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Thesis Title

## Gardella's Lost Legacy: The Church of Alessandria.

Study, 3D documentation and  
Analysis

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Board No. B

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

The Church Building



## Processing the Data

### Step 3: Loading data for Georeferencing

- Import the coordinates of the GCPs that were obtain using the Total Station into Metashape software to improve the quality and precision of the sparse point cloud after the alignment of images.
- The import was carried out using the following parameters:
  - Coordinate system: Local coordinates (m)
  - Rotation angle: Yaw, pitch, roll
  - Delimiter: Semicolon
  - Columns: Rotation box checked
  - Each marker carried the following info: Label, X, Y, and Z coordinates.

#### After importing the GCPs

Aerial Close-Range Chunk: 22 markers  
Aerial Range Chunk: 10 markers

Identification		Coordinates			Number of images the marker has been manually placed.		
Marker	X(m)	Y(m)	Z (m)	Accuracy (m)	Error (m)	Projections	Error (pix)
<input checked="" type="checkbox"/> 100	469719.692	4976257.951	91.286	0.005000	0	0	0.000
<input checked="" type="checkbox"/> 101	469716.914	4976267.433	91.197	0.005000	0	0	0.000
<input checked="" type="checkbox"/> ...	...	...	...	...	...	...	...
Total Error				< 0.1			
Control Points							
Check Points							

Error (pix): mean square root for the reprojection error for the marker, calculated over all images where the marker has been placed. Works as an indicator of the discrepancy a marker can have.

Aim: Less than 1 cm

### Step 4: Georeferencing - Placing markers

- Two methods were employed to place markers. These markers help ensure proper alignment and identify errors related to the model's precision.



- Guided approach**  
The software automatically projects the markers onto the model. They need manual verification before being used in calculations.
- Manual approach**  
Manually placed through "Place a marker" tool. Marked with a green flag once confirmed.

- Both chunks initially used guided approach, followed by the manual approach implemented gradually as follows:

- Places three markers in three different images
- Use the "update transform" tool
- Project each marker in five images
- Use the "optimize camera" tool
- Create checkpoints and increase markers' projections

#### Results after implementing manual apporahc

- 1 & 2. Total error after placing three markers in three different images and use the update transform tool. This tool is used to recalculate and update the global transformation a chunk based on changes made to the georeferencing. By suing this tool any changes done in the markers is reflected in the 3D Model.

Marker	X(m)	Y(m)	Z (m)	Accuracy (m)	Error (m)	Projections	Error (pix)
<input checked="" type="checkbox"/> 100	...	...	...	0.005000	0.001933	3	0.654
<input checked="" type="checkbox"/> 101	...	...	...	0.005000	0	0	0.000
<input checked="" type="checkbox"/> 102	...	...	...	0.005000	0	0	0.00
<input checked="" type="checkbox"/> 103	...	...	...	0.005000	0.001942	3	0.646
<input checked="" type="checkbox"/> 104	...	...	...	0.005000	0	0	0.000
<input checked="" type="checkbox"/> 105	...	...	...	0.005000	0	0	0.000
<input checked="" type="checkbox"/> 106	...	...	...	0.005000	0.002118	3	0.793
<input checked="" type="checkbox"/> 107	...	...	...	0.005000	0	0	0.000
<input checked="" type="checkbox"/> 108	...	...	...	0.005000	0	0	0.000
<input checked="" type="checkbox"/> 109	...	...	...	0.005000	0	0	0.000
<input checked="" type="checkbox"/> 110	...	...	...	0.005000	0	0	0.000
<input checked="" type="checkbox"/> 111	...	...	...	0.005000	0	0	0.000
Total Error				0.001999			
Control Points							
Check Points				0.701			

- 3. The markers help to correct image distortion caused by the camera lens. This is why this third step of increasing projections was taken. After placing the markers, the update transform tool was used again.

Marker	X(m)	Y(m)	Z (m)	Accuracy (m)	Error (m)	Projections	Error (pix)
<input checked="" type="checkbox"/> 100	...	...	...	0.005000	0.017149	5	0.704
<input checked="" type="checkbox"/> 101	...	...	...	0.005000	0.008605	5	0.635
<input checked="" type="checkbox"/> 102	...	...	...	0.005000	0.007726	5	0.401
<input checked="" type="checkbox"/> 103	...	...	...	0.005000	0.015505	5	0.727
<input checked="" type="checkbox"/> 104	...	...	...	0.005000	0.006294	5	0.486
<input checked="" type="checkbox"/> 106	...	...	...	0.005000	0.013646	5	0.980
<input checked="" type="checkbox"/> 107	...	...	...	0.005000	0.010781	5	0.782
<input checked="" type="checkbox"/> 108	...	...	...	0.005000	0.008839	5	0.831
<input checked="" type="checkbox"/> 109	...	...	...	0.005000	0.008852	5	0.592
<input checked="" type="checkbox"/> 110	...	...	...	0.005000	0.007963	5	0.574
<input checked="" type="checkbox"/> 111	...	...	...	0.005000	0.005883	5	0.582
Total Error				0.010723			
Control Points							
Check Points				0.681			

