14th International Conference on Geoinformation and Cartography

Application of Photogrammetry in Documenting Cultural and Historical Heritage – the Example of Fortica Fortress on the Island of Pag

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Introduction

- Project within the courses of *Remote Sensing* and *Spatial Analysis in GIS.*

- The first year students of Applied geography (master study).

- Objectives (what to teach students):
  - *how to* **handle an unmanned aerial vehicle**
  - *how to* **plan missions** for aerial photogrammetry survey
  - *how to* **mark** and **collect ground control points**
  - *how to* create **DSM**, **DOP** and **3D model**
  - *how to* **work in a group**.

Why did we choose this project?

- Similar examples:

- **Church of the Holy Sepulchre** (Agrafiotis et al. 2017).
- **The Case Study at Copan, Honduras** (von Schwerin et al. 2013)
- **Parthenon-Acropolis, Greece** (Theodoropoulos et al. 2009).
- **Jableh Theater, Syria** (Chemla, 2016)
- **Bismarck Monument** (Kersten, 2010)

We are losing the story of where we came from

- **Google Arts and Culture** is partnering with **CyArk** to launch Open Heritage, providing open access to the world's largest 3D heritage collection.
- https://wordlesstech.com/virtual-3d-models-of-ancient-monuments/

Why did we choose this project?

- Cultural and Historical Heritage is endangered by:

Natural Disasters

Treasure Hunters

Religious Extremism

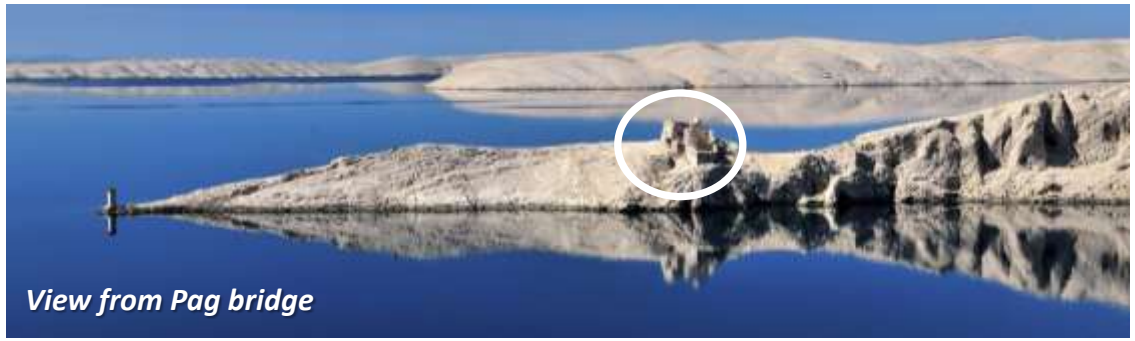
unskilled „experts" and time

- Geospatial technologies, **mainly** photogrammetry and LiDAR**, imposed itself** as a new methods in the documentation of cultural heritage.

