Incremental Dense Reconstruction from Sparse 3D Points with an Integrated Level-of-Detail Concept

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AVIGLE

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Funded by the 2nd competition of the sponsoring competition Hightech.NRW

Ministerium für Innovation, Wissenschaft und Forschung des Landes Nordrhein-Westfalen

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Outline

- Motivation
- Incremental dense reconstruction approach
- Experiments and results
- Future work

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Why Incremental?

- Traditional dense reconstruction
  - Resources
  - Computation time
  - First result -> final result
  - Further images

Project AVIGLE

- Industrial research project
- Three universities and seven industry partners
- Development of a multifunctional aerial service platform
- One of the goals: creation of a virtual world with aerial photographs
  - Swarm of *Miniature Unmanned Aerial Vehicle (MUAV)*
  - Partly autonomous
  - Creation MUAVs are still flying

Example Application

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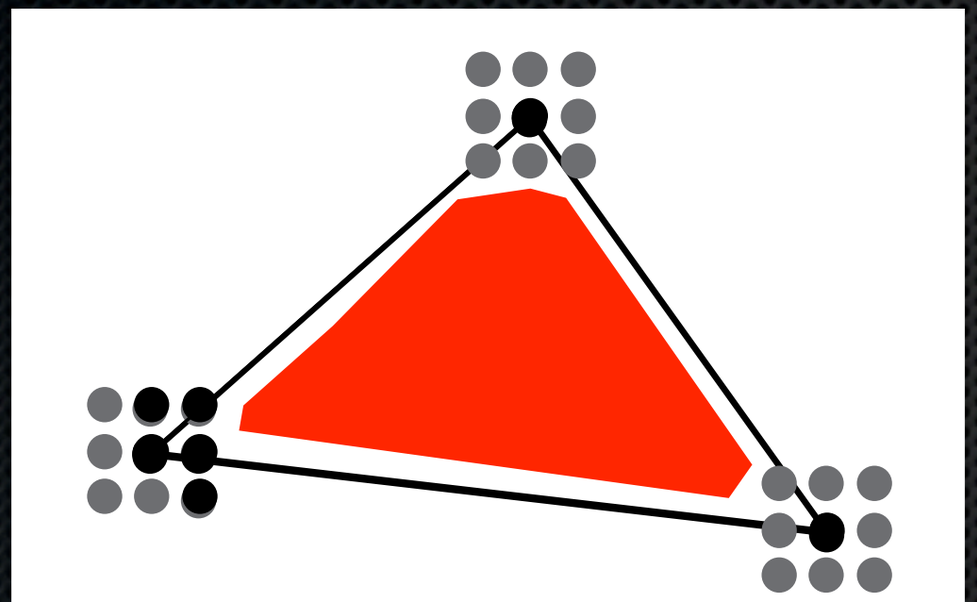
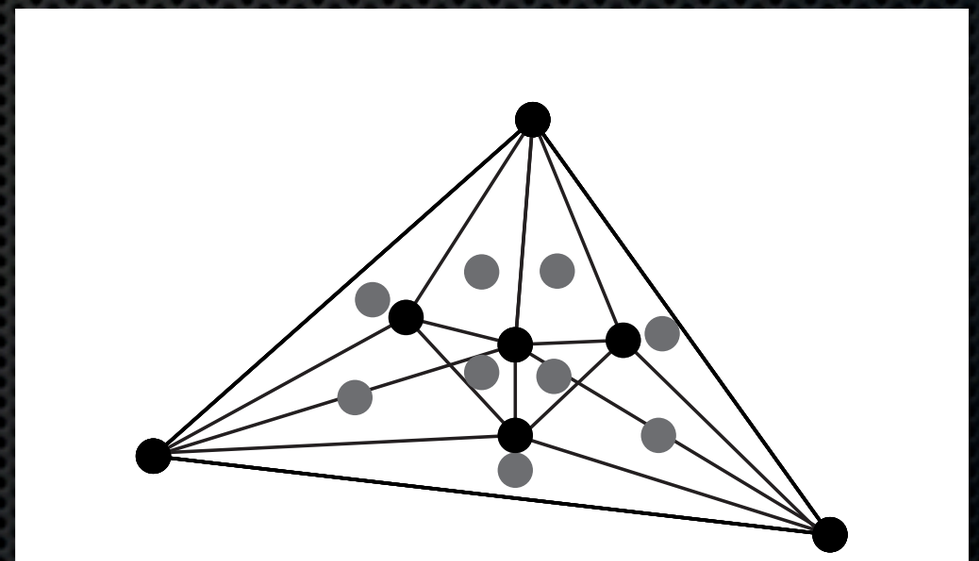
Traditional vs. New Approach



