MULTI-SCALE CAMERA NETWORK FOR ACCURATE STRUCTURE-FROM-MOTION

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Binary Online! — APPROVED

Abstract To obtain high-resolution reconstructions from a large-scale object using SfM, there are many constraints on the quality of image data. In traditional SfM methods, images are acquired at a constant distance to the object which introduces significant drift that cannot be reduced by even bundle adjustment. In this work, we propose to adjust the image acquisition strategy to a multi-scale network and take images at different distances to obtain dense reconstructions while being more accurate.

Motivation
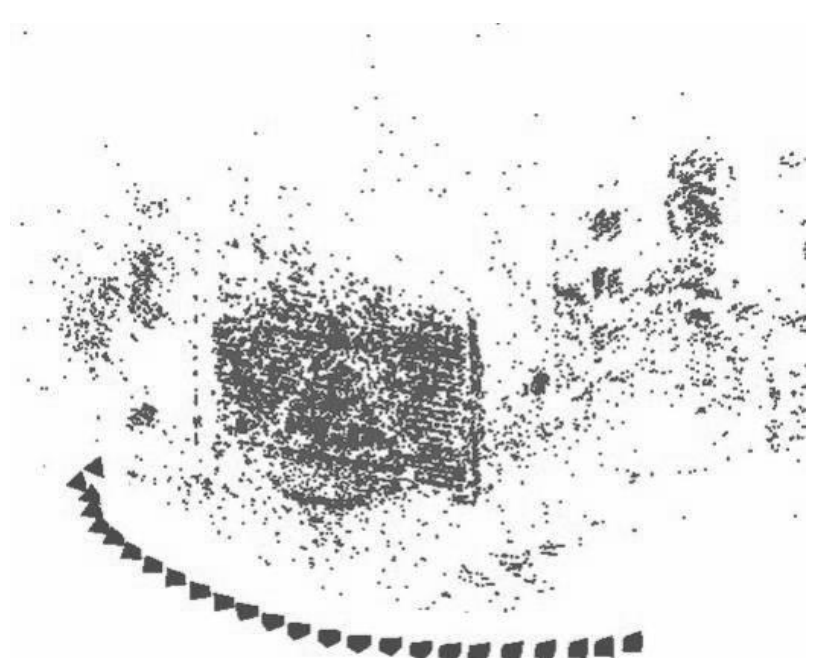
In traditional SfM methods [1] images are acquired at a constant distance

- How to obtain high accuracy and scene completeness of 3D reconstruction at same time?
- How to support the user during image acquisition and view planning to provide robust input data?
- How to remove the problem of drift in Incremental SfM methods?
- No dataset with images at multiple depth and complete ground-truth currently available

Our Contributions

- **The first system for exploring multi-scale camera network for SfM.**
- **Online feedback during image acquisition to end users for planning suitable views.**
- **Novel method for drift removal in Incremental SfM.**
- **A benchmarking dataset and evaluation w.r.t state of the art pipelines and commercial softwares.**

