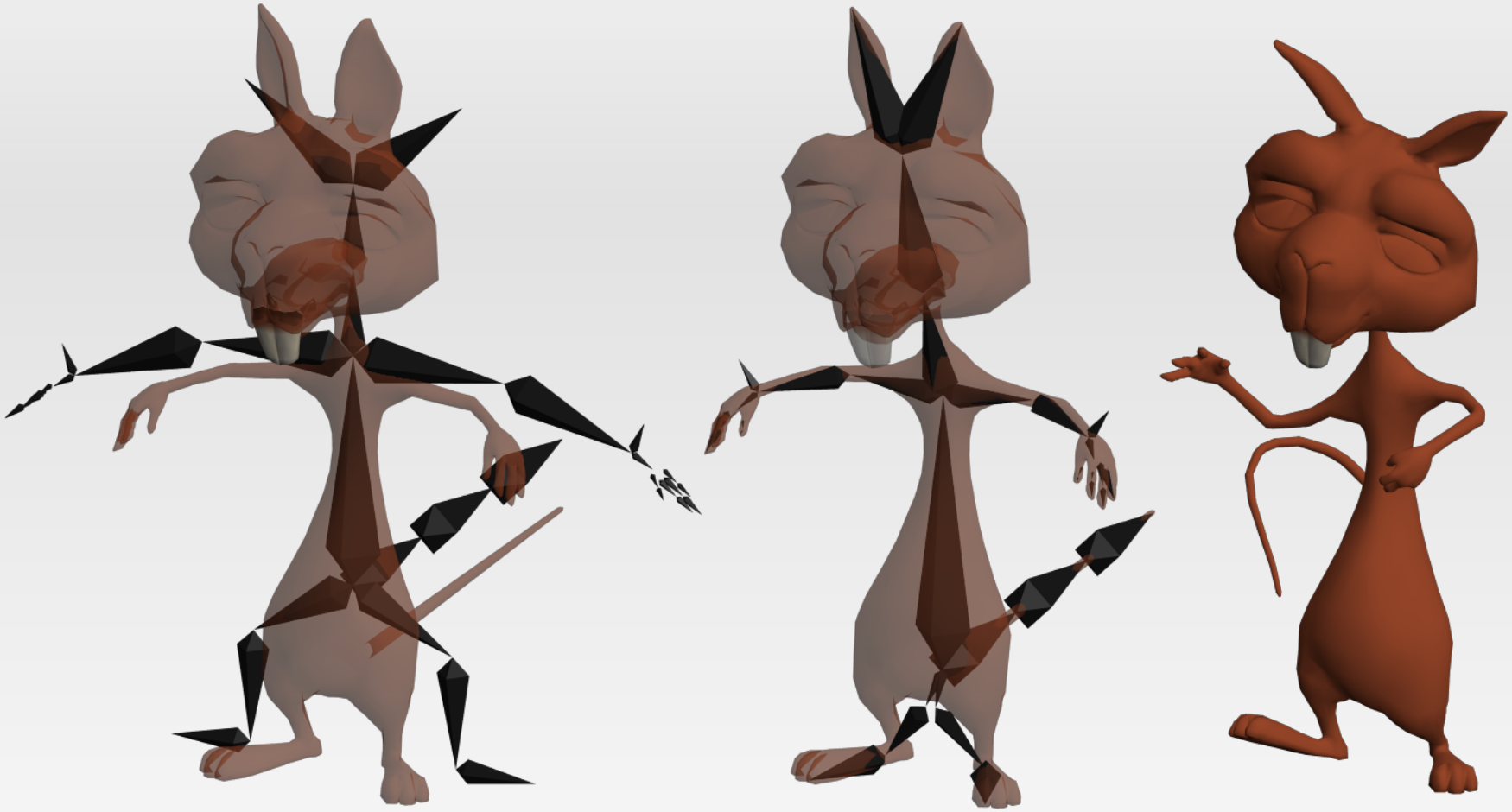
Rig Retargeting for 3D Animation



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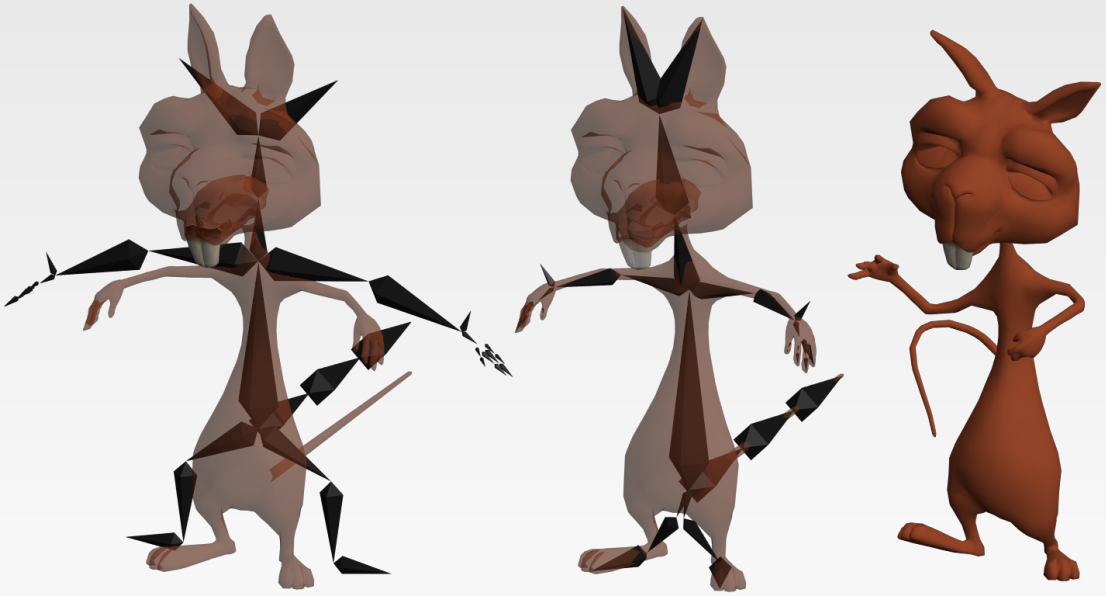
Solving Reusability Problems

- How to reuse professional animation rigs without having to adapt them by hand?
- How do we handle control bones as well as deformation bone?