Traditional



New Approach

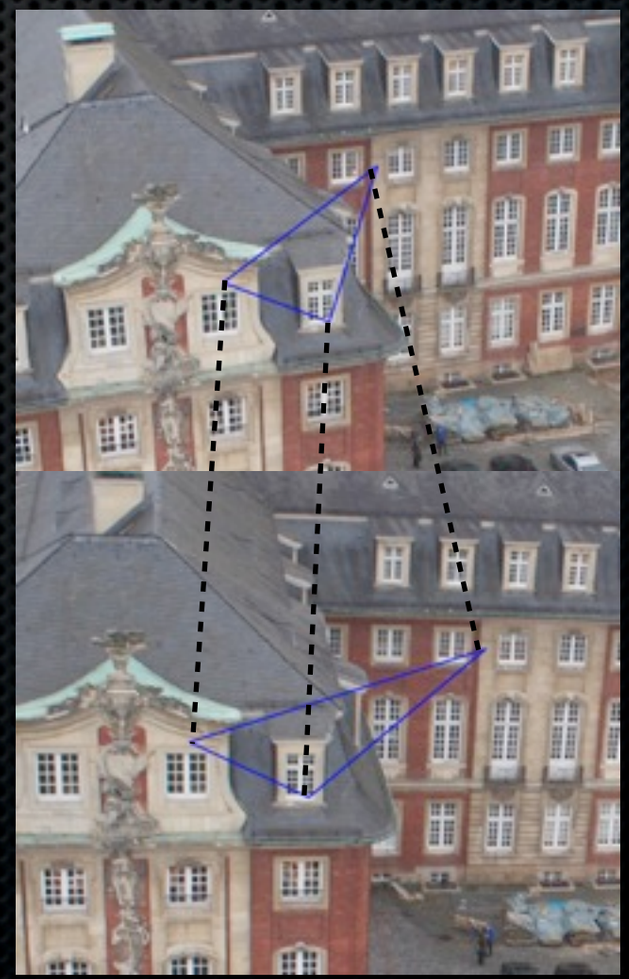
New Approach

- Handles wide-baseline images
- First results are processed quickly
- Reasonable incremental updates are delivered
- New images can be added to the computation process
- Integrates a level-of-detail concept by design

Incremental Dense Reconstruction

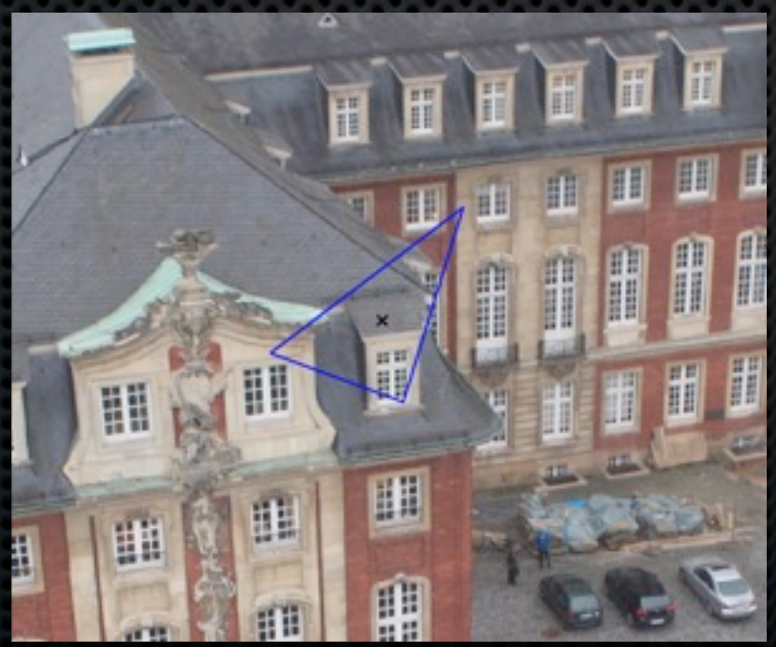
- Sparse geometry, matches and cameras known
- 2-view reconstruction
  - Other views used for verification
- 2D triangulation of feature point matches
  - Midpoints have maximum distance to the triangle points

