



POLITECNICO
DI TORINO

Dipartimento di
Architettura e
Design

Master in Architecture for
Sustainability
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Thesis Title

Gardella's Lost Legacy: The Church of Alessandria.

Study, 3D documentation and
Analysis

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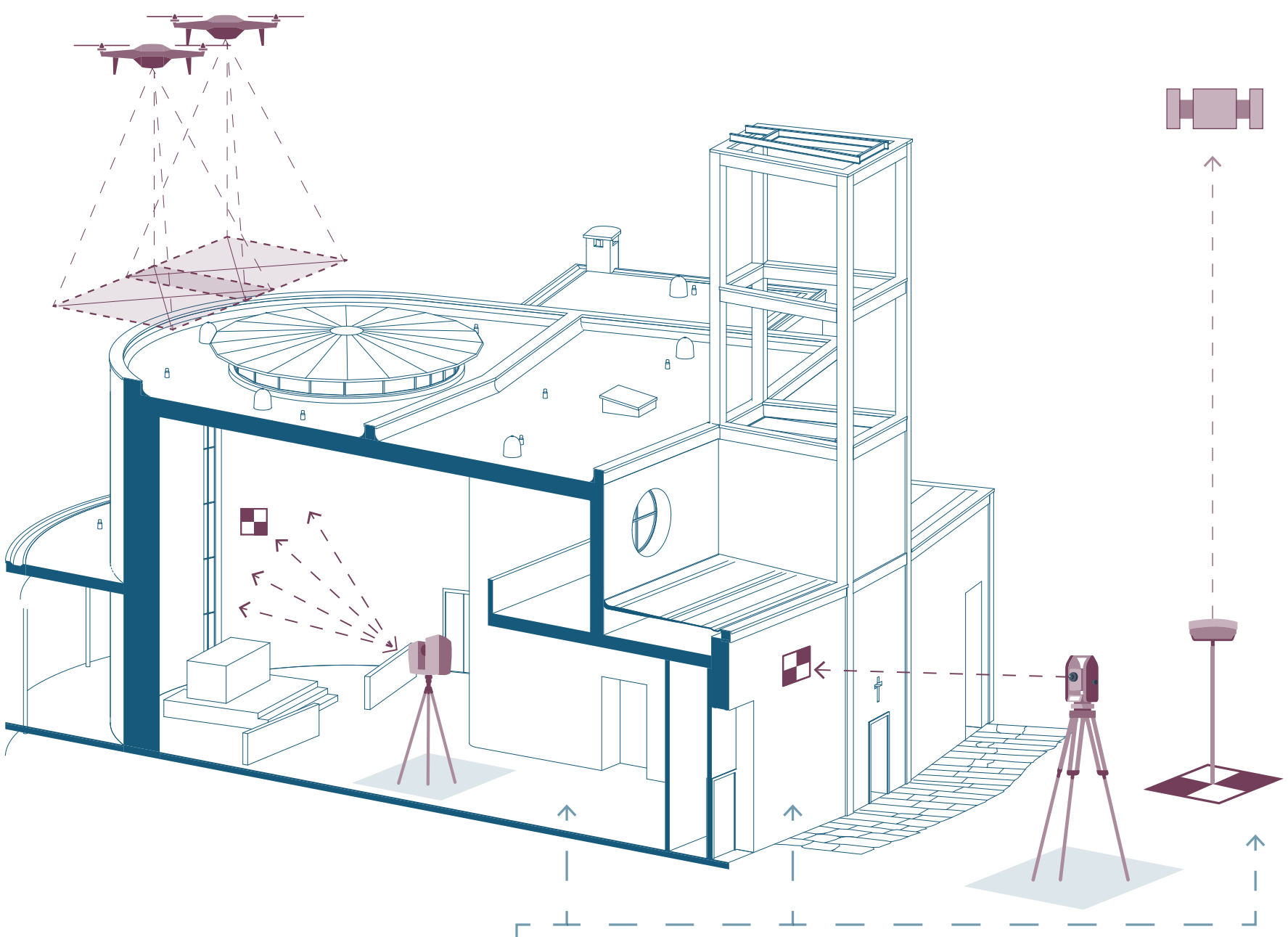
Board A

- TERRITORIAL CONTEXT
- GEOMATICS SURVEY
- 2D DOCUMENTATION
- HBIM DOCUMENTATION
- MATERIAL ANALYSIS
- CURRENT STATE OF
CONSERVATION ANALYSIS
AND SOLUTIONS
- THE PROPOSAL

The Church Building



Surveying Technologies Utilized



Ground Control Points (GCPs)

GCPs are precise points with known geographic coordinates used to align 3D models to coordinate systems, ensuring spatial accuracy, correcting distortions, and enhancing data integration. For Gardella's church, GCPs were used to georeferenced the 3D model by aligning images with real-world coordinates. They were strategically placed inside the church, on the facade, and across the surrounding terrain for accurate alignment.