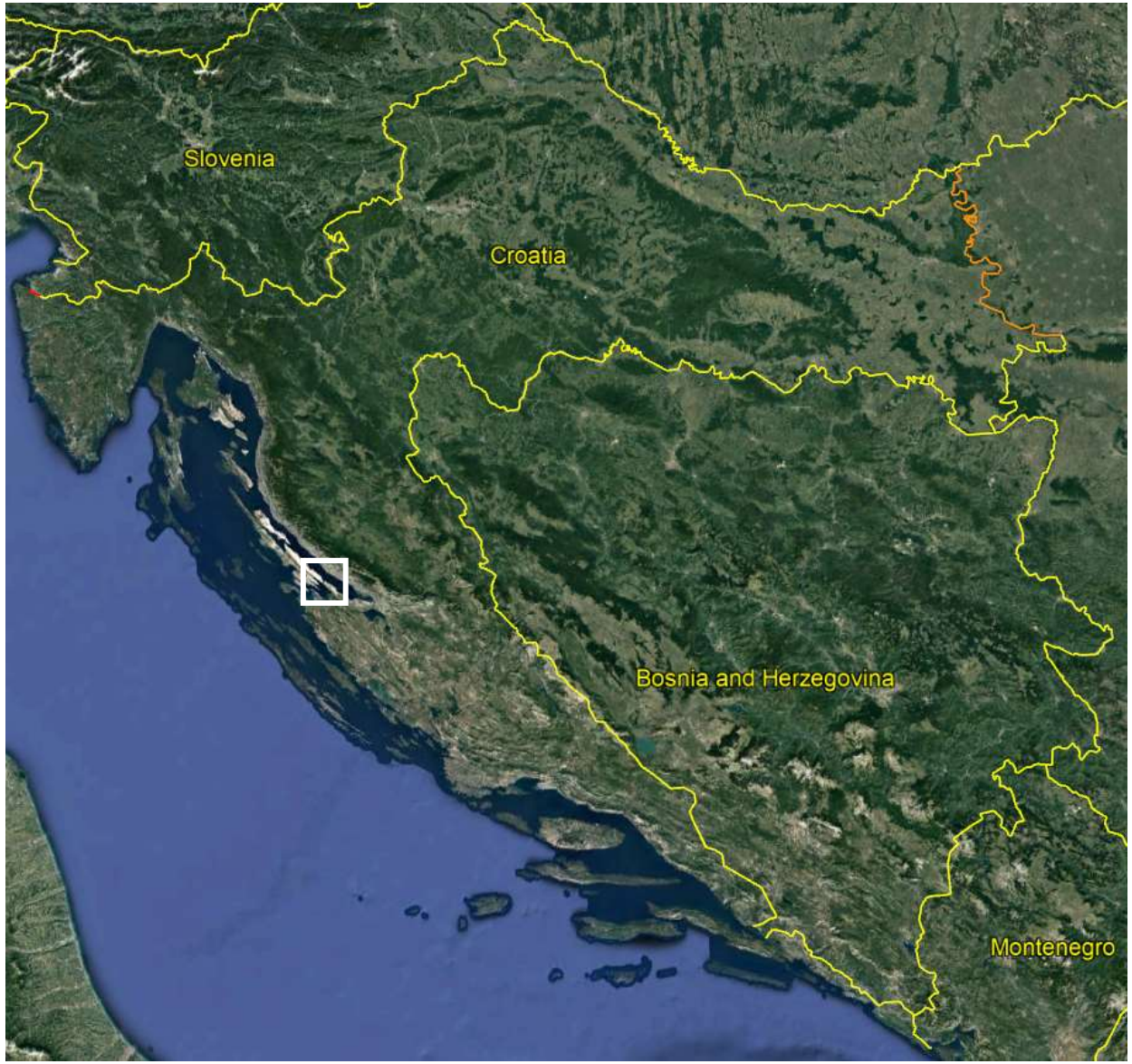
Scope of research

- Fortica Fortress on the Island of Pag

  (44°19'22.54"N, 15°15'19.17"E)



View from Pag bridge



Why did we choose Fortica?

- **an interesting historical background** (surveillance of sea navigation, trade point, remains of Roman pottery).
- one of the **most valuable fortification** on the island.
- **tourism potential**
- **close to Zadar**
- **no vegetation** around the fortress