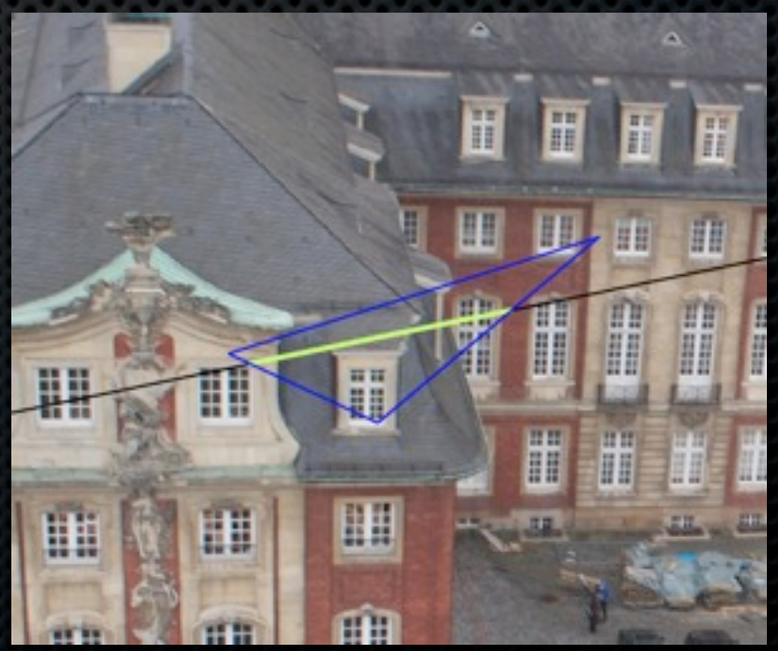
-> Increased visual entropy



Incremental Dense Reconstruction

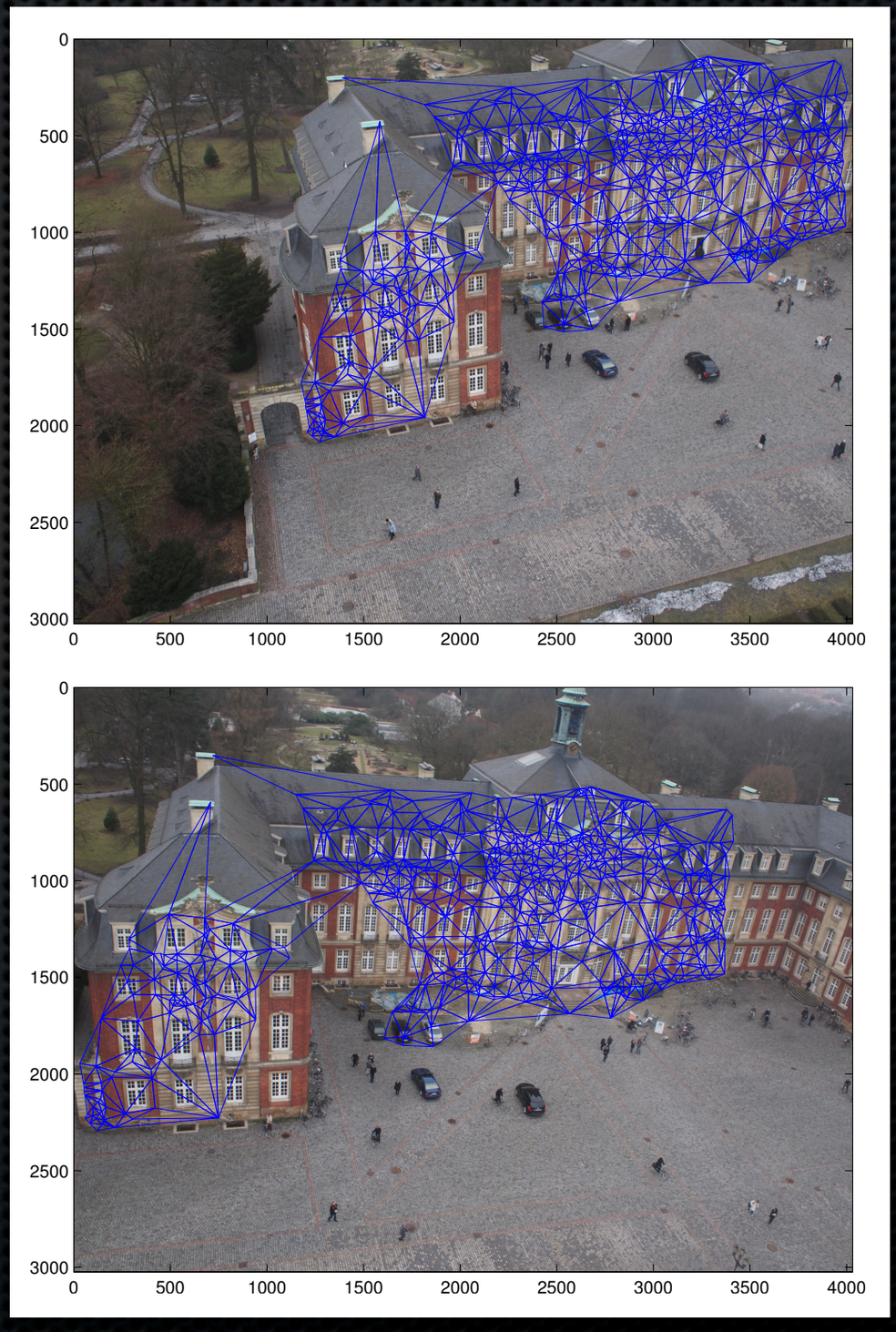
- Midpoint of the first image is matched to the second image
  - FREAK descriptor (Alahi et. al., 2012)
  - Guided matching using epipolar lines
  - Limit boundary to triangle in second image





Triangle Filtering

- Some triangles are unlikely to contain the correct match
- Classify the triangles using filter rules, e.g. size constraint
- Either reject those triangles or search on the whole epipolar line
- Level-of-detail concept by bounding the triangle size



