Automatic Rigging for Animation Characters with 3D Silhouette

Junjun Pan[1], Xiaosong Yang[1], Xin Xie[1], Philip Willis[2], Jian J Zhang[1]

E-mail: pan_junjun@hotmail.com, xyang@bournemouth.ac.uk,

xxie@bournemouth.ac.uk, P.J.Willis@bath.ac.uk, jzhang@bournemouth.ac.uk

1. National Center for Computer Animation, Media School, Bournemouth University, UK

2. Media Technology Research Centre, University of Bath, Bath, UK

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Automatic Rigging for Animation Characters with 3D Silhouette

- Research Objective and Idea
- Algorithm
- Experiment and Comparison

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Research Objective

Most skeletonization method is to solve a “general” problem and usually computationally costly. Here we focus on the animation skeleton extraction and develop an efficient and easy-to-use rigging approach for animating characters.

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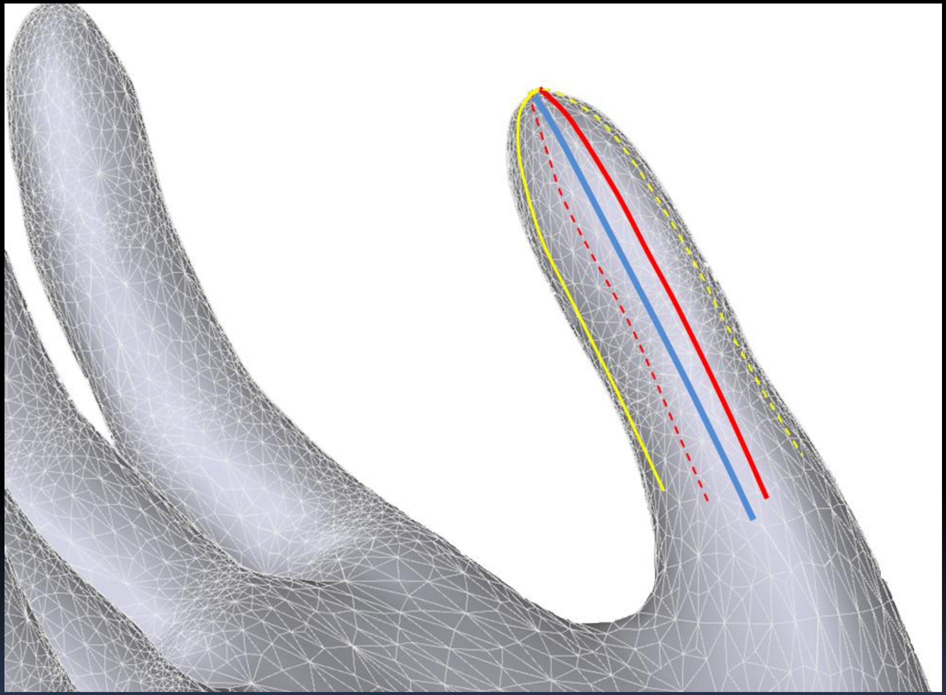
Idea

3D animation characters such as humans and animals are usually composed of a series of segments whose cross-sections are approximately elliptic. The projection of their 3D curve skeleton on a 2D plane can be approximated with the 2D medial axis of the projection of the original model in the same projection plane. This suggests that the 3D problem, which is to find a curve skeleton, can be dealt with in 2D spaces leading to a much cheaper and quicker solution.

Idea

We reconstruct a 3D curve skeleton from multiple 2D medial axes as illustrated in the following example:



3D silhouettes and medial axis in the hand model

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Algorithm

- Primary 3D silhouette detection
- Curve skeleton extraction
- Decomposition
- Curve skeleton refinement
- Animation skeleton generation

Primary 3D silhouette detection

A 3D silhouette is the 2D silhouette with its depth values recorded. We use two level search method to detect it:

- Level 1: global search

  (Find the 3D silhouette vertices of mesh with no regard to the connectivity)

- Level 2: local search

  (Connect the neighbour 3D silhouette vertices considering their connectivity)