Previous Work – Skeleton Extraction

Volumetric methods [Brunner 2007]

- Often limited to closed volume
- Noisy volumetric approximation
- Problems with thin limbs

- Geometric methods [Pascucci 2007]
  - Faster to compute
  - Presence of smaller unimportant arcs
  - Size independant, can handle thin limbs

Previous Work – Generation and Retargeting

- Generation by subdivision of a mesh topology graph
  - Simple templates only [Aujay 2007]
- Retargeting by graph matching/fitting
  - Very simple skeletons [Baran 2007]
- Using an anatomy knowledge base
  - Limited to humans [Dellas 2007]

Contributions

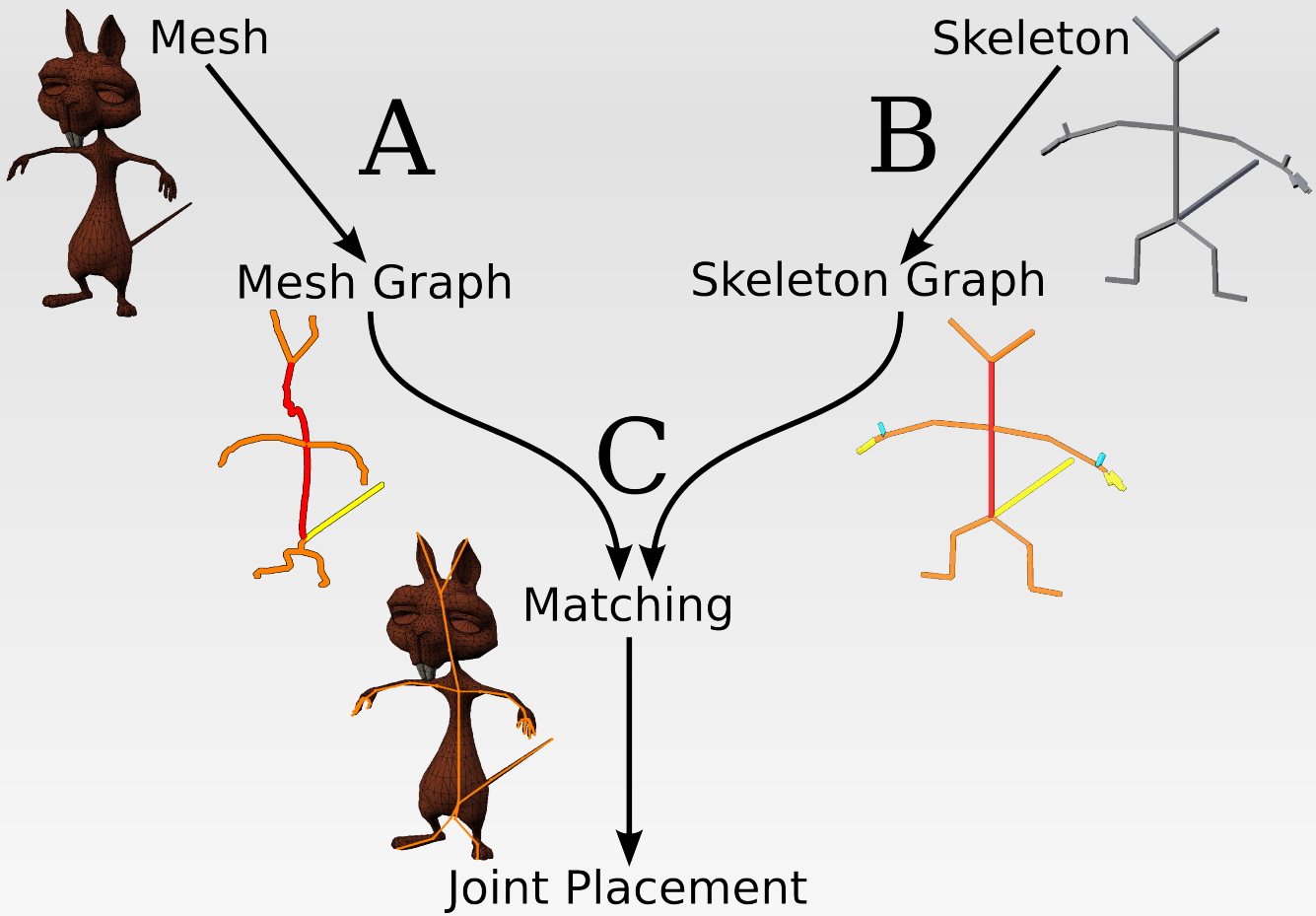
- Multiresolution topology graph filter
- Shape descriptor
- Multiresolution graph matching
- Weighting function for joint placement
- Control bones handling

