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Skeleton-based Joints Position Detection

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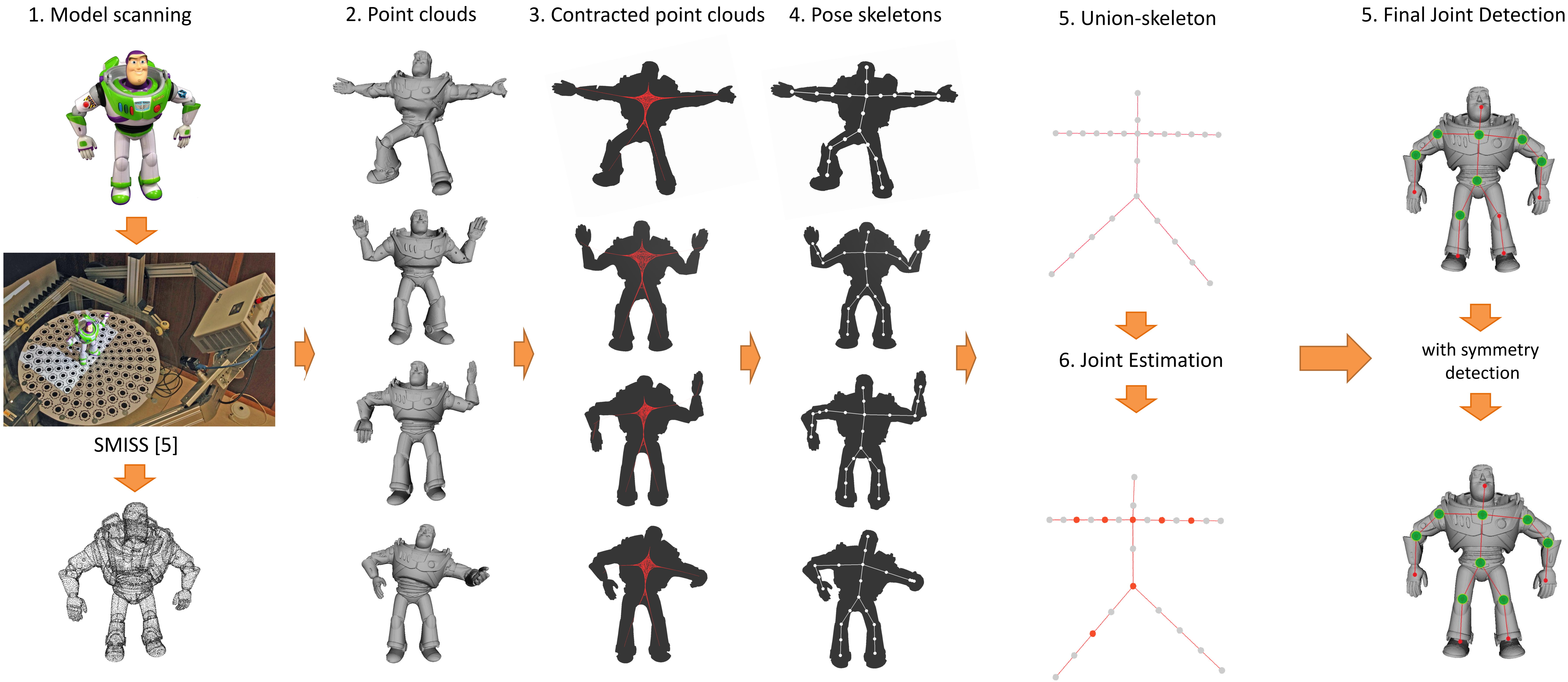
QR code with SMISS [5] video

