hoppe '97

Vertex Tree for deforming meshes

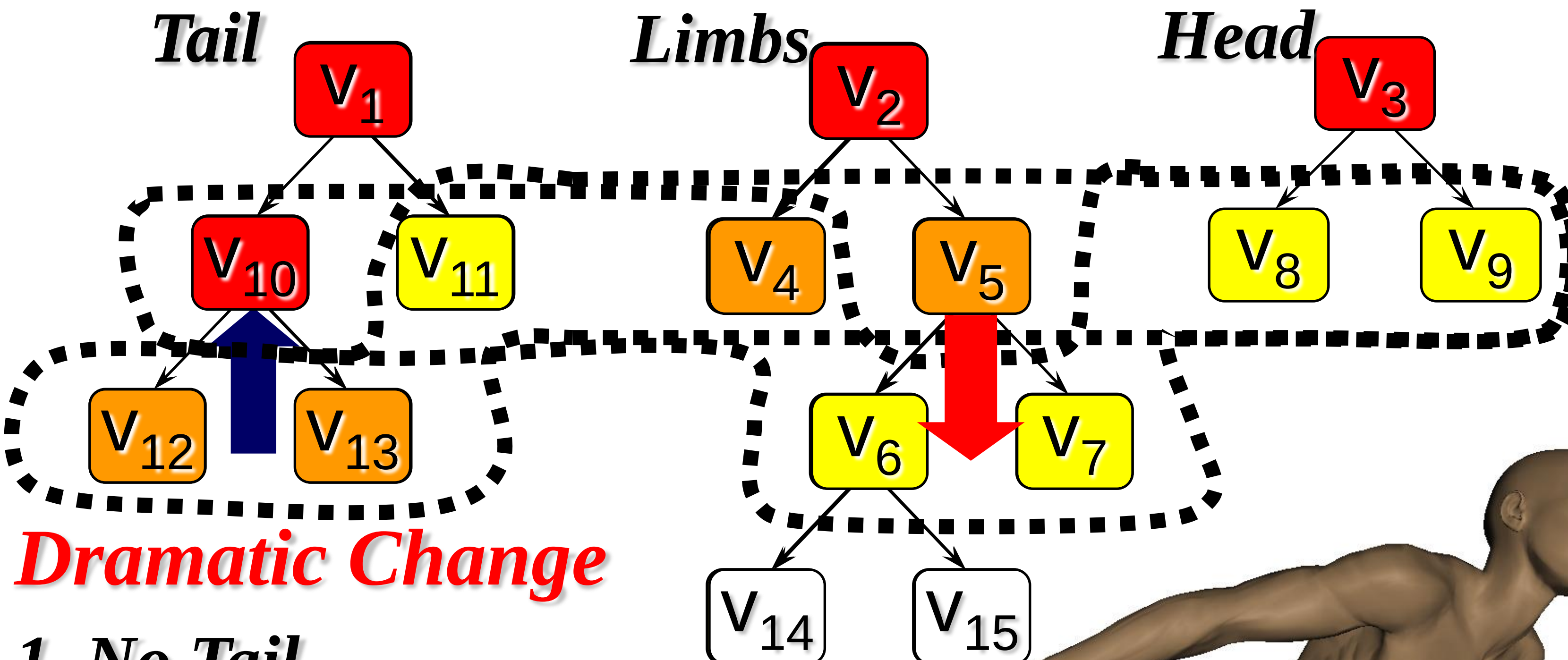


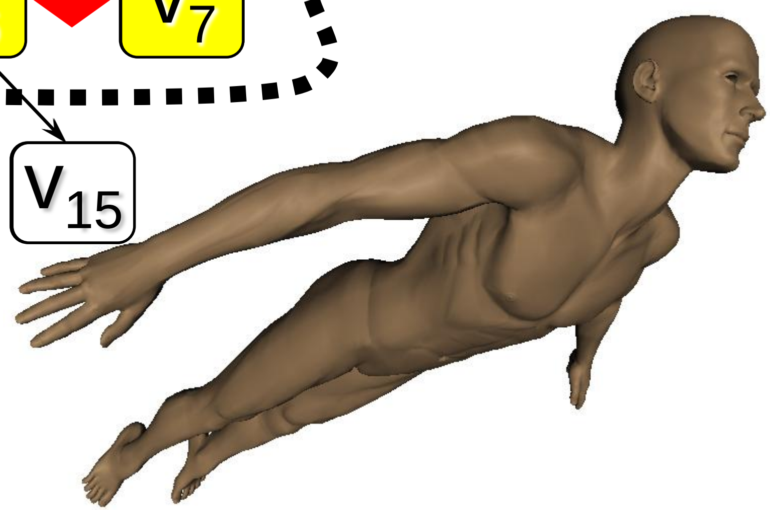
$$\min_{\mathbf{F}\in\Phi_m} \sum_{\mathbf{n}\in\mathbf{F}} \eta(\mathbf{n})$$