Algorithm Overview

A. Extract topological graph from mesh

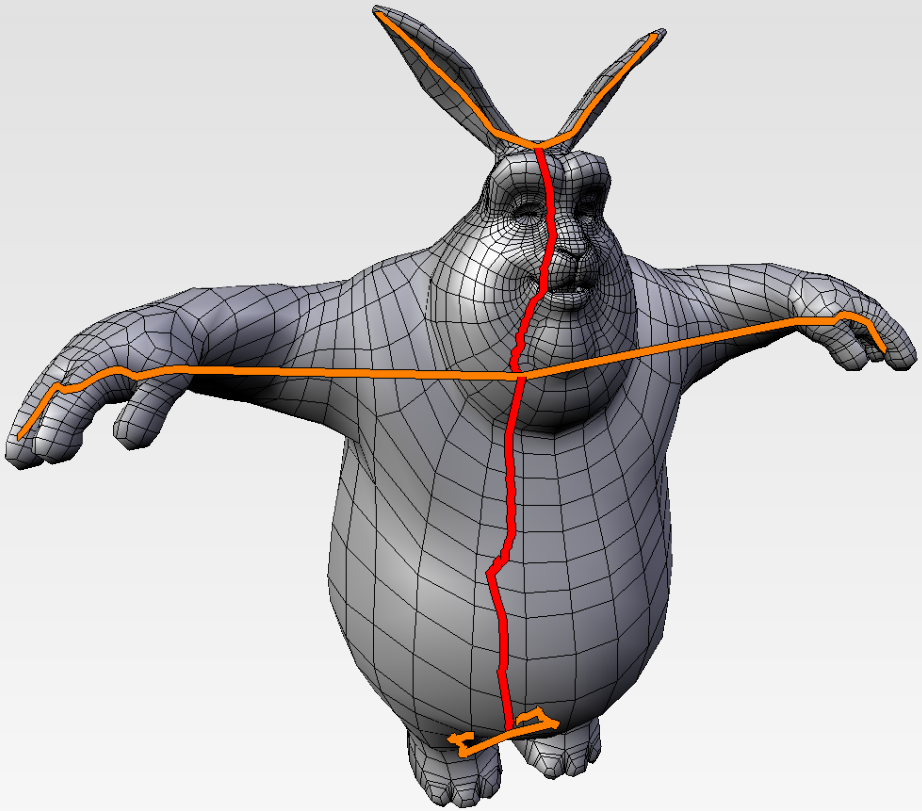
B. Extract graph from skeleton

C. Retarget skeleton to mesh



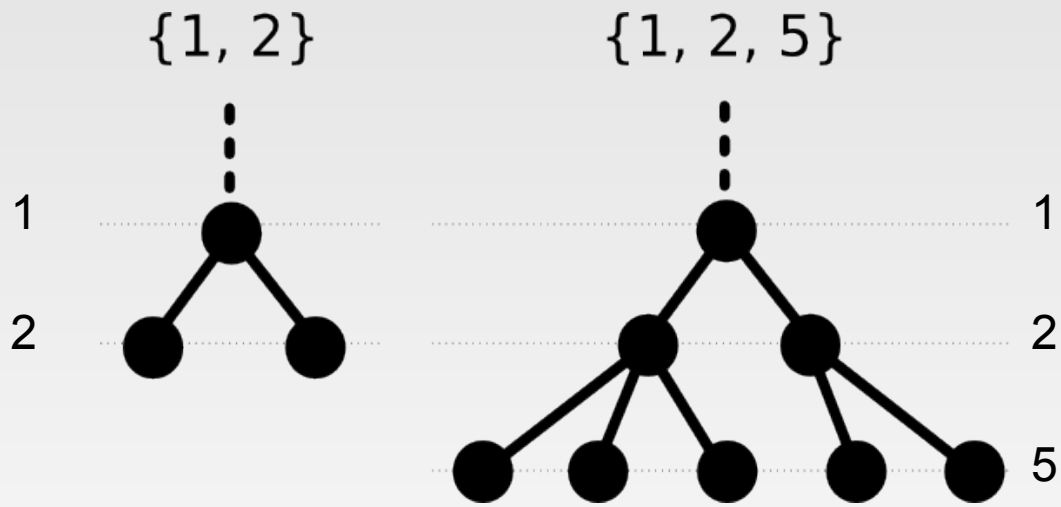
Skeletonization

- Reeb graph from mesh
- Symmetry detection
- Multiresolution filtering



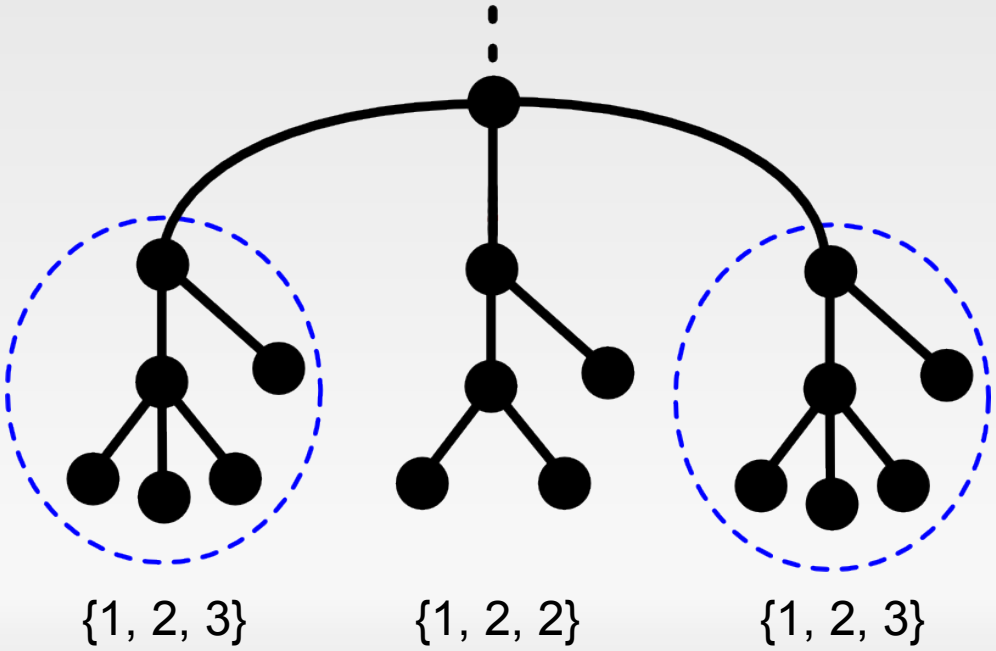
Symmetry Detection