An old fort as a new tourist offer

Stara utvrda kao nova turistička ponuda

Čet, 05/06/2014 - 00:00 · Podijeli: Facebook Twitter

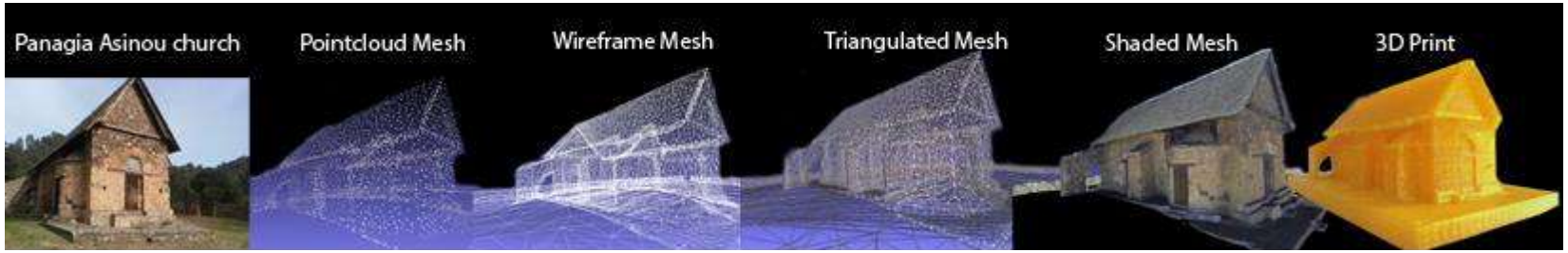
Autor: Vesna Karavanić

Project goals

First part:

1) Create a **high-resolution 3D model** of Fortica
2) Make a **virtual video walk through** the Fortica.
3) Develop a **souvenir of Fortica** for the tourism promotion.

Digital documentation of Cultural Heritage



Second part:

4) Determine **visibility** between the other fortifications in the Zadar archipelago

Methodology

- **CRP** (aerial and terestrical)

- **Equipment:**
- **Phantom 4**
- DSLR **Nikon D5300**
- GNSS **Stonex S10**

- **Softwares:**
- *Pix4D capture*
- *Agisoft Photoscan trial*
- *Lumion trial*
- *Cloud Compare*

1. Image capturing plan
2. Data collection
   - *Ground Control Points*
   - *Aerial and ground-based photos*
3. Data Analysis
4. Data Visualisation

Methodology

- Types of missions created:

1) Double Grid (Pix4D capture)

(front and lateral overlap **80%**)

(camera angle **70°** = oblique images)

2) Circular (Pix4D capture)

(capture angle 10°)

3) Ground-based

(horizontal images)

1. **Image capturing plan**
2. Data collection
   - *Ground Control Points*
   - *Aerial and ground-based photos*
3. Data Analysis
4. Data Visualisation

Methodology

- GNSS Stonex S10
- 17 Ground Control Points

Label	X	Y	Z
OT1	400704.4456	4909996.207	11.6281
OT2	400693.8159	4909984.732	11.2097
OT3	400687.3657	4909976.169	10.9682
OT4	400704.3736	4909975.311	11.4209
OT5	400714.0304	4909990.519	12.1312
OT6	400712.7785	4909972.116	16.4019
OT7	400704.4809	4909964.723	14.9673
OT8	400696.4986	4909952.617	13.0518
OT9	400702.0193	4909946.003	13.5150
OT10	400710.2568	4909953.653	15.2806
OT11	400724.8127	4909934.089	12.7540
OT12	400726.2282	4909945.321	13.6116
OT13	400723.0857	4909954.251	14.6283
OT14	400736.8122	4909966.295	9.0256
OT15	400727.9492	49099780.62	10.8524
OT16	400729.1050	4909971.768	12.3556
OT17	400715.3062	4909963.093	16.7581

1. Image capturing plan
2. **Data collection**
   - ***Ground Control Points***
   - *Aerial and ground-based photos*
3. Data Analysis
4. Data Visualisation

