Explorative Analysis and Visualization of Large Information Spaces

Efficient 3D Shape Acquisition and Registration Using Hybrid Scanning Data

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1 Introduction

1.1 Problem Statement

Most previous 3D acquisition and surface registration approaches do not use global shape information for optimal local surface registration:

- hard to select suitable surface patches from large number of scans;
- small alignment errors accumulate to large distortion;
- It is hard to find global geometric prior for optimally registering numerous local surfaces.

1.2 Motivation

- We consider efficient 3D shape acquisition and surface registration using dissimilar laser range scanners. [1]
- The goal of our hybrid laser scanning system is to aid local surface registration using global shape information.

1.3 Main Contributions

- We exploit the fundamental 3D scanning trade-off between the coverage of the global shape structure and local surface patches to construct a hybrid laser scanning system.
- A prototype system is implemented based on two laser range scanners, a hand-held one for the coarse global low-resolution model and a second stationary high-resolution line scanning system.
- A proposed approach is implemented for local-to-global simultaneous rigid and non-rigid surface registration.

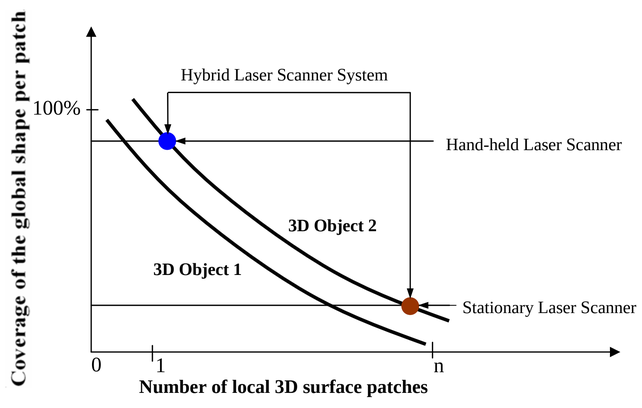

Figure 1: The trade-off between the number of scanned local surface patches and the coverage of the global shape structure. More high-resolution local surface scans cause more difficulties on surface registration.

2 Algorithms and Implementation

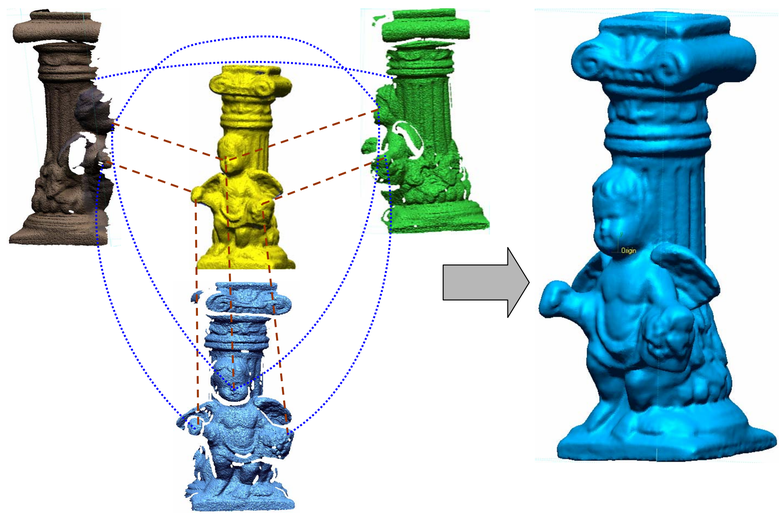

Figure 2: Left: high resolution local surface patches (brown, green, blue) and the low resolution global shape model in the middle. Local surface correspondence (blue lines) and related features in the optimal global positions (brown lines) via iterative local-to-global nonrigid adjustment.

- **Input:** Low-resolution global shape prior and high-resolution surface patches.

1. Using features, one automatically or manually localize corresponding points on the global model.
2. Patches are registered incrementally to each other in a growing process using an adaptive ICP method.
3. After each registration, the merged patches are registered with the global model in an adaptive way using a probabilistic distribution of feature positions.
4. In case of incorrect merging, non-rigid global Thin-Plate-Spline (TPS) is simultaneously used for optimal surface adjustment.