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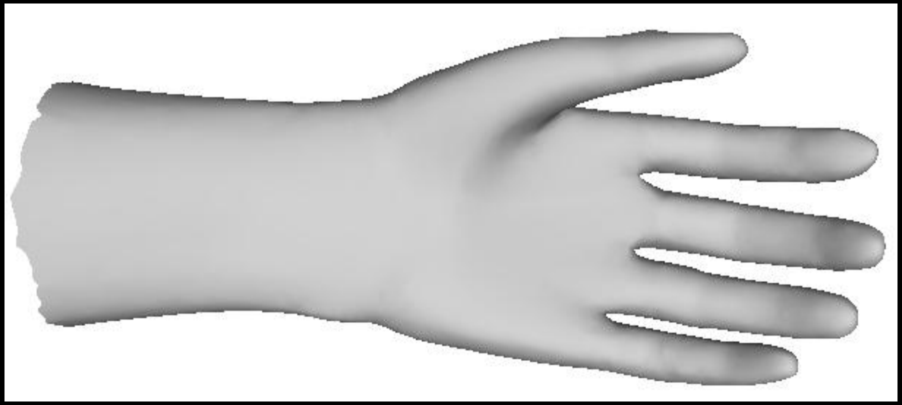
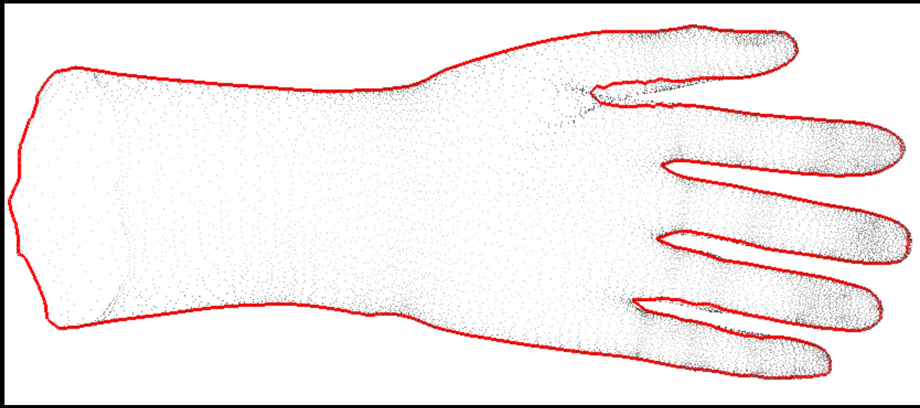
Primary 3D silhouette detection