- Shape descriptor
  - Sum of the number of child at each level



Symmetry Detection

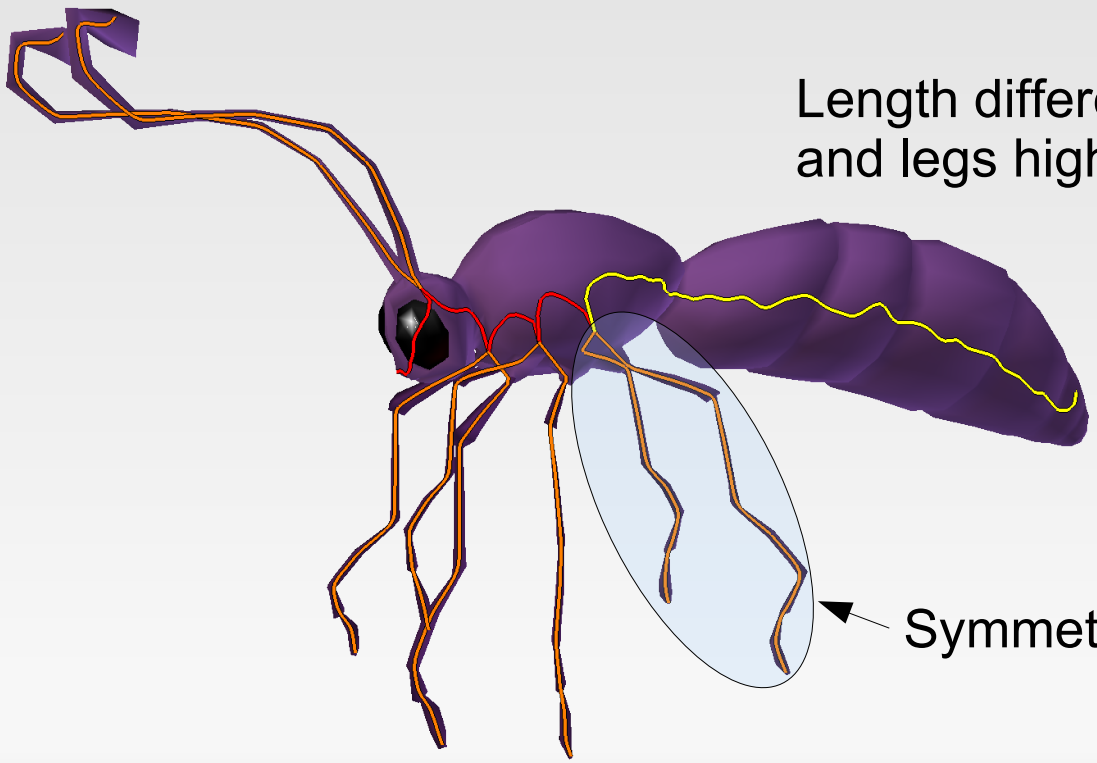
- Detect topological symmetry by comparing shape descriptors
- Test if symmetry is also geometrical



Grouping

video symmetry

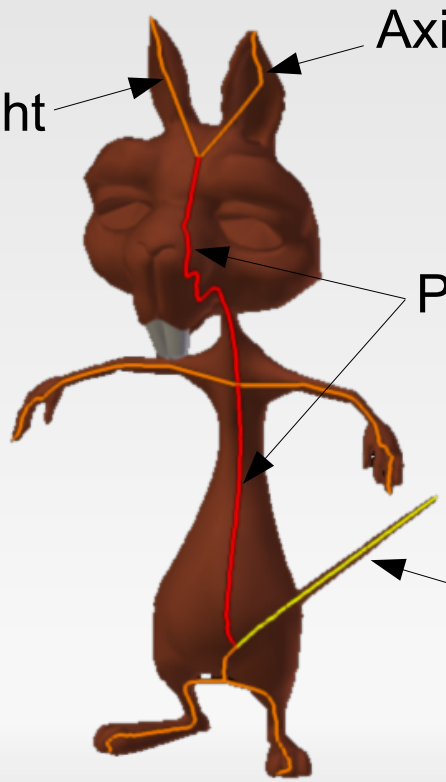
- Length grouping to restrict symmetry groups to arcs of similar lengths



