RSM02: Terrestrial and Airborne Lidar and Photogrammetry Systems (Summer 2024)

Final Project

Comparative study of a point cloud model: Structure from Motion against Airborne LiDAR Data

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Research Question:

In which aspects does a
Structure from Motion Point Cloud differ from an
Airborne Lidar Point cloud (2018)
in the case of **Berlin Victory Column**?

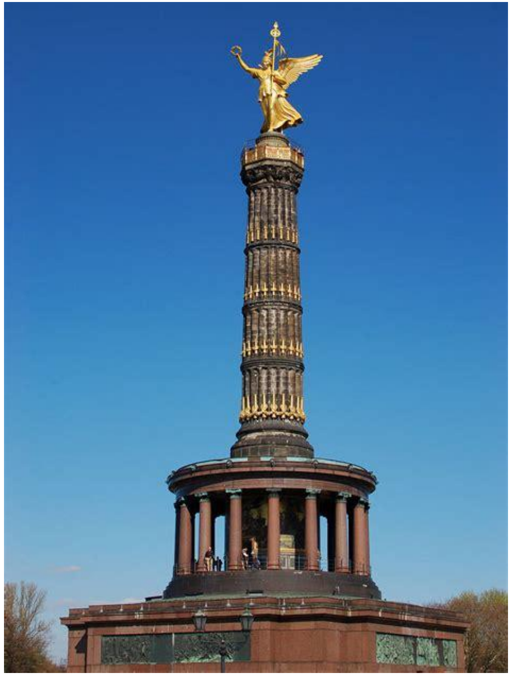

Fig. 1: Berlin Victory Column

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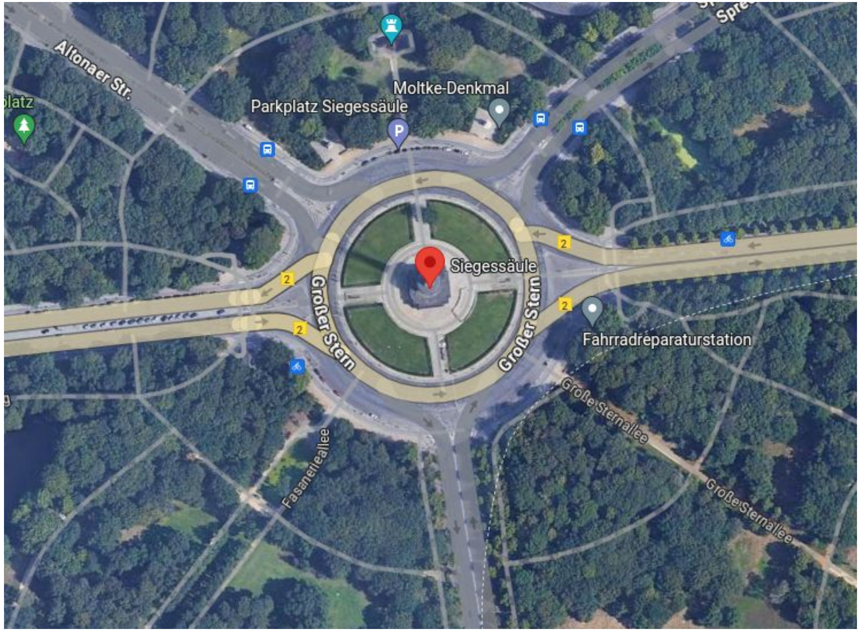
Study Area

