FULLY AUTOMATED HIGHLY ACCURATE 3D RECONSTRUCTION FROM MULTIPLE VIEWS

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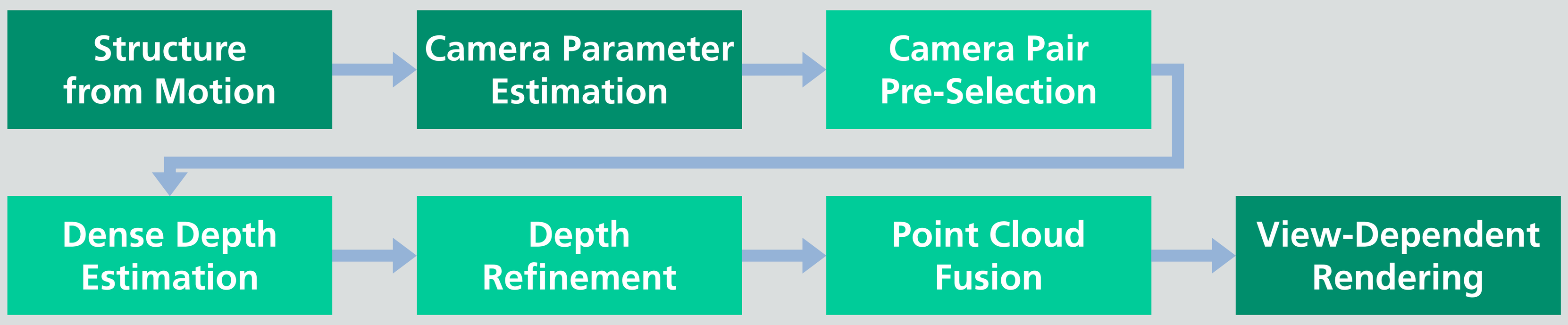
(1) Introduction

- Highly accurate 3D reconstructions of real-world objects are more and more important in various fields of application, e.g. for realistic scenes of architectural sites in virtual museums
- Algorithmic pipeline from input images to output 3D model
- Core component: dense depth based 3D surface reconstruction
- Main objective: high degree of automation and reconstruction accuracy

(2) Fully automated pipeline

- Input: set of images capturing the object from different views
- Initial 3D point cloud and calibration parameters by applying VisualSFM[1] and SIFT on GPU[2]
- Automatic pairwise camera pre-selection for robust depth estimation by considering the constraints *Compactness*, *Suitability*, and *Coverage*
- Initial depth map generation by extracting visibility information from SFM output
- Depth refinement by applying the highly accurate Patch-Sweeping algorithm[3]
- Depth map fusion by applying the visibility-driven patch group generation[4]
- Output: high-resolution 3D model



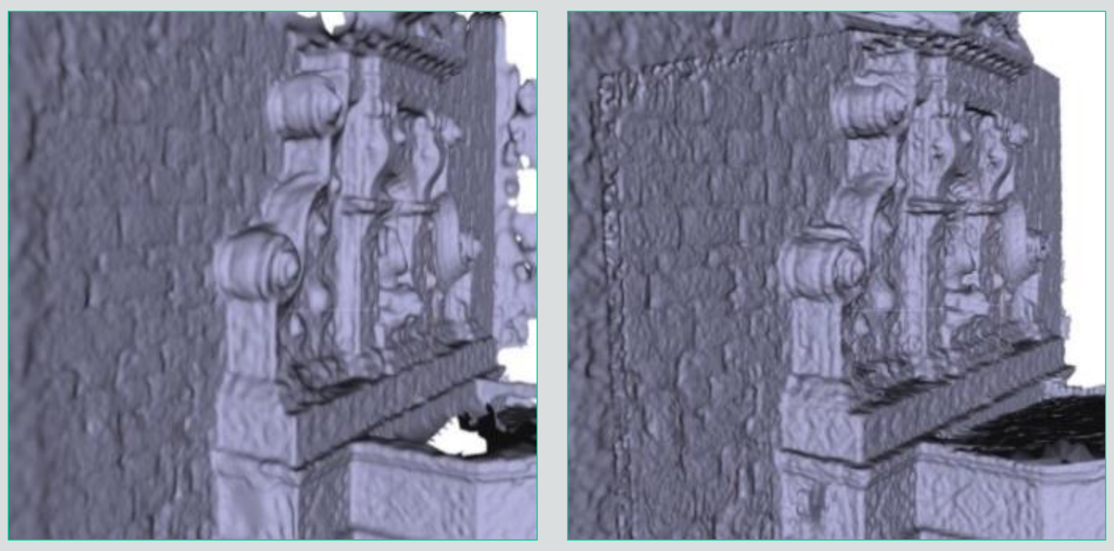
Algorithmic architecture of proposed approach: commonly available approaches (dark green) and our proposed extension (light green) for 3D surface reconstruction