Tagging

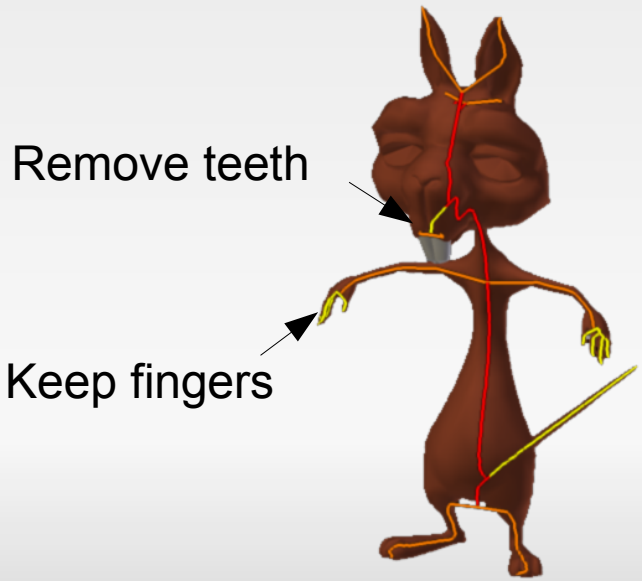
video symmetry

- Tagging
  - *Radial/Axial* symmetry
  - *Left/Right* side



Multiresolution Filtering

- Remove unneeded and unwanted details from topology graphs
- Problem with single threshold filtering
  - Hard to adjust
  - Sometimes a correct solution doesn't exist
- Solution
  - Multiresolution filtering



Retargeting

- Multiresolution matching
- Skeleton retargeting
- Joints placement
- Control bones retargeting

Multiresolution Matching

- Starting from the head node

1. Match skeleton arc to mesh arc using **symmetry** information
2. Find multiresolution level where mesh arc has **equal local shape** descriptor
3. Continue to the **next node** along the arc
4. Find coarsest multiresolution level where mesh node has **equal local shape** descriptor
5. **Recursively** work from this node

Multiresolution Matching

video matching

- Starting from the head node

1. Match skeleton arc to mesh arc using **symmetry** information
2. Find multiresolution level where mesh arc has **equal local shape** descriptor

Go to **finer** resolutions to add needed arcs

3. Continue to the **next node** along the arc
4. Find coarsest multiresolution level where mesh node has **equal local shape** descriptor

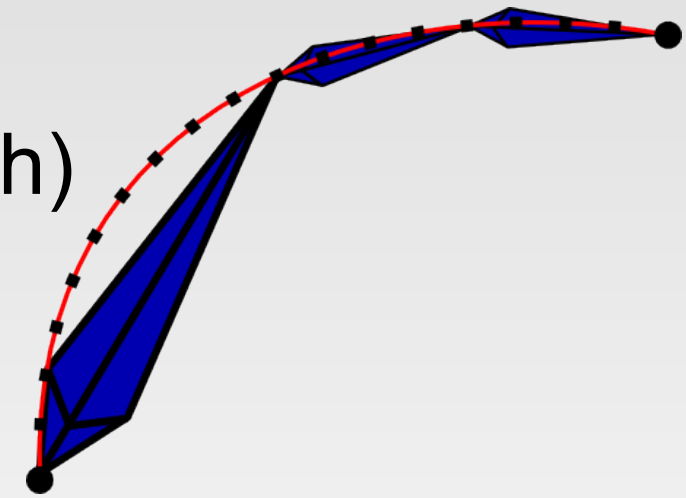
Go to **coarser** resolution to remove unneeded arcs

5. **Recursively** work from this node

Joint Placement

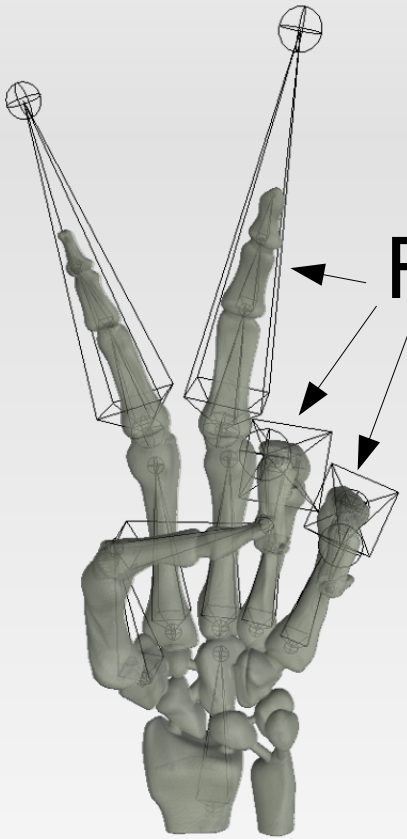
video weights

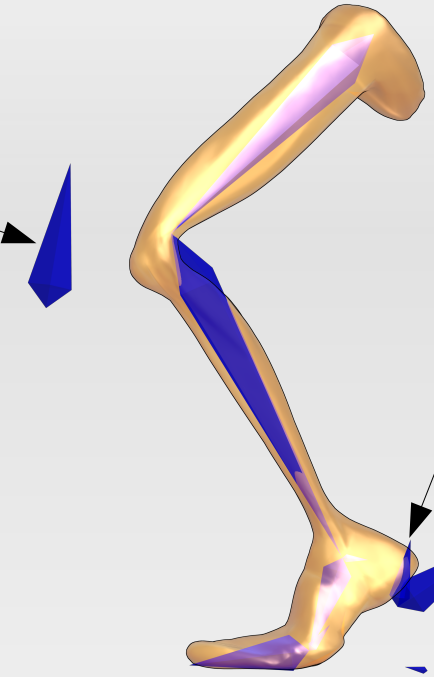
- Minimizing a sum of penalty functions
- Balancing between
  - skeleton shape (angle, length)
  - mesh shape (distance)