Located in Berlin, Germany

67m-high gilded column

Monument with a deck for city views

Urban characteristics

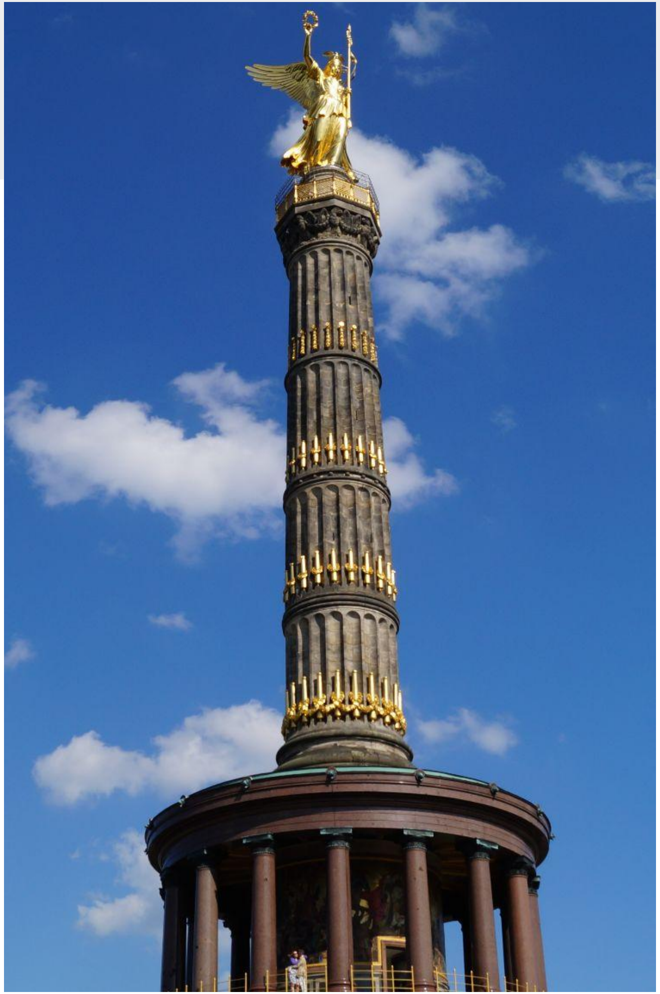


Workflow

1. Generate a point cloud with the Structure from Motion (SfM) method
    a. Take pictures
    b. Build point cloud (Metashape Pro)
    c. Filter point cloud (CloudCompare)
2. Prepare LiDAR data
    a. Download
    b. Clip
    c. Filter and clean up (CloudCompare)
3. Align and Merge point clouds (CloudCompare)
4. Compare Point Clouds

