GEO1101 Synthesis Project

Digitizing
Real-world Scenes from Images

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1. Introduction

Pictures

Point Cloud – 3D Models

Existing Knowledge

@NARUX3D

GO GREENER FLORIADE ALMERE 2022

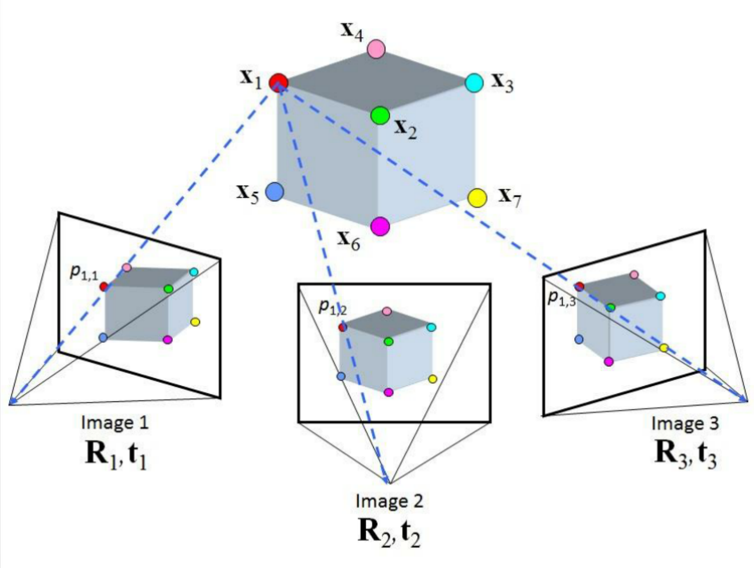
- Why go 3D?
- What is behind the image?

- 1 Introduction
- 2 Technical pipeline
- 3 Software presentation
- 4 Results and limitations
- 5 Conclusions & Future work

Photogrammetry

By a sequence of overlapping images depth can be captured

Solving many equation returns 3D parameters of points that are visible from cameras



But how can we find correspondences in images??

Features!

Point clouds from images

- Image quality against cost is advantageous
- Drone can capture every surface
- Surfaces behind obstacles can be transformed as well as a wide range of objects.
- Online pictures from artifacts and monuments can be used
- Colour can be adjusted to points

LIBRARIES

Dense reconstruction

- Calls findMatch class

pmoulon / CMVS-PMVS

Search or jump to...

```
PMVS3::CfindMatch findMatch;
findMatch.init(option);
findMatch.run();
```

```
const int TIME = 3;
for (int t = 0; t < TIME; ++t) {
        m_expand.run();

        m_filter.run();

        updateThreshold();

        cout << "STATUS: ";
```

