ACCURATE MESH-BASED ALIGNMENT FOR GROUND AND AERIAL MULTI-VIEW STEREO MODELS

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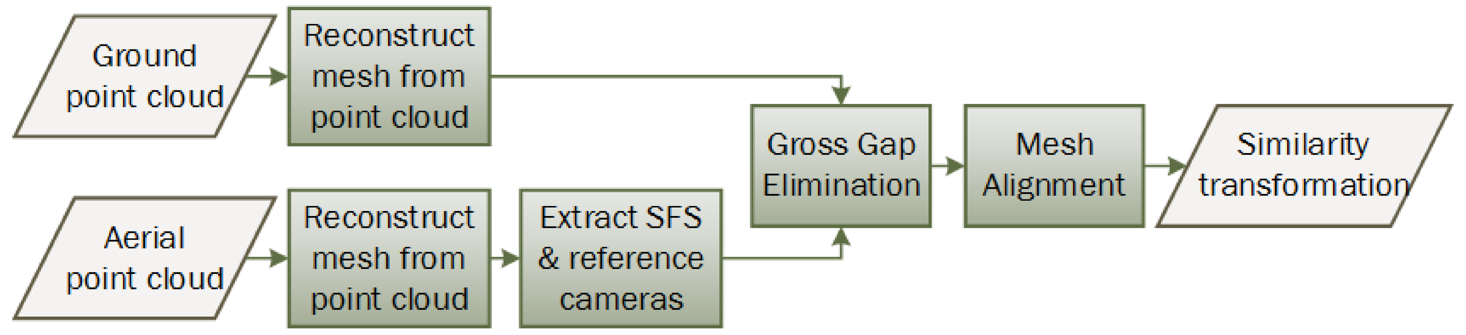
Motivation

In the reconstruction of large scale outdoor scenes from joint imagery of aerial and ground images, the result often lead to badly aligned models due to the wide baselines and the varying imaging conditions between the images from different sources. To improve the quality of the models generated from combined aerial and ground images, we propose a novel method to align the two MVS models separately reconstructed from different sources.

Method Overview

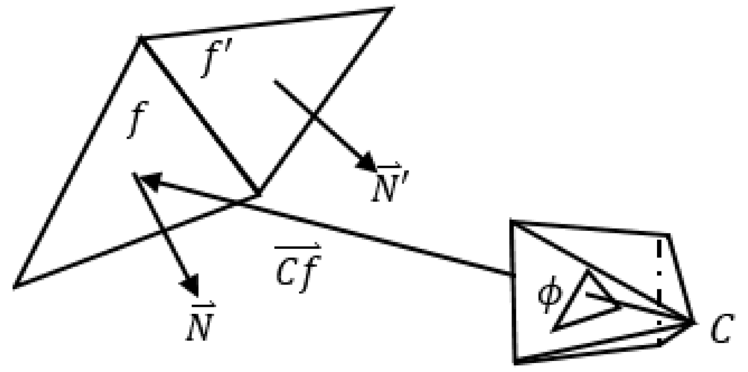


Skeleton Facet Set (SFS)

Constraints:

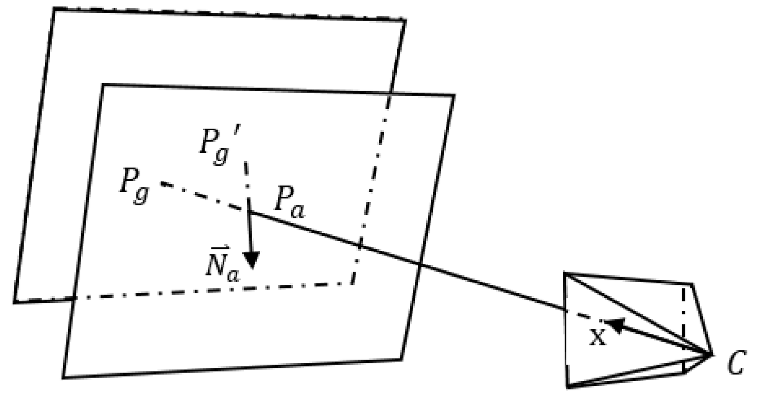
- $\langle \vec{N}, \vec{N'} \rangle < \theta_a$;
- $\langle \vec{N}, \vec{Cf} \rangle < \theta_v$;
- Facet projection ϕ

on its reference camera should be greater than ϕ_s.