Geometry cost



Vertex Tree for deforming meshes



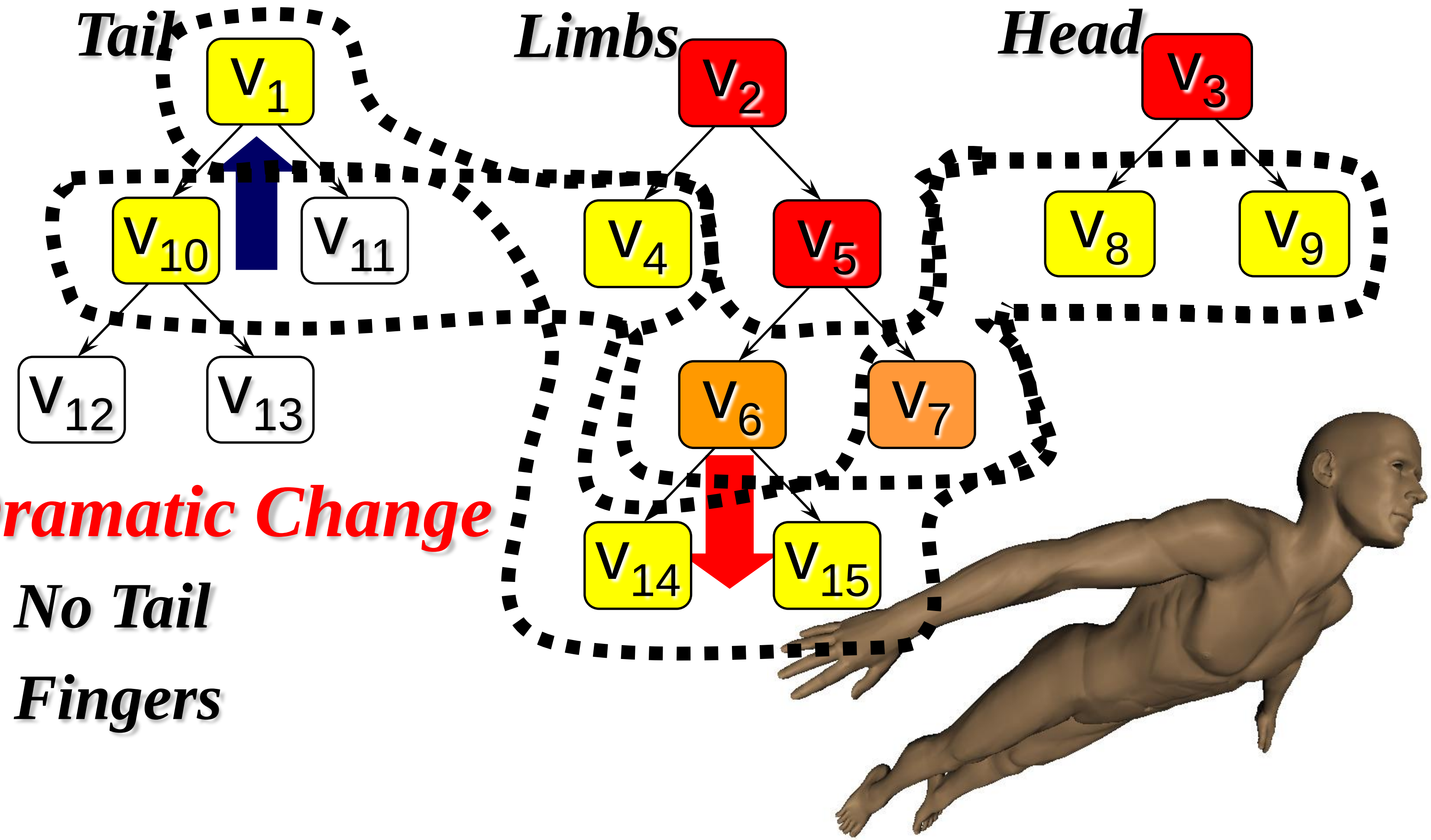


Dramatic Change

1. No Tail

2. Fingers

Vertex Tree for deforming meshes



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