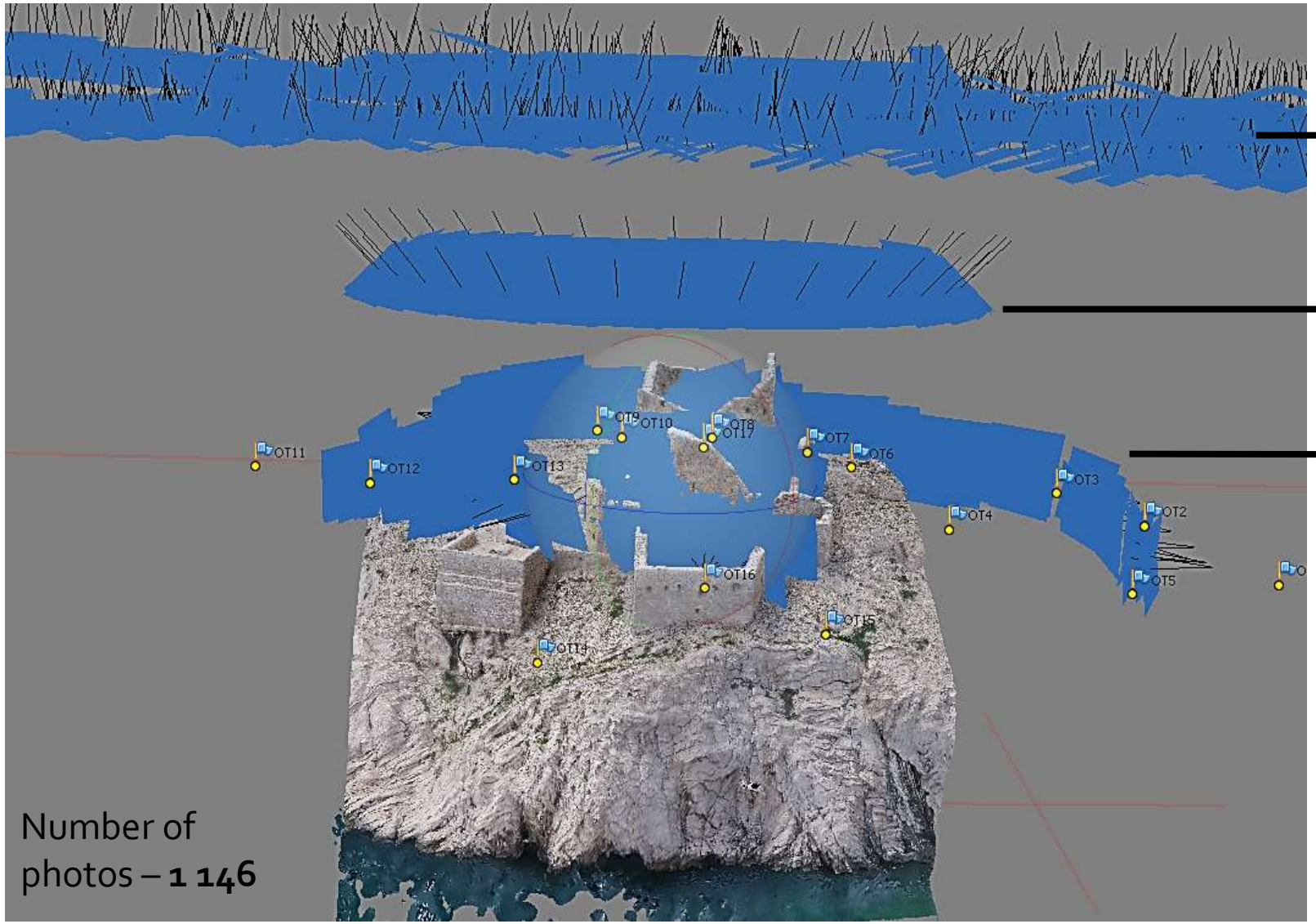
Methodology

Methodology

- Calibration of Phantom 4
- IMU, compass, camera.

1. Image capturing plan
2. Data collection
   - *Ground Control Points*
   - *Aerial and ground-based photos*
3. Data Analysis
4. Data Visualisation

