Structure from Motion summary

C. Symeonidis, I. Karakostas, Prof. Ioannis Pitas
Aristotle University of Thessaloniki
F. Zhang, D. Hall, T. Xue, S. Boyle D. Bull
University of Bristol
pitas@csd.auth.gr
www.aiia.csd.auth.gr

Version 3.0

Artificial Intelligence & Information Analysis Lab

Structure from Motion

- **Image-based 3D Shape Reconstruction**
- Structure from motion
- Structure from motion applications
- 3D Shape reconstruction workflow issues

Calibrated monocular image

Victor Blacus
(https://commons.wikimedia.org/wiki/File:Amagnetic_theodolite_Hepites_1.jpg),
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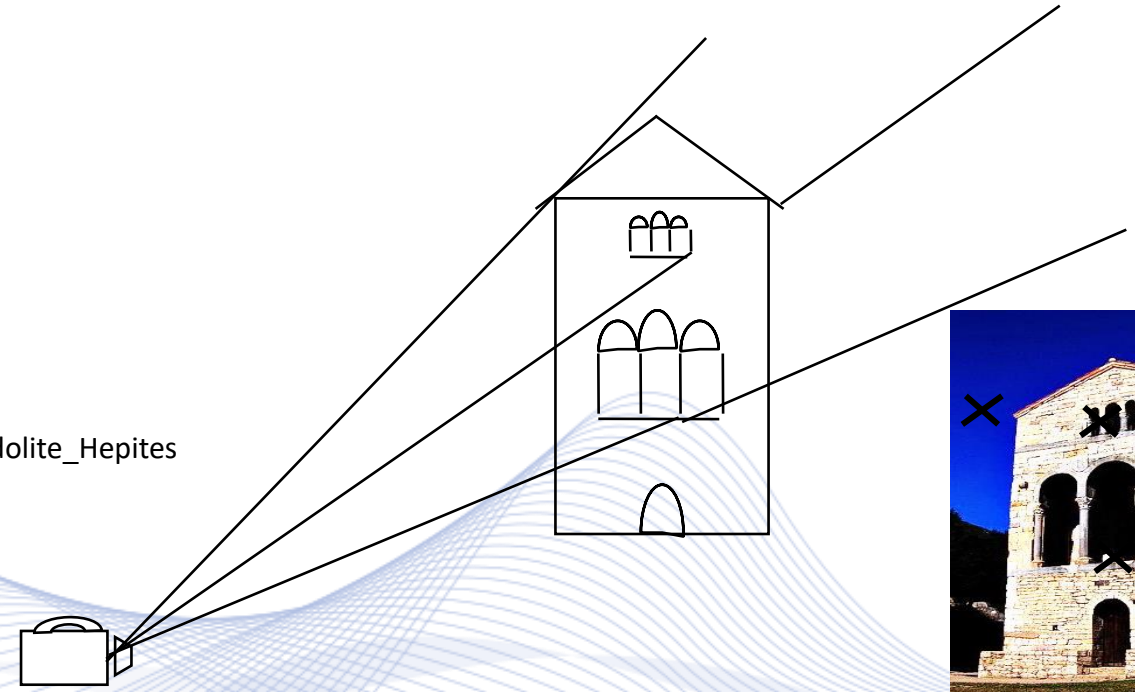

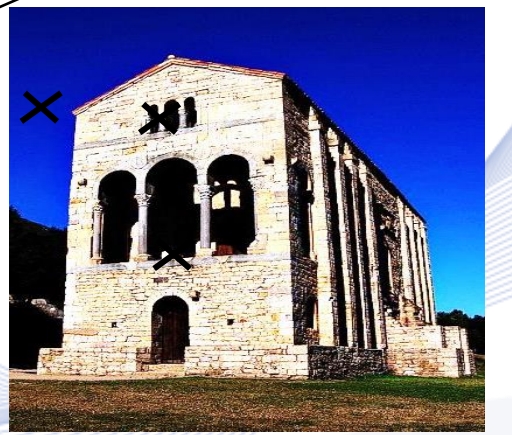

Ángel Miguel Sánchez
(https://commons.wikimedia.org/wiki/File:Sta_Maria_Naranco.jpg),
"Sta Maria Naranco", modified,
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Stereo imaging