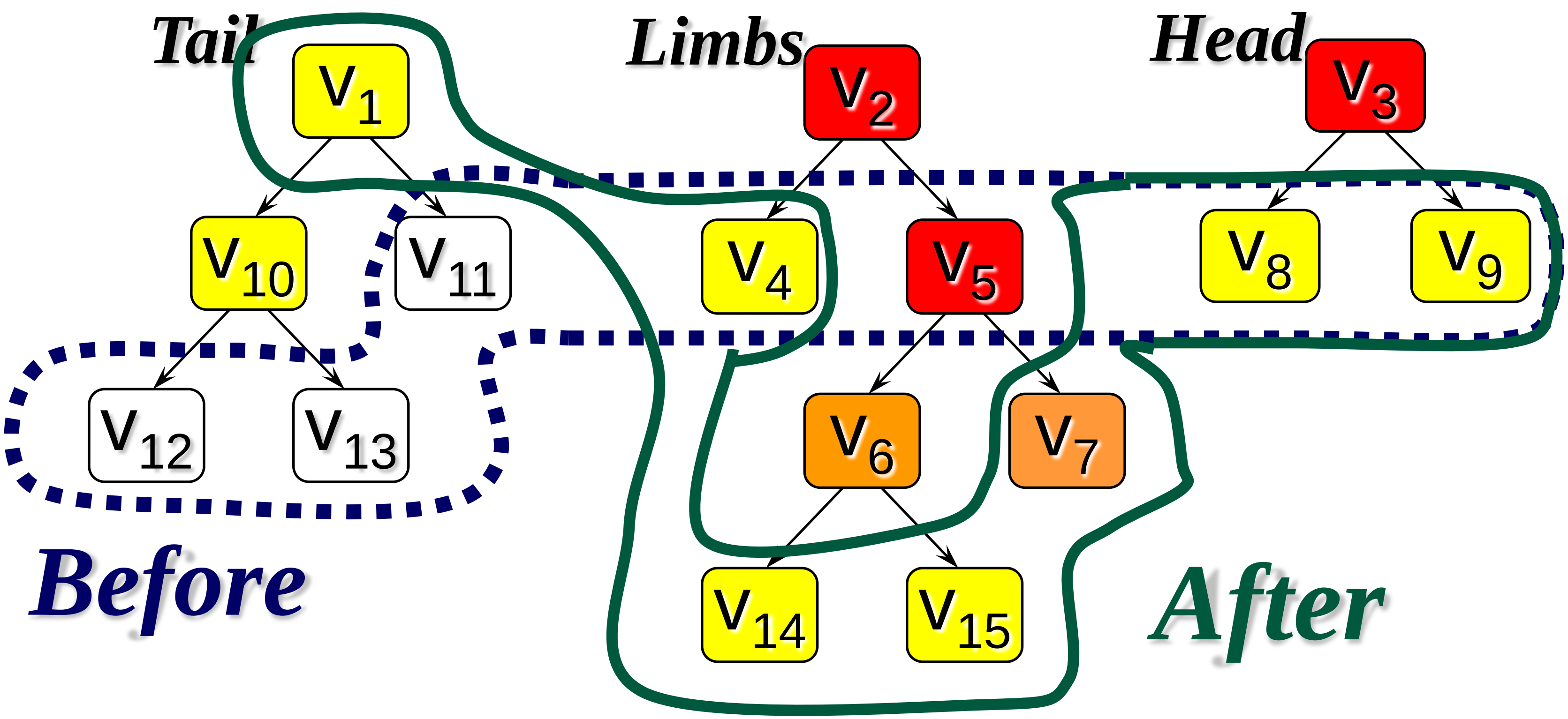
Vertex Tree for deforming meshes



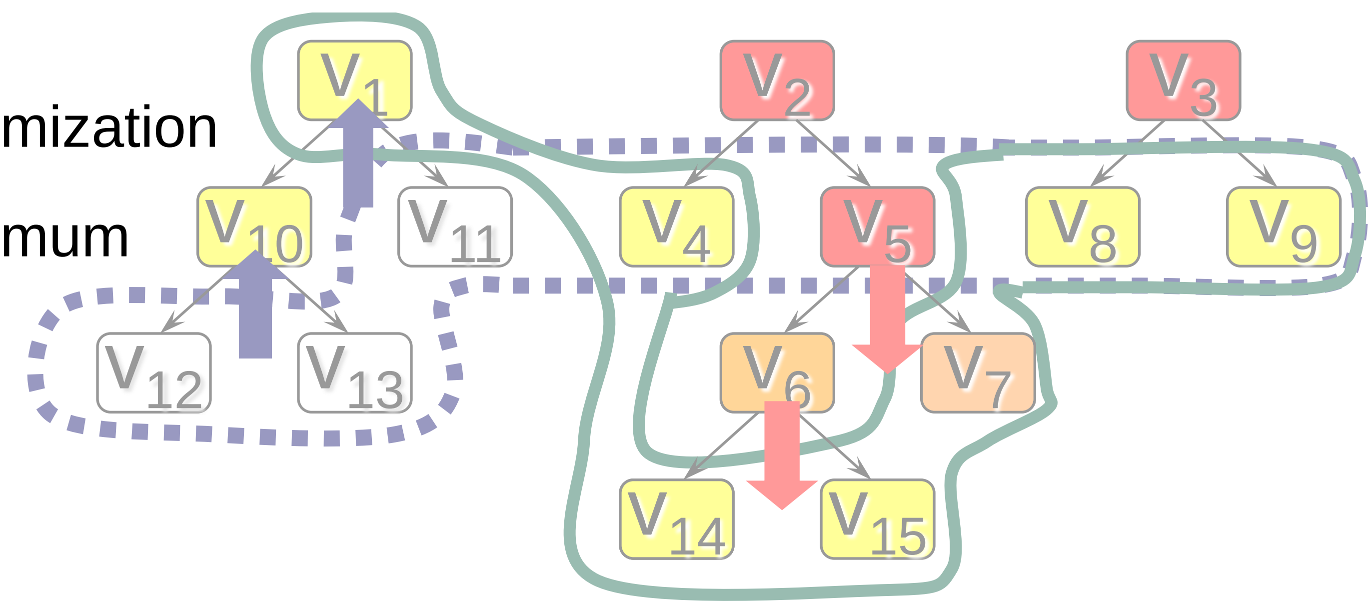
1. *No constraints on temporal coherences*
2. *Updating b2n frames*