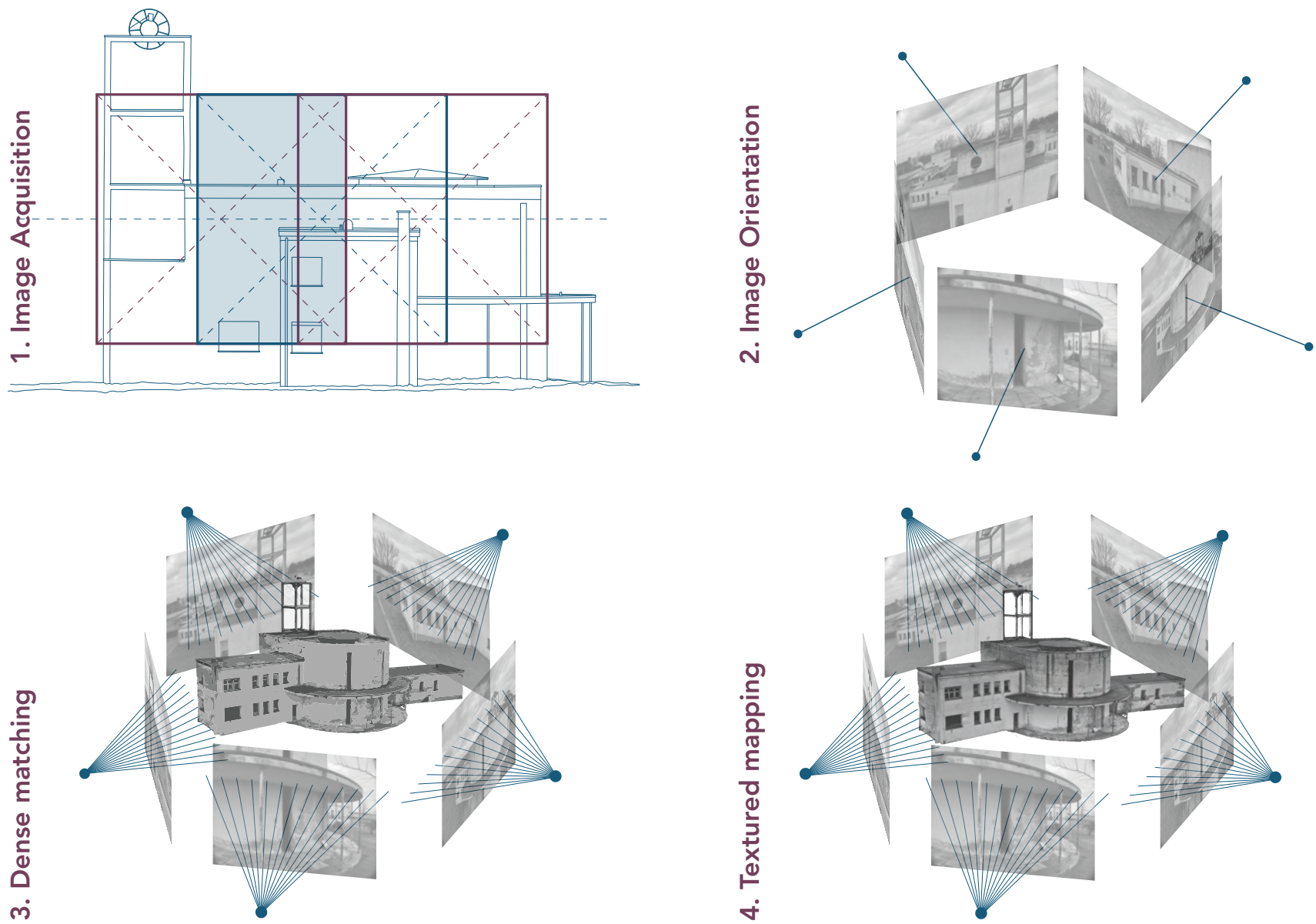
Total station

The total station is a geodetic instrument that measures horizontal and vertical angles and distances to generate precise 3D coordinates within a reference system. In heritage building analysis, it captures high-precision spatial data necessary for modeling, documentation, and conservation. During the survey, a **Leica Viva TS16** Total Station was used to measure GCPs on the church facade, the terrain, and the interior, ensuring the accuracy of georeferenced data.