Multi-Scale Camera Network

Scene Completeness Vs. High Accuracy

Error = 45.22mm

Error = 15.36mmc

Error = 5.71mm

Mean Error **Completeness**
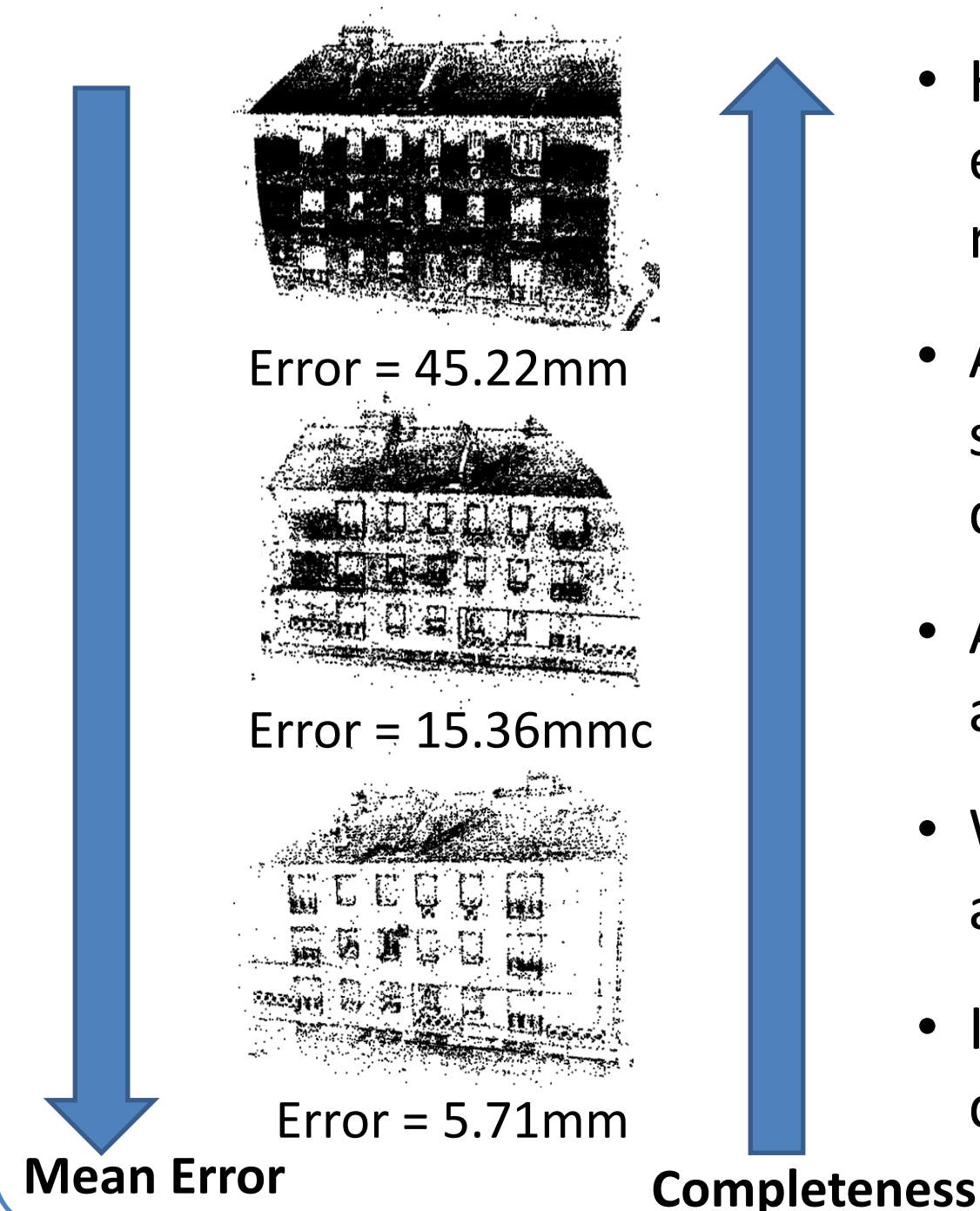
- High resolution images is expected to give "better" reconstruction.
- As we go closer to an object, scene completeness increases due to high GSD.