- 4. To reduce the error per chunk, the optimize camera alignment tool was used. This command performs a full bundle adjustment procedure on the aligned photogrammetric block, simultaneously refining exterior and interior camera orientation parameters and triangulated tie points coordinates. The adjustment is made based on all available measurements. The next parameters were chosen:

Fit f	Fit k1	Fit k2	Fit k3	Fit k4	Fit p1	Fit p2	Fit b1	Fit b2	Fit additional correctoons
<input checked="" type="checkbox"/> 100	...	...	...	0.005000	0.017358	5	0.611		
<input checked="" type="checkbox"/> 101	...	...	...	0.005000	0.010937	5	0.580		
<input checked="" type="checkbox"/> 102	...	...	...	0.005000	0.005874	5	0.240		
<input checked="" type="checkbox"/> 103	...	...	...	0.005000	0.013363	5	0.399		
<input checked="" type="checkbox"/> 104	...	...	...	0.005000	0.008324	5	0.357		
<input checked="" type="checkbox"/> 106	...	...	...	0.005000	0.010900	5	0.729		
<input checked="" type="checkbox"/> 107	...	...	...	0.005000	0.008636	5	0.480		
<input checked="" type="checkbox"/> 108	...	...	...	0.005000	0.005967	5	0.435		
<input checked="" type="checkbox"/> 109	...	...	...	0.005000	0.010299	5	0.462		
<input checked="" type="checkbox"/> 110	...	...	...	0.005000	0.008816	5	0.487		
<input checked="" type="checkbox"/> 111	...	...	...	0.005000	0.006766	5	0.391		
Total Error				0.010277				0.487	
Control Points									
Check Points									

Marker	X(m)	Y(m)	Z (m)	Accuracy (m)	Error (m)	Projections	Error (pix)
<input checked="" type="checkbox"/> P01	...	...	...	0.005000	0	0	0.000
<input checked="" type="checkbox"/> P02	...	...	...	0.005000	0	0	0.000
<input checked="" type="checkbox"/> P03	...	...	...	0.005000	0.000610	3	0.253
<input checked="" type="checkbox"/> P04	...	...	...	0.005000	0	0	0.000
<input checked="" type="checkbox"/> P05	...	...	...	0.005000	0	0	0.000
<input checked="" type="checkbox"/> P06	...	...	...	0.005000	0	0	0.000
<input checked="" type="checkbox"/> P07	...	...	...	0.005000	0	0	0.000
<input checked="" type="checkbox"/> P08	...	...	...	0.005000	0.000619	3	0.411
<input checked="" type="checkbox"/> P09	...	...	...	0.005000	0	0	0.000
<input checked="" type="checkbox"/> P10	...	...	...	0.005000	0	0	0.000
<input checked="" type="checkbox"/> P11	...	...	...	0.005000	0	0	0.000
<input checked="" type="checkbox"/> P12	...	...	...	0.005000	0	0	0.000
<input checked="" type="checkbox"/> P13	...	...	...	0.005000	0	0	0.000
<input checked="" type="checkbox"/> P14	...	...	...	0.005000	0.000631	3	0.263
<input checked="" type="checkbox"/> P15	...	...	...	0.005000	0	0	0.000
<input checked="" type="checkbox"/> P16	...	...	...	0.005000	0	0	0.000
<input checked="" type="checkbox"/> P17	...	...	...	0.005000	0	0	0.000
<input checked="" type="checkbox"/> P18	...	...	...	0.005000	0	0	0.000
<input checked="" type="checkbox"/> P19	...	...	...	0.005000	0	0	0.000
<input checked="" type="checkbox"/> P20	...	...	...	0.005000	0	0	0.000
<input checked="" type="checkbox"/> P21	...	...	...	0.005000	0	0	0.000
<input checked="" type="checkbox"/> P22	...	...	...	0.005000	0	0	0.000
Total Error				0.000620			
Control Points							
Check Points				0.317			