expand.cc	Initial Release
expand.h	Initial Release

filter.cc	Initial Release
filter.h	Initial Release

Functional Requirements

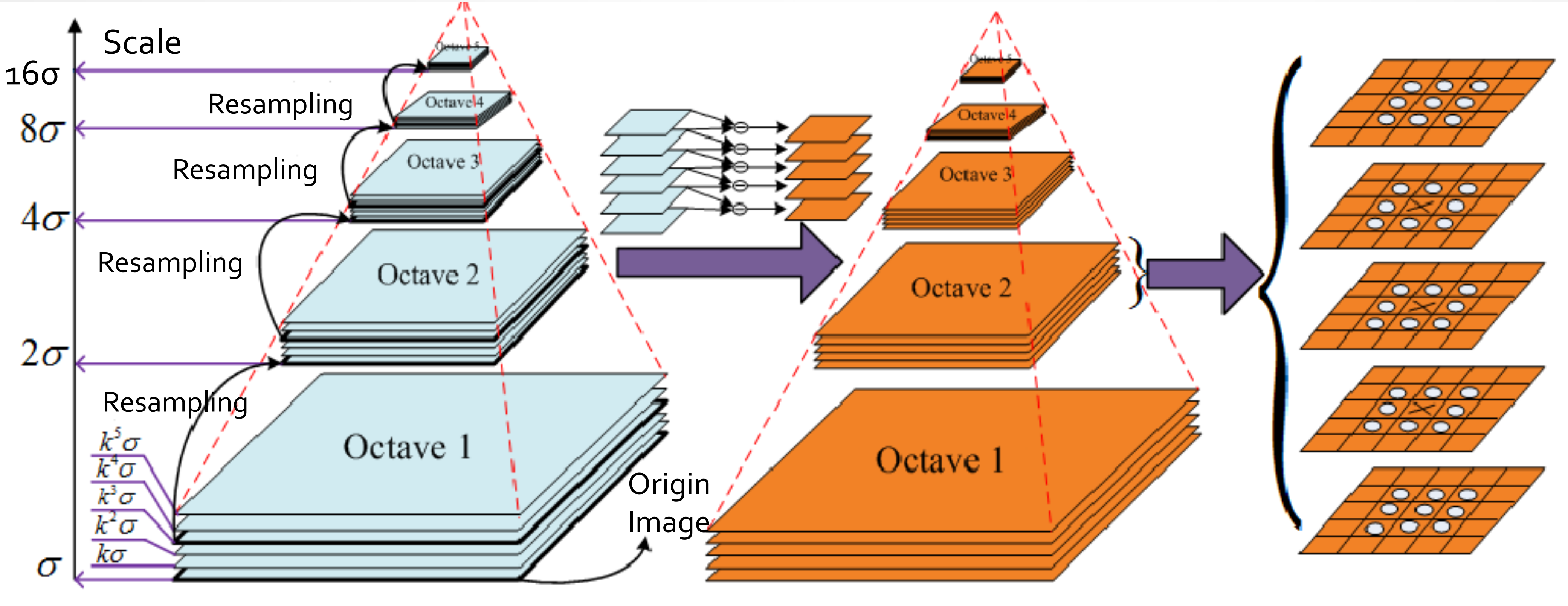
- ✓ Data management
- ✓ Implementation of image matching (SIFT method)
- ✓ Implementation of structure from motion
- ✓ Implementation of Multi-view stereo
- ✓ Reconstruct 3D objects with smooth surfaces
- ✓ Reconstruct 3D objects with piece-wise planar surfaces.
- ✓ Export result of each step

2. Technical Pipeline

Module A: Image Matching

Image matching

1. **Scale-space extrema detection:** The first stage of computation searches over all scales and image locations. It is implemented efficiently by using a difference-of-Gaussian function to identify potential interest points that are invariant to scale and orientation.