- Accuracy decreases significantly as affects due to drift increases.
- We use a multi scale frame work as shown to preserve both.
- Image overlap is kept constant at different scales.
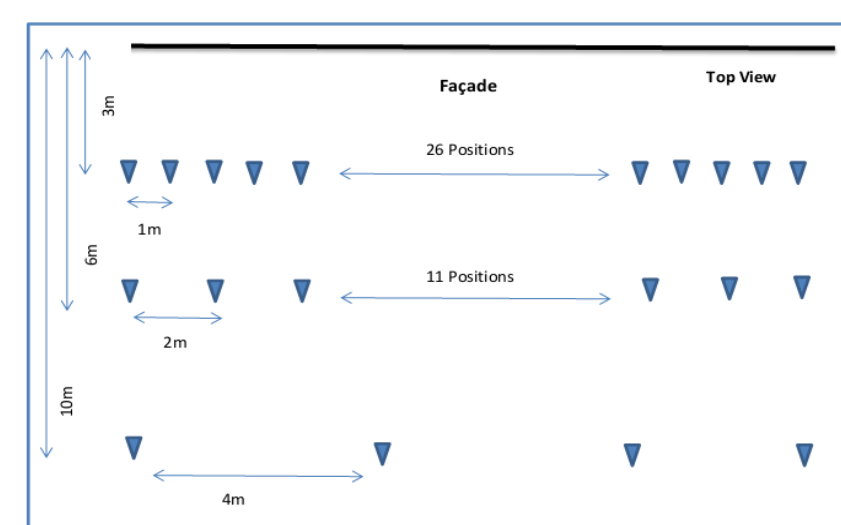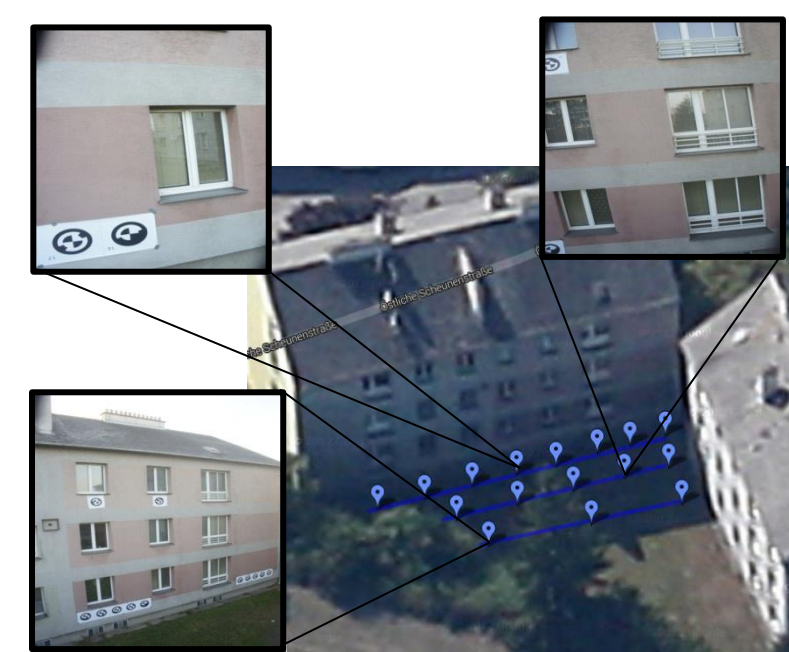
An example of multi-scale image acquisition framework