Video: Without Coherence

Revised Cost Function

$$\sum_{\mathbf{n} \in \mathbf{F}^t} \eta(\mathbf{n})$$

- Problem:
  - Huge minimization
  - Local minimum



Approximation

- Facts:

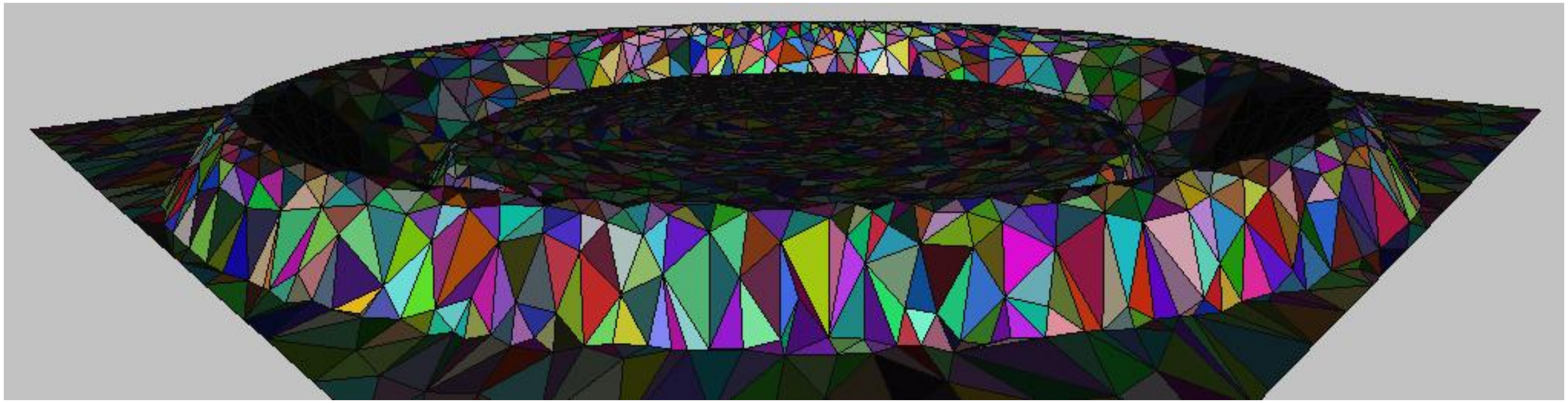
$$\min_{\mathbf{F}^1,\ldots,\mathbf{F}^f \in \Phi_m} \left(\underbrace{\sum_{t=1}^{f} \sum_{\mathbf{n}\in\mathbf{F}^t} \eta(\mathbf{n})}_{\textbf{distortion}} + k \underbrace{\sum_{t=1}^{f-1} D(\mathbf{F}^t, \mathbf{F}^{t+1})}_{\textbf{coherence}} \right)$$

$$= \mathbf{0},\ \mathbf{F}^t = \mathbf{F}^{t+1} = \overline{\mathbf{F}}$$

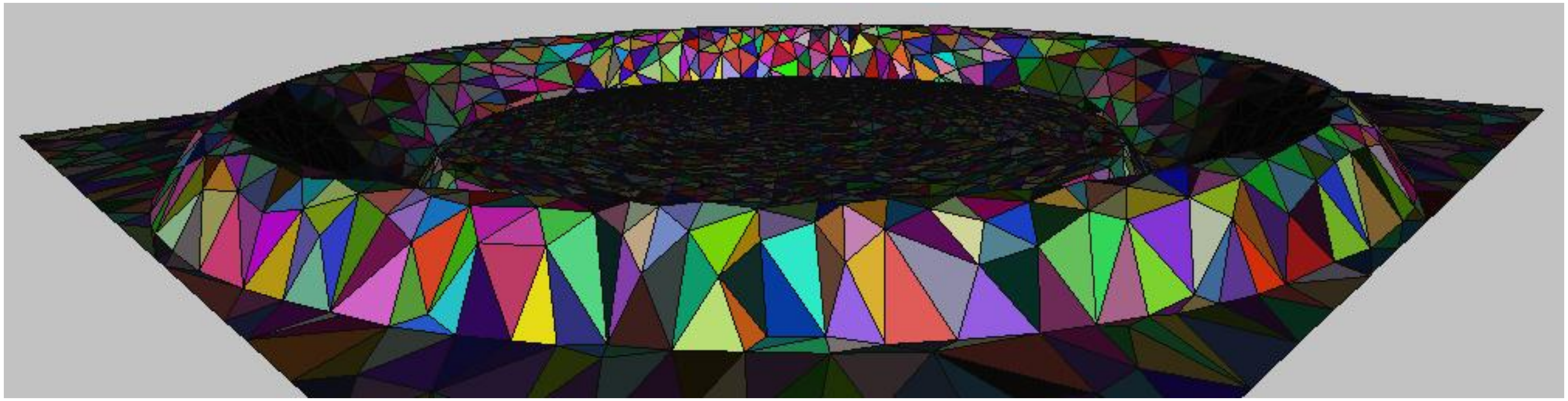
- Given initial guess
  - 1^{st} term
  - 2^{nd} term

$$\min_{\mathbf{F}\in\Phi_m} \left(\sum_{\mathbf{n}\in\mathbf{F}} \eta(\mathbf{n}) + k * D(\mathbf{F}, \overline{\mathbf{F}}) \right)$$