Methodology



Number of photos – **1 146**

Double Grid

Circular Mission

Ground-based Mission

Methodology

Double Grid Mission

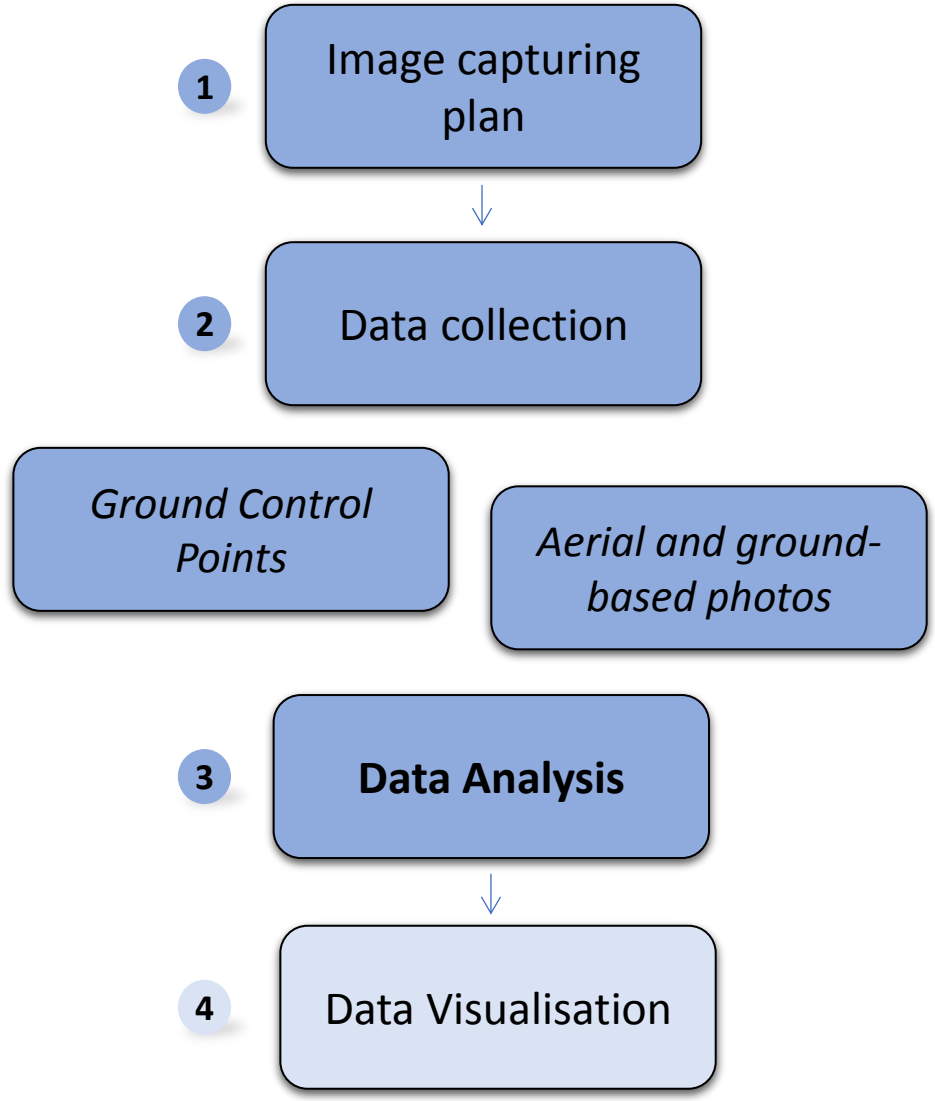
Circular Mission

Ground-based Mission

Methodology

- **Align photos:** High quality - Sparse cloud
- **Pair preselection:** Reference and Generic
- **Aligned photos:** 100%
- **Matching time:** 3 hours 1 minutes

- **Dense cloud:** High quality
- **Depth filtering:** Aggressive
- **Processing time:** 2 days 12 hours
- **Mesh:** Arbitrary (3D)
- **Mesh:** High quality
- **Processing time:** 59 minutes 5 seconds



Methodology

- Export (format .obj)
- Programs: *Autodesk ReCap*, *ContextCapture*, ***Lumion 8.0***, ***Cloud Compare*.**

- Lumion 8 = user friendly program
- The quality of the created 3D model must be **devalued**.
- „Creation" of landscapes