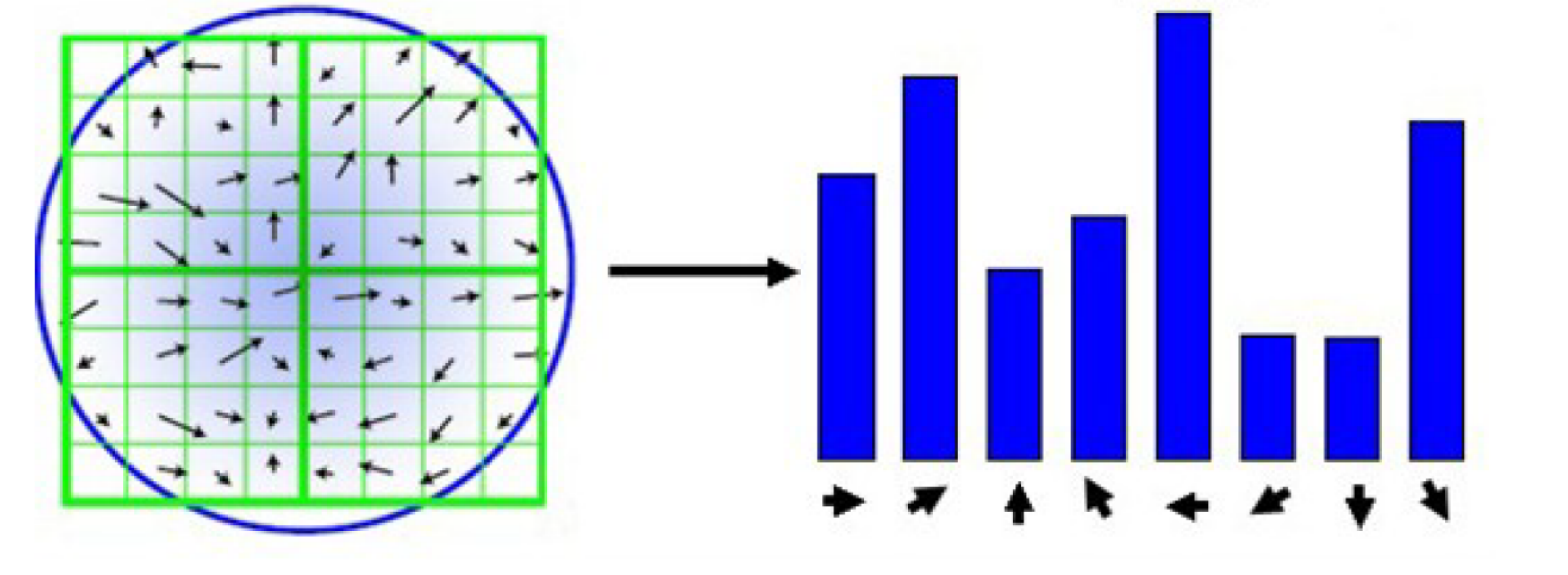
Gaussian　　Difference of Gaussian(DOG)　　Extrema Detection

Extrema points (x, y, scale)

Image matching

2. **Orientation assignment:** One or more orientations are assigned to each keypoint location based on local image gradient directions.

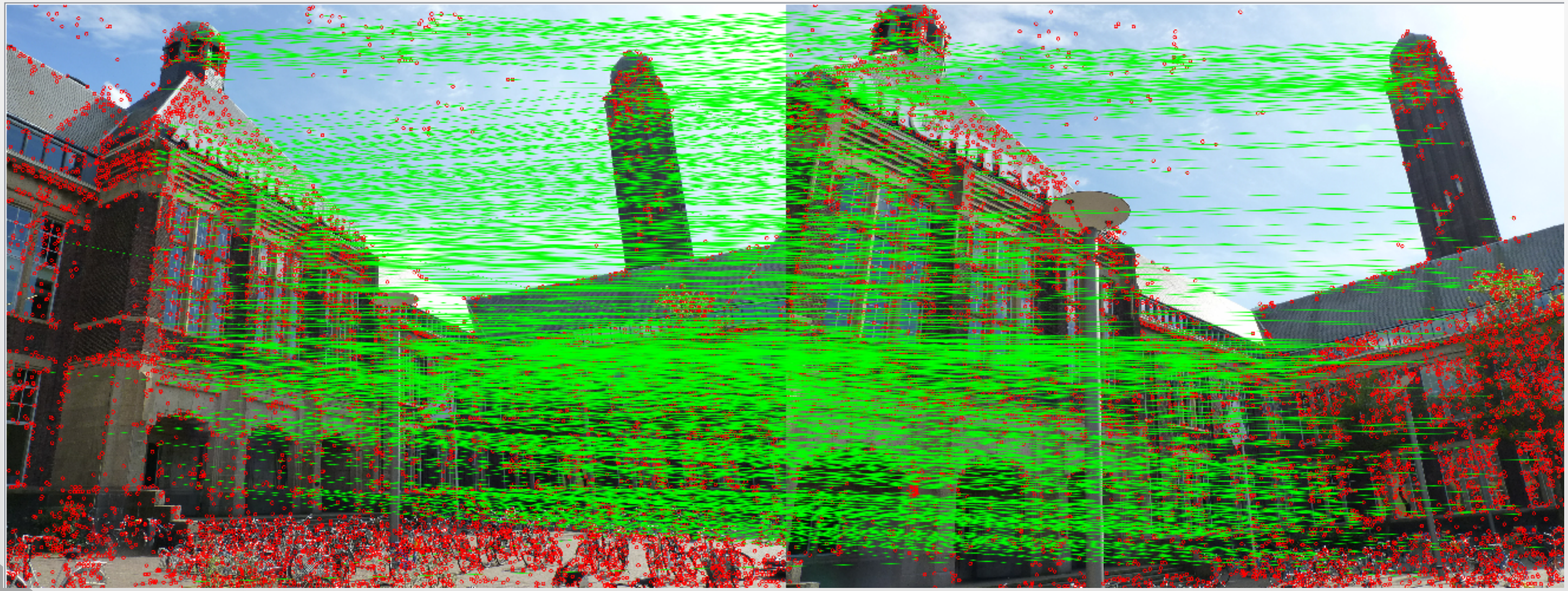
- ✓ Create histogram of local gradient directions at selected scale
- ✓ Assign orientation at peak of smoothed histogram
- ✓ (assistant orientation >80%peak)