Result: DCU against DOD only



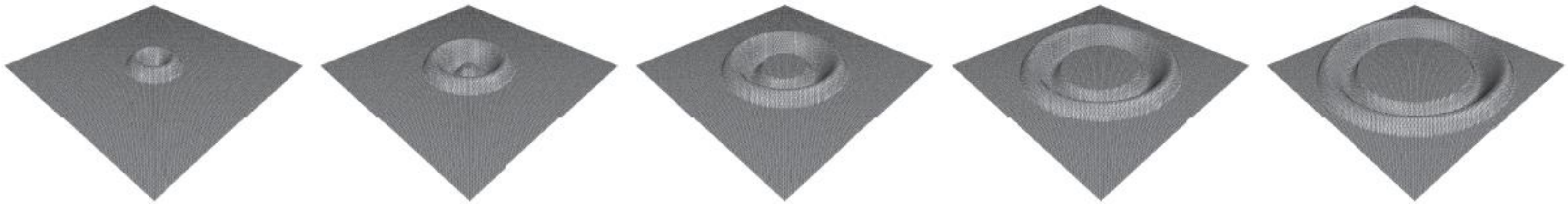
Dynamic Connectivity

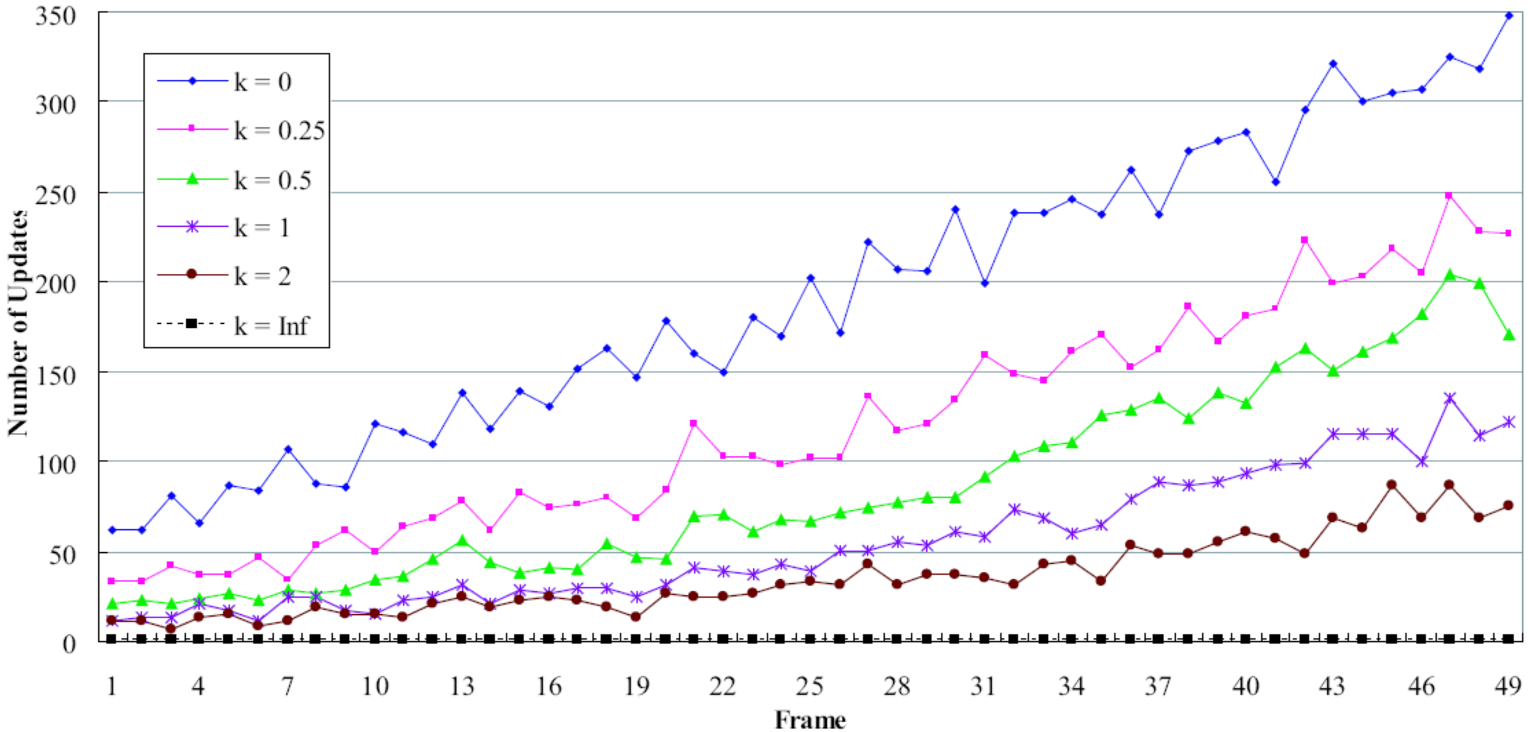


Static Connectivity

Video: Connectivity Updating