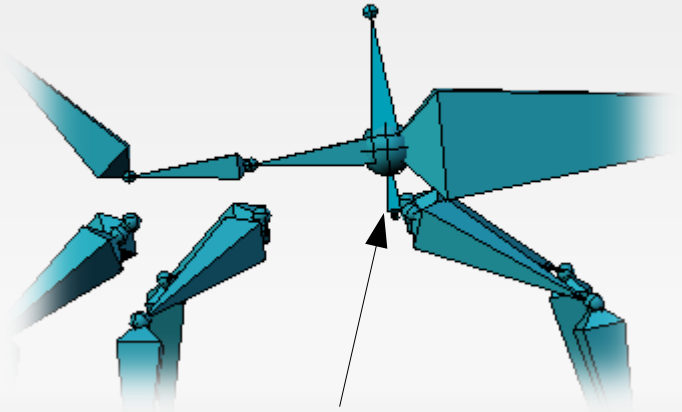


$$weight = \sum_{i=1}^{t} \underbrace{\gamma_\theta |\theta_i|}_{\text{angle}} + \sum_{i=1}^{t+1} \underbrace{\left[\gamma_l |l_i|^2\right.}_{\text{length}} + \underbrace{\left.\gamma_x x_i\right]}_{\text{distance}}$$

Control Bones - Examples





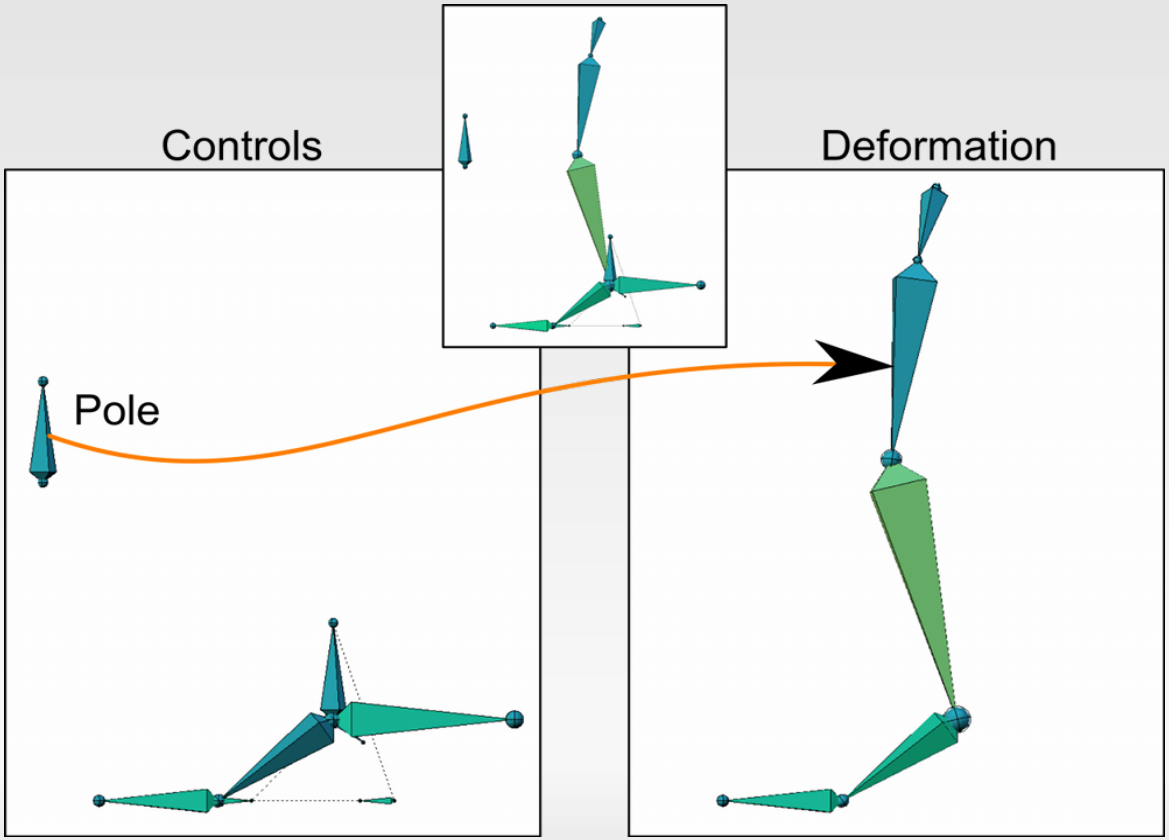


Control Bones

- Problem
  - Position not directly linked to character topology
- Solution
  - Link to deformation bones and propagate retargeting changes
- Different class of control bones
  - Constraint
  - Child
  - Root

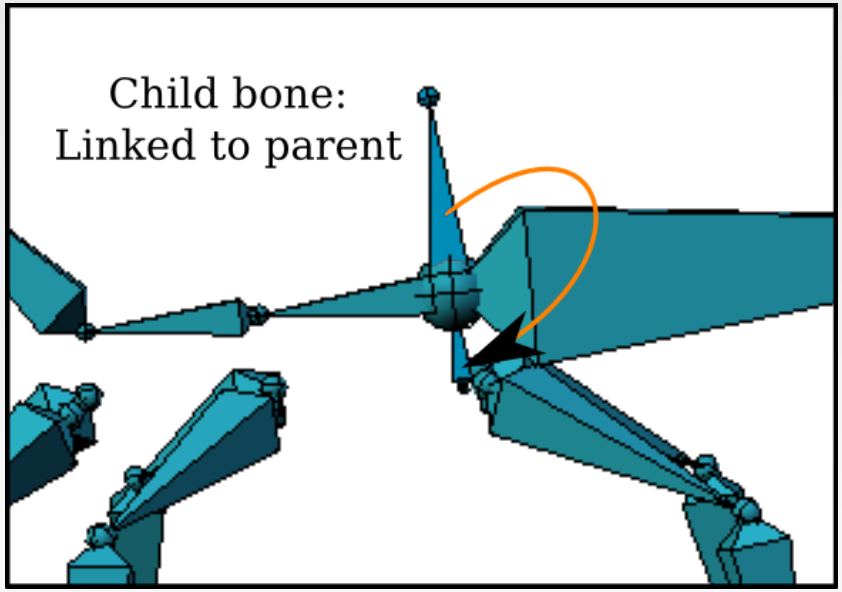
Control Bones - Constraints

- Bones used as inverse kinematics and pole targets, action controls and the like
- Linked to the constraint owner