UAV - Based photogrammetry

UAV-based photogrammetry uses drones equipped with cameras to capture aerial images that are processed into 3D models. This method is widely used for documenting large or hard-to-reach areas due to its ability to capture details with high precision and efficiency. However, in this study, the technique was chosen primarily because it is non-invasive, making it ideal for preserving the integrity of the heritage building during the survey. A **Mavic 3M** drone was used in this study, equipped with a 20 MP RGB camera and an RTK module for centimeter-level positioning. The drone captured detailed images of the church's exterior and its immediate surroundings, helping to create a precise and georeferenced 3D model

Structure from Motion - SfM

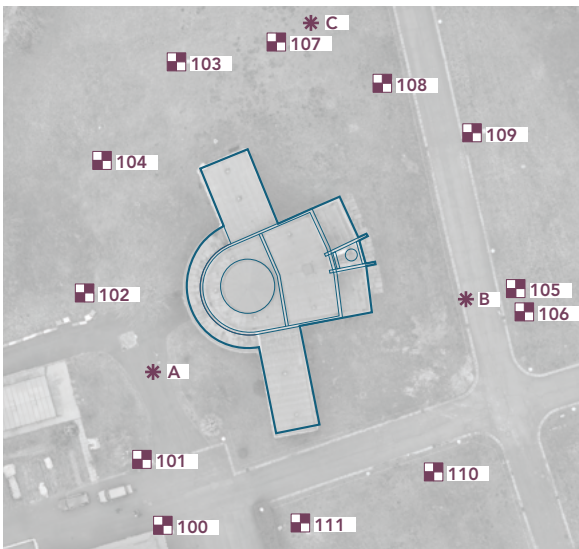


Structure from Motion (SfM) is a digital technique that generates three-dimensional (3D) models from two-dimensional (2D) images captured from various perspectives. It allows the documentation of complex geometries and architectural details by identifying key points in images and reconstructing their spatial position. It is particularly important in heritage building analysis because it is non-invasive, flexible, and produces detailed models with high accuracy. In the study of Gardella's church, SfM was used to process images and create a precise 3D model reflecting its geometry and conservation state.

Initial Data

GCPs - Eidotype

For terrain and church's facade



GCPs - Coordinates

Terrain markers: 100 - 111
Church's facade markers: P01 - P22

Information provided:
Longitude
Latitude
Height

Processing the Data

Step 1: Importing the data from images

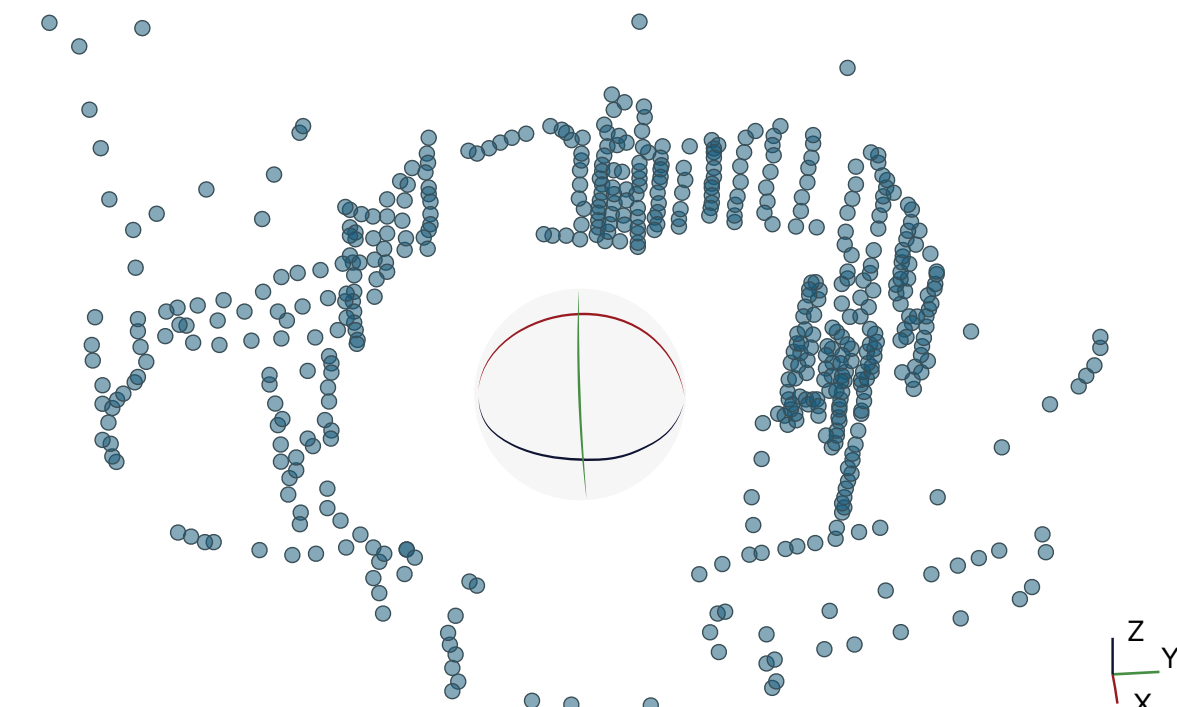
- Images captured during UAV surveys are uploaded. These were collected through two flight plans at different altitudes and distances. Each image brings information as follows:

Property	Value
Frame 1	
Path	C:/Users/XXX/XXX
Resolution	5280 X 3956
Colors	3 Bands, uint8
Date & time	2024:02:23 11:51:02
Model	M3M
Focal length	12.29
F-Stop	F/2.8
ISO	100
Shutter	1/500
35mm focal	24

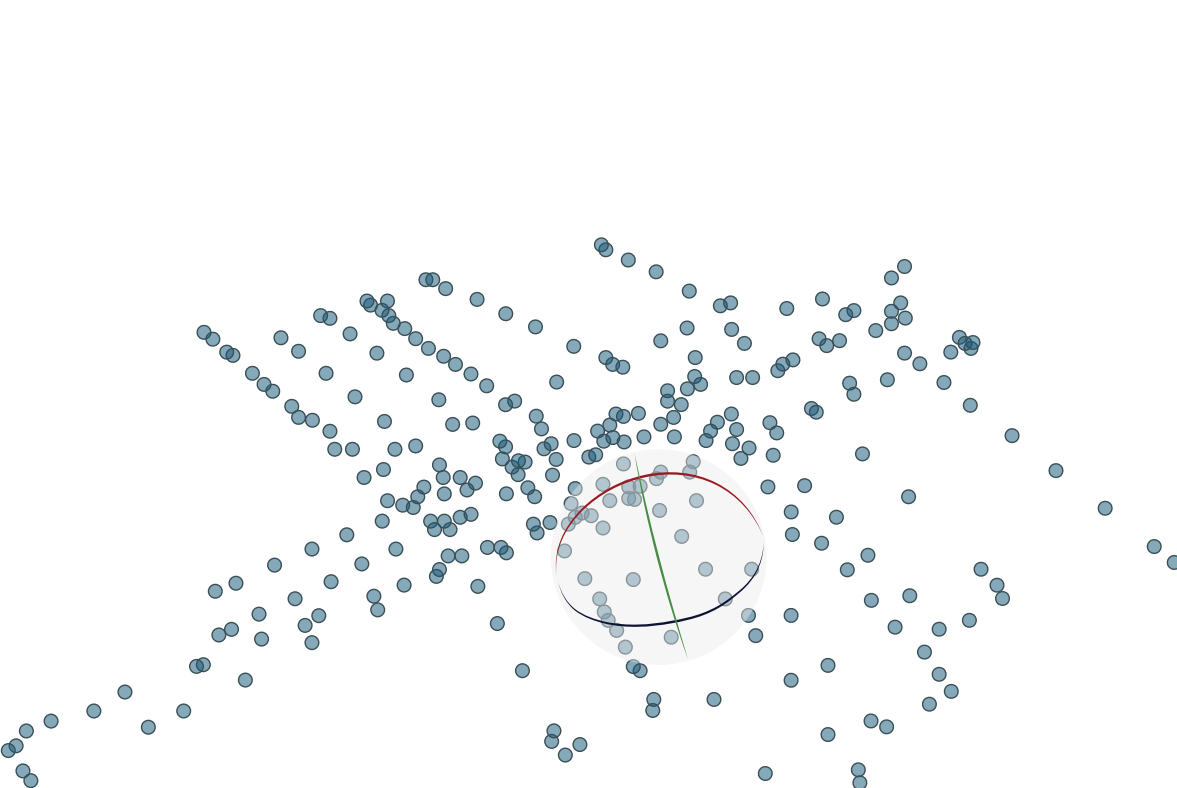
Cameras	Long.	Latitude	Altitude(m)	Accuracy(m)
<input checked="" type="checkbox"/> DJI...	8.616606	44.939324	137.86200	10.00000
<input checked="" type="checkbox"/> DJI...	8.616609	44.939330	137.85700	10.00000
<input checked="" type="checkbox"/> DJI...	8.616625	44.939324	137.89200	10.00000
<input checked="" type="checkbox"/> DJI...	8.616656	44.939313	137.82600	10.00000
<input checked="" type="checkbox"/> DJI...	8.616655	44.939313	137.33200	10.00000
<input checked="" type="checkbox"/> DJI...	8.616657	44.939313	137.52700	10.00000