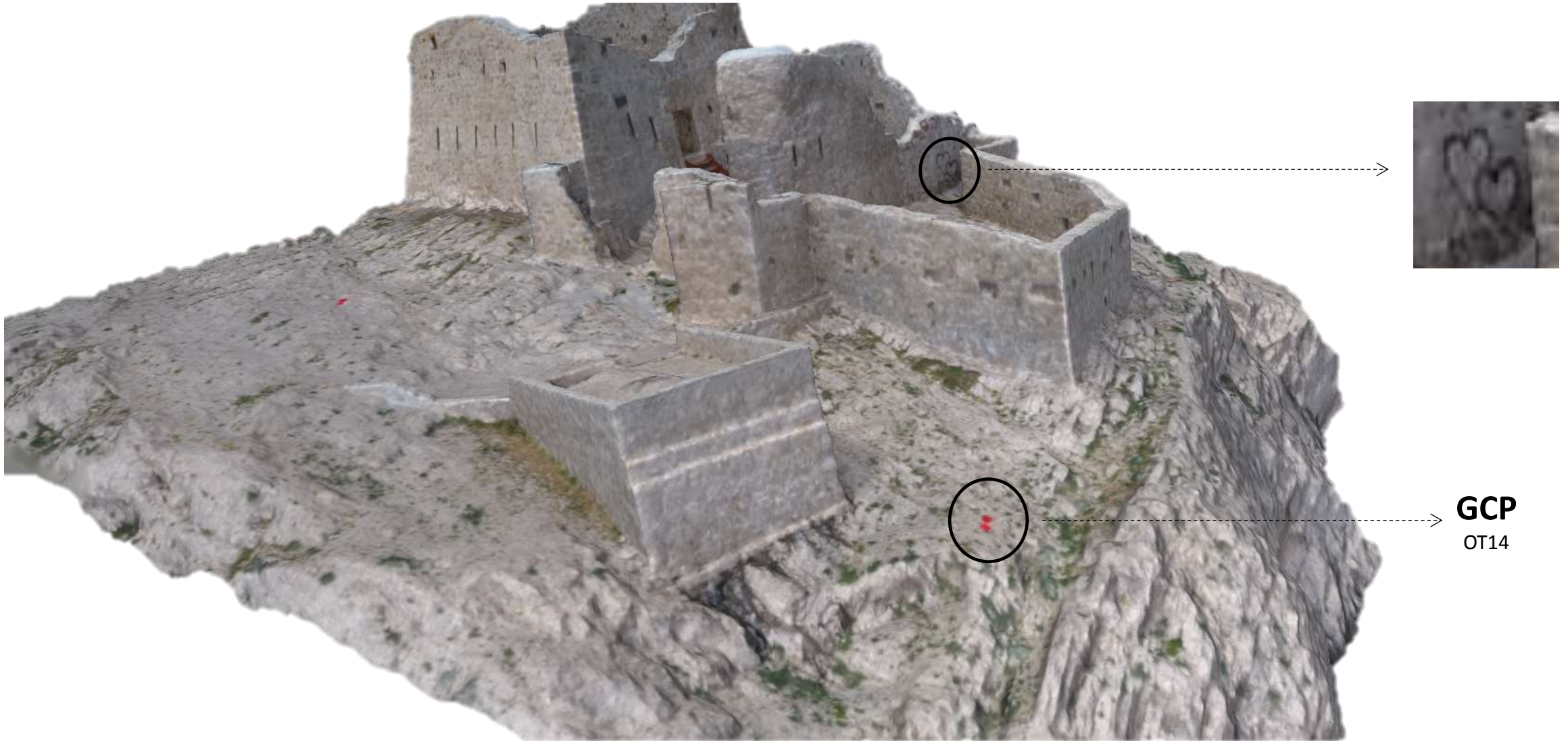
1. Image capturing plan
2. Data collection
   - *Ground Control Points*
   - *Aerial and ground-based photos*
3. Data Analysis
4. **Data Visualisation**