1. Generate a point cloud with the Structure from Motion (SfM) method

first photoshoot with SONY SLT- A85 camera & tripod



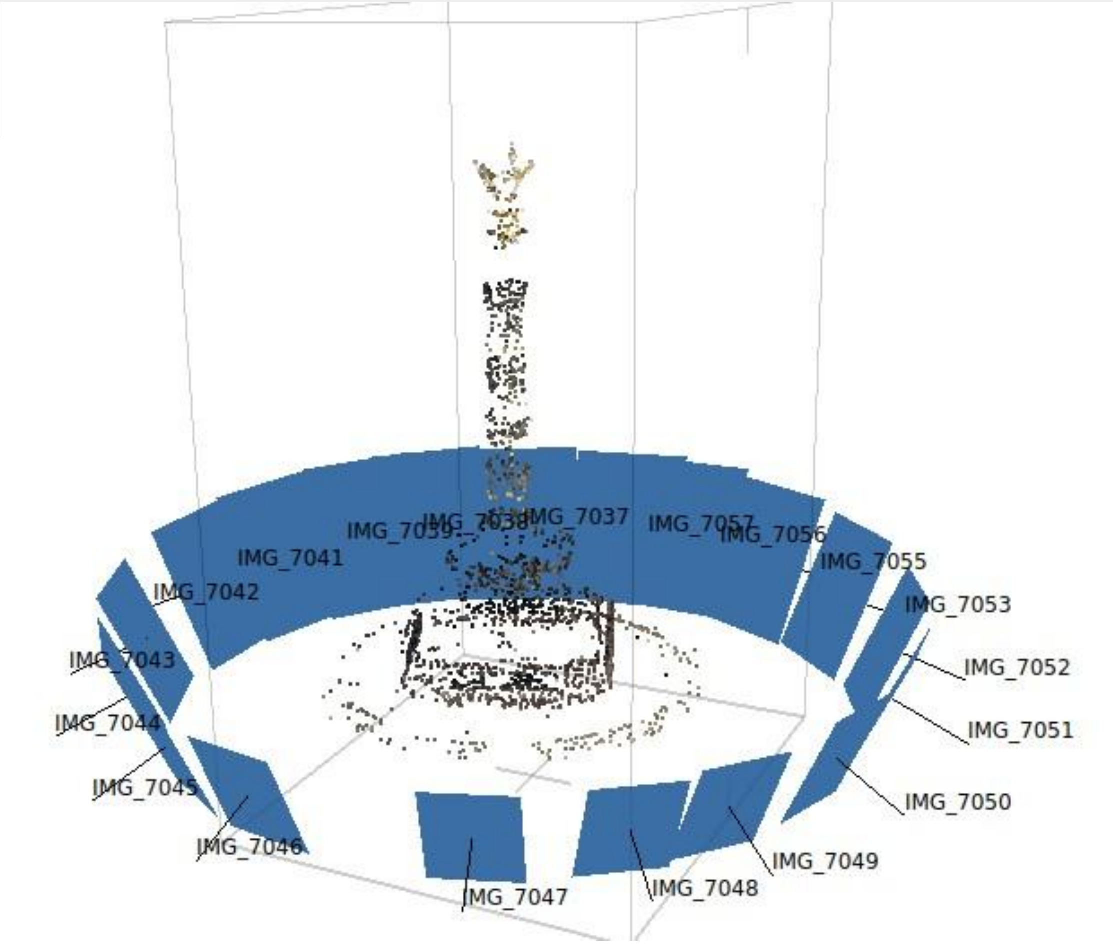
1. Generate a point cloud with the Structure from Motion (SfM) method

second photoshoot with iPhone & tripod

1. Generate a point cloud with the Structure from Motion (SfM) method

Align photos with Metashape Pro

→ only worked when no optional settings were selected



1. Generate a point cloud with the Structure from Motion (SfM) method

build point cloud with Metashape Pro

1. Generate a point cloud with the Structure from Motion (SfM) method

Filter point cloud with CloudCompare

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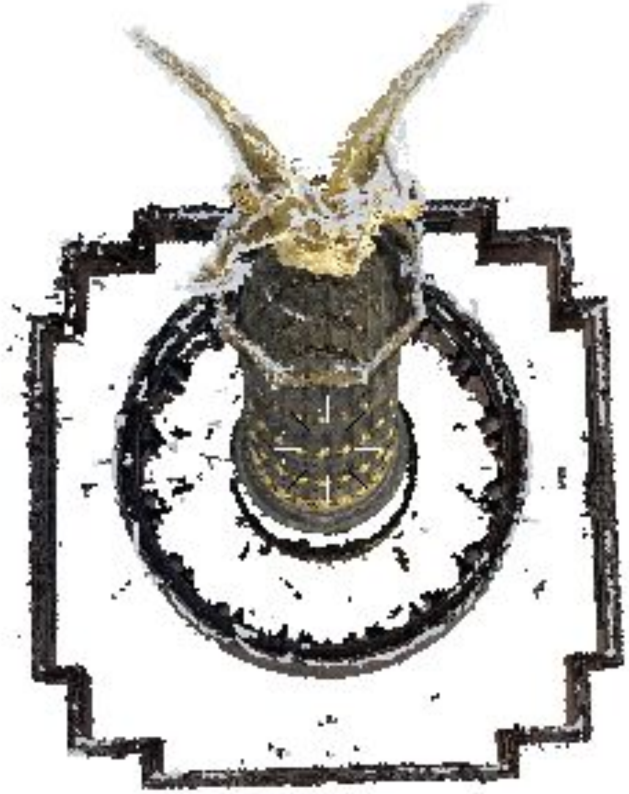