Online Feedback and View-Planning

- We utilize our online-SfM method [2] to give end-user an instant feedback about GSD (ground sampling distance) and image overlap for view-planning.
- B**enefits:** To ensure that image matching can be performed across multiple scales and fidelity of eventual reconstruction.
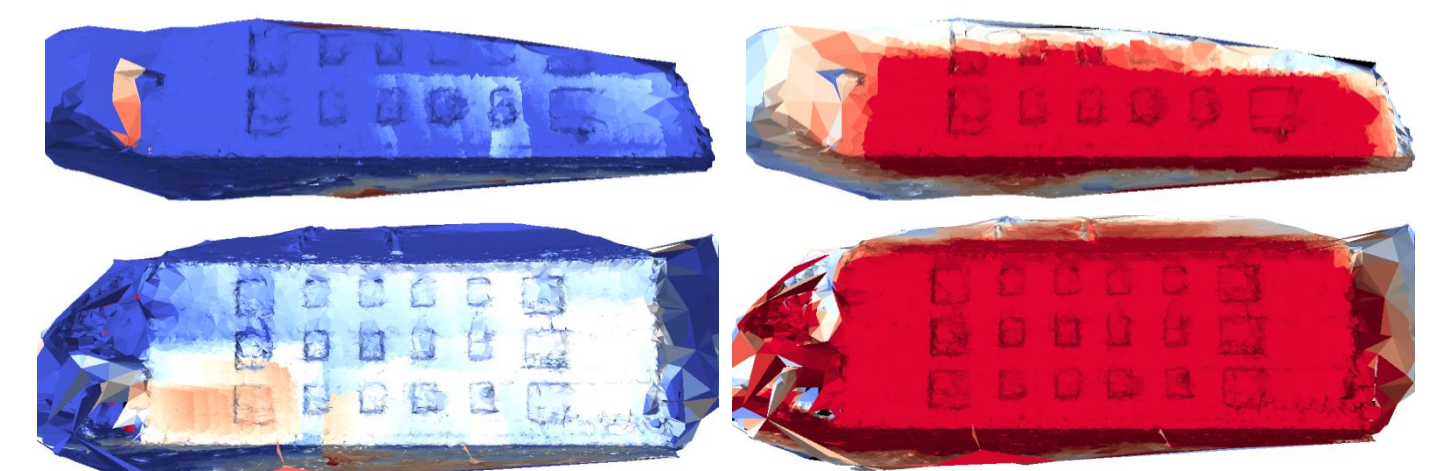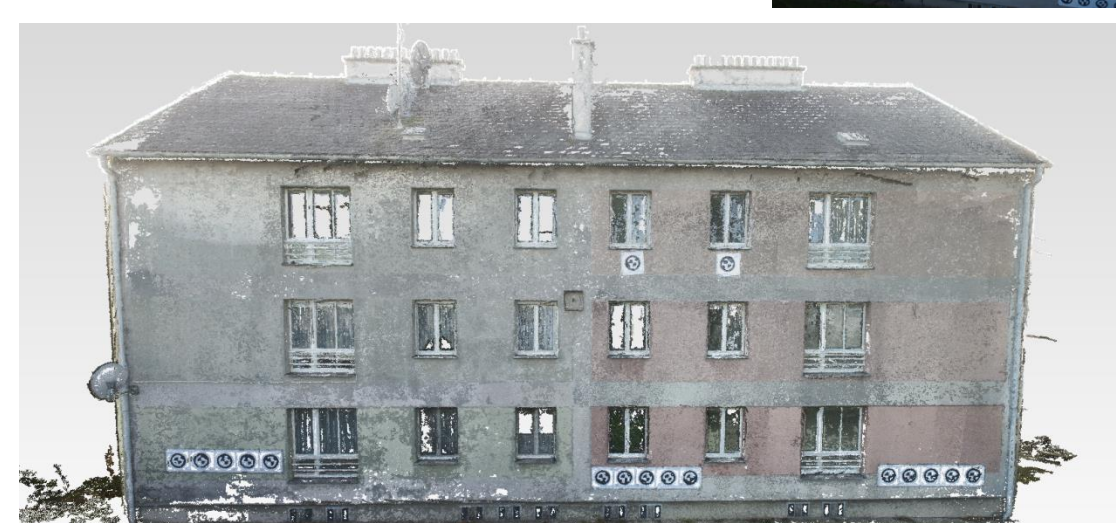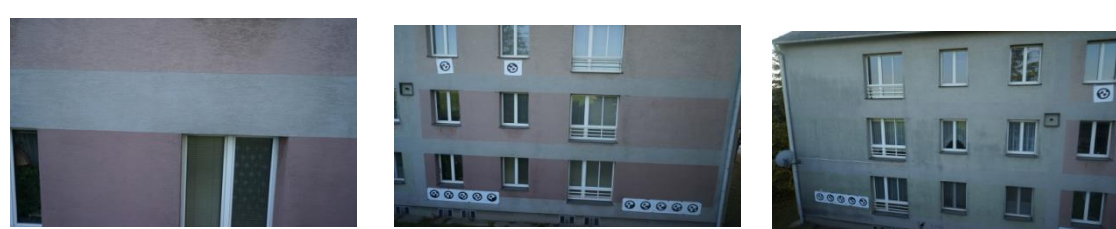
Evolution of the reconstructed façade over time

Performance Evaluation and Results

Benchmarking Dataset

- 1000 images acquired at different depths, heights and angle to façade.
- Ground-truth of urban façade measured with LIDAR.