Results (*Dense Cloud*):

approximately **33 500 000 points**

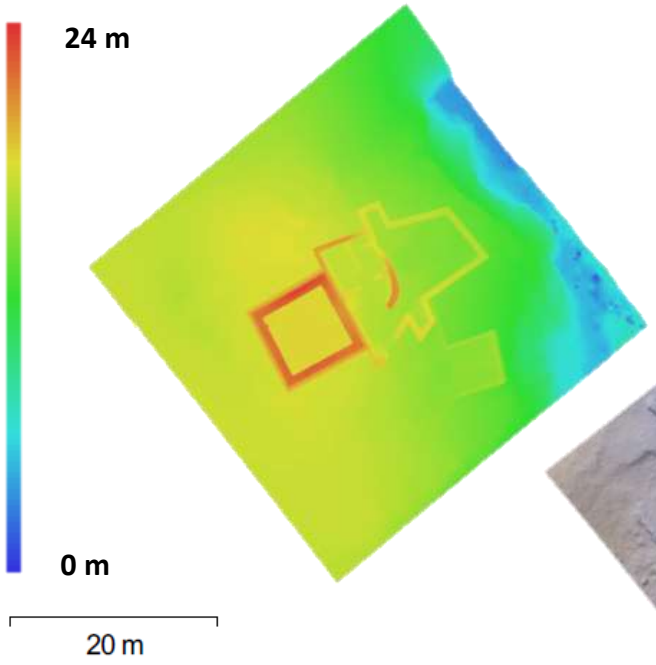
approximately **96 000 points per sq m**