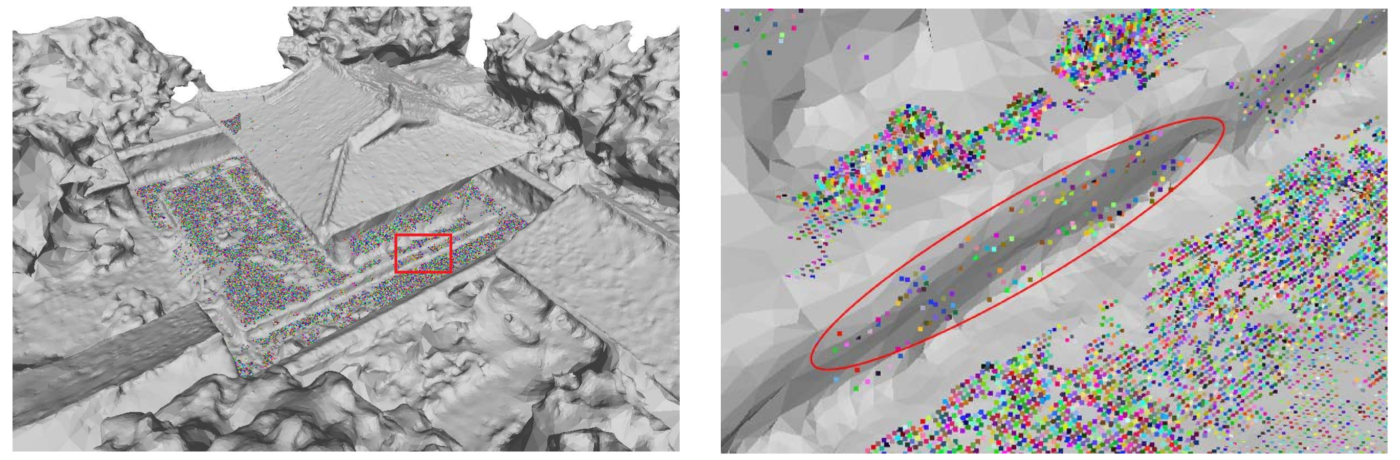
Point Pairs Acquisition

- Rough point pairs (P_a, P_g)
- Shifted point pairs (P_a, P_g');

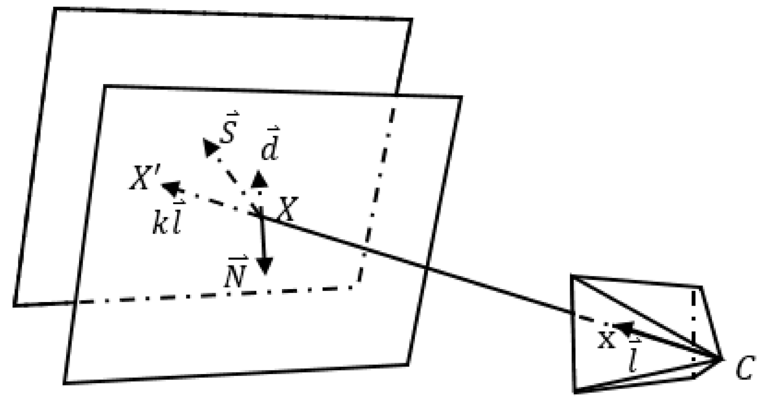


Mesh-based Alignment

- Gross Gap Elimination
  - $\vec{T}_g = \frac{\sum_i w_i (P_{a,i} - P_{g,i})}{\sum_i w_i}$
- Mesh Alignment
  - Estimate the similarity transformation S from (P_a, P_g) ;
  - Check if shift needed and solved with energy minimization;
  - Transform the ground model until S converges.
- Eliminate Shift with Energy Minimization