Original mode

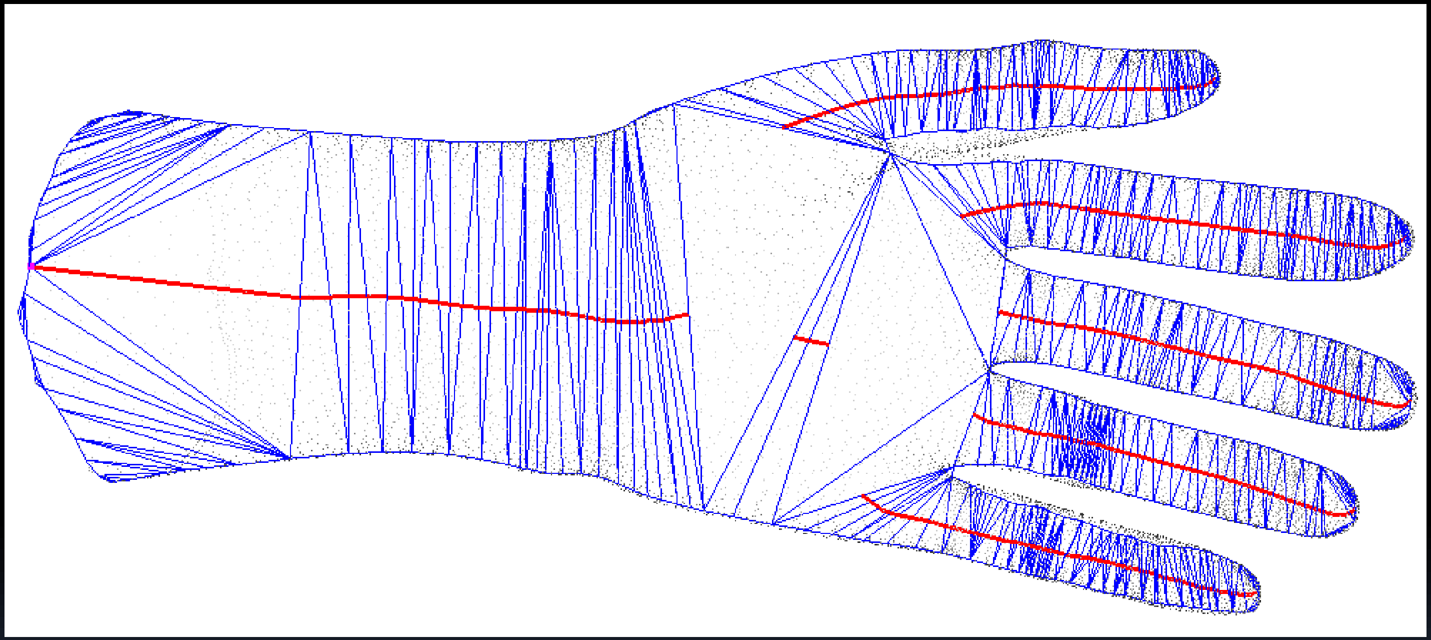


Primary 3D silhouette

Curve Skeleton Extraction

After the constrained Delaunay triangulation of the 3D silhouette, we can divide all the triangles into three categories: triangles with two external edges (*terminal triangles*), triangles with one external edge (*sleeve triangles*), and triangles without external edges (*junction triangles*). A medial axis is obtained by connecting the midpoint of the internal edges.

Curve Skeleton Extraction



3D medial axis of hand model

Decomposition

When a coarse curve skeleton is extracted from the primary 3D silhouette, we need to decompose the object and detect the second 3D silhouette in another perpendicular projection plane to adjust the *z* coordinates of the skeleton for each branch.

We use following formula to classify all the vertices of object. It is similar to the nearest-neighbour algorithm in pattern recognition.

$$s(v_i, k) = \min_{j=(1,n)}^{k} | distance(v_i, m_{k,j}(x, y, z)) - l_{k,j} |$$

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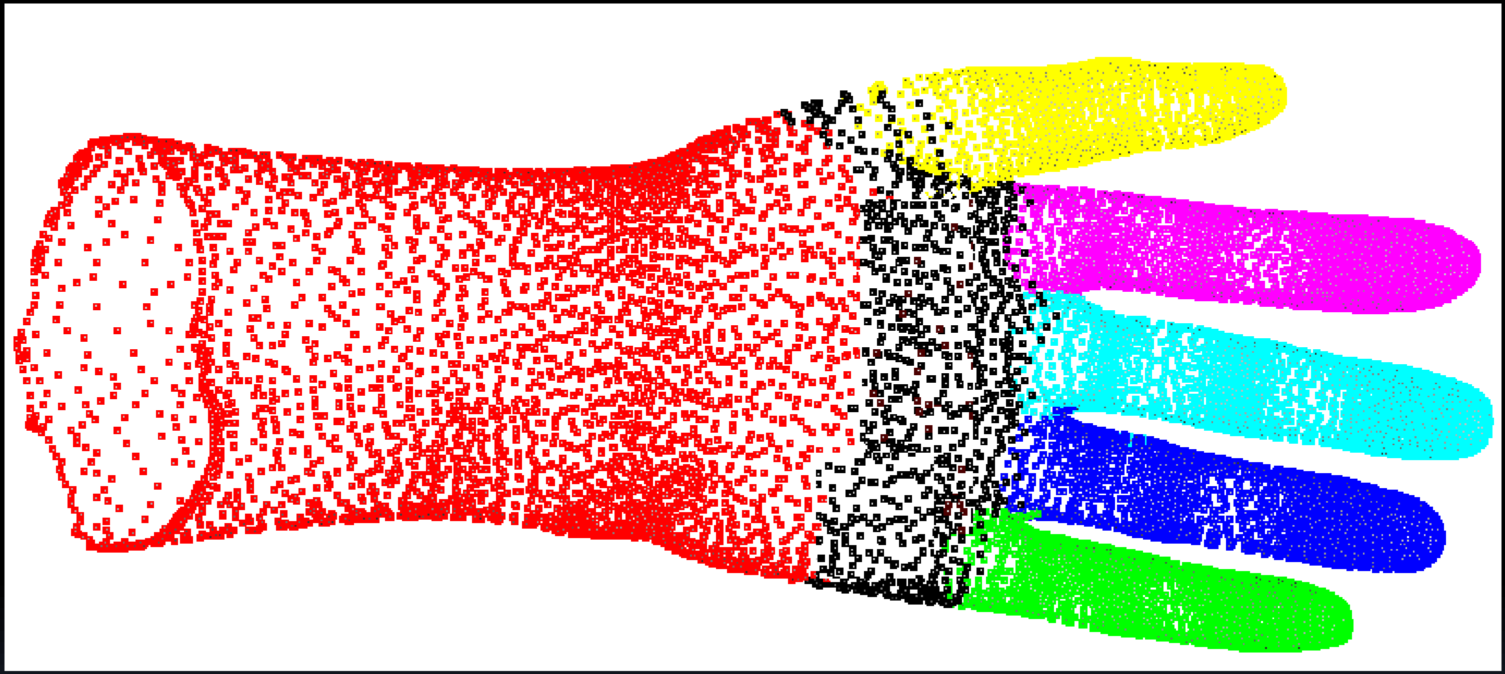
Decomposition