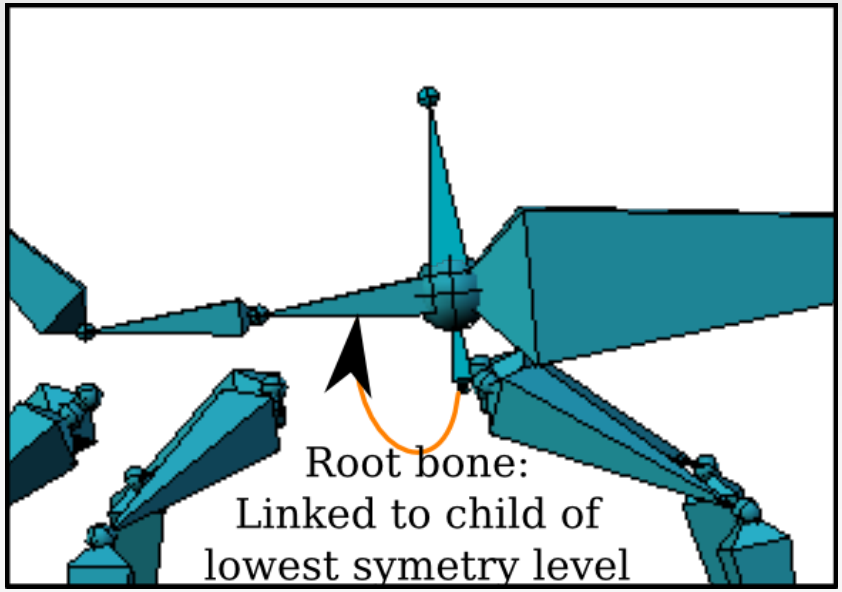
Control Bones – Children

- Bones used in chains of control bones
- Linked to their parent

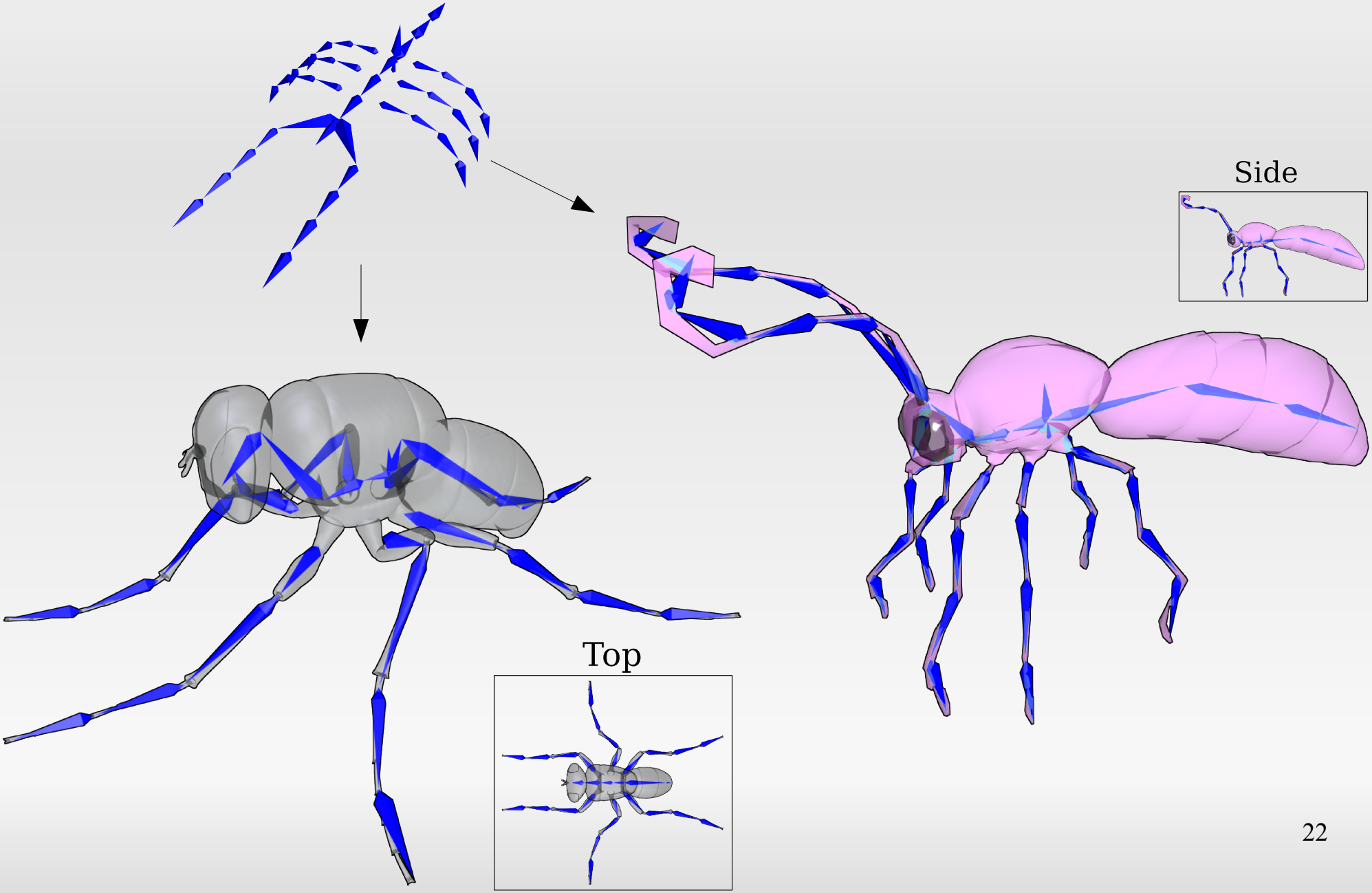


Control Bones - Roots

- Bones used as hierarchical roots
- Linked to the child of lowest symmetry level