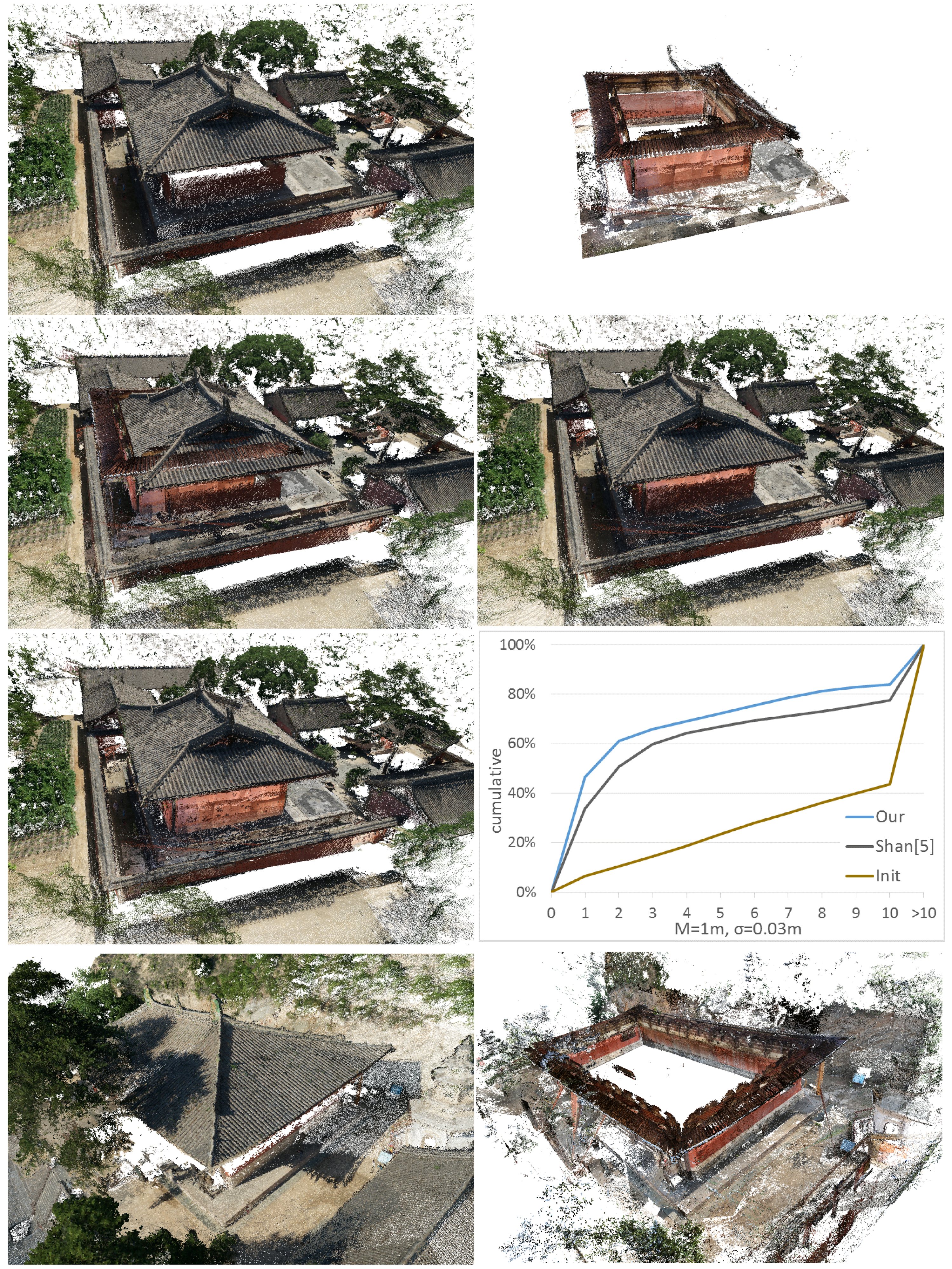
- Find the longest $\vec{S} \in \Omega_s$ ($\Omega_s = \{\vec{S}_i | \vec{S}_i = P_{a,i} - P'_{g,i}, \forall i\}$) passes QEDST, Translate ground mesh by $\vec{S}$ if exists.
- Quick Energy Decreasing Shift Test (QEDST)