Statistics - Updating



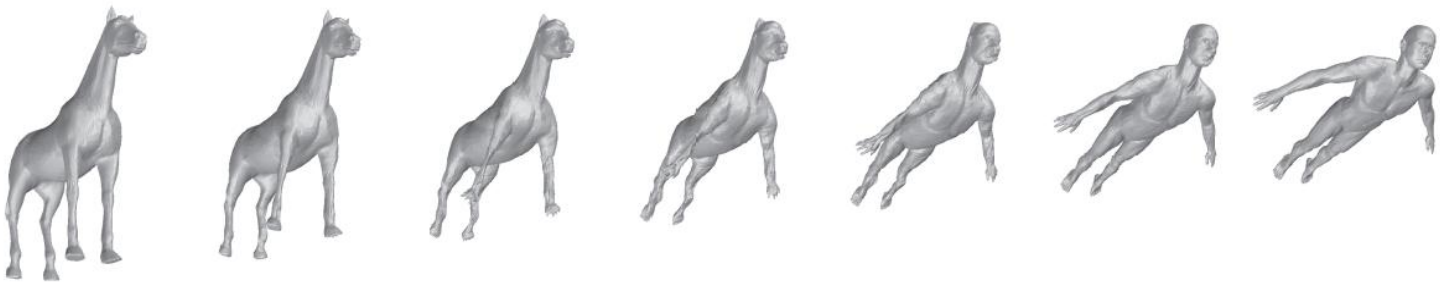


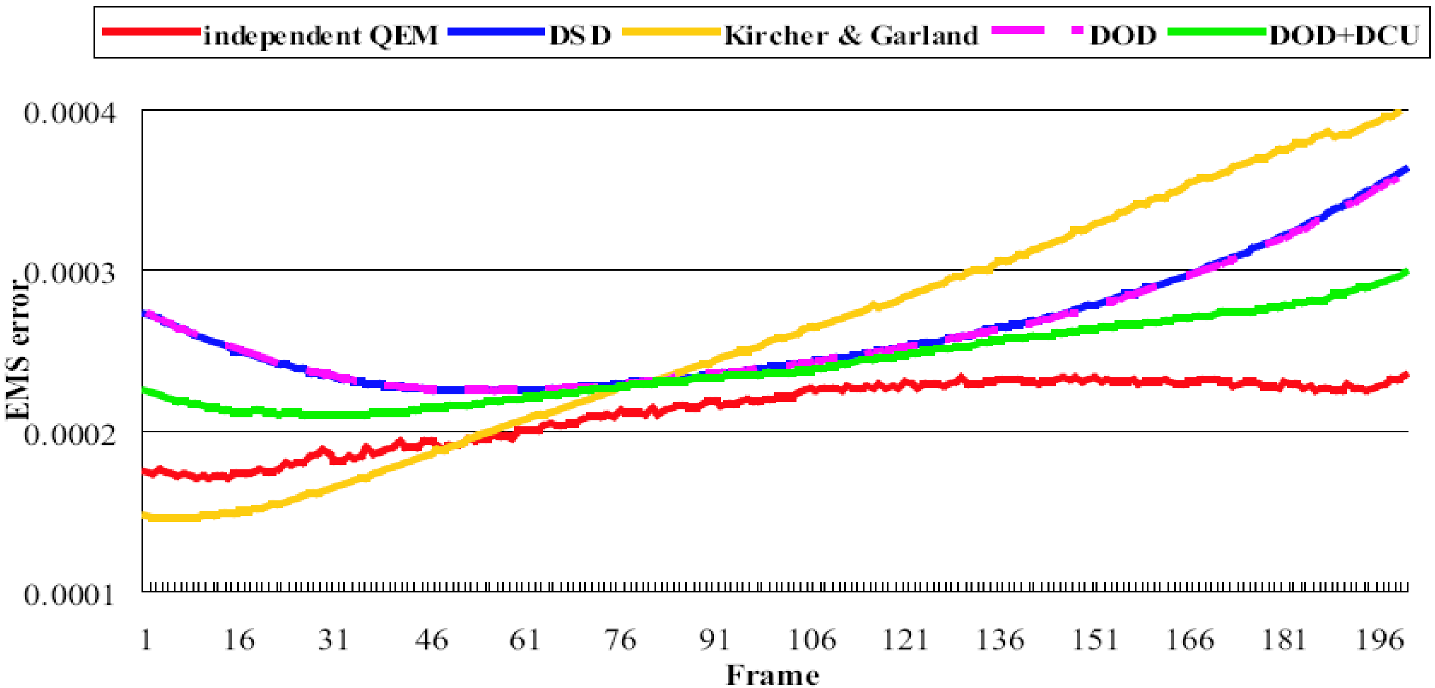
Results

Previous method

Kircher and Garland (SCA05)

