Three-dimensional Self-calibrating Surface Reconstruction using Digital Photogrammetry

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INTRODUCTION

- Classical 3-D reconstruction with calibrated camera...
  - complicated to handle,
  - sensitive to environmental changes.
- Here: New method of self-calibration based on matrix factorization...
  - relevant and practical,
  - versatile, simple and inexpensive.

STUDY OBJECTIVES

- Propose a detailed and accurate computational algorithm for 3-D reconstruction problem without using calibration objects.
- Conduct several experiments to prove the truth and performance of the self-developed codes.

SELF-CALIBRATION ALGORITHM

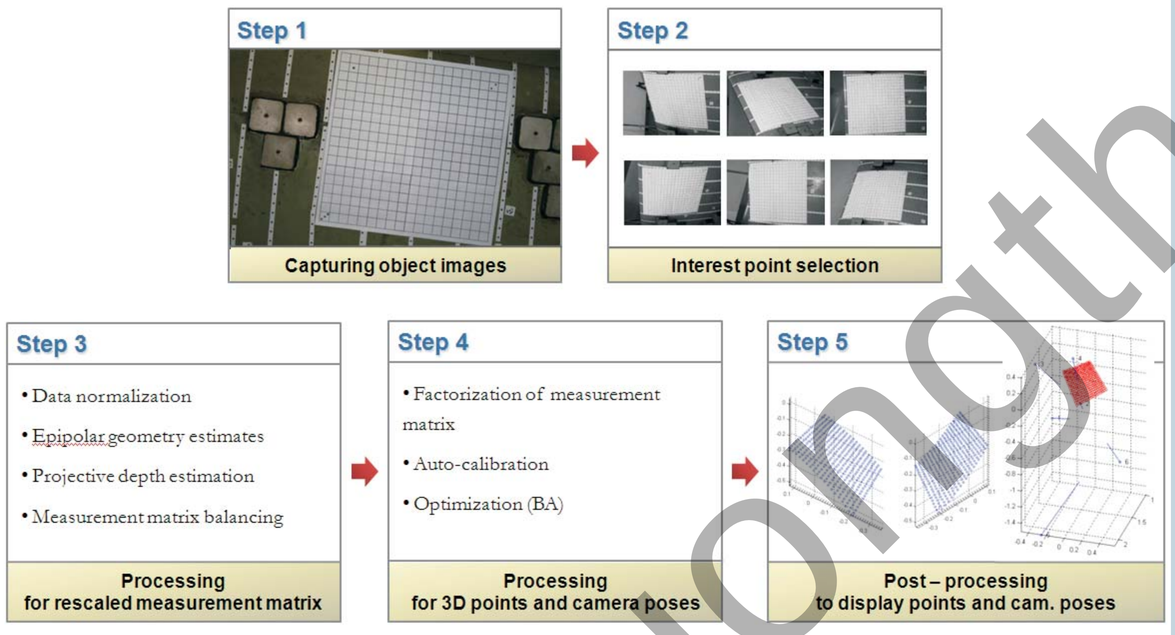

Figure 1: The five-step self-calibrating algorithm based on matrix factorization

1. The investigated object is captured at different positions by a single camera.
2. Interest points are separately selected in every image.
3. Coordinates of those points are normalized and collected in a measurement matrix, which will be scaled by projective depths and balanced for uniform magnitudes.
4. The rescaled matrix is factorized into 3-D point cloud and projection matrices of the camera. The results are transferred to Euclidean space by auto-calibration.
5. Post-processing of displaying the camera setup as well as the recovered point cloud.