Marker	X(m)	Y(m)	Z (m)	Accuracy (m)	Error (m)	Projections	Error (pix)
<input checked="" type="checkbox"/> P01	...	...	...	0.005000	0.004613	5	0.670
<input checked="" type="checkbox"/> P02	...	...	...	0.005000	0.007414	5	0.684
<input checked="" type="checkbox"/> P03	...	...	...	0.005000	0.009255	5	1.524
<input checked="" type="checkbox"/> P04	...	...	...	0.005000	0.007411	5	0.546
<input checked="" type="checkbox"/> P05	...	...	...	0.005000	0.007304	5	0.475
<input checked="" type="checkbox"/> P06	...	...	...	0.005000	0.010496	5	0.592
<input checked="" type="checkbox"/> P07	...	...	...	0.005000	0.010150	5	0.731
<input checked="" type="checkbox"/> P08	...	...	...	0.005000	0.019292	5	0.546
<input checked="" type="checkbox"/> P09	...	...	...	0.005000	0.013527	5	0.468
<input checked="" type="checkbox"/> P10	...	...	...	0.005000	0.008285	5	0.411
<input checked="" type="checkbox"/> P11	...	...	...	0.005000	0.013128	5	0.658
<input checked="" type="checkbox"/> P12	...	...	...	0.005000	0.008851	5	0.271
<input checked="" type="checkbox"/> P13	...	...	...	0.005000	0.011368	5	0.469
<input checked="" type="checkbox"/> P14	...	...	...	0.005000	0.008326	5	0.351
<input checked="" type="checkbox"/> P15	...	...	...	0.005000	0.006125	5	0.618
<input checked="" type="checkbox"/> P16	...	...	...	0.005000	0.007698	5	0.475
<input checked="" type="checkbox"/> P17	...	...	...	0.005000	0.002028	2	0.165
<input checked="" type="checkbox"/> P18	...	...	...	0.005000	0.007041	5	1.031
<input checked="" type="checkbox"/> P19	...	...	...	0.005000	0.005604	5	0.499
<input checked="" type="checkbox"/> P20	...	...	...	0.005000	0.009843	5	0.622
<input checked="" type="checkbox"/> P21	...	...	...	0.005000	0.009687	5	0.409
<input checked="" type="checkbox"/> P22	...	...	...	0.005000	0.012505	5	0.380
Total Error				0.009674			
Control Points							
Check Points				0.637			

Marker	X(m)	Y(m)	Z (m)	Accuracy (m)	Error (m)	Projections	Error (pix)
<input checked="" type="checkbox"/> P01	...	...	...	0.005000	0.007130	5	0.362
<input checked="" type="checkbox"/> P02	...	...	...	0.005000	0.009383	5	0.371
<input checked="" type="checkbox"/> P03	...	...	...	0.005000	0.006792	5	0.398
<input checked="" type="checkbox"/> P04	...	...	...	0.005000	0.004133	5	0.756
<input checked="" type="checkbox"/> P05	...	...	...	0.005000	0.002732	5	0.355
<input checked="" type="checkbox"/> P06	...	...	...	0.005000	0.008382	5	0.241
<input checked="" type="checkbox"/> P07	...	...	...	0.005000	0.010262	5	0.546
<input checked="" type="checkbox"/> P08	...	...	...	0.005000	0.011952	5	0.360
<input checked="" type="checkbox"/> P09	...	...	...	0.005000	0.011349	5	0.348
<input checked="" type="checkbox"/> P10	...	...	...	0.005000	0.007777	5	0.276
<input checked="" type="checkbox"/> P11	...	...	...	0.005000	0.009592	5	0.512
<input checked="" type="checkbox"/> P12	...	...	...	0.005000	0.007444	5	0.422
<input checked="" type="checkbox"/> P13	...	...	...	0.005000	0.010855	5	0.331
<input checked="" type="checkbox"/> P14	...	...	...	0.005000	0.008627	5	0.317
<input checked="" type="checkbox"/> P15	...	...	...	0.005000	0.006425	5	0.193
<input checked="" type="checkbox"/> P16	...	...	...	0.005000	0.006032	5	0.375
<input checked="" type="checkbox"/> P17	...	...	...	0.005000	0.001717	2	0.131
<input checked="" type="checkbox"/> P18	...	...	...	0.005000	0.005390	5	0.340
<input checked="" type="checkbox"/> P19	...	...	...	0.005000	0.005576	5	0.318
<input checked="" type="checkbox"/> P20	...	...	...	0.005000	0.009245	5	0.658
<input checked="" type="checkbox"/> P21	...	...	...	0.005000	0.008560	5	0.336
<input checked="" type="checkbox"/> P22	...	...	...	0.005000	0.010741	5	0.471
Total Error				0.008179			
Control Points							
Check Points				0.412			

### Step 4: Georeferencing - Placing markers