key point(x,y,scale,orientation)

Image matching

3. Keypoints matching



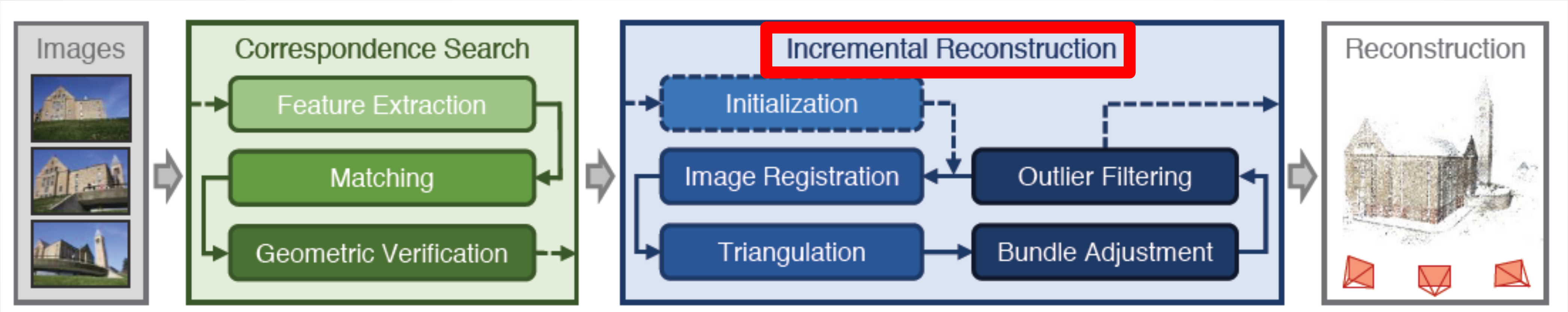
Module B: Structure from Motion (SfM)

Structure from Motion (SfM)

Structure from Motion (SfM): The process of reconstructing 3D geometries from a sequence of 2D images taken from different viewpoints on same objects.

Output of SfM is a bundle file containing:

- Sparse point cloud (X,Y,Z, n)
- Camera parameters (center, rotation)
- Their correlation



Source: Schonberger, J. L., & Frahm, J. M. (2016). Structure-from-motion revisited.