Decomposition result of hand model

Curve skeleton refinement

We detect the second 3D silhouette for each branch to fine tune the *z* coordinates of the curve skeleton on the second projection plane, which is perpendicular to the first projection plane. Here, we use the global search method described in primary 3D silhouette detection to extract the second 3D silhouette for each decomposed part of the model.

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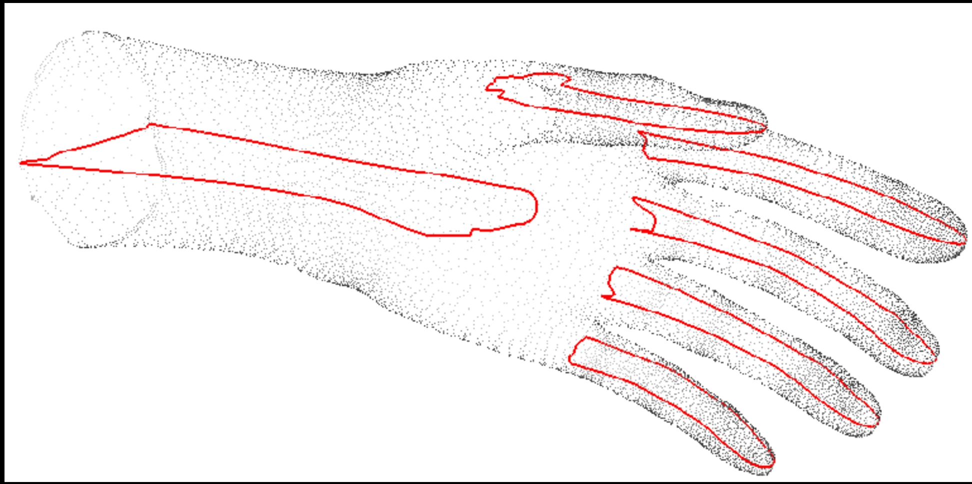
Curve skeleton refinement