Cameras	Yaw (°)	Pitch (°)	Roll (°)	Accuracy(°)
<input checked="" type="checkbox"/> DJI...	289.700	84.300	0.000	10.00000
<input checked="" type="checkbox"/> DJI...	299.700	84.300	0.000	10.00000
<input checked="" type="checkbox"/> DJI...	300.100	84.300	0.000	10.00000
<input checked="" type="checkbox"/> DJI...	300.100	84.300	0.000	10.00000
<input checked="" type="checkbox"/> DJI...	300.100	84.300	0.000	10.00000
<input checked="" type="checkbox"/> DJI...	300.100	84.300	0.000	10.00000
<input checked="" type="checkbox"/> DJI...	300.100	84.300	0.000	10.00000

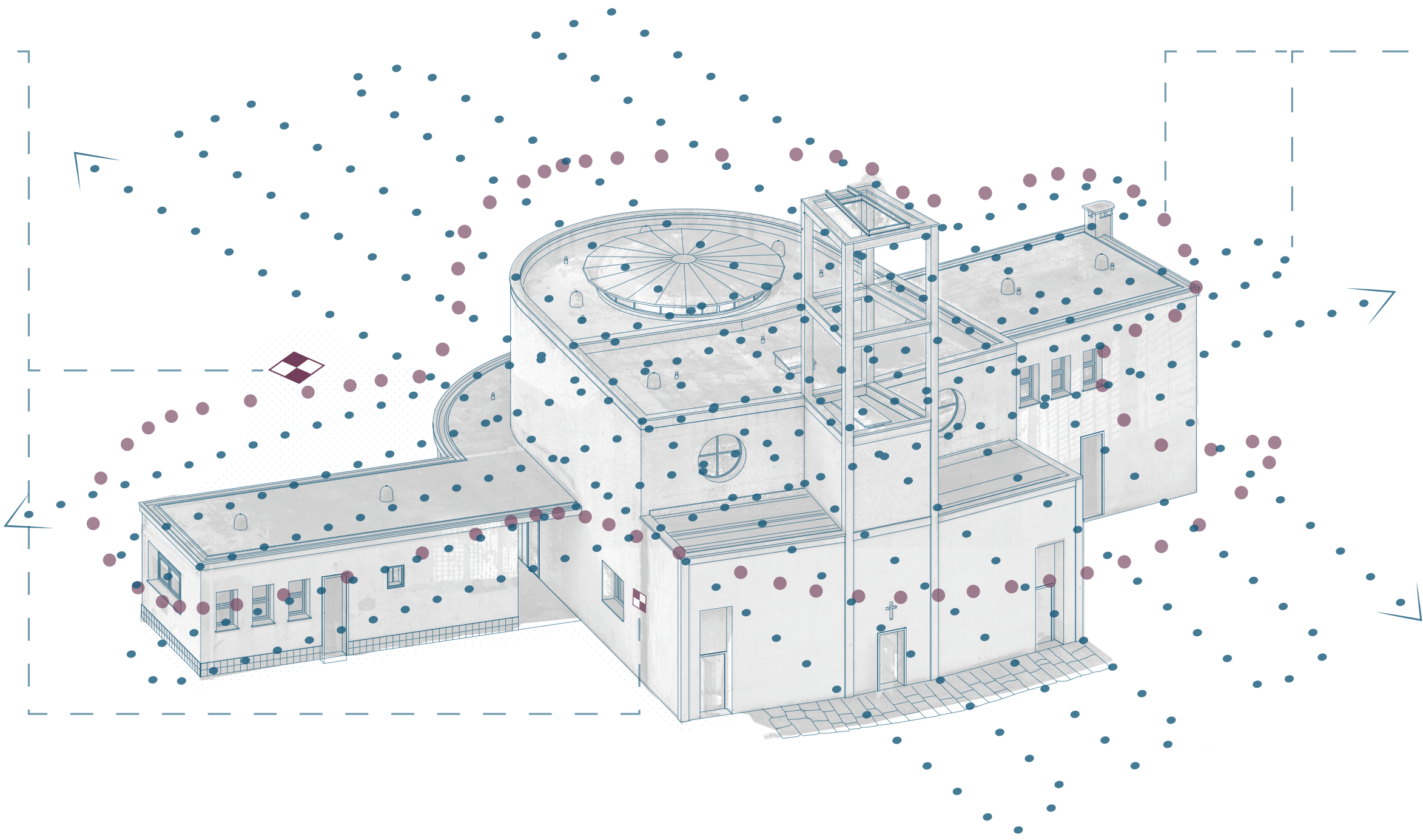
- The images are divided into two chunks: Aerial close range and aerial range, representing the different datasets.