- **Output:** a high-quality 3D shape model.

3 Results

- Construct the hybrid laser scanning system and acquire 3D shape data.
- Comparison of methods.

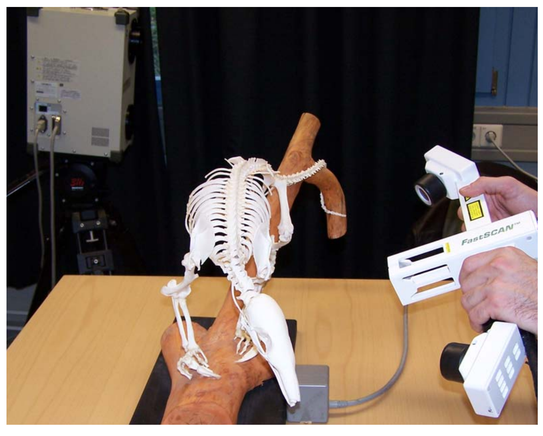

Figure 3: Tripod stationary scanner (background) and the hand-held scanner

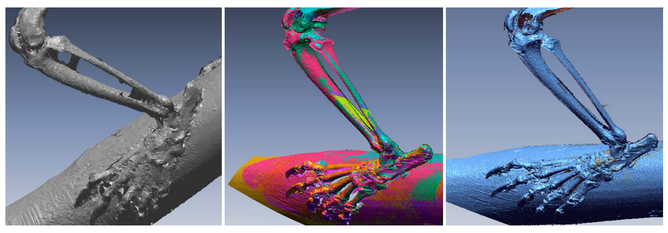

Figure 4: $a|b|c$. Registration of high-resolution local surface patches to low-resolution global shape model. (a) Low-resolution 3D shape model from the hand-held scanner. (b)(c) Registration results using high-resolution 3D surface patches together with the low-resolution 3D shape model (a).

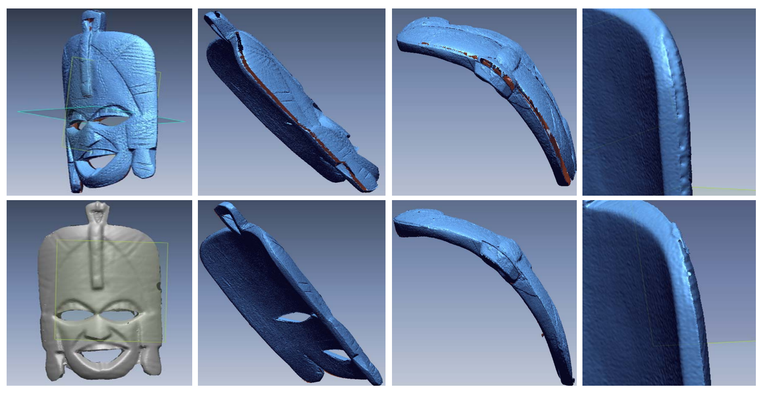

Figure 5: $\frac{a|b|c|d}{e|f|g|h}$. Top row shows registration using only high-resolution patches: a high-resolution patch (a) and resulting registration errors (brown colored holes) (b–d). Bottom row shows registration with the hybrid method: the low-resolution global shape model (a) and high-quality registration using hybrid scanning data (f–h).

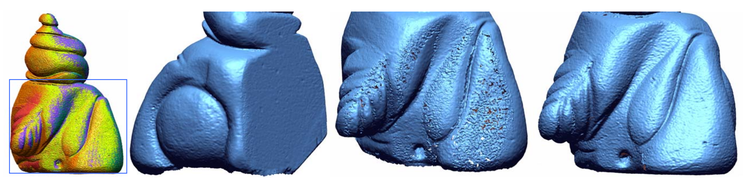

Figure 6: $a|b|c|d$. (a) A 3D shape model. When registering high-resolution patches one side of the object registers well (b), while the other side has large distortions (c). Registration with hybrid data produces a better result (d).