Results



Results

video results

Performance

- Multithreading: while matching, each arc is concurrently dispatched for joint placement
- Memoization: optimizing the joint placement problem

Performance (CoreTM 2 Duo 2.4GHz / 4 GB RAM)

Model	Faces	Joints	Graph	Retarget	Total
Butterfly	2428	51	0.3s	1.5s	1.8s
Fly	8834	41	1.2s	4.5s	6.0s
Rinky	8562	42	1.9s	0.4s	2.7s
Toon	27232	136	7.5s	23.8s	32.6s

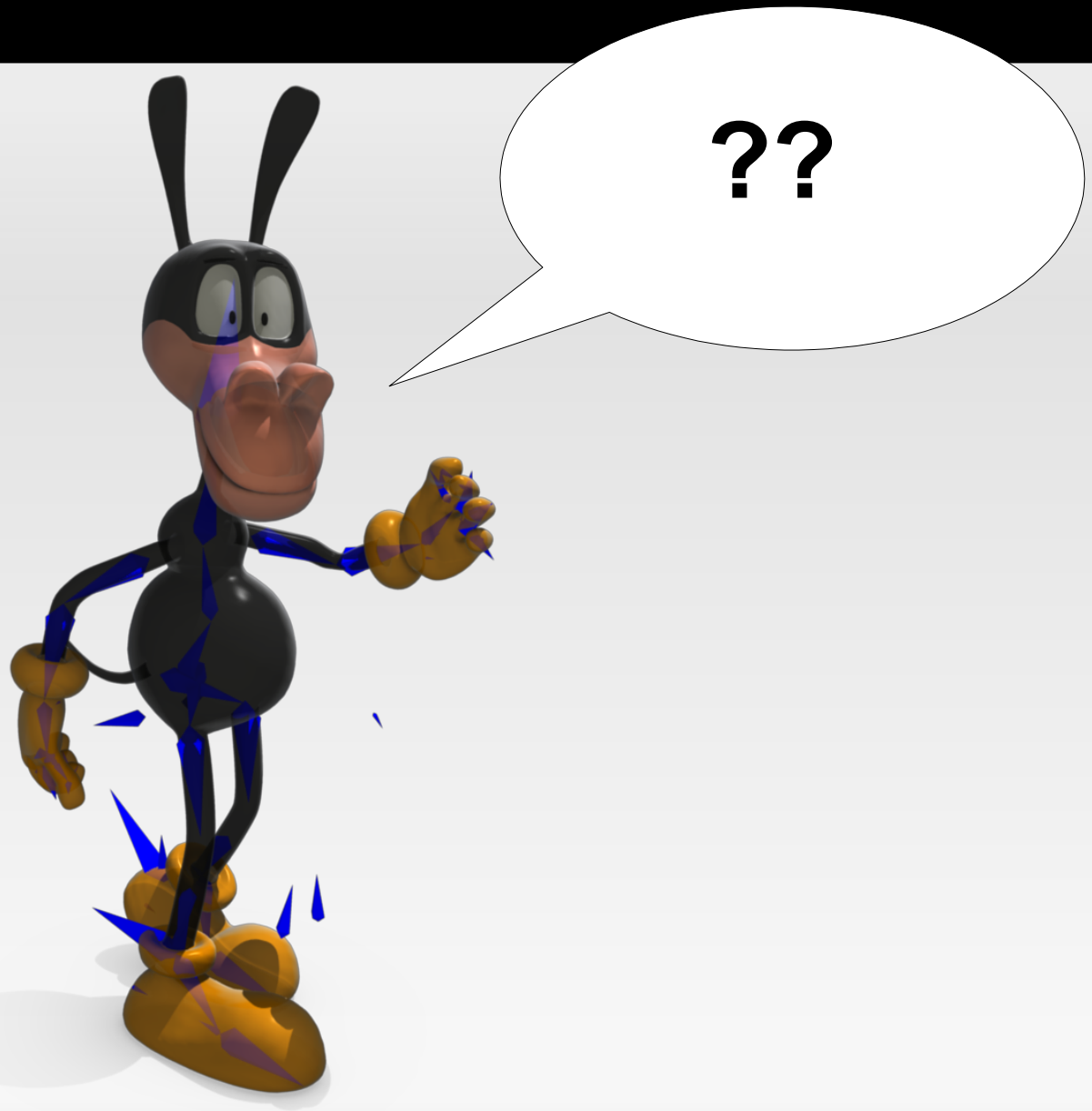
Conclusion

- Shape descriptor for symmetry detection and matching
- Multiresolution graph filtering and matching
- Weights for balanced joint placement
- Effective control bones handling
- Working implementation in Blender

Future Work

- Joint placement
  - Don't restrict position of start and end of arcs
  - Mesh segmentation
- Non-topological deformation bones
  - Muscles
  - Facial expressions
- Sketching ~ SIGGRAPH '09

Questions



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