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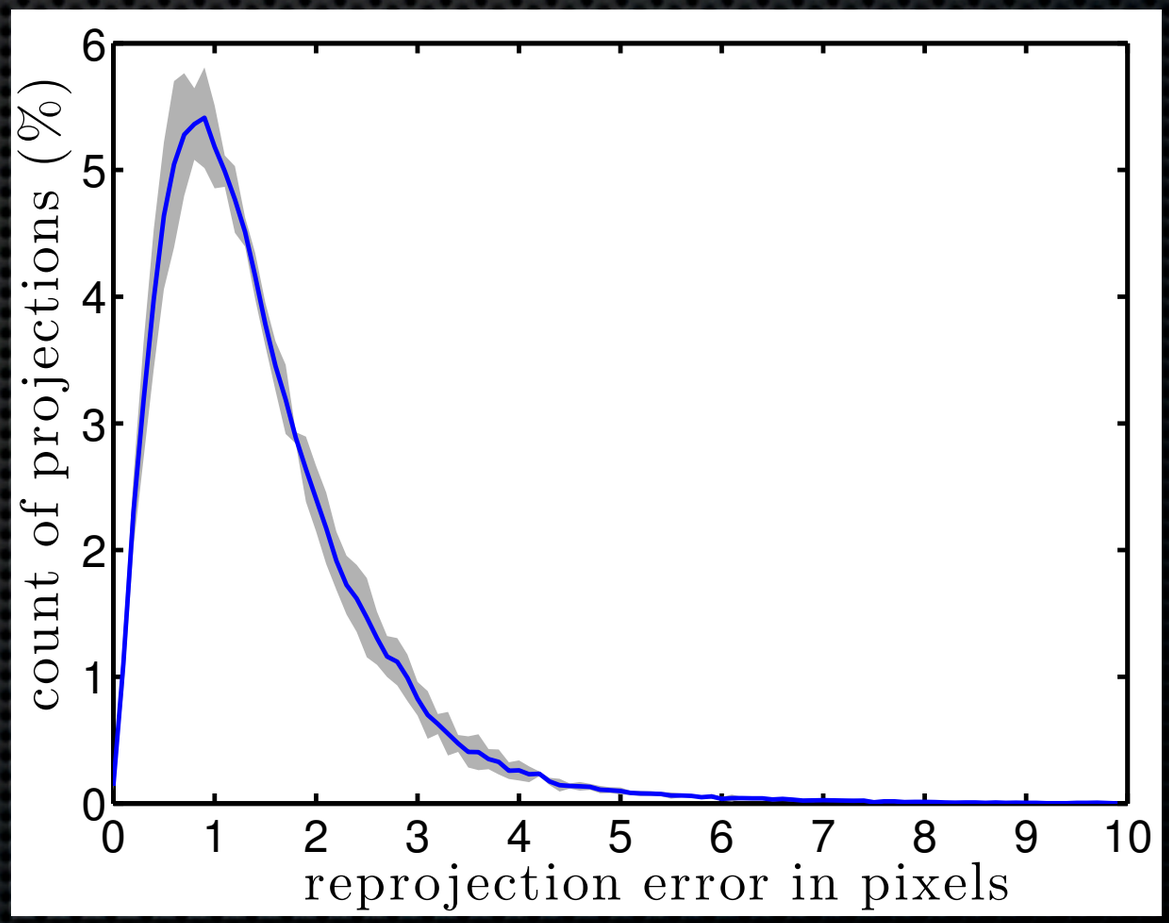
Ground Truth Dataset

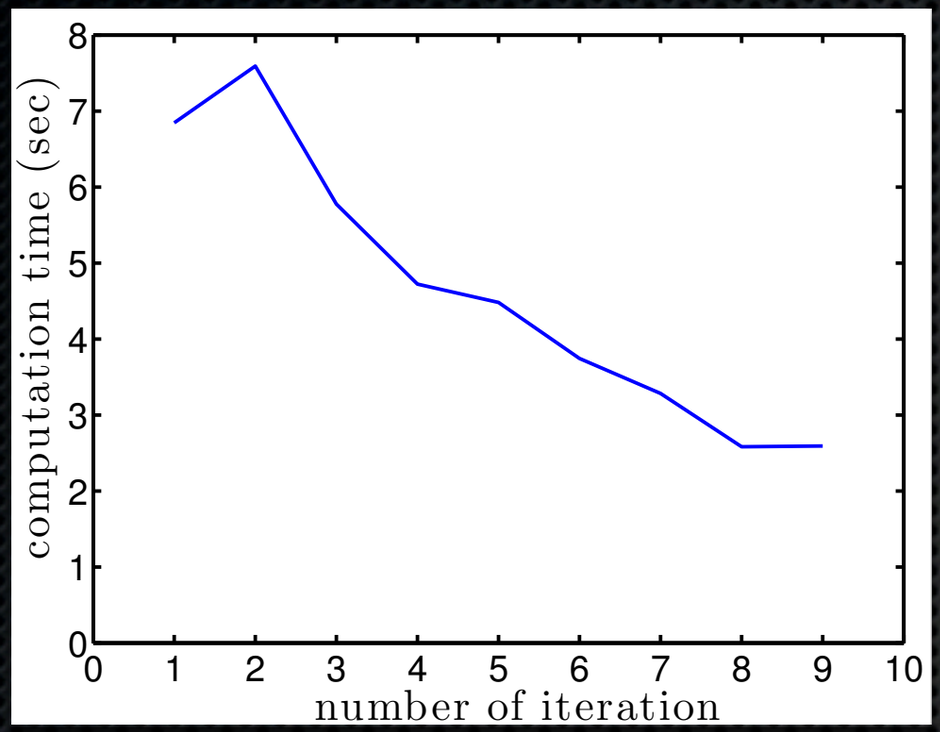
- Evaluation with ground truth dataset
  - The city of sights (Gruber et. al., 2010)
  - 7 images (1920x1080) with additional depth image