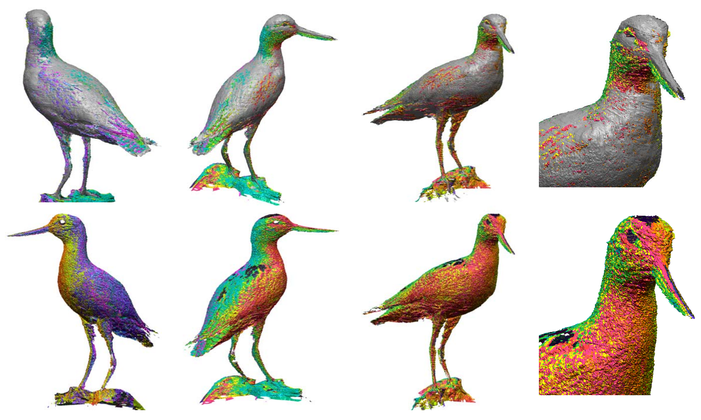

Figure 7: $\frac{a|b|c|d}{e|f|g|h}$. (a)(b)(c)(d) Results of registering, merging hybrid data. (e)(f)(g)(h) Results of registering, without merging hybrid data. Patches are color coded.

4 Conclusions

The proposed approach:

- integrates local and global information for global optimization,
- reduces the number of required scans,
- easily fills holes, eliminates accumulated errors, and is robust to noise and outliers.

References

[1] Hongwei Zheng, Dietmar Saupe, Markus Roth, Andreas Böhler, and Peter Opuchlik. Efficient 3d shape acquisition and registration using hybrid scanning data. *Proceedings of 3DPVT 2008*.

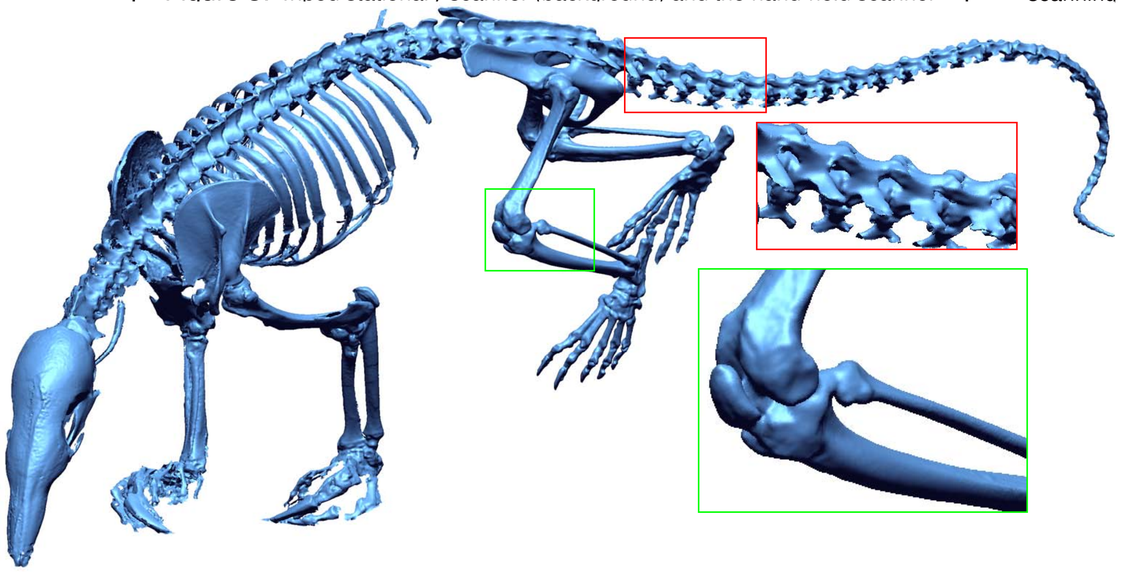

Figure 8: Acquired 3D shape model for an anteater skeleton using the hybrid data