Module C: Multiview Stereo

Multiview Stereopsis

- Aim : The construction of a dense point cloud
- Input : Images & camera parameters, matches, sparse point cloud
- Output characteristics : Points3D, normals, colour

Multiview Stereopsis

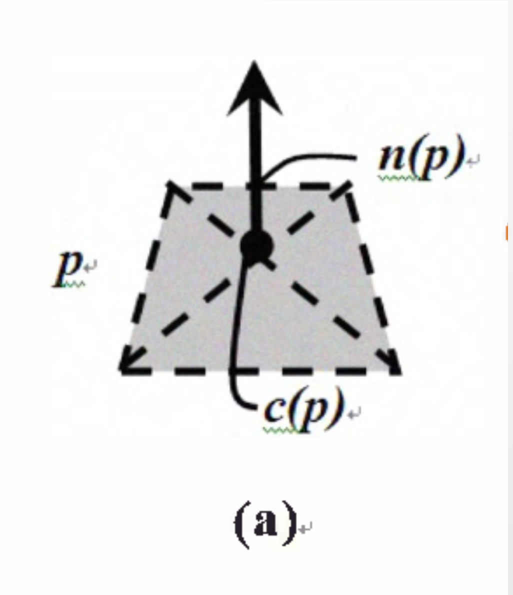
Patch based algorithm

Initializes patches to matching cells

Expand , Filtering (3 times)

Advantages:

- Works on occlusion and moving object existence
- Can reconstruct all the surfaces visible to cameras



Modula e: Surface Reconstruction

Smooth Surface Reconstruction

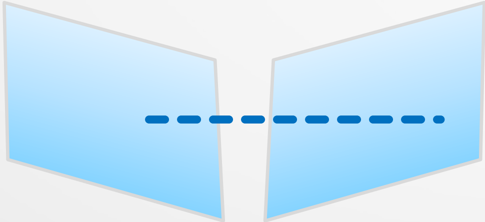
- Good for curved and complex objects
- Using PoissonRecon by Kazhdan et al.
- Input : dense point cloud in PLY format with position, normal and colour of points
- Approached as a spatial Poisson problem
- Output : smooth and detailed triangulated meshes

Planar Surface Reconstruction

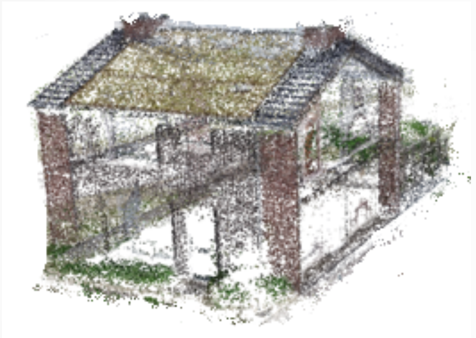
- Useful for typical buildings with straight surfaces
- Input , dense point cloud in format
- Using the PolyFit method by Nan and Wonka
- Creates planes from point neighbourhoods and cuts at intersections
- Output: watertight solid