1. Generate a point cloud with the Structure from Motion (SfM) method - LEARNINGS

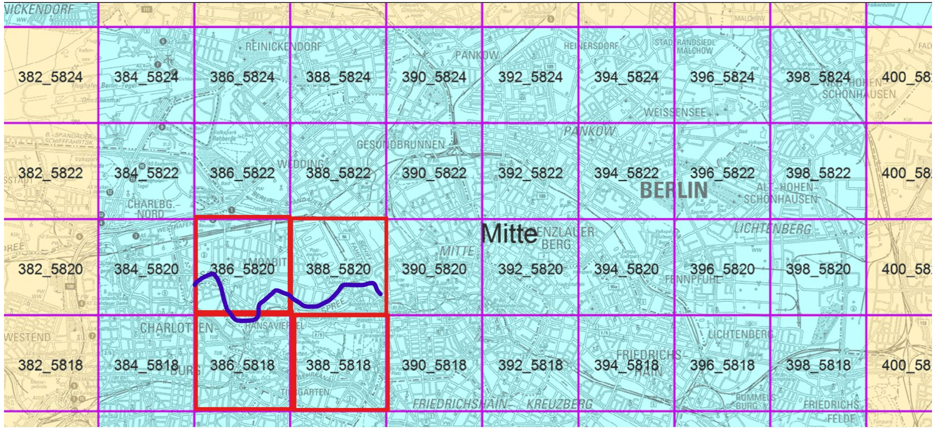
- photos should be taken on a cloudy day and from them same perspective
- zoom-in photos aren’t alignable
- a camera isn’t always the best choice

- optional settings aren’t always helpful
- cleaning the sparse point cloud increases quality of dense point cloud

2. Prepare LiDAR data

Require corresponding LiDAR point cloud data for the same area for comparative analysis.

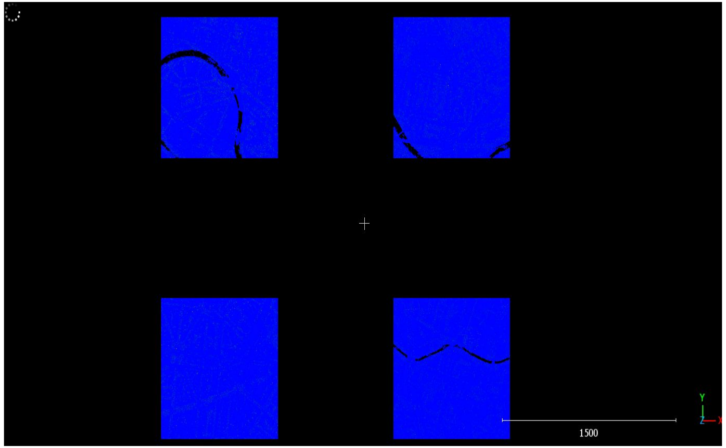
Attempted to obtain this data from the Berlin geoportal website: [Geoportal Berlin]



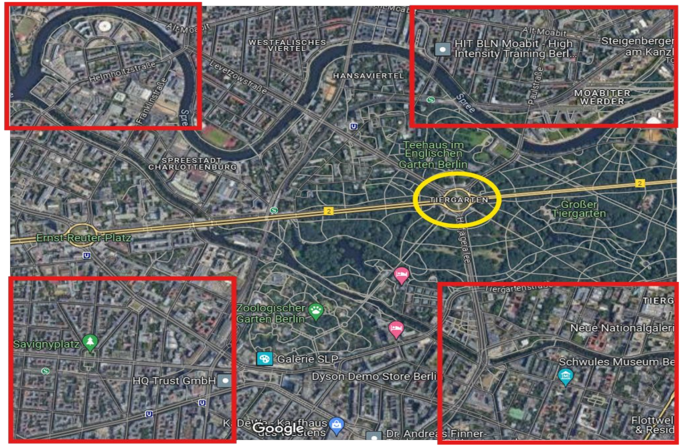
Screen shot from Geoportal Berlin

2. Prepare LiDAR data

The provided data sets do not cover our area of interest.