Abstract

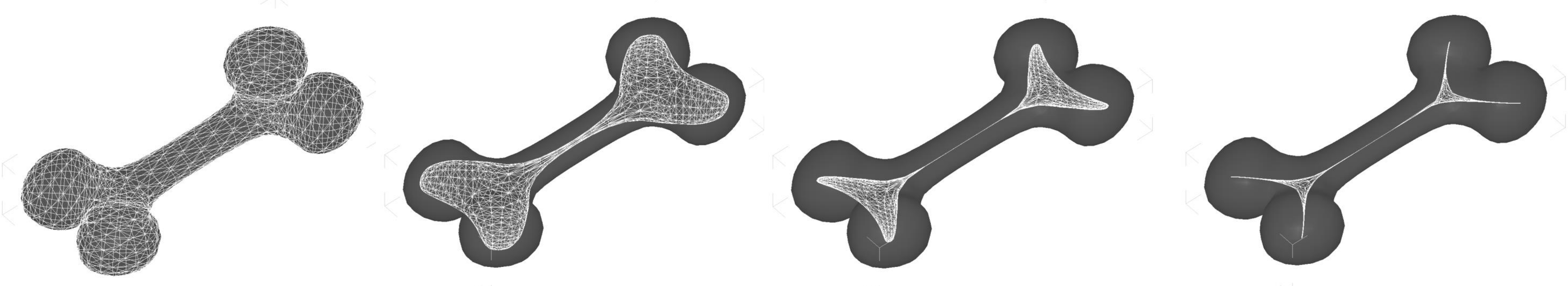
We present a system for detection of joint positions in scans of articulated models. First, skeletons are extracted from scans and then an estimation of possible matches between skeletons is performed. The matches are evaluated and sorted out. The whole matching process is fully automatic, but some user-driven suggestions can be included. Finally, we pick the best matching of skeletons and create a union-skeleton containing all the nodes from all the skeletons. We find nodes in the union-skeleton with rotation changes higher than the predefined threshold and take them as joints.

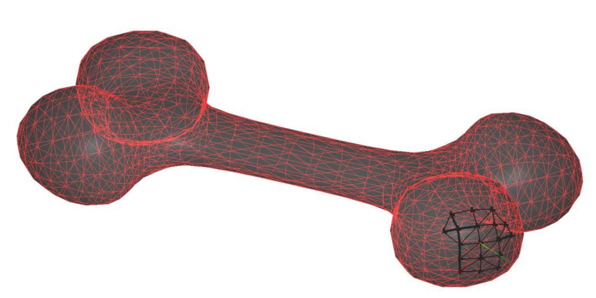
Overview



Skeleton Extraction

Modified version of Au's algorithm [1] extended to point clouds is used. We use construction of local Delaunay's triangulations for Laplacian estimation, similar solution to Cao's approach [2], but for construction of the final skeleton a simplification of global triangulation is used instead of Euclidian distance.





- for each local neighborhood a tangent plane is computed using PCA
- all the points in local neighborhood are projected into the tangent plane and a local Delaunay triangulation is computed
- global triangulation is composed of local Delaunay's triangulations

Note that all the existing video and Kinect-based approaches as [4] work on human-like figures only. They are based on fitting of skeleton templates into a set of images. Our approach is general and works for models with arbitrary topology and skeleton branching.

Skeleton Matching

- **Simplification**
  - paths between branch nodes and leaf nodes in graph are reduced
- **Backtracking**
  - constraint by same neighborhood, equal or higher valence
- **Topological rating**
  - penalization for each node that is extra or missing in graph edge
- **Distance rating**
  - Euclidian distance of matched nodes
- **Final matching**
  - sorted in ascending order from best to worst, the best is picked

Joint Estimation

- **Union-skeleton**
  - we merge all the mapped skeleton segments into a union-skeleton
- **Measurement of rotation changes**
  - change in rotation between original skeleton pose and matched union-skeleton is measured
- **Joint detection**
  - nodes where rotation changes are higher than predefined threshold are detected as joints
  - graph symmetry is used to detect joints in symmetrical body parts

Applications and Future Work

- with existing approaches for 3D printing of articulated models [3] and detection of joints in combination with an automatic extraction of skinning weights, our approach can be used for automatic cloning of articulated toys
- extension for humans
  - estimation of joint position and length of human bones
  - applications in biometry, motion capture and other analysis of human body

References

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[2] CAO J., TAGLIASACCHI A., OLSON M., ZHANG H., SU Z.: Point cloud skeletons via laplacian based contraction. In Proceedings of the 2010 SMI Conference (2010), pp. 187–197.

[3] BÄCHER M., BICKEL B., JAMES D. L., PFISTER H.: Fabricating articulated characters from skinned meshes. ACM Trans. Graph. (Proc. SIGGRAPH) 31, 4 (2012).

[4] SHOTTON J., SHARP T., KIPMAN A., FITZGIBBON A., FINOCCHIO M., BLAKE A., COOK M., MOORE R.: Realtime human pose recognition in parts from single depth images. Commun. ACM 56, 2013, 116–124

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