(a) Images at 4m, 6m and 10m scales.
(b) Dense reconstruction of the Façade.

Quantitative Evaluation

- Visible accuracy gains with online feedback during image-acquisition and quality measures during planning.

	Ours	**Bundler [3]**	**Agisoft©**
Mean Error	**8.02mm**	15.5mm	21.55mm

(GCP measured with Theodolite with uncertainty ~1mm)

Geometric Fidelity of Reconstruction

- Significant bends and drift along fringes using bundler [3]
- Using the Multi-Scale Acquisition framework we get straight wall reconstruction.

Bundler

Ours
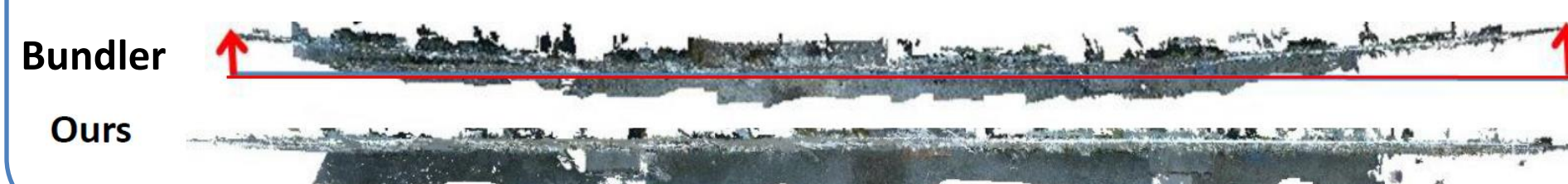
Application to Façade Modeling

- Automatic segmentation of façade and window/door detection with high accuracy.
- Multi-scale acquisition gives accurate and complete data required for such application
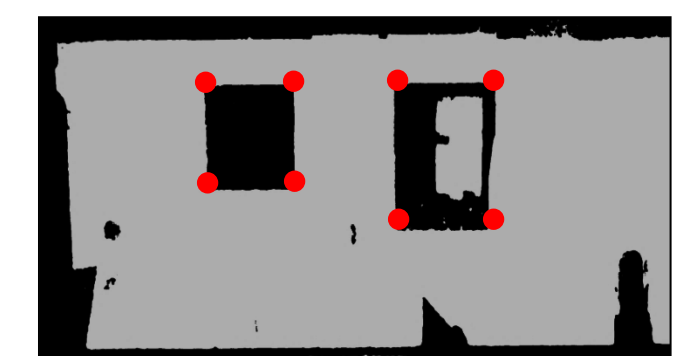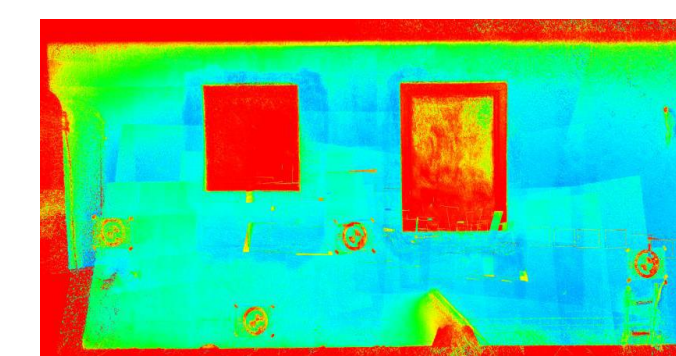
(a) Façade probability map (b) window detection result

	L. Window	**R. Window**
Ground Truth	107.3 cm	119.7 cm
Reconstructed	107.1 cm	120.0 cm
Mean Error	0.25 cm	

Mean Error in Façade element detection

References

[1] C. Stretcha *et al.* On Benchmarking Camera Calibration and MVS. for High Resolution Imagery, CVPR'08

[2] C. Hoppe *et al.,* Online Feedback for Structure-from-Motion Image Acquisition, BMVC'12

[3] N. Snavely *et al.,* Modeling the World from Internet Photo Collections, IJCV'07