Technical pipeline

1. Data collection



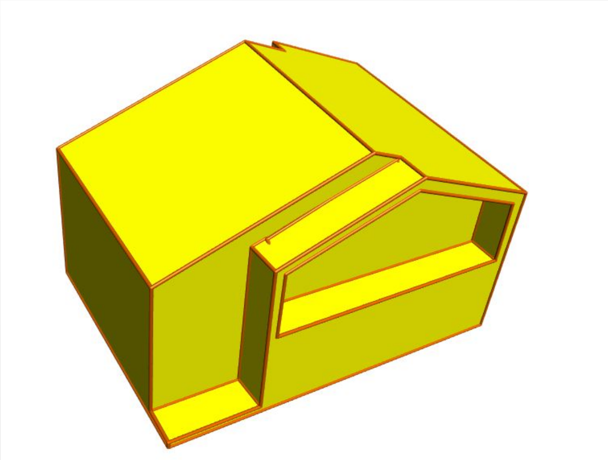
2. Image matching



3. Sparse reconstruction

4. Dense reconstruction

5.1 Smooth surface reconstruction



5.1 Plane surface reconstruction

3. Software presentation

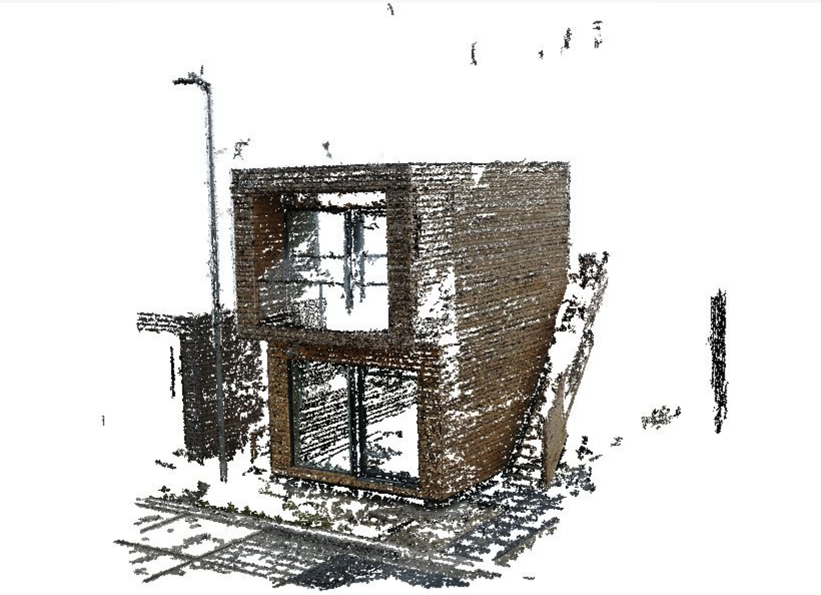
4. Results and limitations

Almere Watchtower

Almere Watchtower

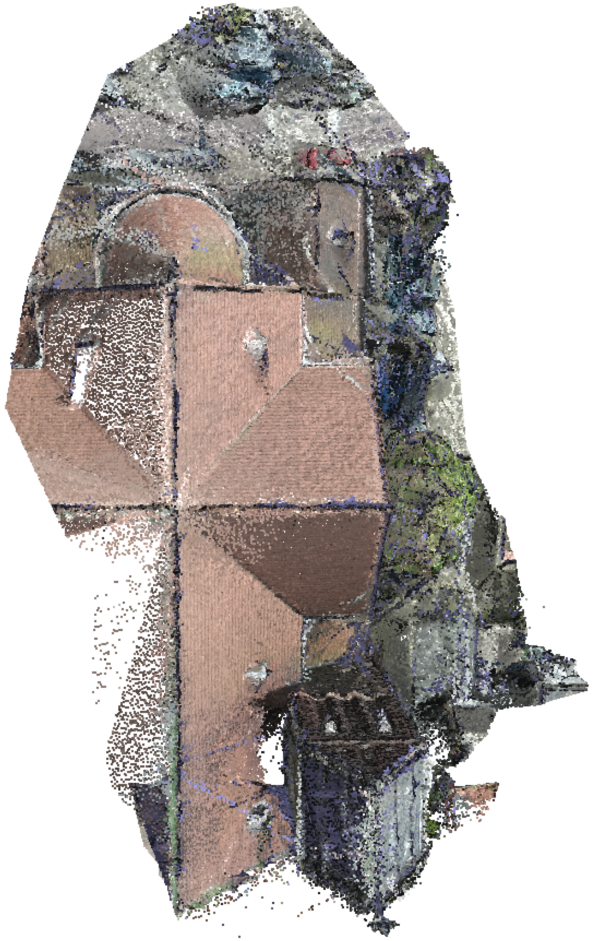
Object	Camera	number of pictures	angle of sight	number of points (after clipping to extent)
Watchtower	Drone	99 - 27	235	892,068

Wooden House



Object	Camera	number of pictures	angle of sight	number of points (after clipping to extent)
Wooden House	Mobile Phone	59 - 45	270	1,679,687