Accuracy

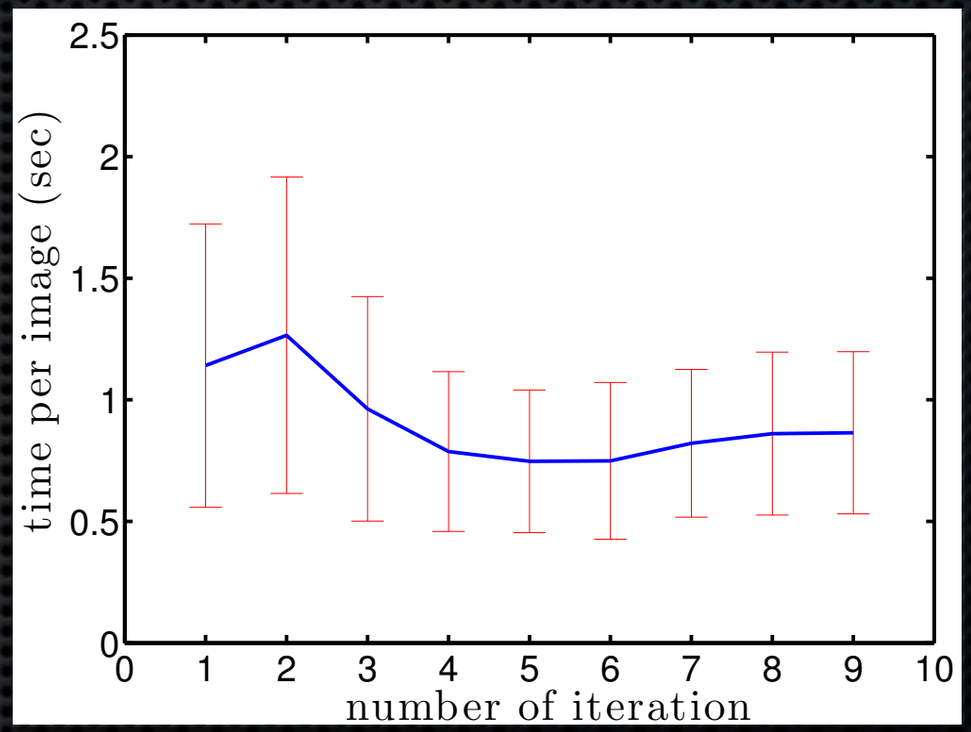
- Accuracy measured as reprojection error
- Total mean accuracy about 1.5 pixels
- Total standard deviation about 1.49 pixels



Time Measurement



all images



“mean” images

- Decreasing computation time
  - More triangles are rejected
  - Images are at highest level-of-detail