The second 3D silhouettes for six branches of the hand model

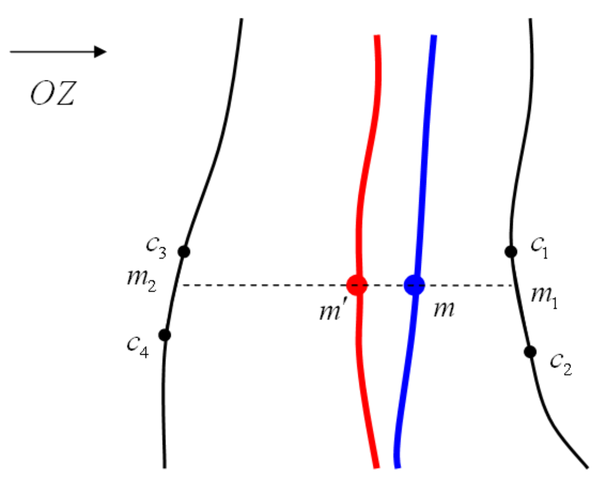
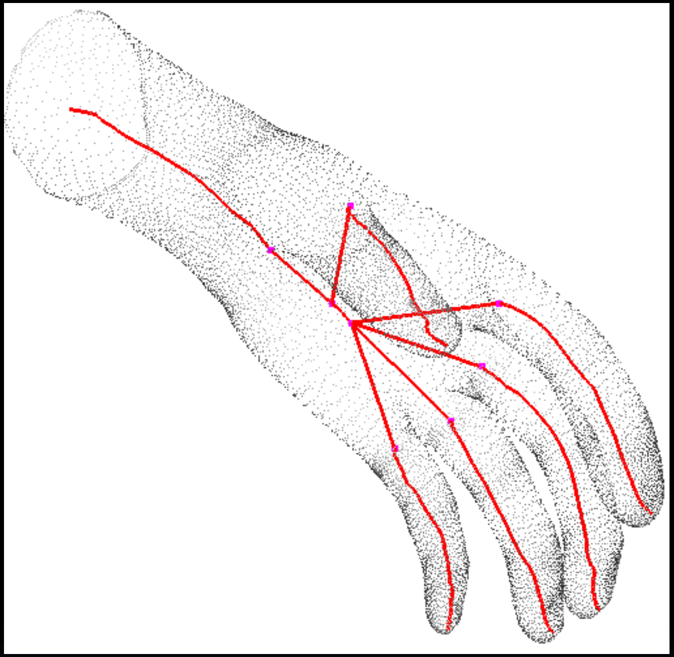
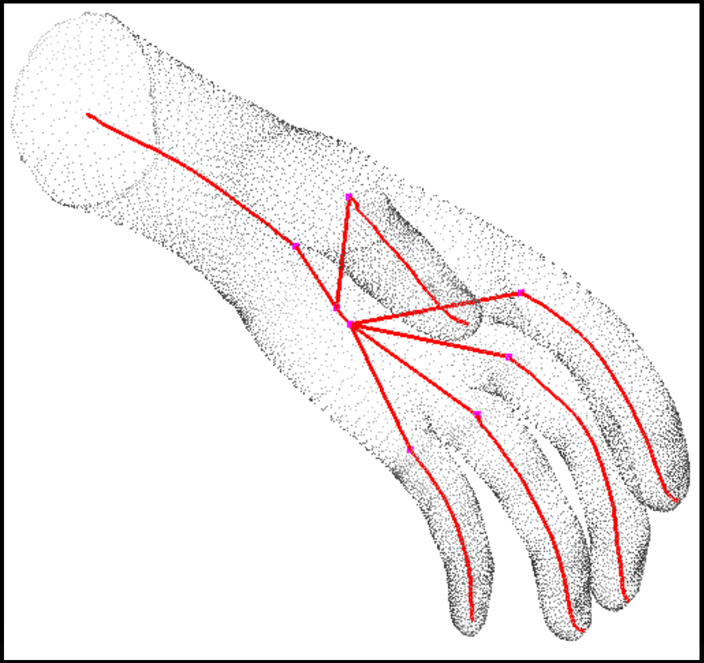


Illustration of the curve skeleton refinement

Curve skeleton refinement





Comparison between curve skeletons of hand model before and after refinement. Left: skeleton before refinement, right: skeleton after refinement

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Animation skeleton generation

The end and start points of the 3D medial axes form the key skeletal joint points for the animation skeleton. To identify the left middle joint points, we provide two methods. One is called down sampling, the other is using a skeleton template.

In addition, the user is also allowed to interactively add, remove joints and adjust the positions of the joints produced by the automatic algorithm to make the final decision.