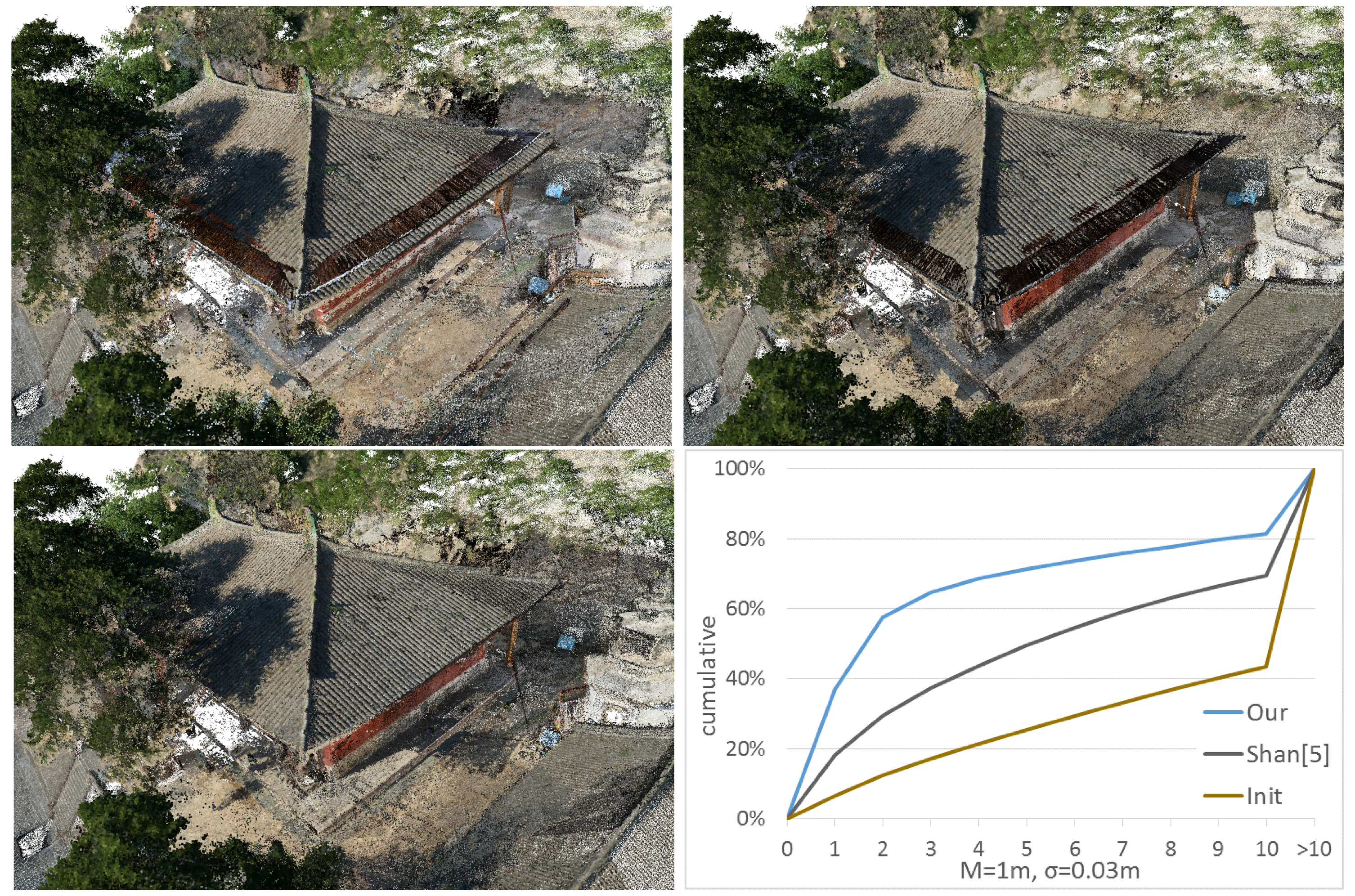


- $|\vec{d}| = |k\vec{l} \cdot \vec{N}| = |\vec{S} \cdot \vec{N}|$
- $$\begin{aligned} E_x(\vec{S}) &= \left|(D_a(x) - D_g(x) - k)\vec{l} \cdot \vec{k}\right| \\ &= \left|\left(D_a(x) - D_g(x)\right)\vec{l} \cdot \vec{N} - \vec{S} \cdot \vec{N}\right| \end{aligned}$$
- $E_t(\vec{S}) = \sum_{f \in SFS} \sum_{x \in \Omega_f} E_x(\vec{S})$
- If $E_t(\vec{S}) < E_t(0)$, $\vec{S}$ passes QEDST.

Evaluation

- Evaluation Method
  - For each point p in the ground point cloud, find its nearest point p' in the aerial point cloud; discard if distance is greater than M;
  - Draw a Cumulative Error Curve (CEC) from the distances projected to the normal direction of p' .
- Evaluation Results





Conclusion

- Strength
  - Accurate;
  - No requisition of accurate model;
  - No requisition of accurate correspondences.
- Limitations
  - Require a proper initial status;
  - Relatively slowly.

References

[1] Michal Jancosek and Tomas Pajdla, "Exploiting visibility information in surface reconstruction to preserve weakly supported surfaces," International Scholarly Research Notices, vol. 2014, 2014.

[2] Qi Shan, Changchang Wu, Brian Curless, Yasutaka Furukawa, Carlos Hernandez, and Steven M Seitz, "Accurate geo-registration by ground-to-aerial image matching," in 2014 2nd International Conference on 3D Vision. IEEE, 2014, vol. 1, pp. 525–532.