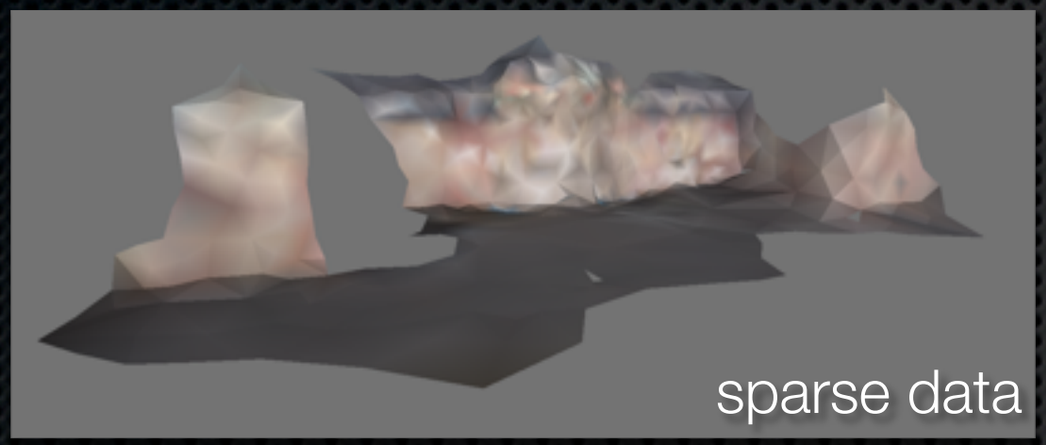
Real World Scene

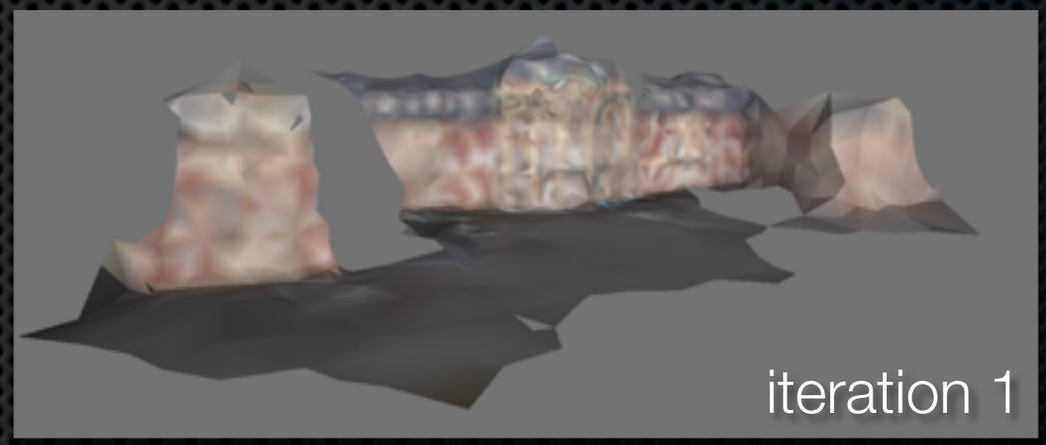
- 7 aerial images (4032 x 3024)
- Castle of Münster
- Sparse data obtained by VisualSFM (Changchang Wu)