Statistics - Distortion





Result : Elephant-Horse Morphing

Elephant-Horse Morphing

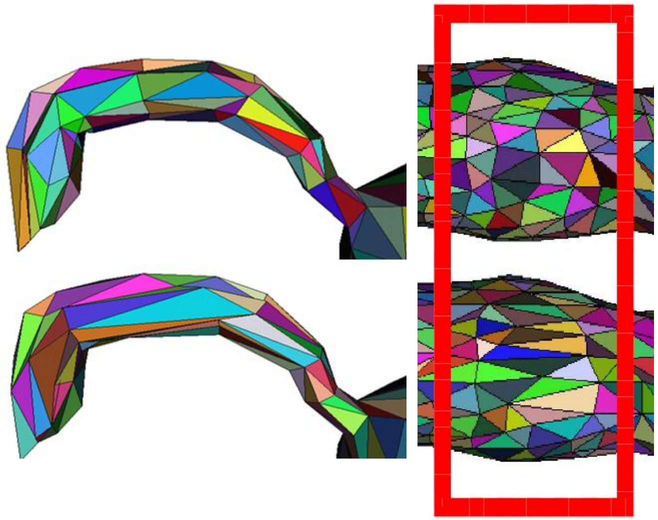
42900v/85796f

Result : SpaceTime Face

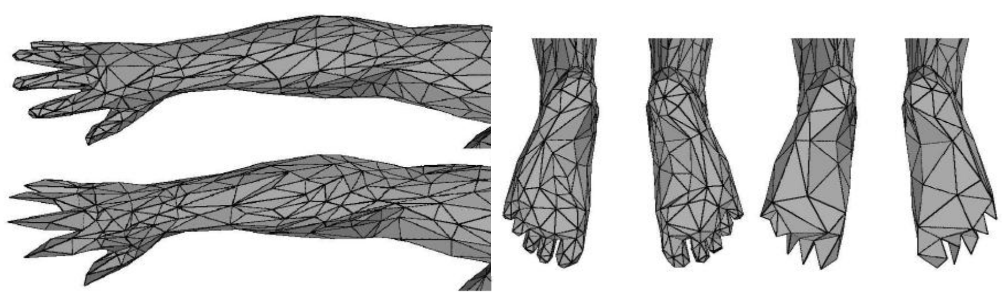
SCA´06

Summary

- **DOD**
  - Addition of deformation term
  - Better triangulation and more tri.



- **DCU**
  - Utilization of vertex trees
  - Lower distortion and less updating



Limitation

- **Heuristics formulation for DOD**
  – Used for contract-priority only
- **Sub-optimal solution for DCU**
  – Approximated objective function
- **Not incremental**
  – As opposed to [Kircher and Garland ‘05]
- **No hardware support**

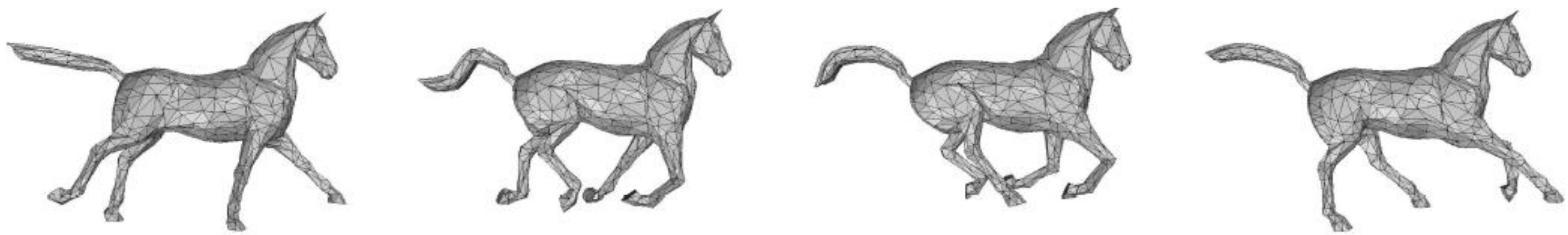
Acknowledgement

- Models
  - Sumner and Popovi´c for the horse-gallop animation
  - Alla Sheffer for the morphing data
  - Li Zhang for the facial expression animation
- Reviewers
- Supports
  - NSC, Taiwan
  - National Taiwan University