(3) Reconstruction results

- Verification of the reconstruction accuracy using several reference data sets, e.g. *fountain-P11*[5]

Original image (left) and 3D reconstruction (right) of fountain-P11

- Comparison of the reconstruction quality with several reference methods, e.g. the Patch-based Multi-view Stereo Software (PMVS)[6]
- Significant improvement of visual quality and geometric details compared to PMVS method



- more geometric details in the surface of the bricks and the fountain
- border area on the right-hand side of the wall with higher quality and less artefacts

3D model of fountain-P11 data set reconstructed with PMVS reference method (left) and our approach (right)

Comparison of reconstruction details of Arco Valentino in Torino

Comparison of reconstruction details of the Statue of Goethe in Berlin

(4) Comparison with state-of-the-art software

- Evaluation of several professional tools available on the market
- Individual pros and cons regarding automation and performance

Autodesk ReMake[7]	Our Approach	Agisoft PhotoScan[8]
– supports only JPEG images	+ supports several image formats	+ supports several image formats
+ visual quality of reconstructed object	+ visual quality of reconstructed object	+ visual quality of reconstructed object
– coarse geometry, details mainly through texture	+ highly accurate and dense geometry	+ highly accurate and dense geometry
+ meshes usually watertight	+ meshes usually watertight	– meshes often contain holes
+ fully automated	+ fully automated	– semi-automated
+ easy-to-use workflow	+ easy-to-use workflow	– complicated workflow
+ good background segmentation	+ good background segmentation	– manual masking recommended
– manual parameter adjustments not possible	+ manual parameter adjustments possible	+ manual parameter adjustments possible

Comparison of most significant Pros (+) and Cons (–)

[1] Wu, C., "VisualSFM: A visual structure from motion system," 2011.

[2] Wu, C., "SiftGPU: A GPU implementation of scale invariant feature transform (SIFT)," 2007.

[3] Waizenegger, W., Feldmann, I. and Schreer, O., "Real-time Patch Sweeping for High-Quality Depth Estimation in 3D Videoconferencing Applications," IS&T/SPIE Electronic Imaging. International Society for Optics and Photonics, 2011.

[4] Ebel, S., Waizenegger, W., Reinhardt, M., Schreer, O. and Feldmann, I., "Visibility-driven patch group generation," IEEE International Conference on 3D Imaging (IC3D), 2014.

[5] Strecha, C., von Hansen, W., Van Gool, L., Fua, P. and Thoennessen, U., "On benchmarking camera calibration and multi-view stereo for high resolution imagery," IEEE Conference on CVPR, Anchorage, AK, 2008.

[6] Furukawa, Y. and Ponce, J., "Accurate, dense, and robust multiview stereopsis," IEEE transactions on pattern analysis and machine intelligence, Vol. 32, No. 8, pp. 1362-1376, 2010.

[7] Agisoft PhotoScan (v1.3.0), http://www.agisoft.com

[8] Autodesk ReMake (v17.25.0.16), http://remake.autodesk.com

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