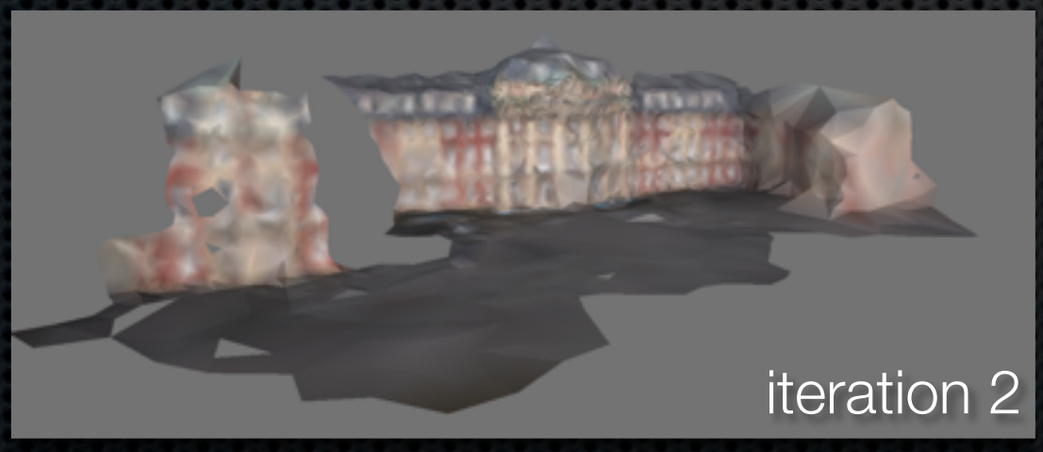
Real World Scene

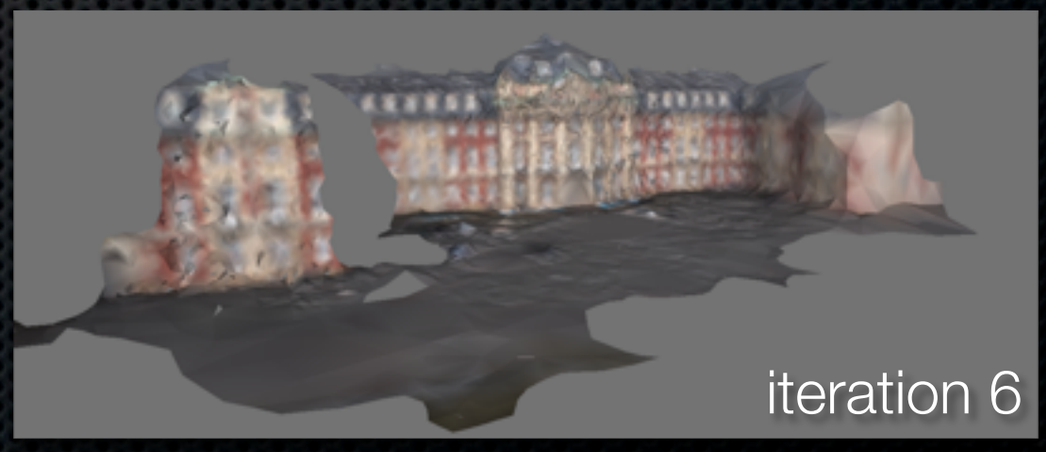
Further Processing Example

- Mesh reconstruction









Vierjahn et al., sGNG: Surface Reconstruction Using Growing Neural Gas, Eurographics 2013, submitted

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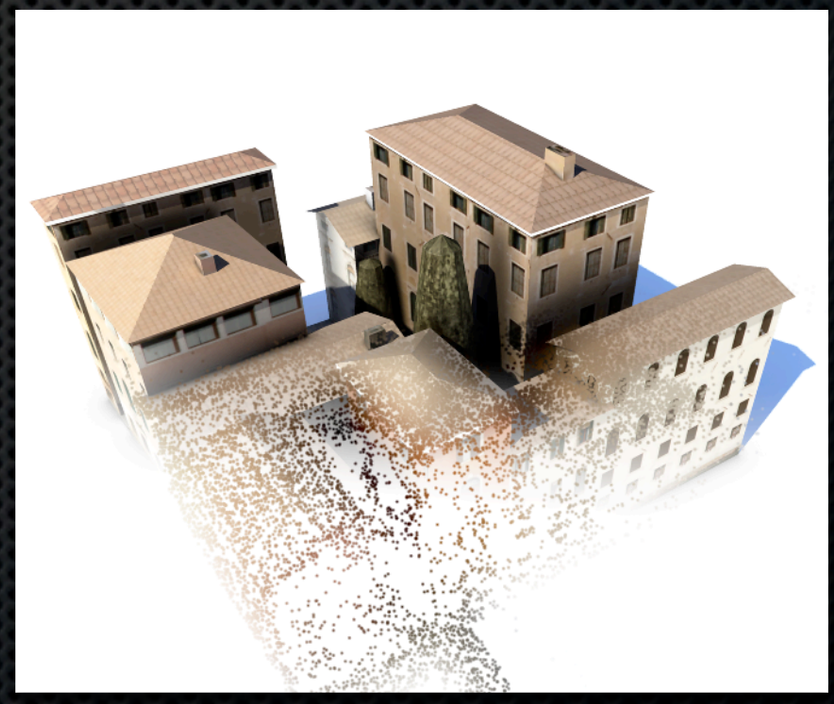
Future Work

- Close holes in the reconstruction
  - Especially at the borders of objects
- Improve triangle filters
- Subpixel accuracy



Thank you for your attention!

Questions?

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