Thank You

Goal – Level of Details

- Static connectivity (DOD)
  - Articulated mesh

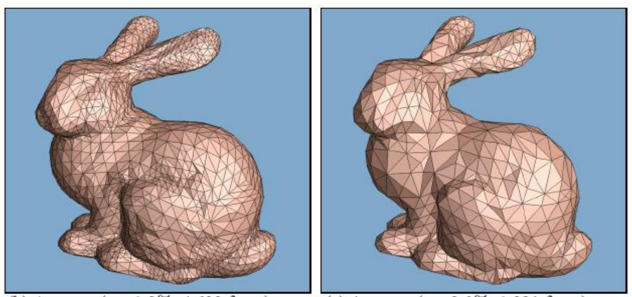


- Dynamic connectivity (DCU)
  - Extreme deformation, 3D morphing

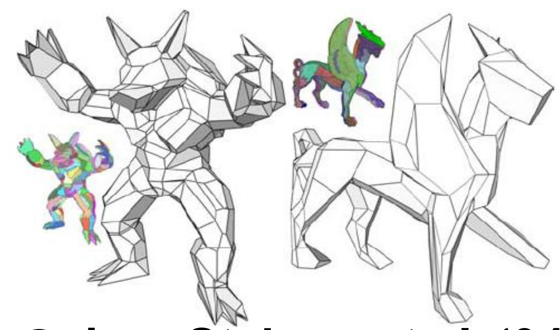
Related Work

Related Work

- Static Mesh
  - Re-meshing approach

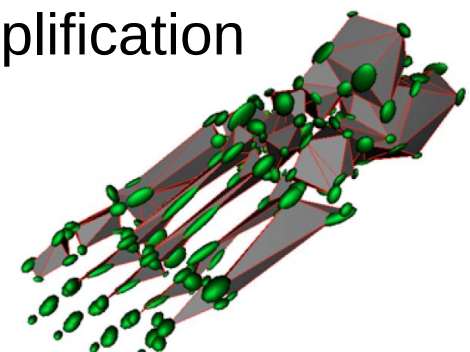


Eck et al. '95

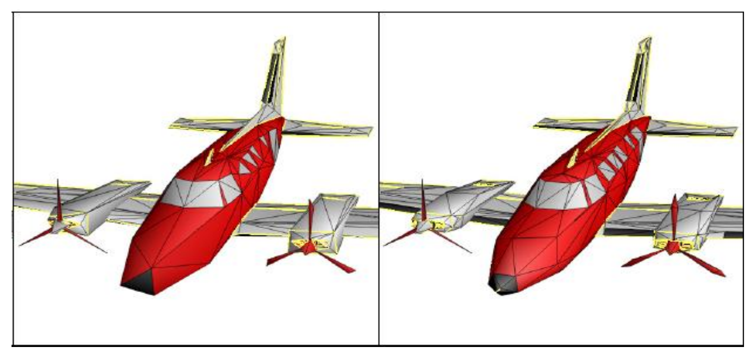


Cohen-Steiner et al. '04

  - Simplification



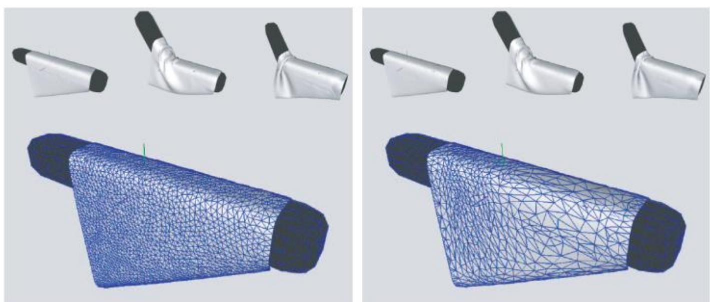
Garland & Heckbert '97



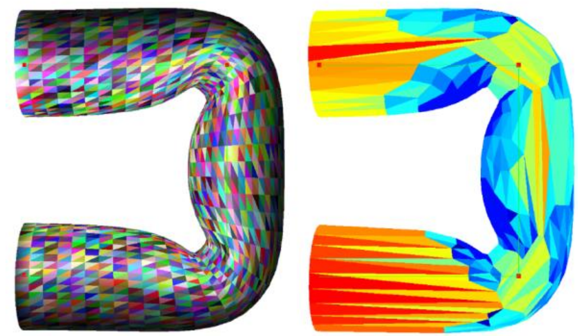
Hoppe '96

Related Work

- Deforming Mesh
  - Static connectivity

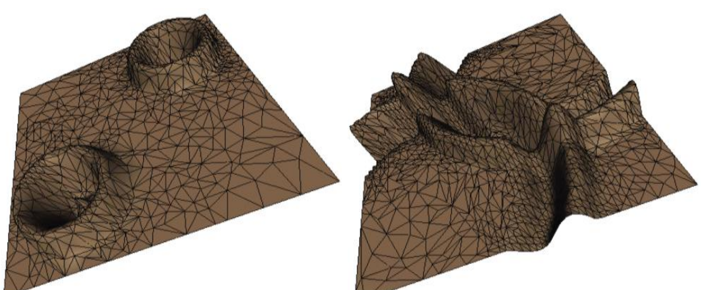


Mohr & Gleicher ‘03

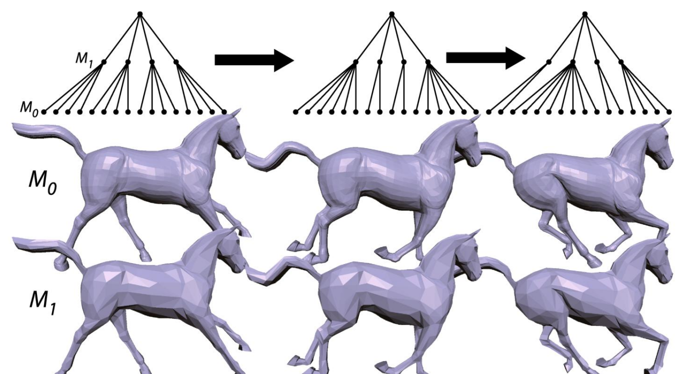


DeCoro & Rusinkiewicz ‘05

  - Dynamic connectivity



Shamir *et al.* ‘00, ‘01



Kircher & Garland ‘05