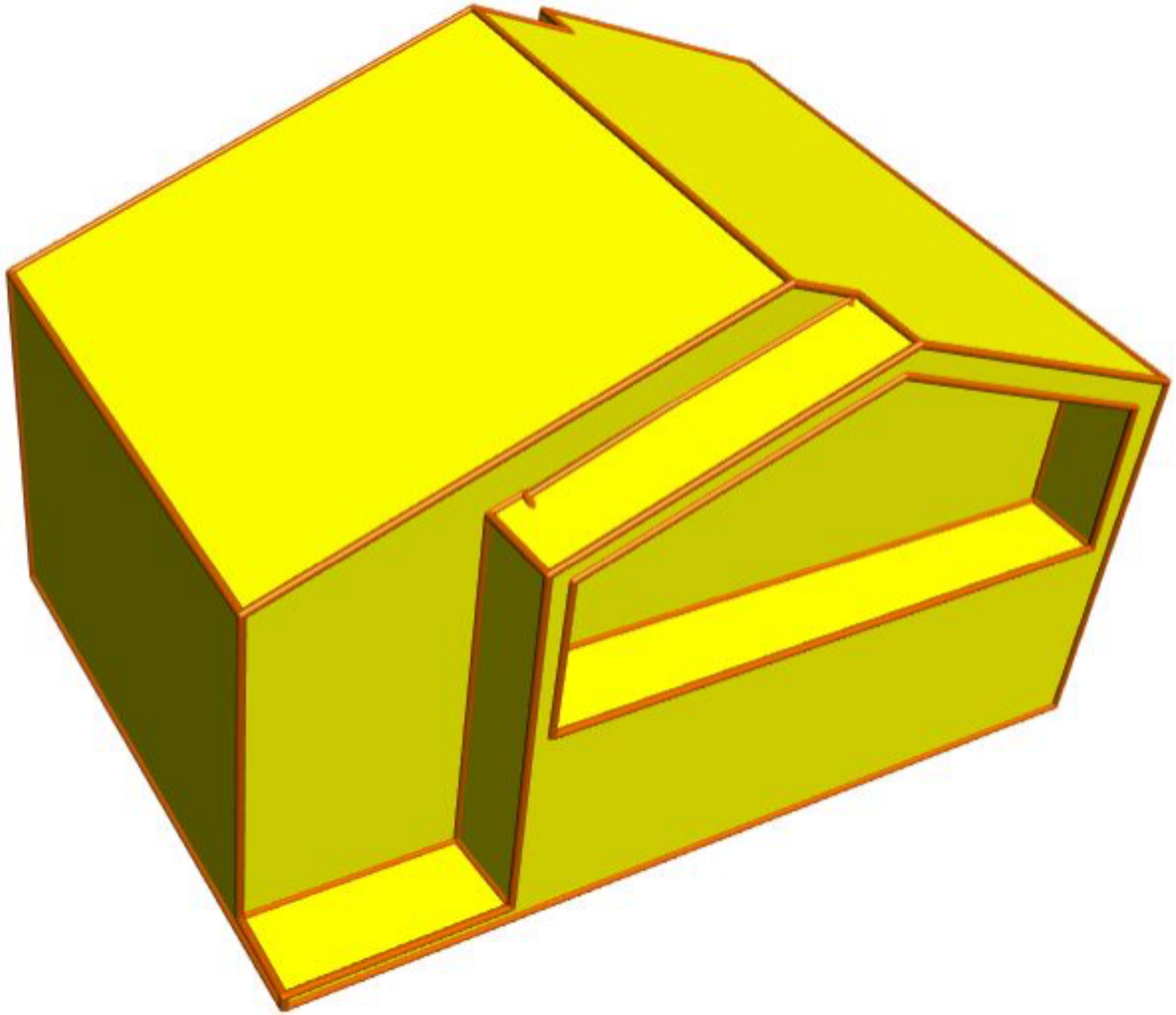
Church in Delft

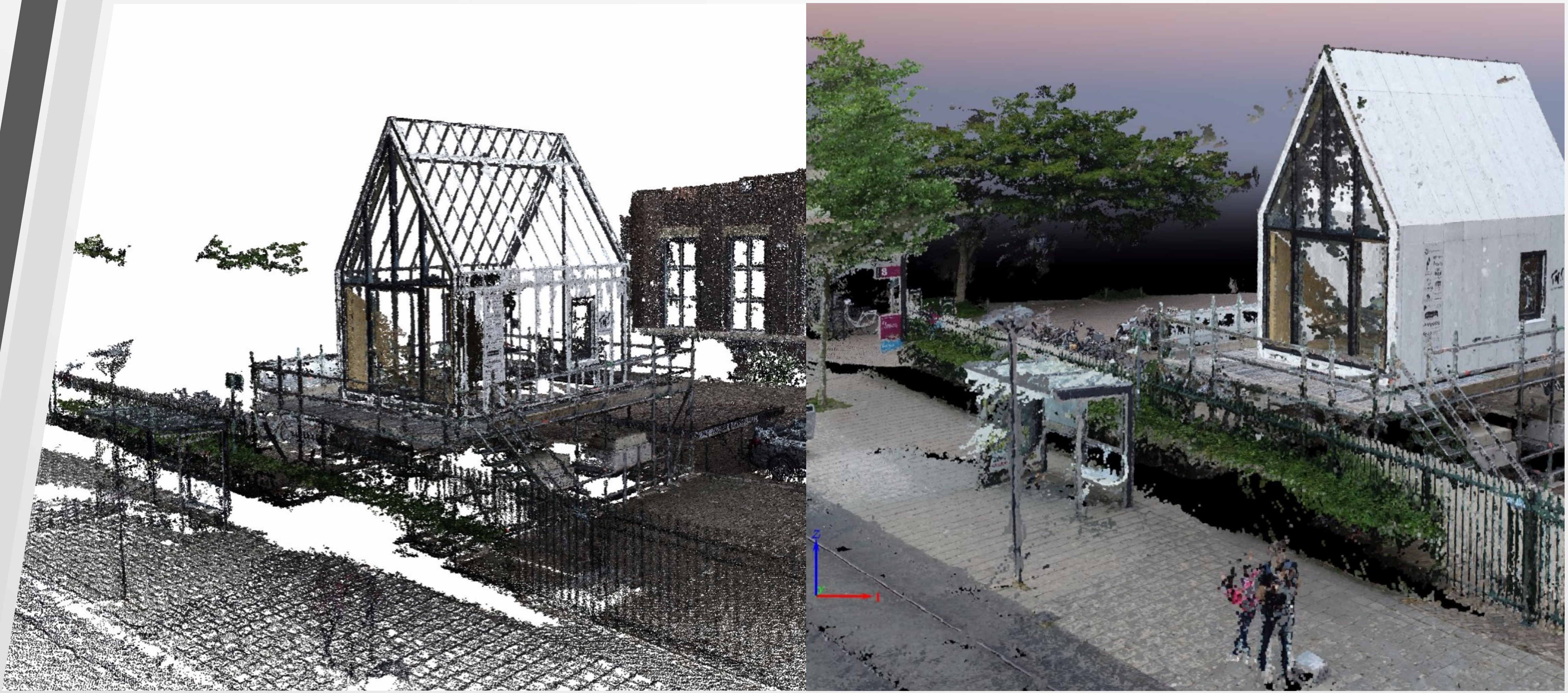


Object	Camera	number of pictures	angle of sight	number of points (after clipping to extent)
Church	Drone	400 - 400	180	4,287,413

Home with a skin

Object	Camera	number of pictures	angle of sight	number of points (after clipping to extent)
Home with a skin	Drone	99 - 99	360	552,249





Comparison with Pix4DMapper

5. Conclusions

- NARUX3D performed good overall
- One object at a time
- Quality of input will define the quality of final model
- Drone capturing oblique images gave the better output
- Problem definition is needed for algorithm selection
- NARUX3D requires further testing

Thank you!