CloudCompare



Google Maps

3. CloudCompare : Aligning Two Point Clouds

Why align LiDAR data from Structure-from-Motion with airborne LiDAR data?

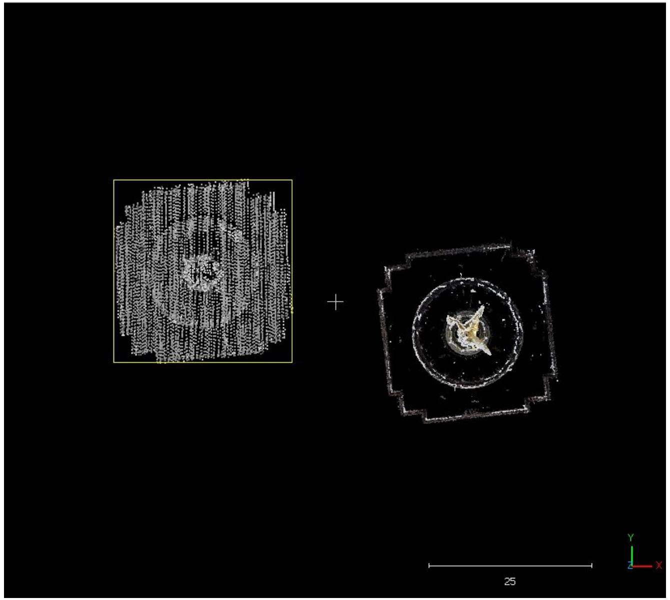
- Consistency in Geospatial Analysis : Uniform Georeferencing (EPSG 25833)

- Accuracy Improvement :

1. SFM : may have scale inaccuracies and errors due to lack of precise georeferencing.
2. Airborne LiDAR: may lack the fine detail in certain areas due to its typically lower resolution compared to SfM.

3. CloudCompare : Aligning Two Point Clouds

Side view



Top view

3. CloudCompare : Aligning Two Point Clouds

1. Align (points pair picking)

Align info

Final RMS: 0.112679

Transformation matrix

1.000	-0.020	0.000	-38.427
0.020	0.997	-0.069	-89.006
0.001	0.069	0.998	-6.755
0.000	0.000	0.000	1.000

Scale: fixed (1.0)

Refer to Console (F8) for more details

2. Fine registration (ICP : Iterative closest point)

Registration info

Final RMS*: 0.735564 (computed on 4210 points)
(* RMS is potentially weighted, depending on the selected options)

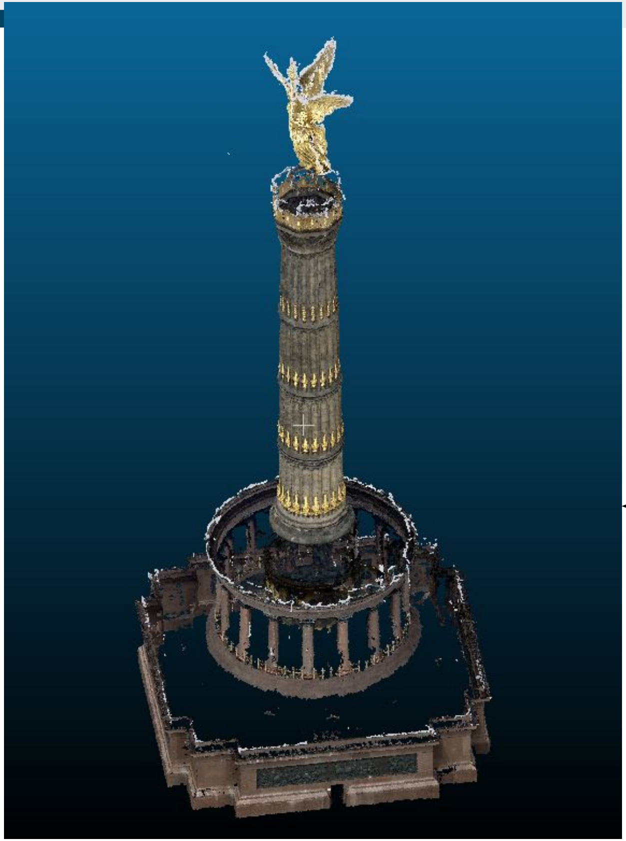
Transformation matrix

0.999	0.047	0.003	-0.972
-0.048	0.997	0.067	-1.922
-0.000	-0.067	0.998	1.613
0.000	0.000	0.000	1.000