RESULTS

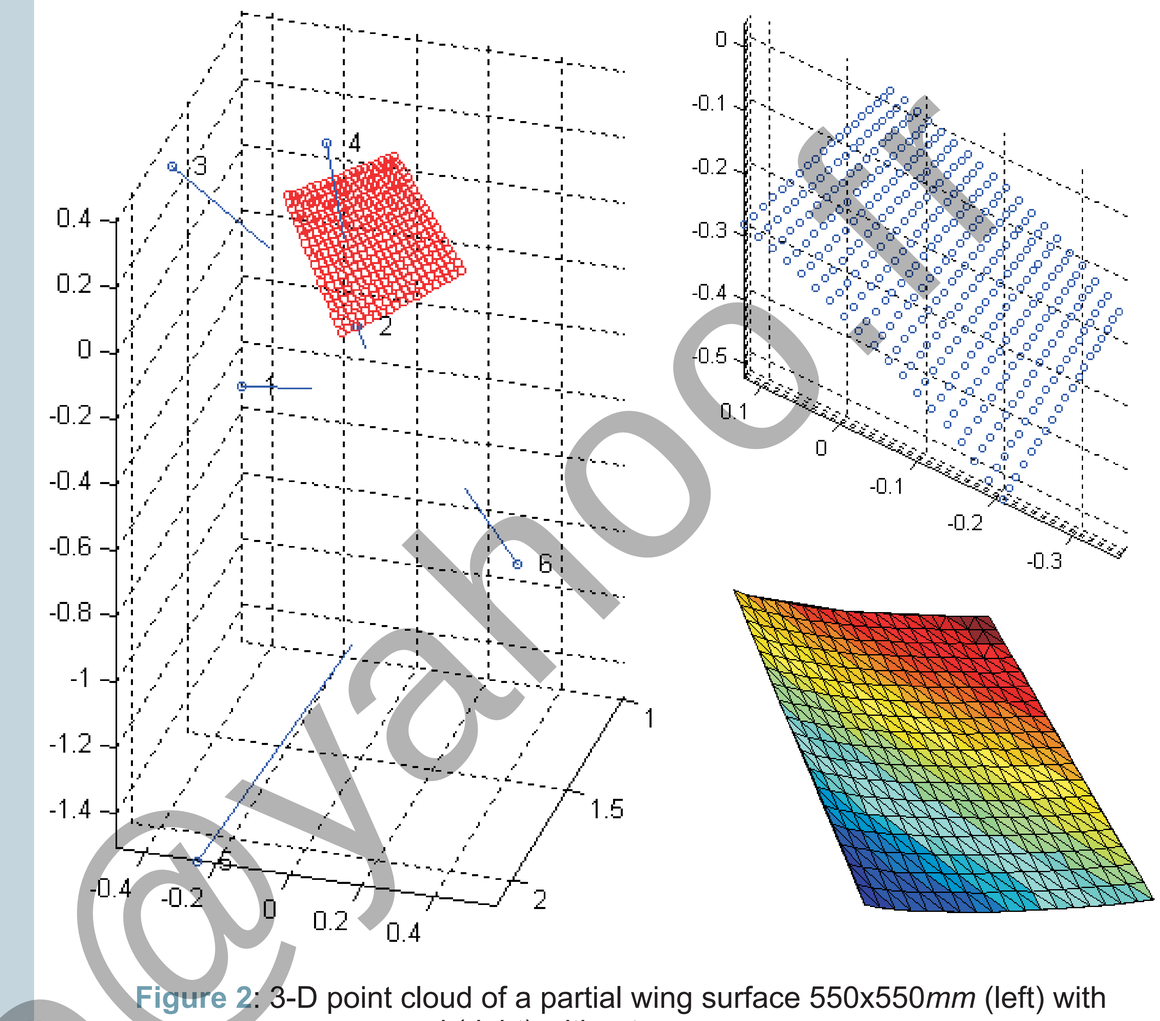

Figure 2: 3-D point cloud of a partial wing surface 550x550*mm* (left) with and (right) without camera poses.

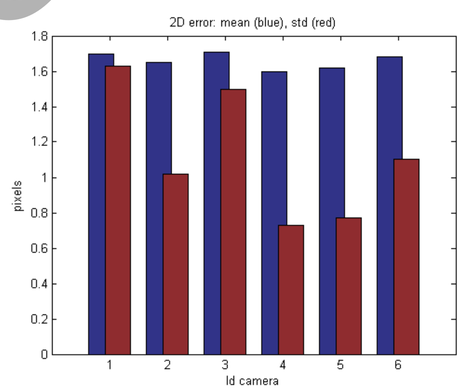

Figure 3: Errors generated in each image of the wing sequence (blue: average reprojection errors; red: standard deviation).

Scene name	WING					
Point detection	Manual					
Number of pts.	361					
Processing time [sec]	15.40					
Error (before BA) [px]	2.42 (~1.21*mm*)					
Error (after BA) [px]	1.66 (~0.83*mm*)					
Image No. [1728x1152]	1	2	3	4	5	6
Mean errors [px]	1.70	1.65	1.71	1.60	1.62	1.68
Std. errors [px]	1.63	1.02	1.50	0.73	0.77	1.10

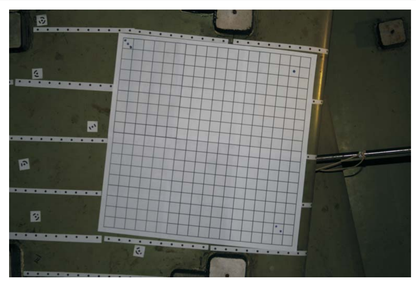

Table: Real scene of a wing surface reconstructed from a sequence of 6 images/361 points.

CONCLUSIONS

- The proposed algorithm is versatile, compact and no calibration object is needed.
- It could be applied for static objects of various sizes.
- The error is of 1 part in 1000 of the object volume.

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