Imported images without alignment in Aerial close range chunk. 0 POINTS.



Imported images without alignment in aerial range chunk. 0 POINTS.



Camera

Camera model: M3M
Focal lenght: 12.29 mm
Resolution: 5280 X 3956
Pixel size: 3.36 x 3.36 µm
Precalibrated: Yes

Aerial Close Range Images

Icon: ●
Number of images: 709
Flying altitude: 6.98 m
Ground resolution: 2.63 mm/pix

Aerial Range Images

Icon: ●
Number of images: 322
Flying altitude: 59.8 m
Ground resolution: 1.19 cm/pix

Information Provided:

EXIF metadata: Longitude,
latitude, altitude, date and time, model,
focal length, ISO, shutter.
No EXIF: Colors band, resolution.

Step 2: Alignmet of Photos

- During the process of alignment the software processes the imported images to identify key points and matches them across images to generate tie points.
- These tie points help to build a sparse point cloud that provides a basic structured and orientation of the photographed scene giving a numerical and visual output.

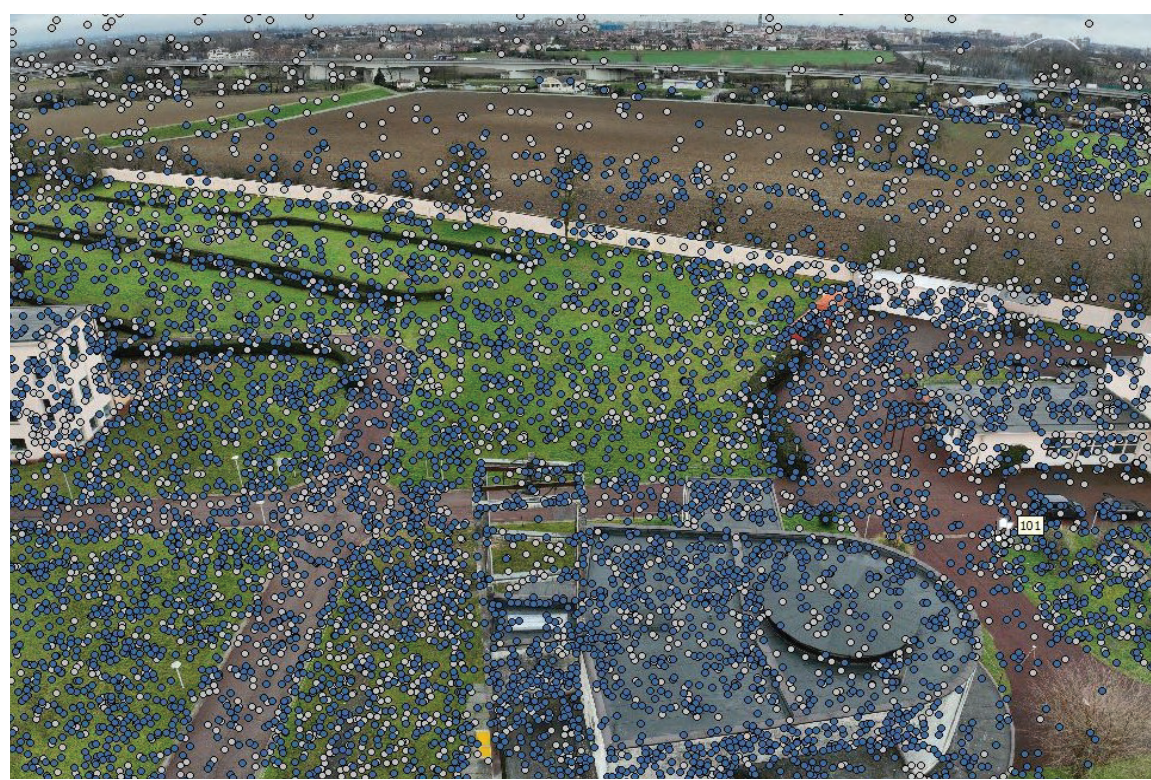
- Parameters choosen to optimize camera alignment:

High accuracy
Generic preselection.

During the process of alignment

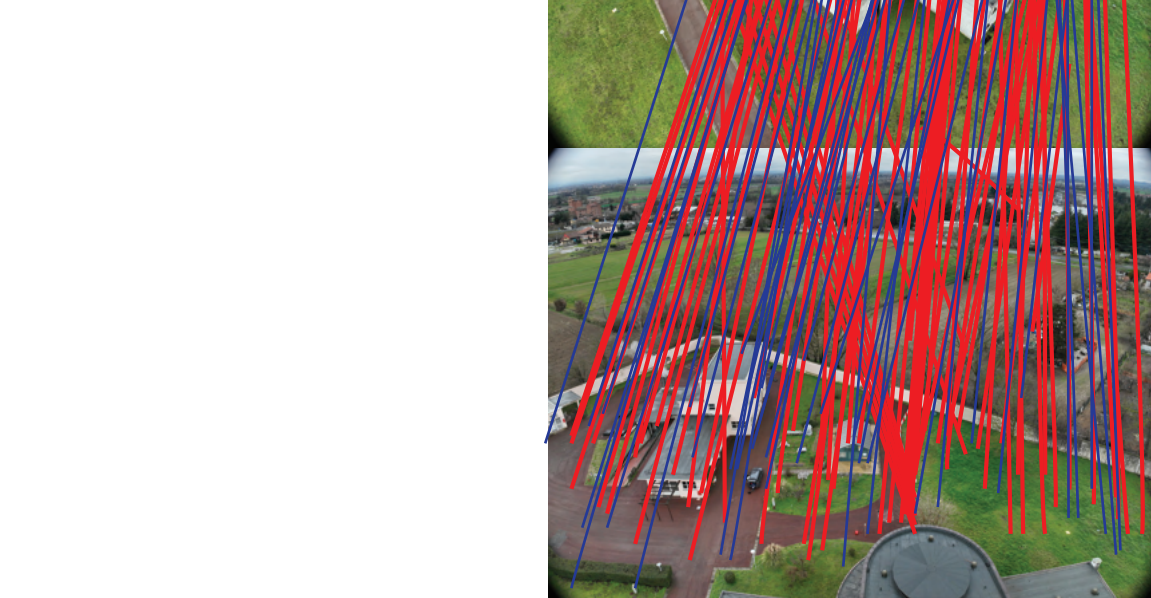
Outputs after alignment

Software Metashape identifying key and tie points. After it the tie point will pass through a process of valid and invalid.



During the process:

- Key Points
- Tie Points
- Valid Points
- Invalid Points



Aerial Close Range

Number of Images	709
Flying altitude	6.98 M
Ground Resolution	2.63 mm/pix
Coverage Area	8.29e + 03m2
Camera stations	709
Tie points	266,532
Projections	2,068,254
Reprojection error	0.978 pix

Aerial Range

Number of Images	322
Flying altitude	59.8 M
Ground Resolution	1.99 cm/pix
Coverage Area	0.113 km2
Camera stations	322
Tie points	458,181
Projections	2,151,474
Reprojection error	0.757 pix

Sparse Point Cloud of Aerial close range
458,181 points



Sparse Point Cloud of Aerial range
263,532 points