Scale: fixed (1.0)

Theoretical overlap: 95%

This report has been output to Console (F8)



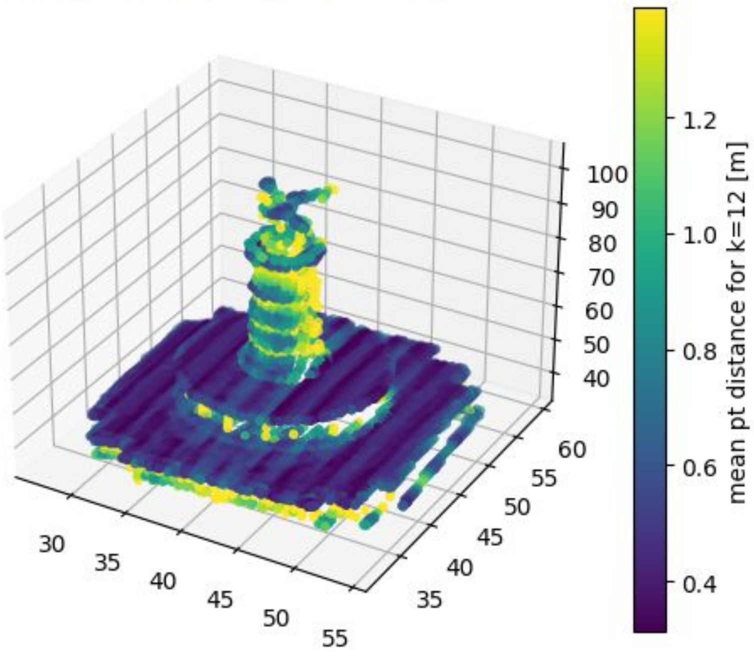
After Aligning →

← **Before Aligning**

4. Compare Point Clouds

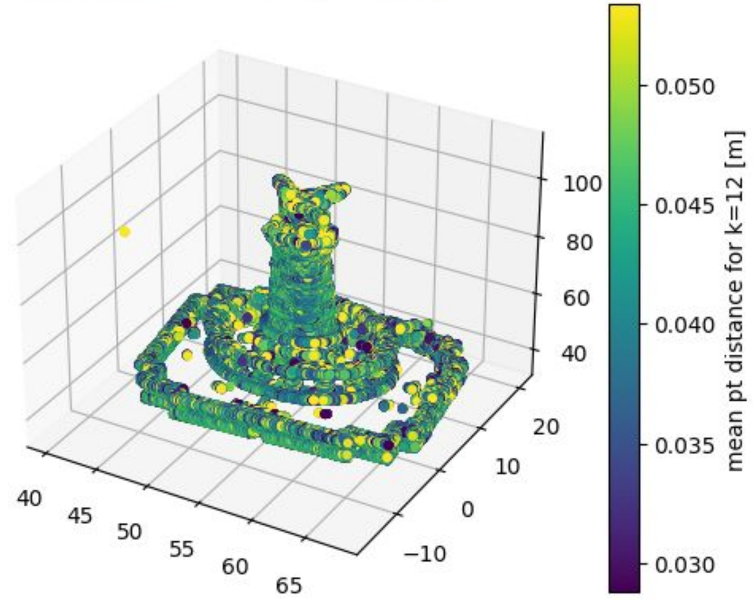
Airborne Lidar Point cloud (2018)

Metric	Value
Point density (points/m³)	0.176198
Average Point-Spacing (m)	0.536582