Results *(Mesh)*

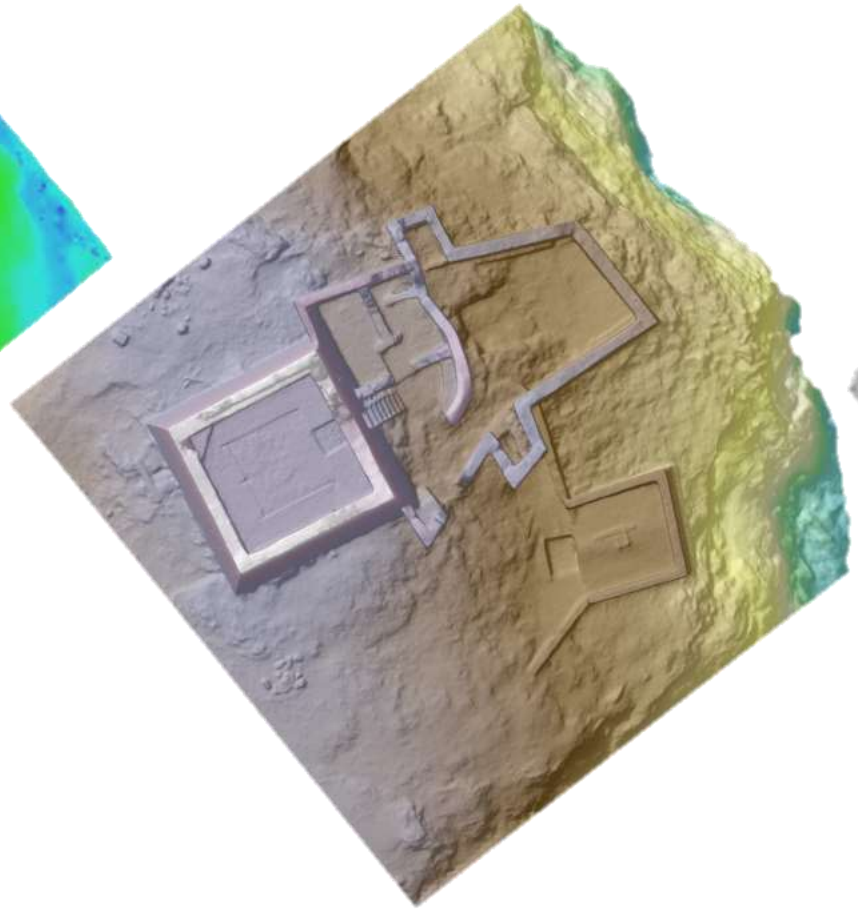


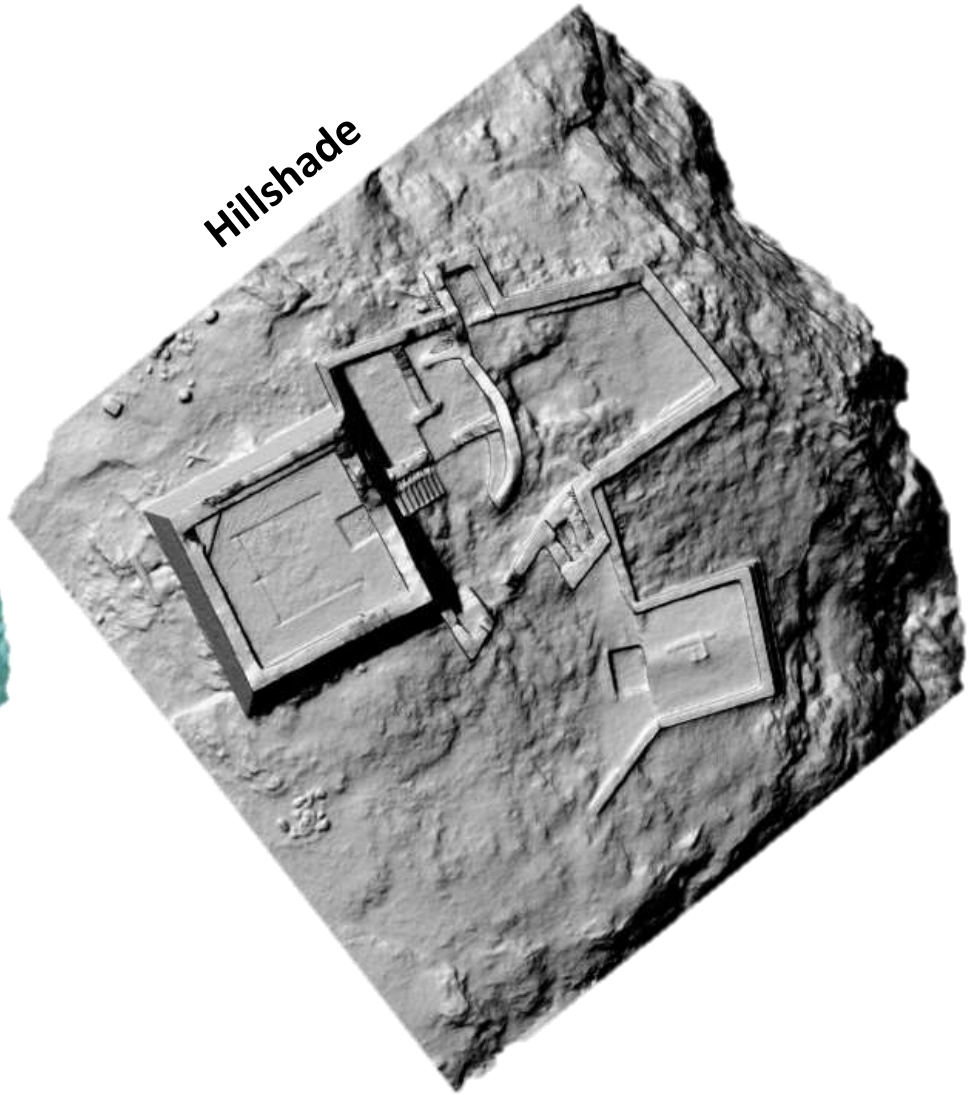
approximately **3 500 000 polygons**

Results *(DSM)*



Pixel size < 1 cm





Results *(DOP)*

Results *(3D model - CloudCompare)*

Results *(3D model – Lumion)*

Results

Photos **vs.** **3D model in Lumion**

Conclusion:

- **Cultural heritage** is a link between "*what people inherited*" and" *what we leave behind*".
- **CRP** is an extremely **useful method** for documentation of cultural heritage.
- **Method of data acquisition** depends on the **size of the recorded object** (*pottery or large sites*) and **purpose** of the survey.
- Creation of the **souvenir** and **visibility analysis** are still **in process.**
- **Students** are very satisfied with the **project type** of teaching.


THANK YOU FOR YOUR
ATTENTION!!