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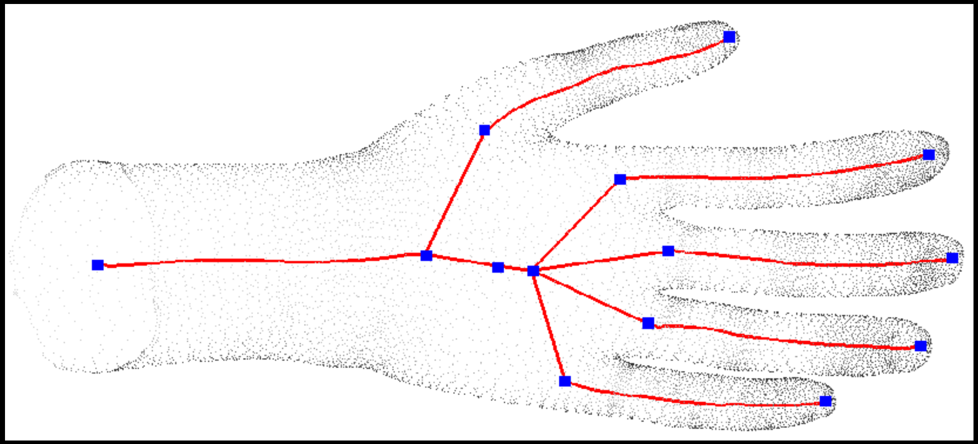
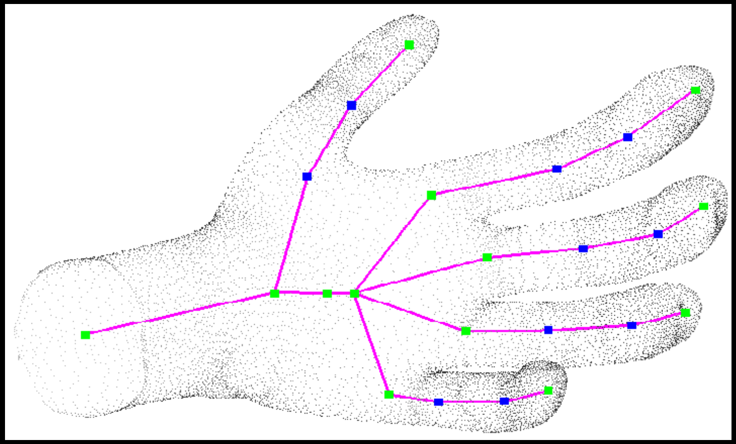
Animation skeleton generation



Curve skeleton and key skeleton points



Animation skeleton and skeletal joints

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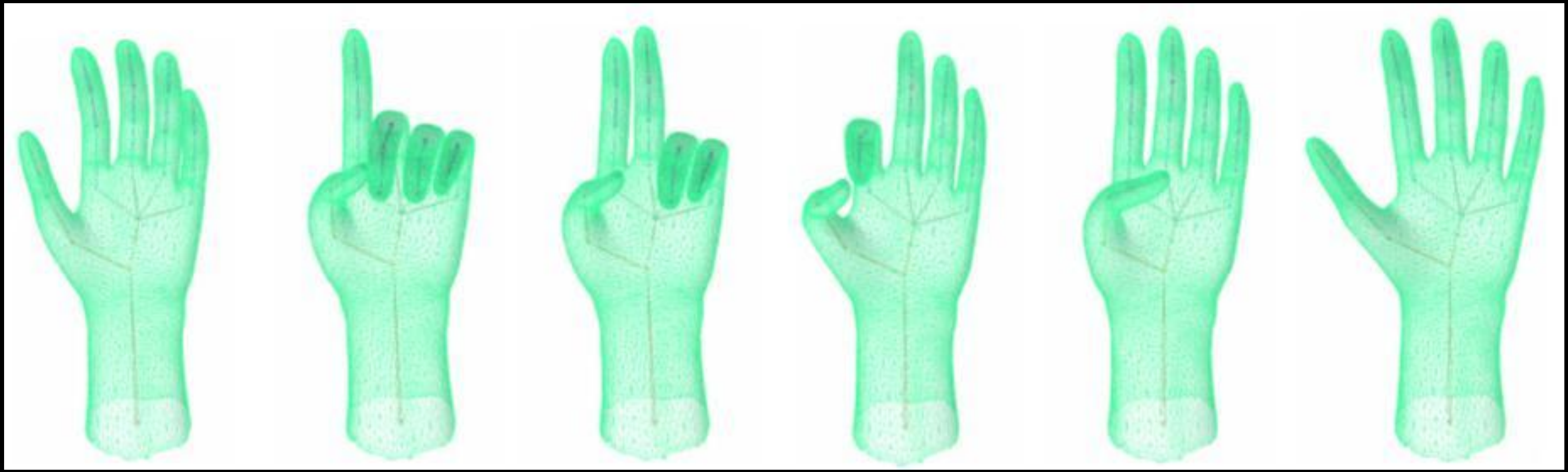
Experiment and Comparison



An animation sequence of the hand model rigged with our method

Experiment and Comparison

Comparisons with other curve skeleton extraction algorithms. From left to right: our method, a standard rigged hand model, medial surface, Reeb Graph, thinning, distance field, potential field

Thank you!