Structure from Motion Point Cloud

Metric	Value
Point density (points/m³)	26.774172
Average Point-Spacing (m)	0.041043



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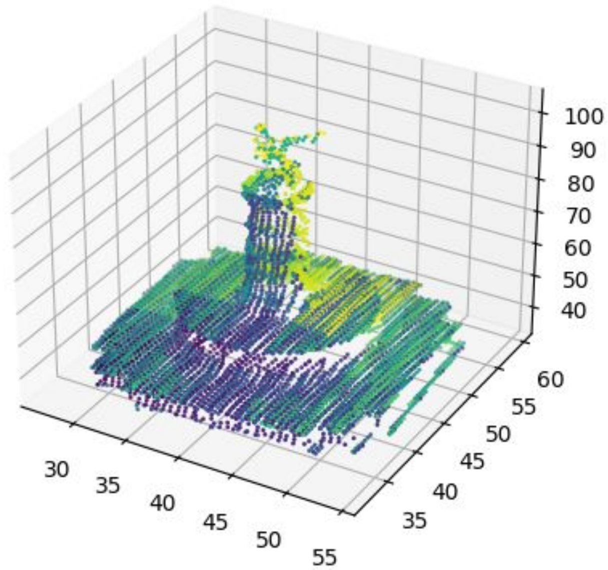
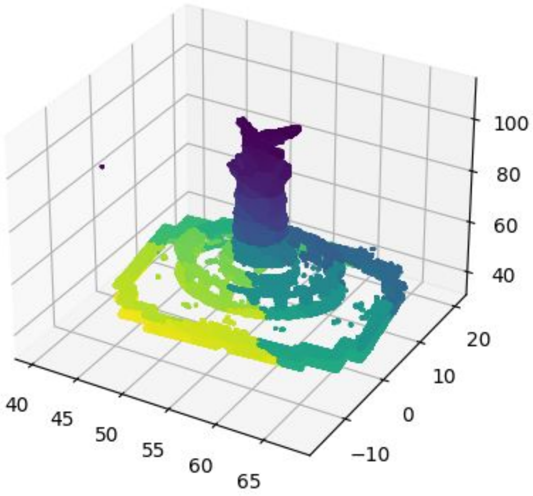
Detrended Data

Airborne Lidar Point Cloud

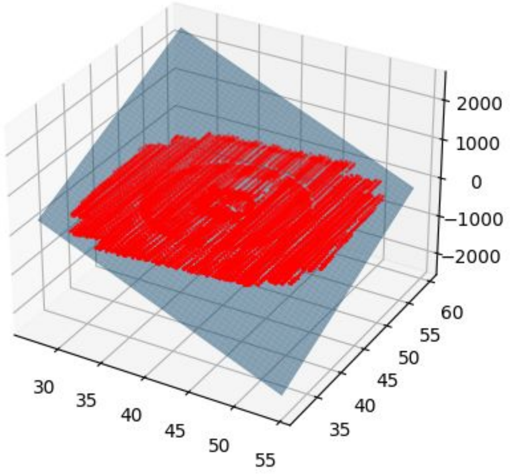


Structure from Motion Point Cloud

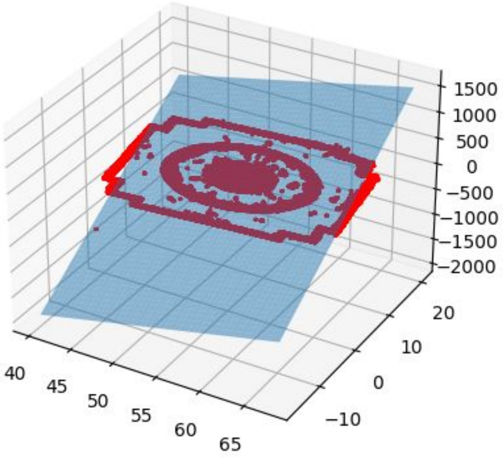


Fitted Plane

Airborne Lidar Point Cloud



SFM Point Cloud



Comparison Metrics

Datasets	Standard Deviation	Inter-Quartile Range (IQR)	Number of Points
SfM	488.117980	438.131118	2022655
Airborne Lidar	820.409822	1186.881067	8881

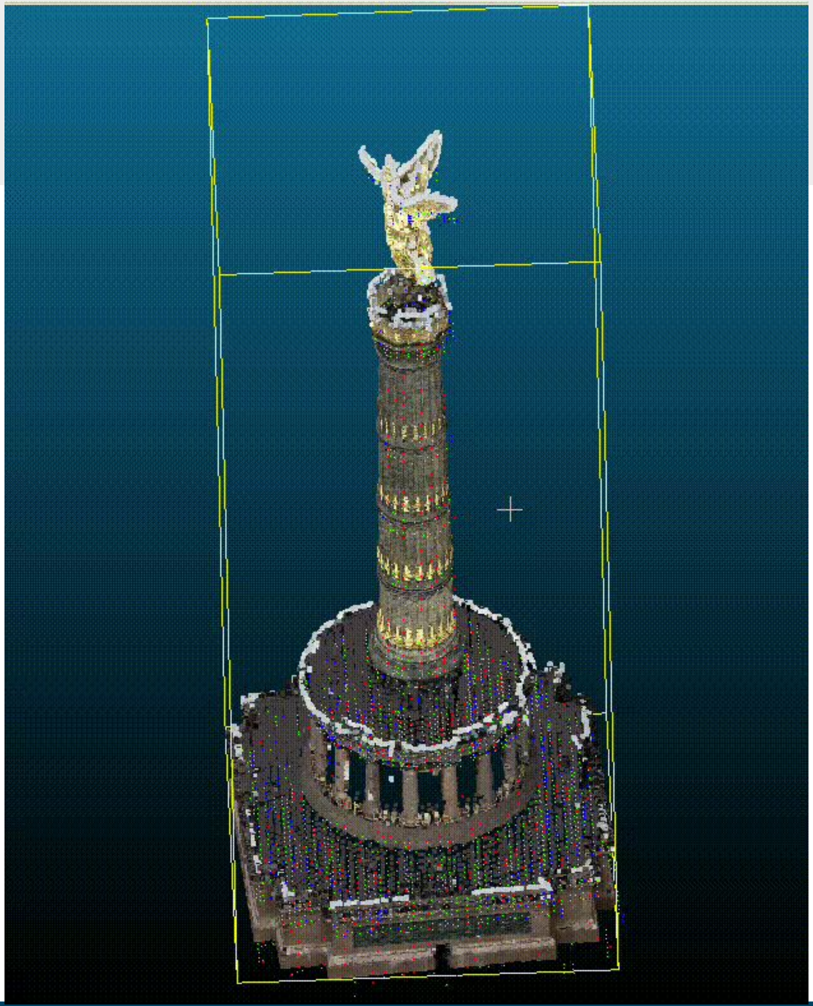
Conclusion and Limitations

- Locating Lidar data from open source can be challenging.

- Airborne point cloud data demonstrated more accuracy on the top part of the building, while SFM data from the side areas because the images were taken from different angles.

- SfM can capture fine details in small areas, whereas airborne LiDAR covers larger areas with less detail.

- By understanding the strengths of different geospatial data sources and using algorithms like ICP for precise alignment, we can achieve highly accurate and detailed 3D models for various applications.



Literature

- E. Widyaningrum, B.G.H Gorte. Comprehensive Comparison of LiDAR and Image-Based Point Clouds for Large-Scale Mapping, September 2017. https://doi.org/10.5194/isprs-archives-XLII-2-W7-557-2017

- Liao, Jianghua, Zhou, Jinxing and Yang, Wentao. "Comparing LiDAR and SfM digital surface models for three land cover types" *Open Geosciences*, vol.13, no.1, 2021. https://doi.org/10.1515/geo-2020-0257