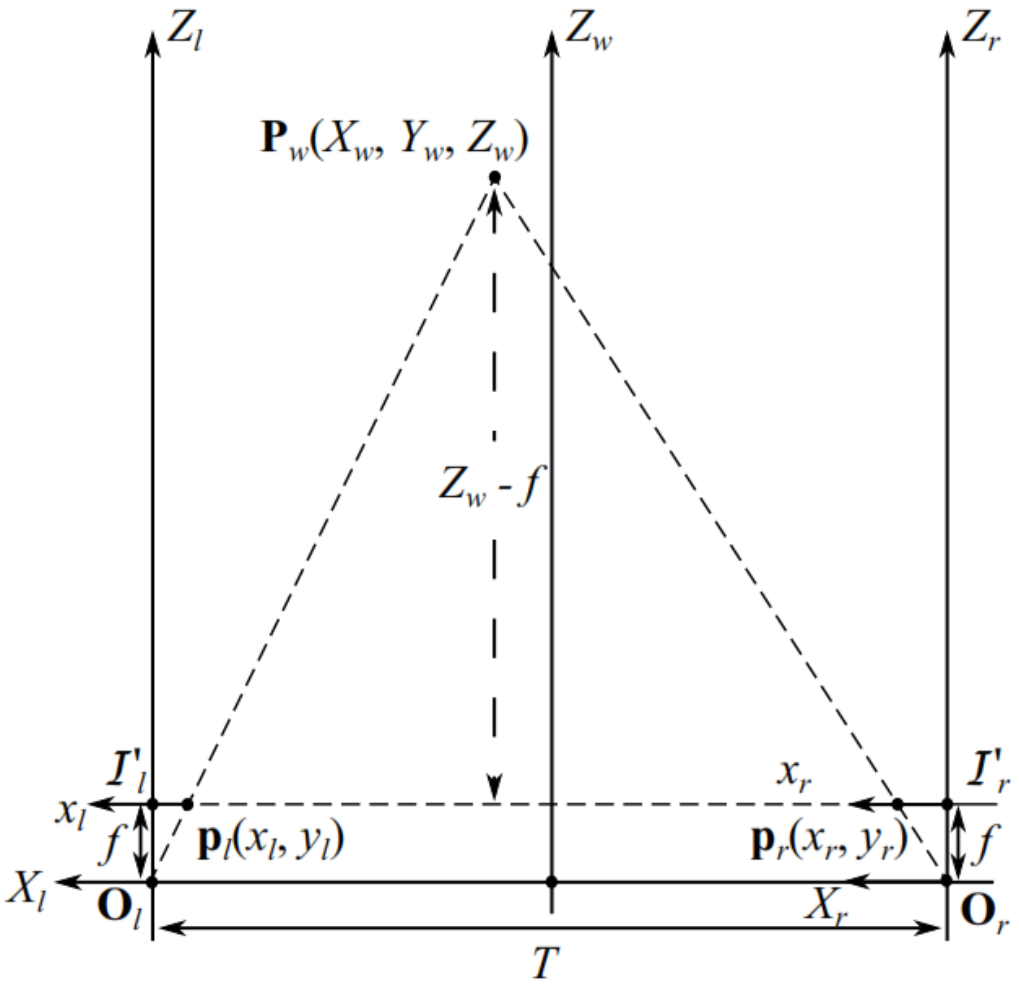
- Two cameras in known locations.
- Calibrated cameras.
- Stereo images can create a disparity (depth) map.

a) Left image; b) Right image; c) Dense disparity map.

Parallel Camera Setup

Parallel Stereo vision Geometry

T: baseline
f: focal length



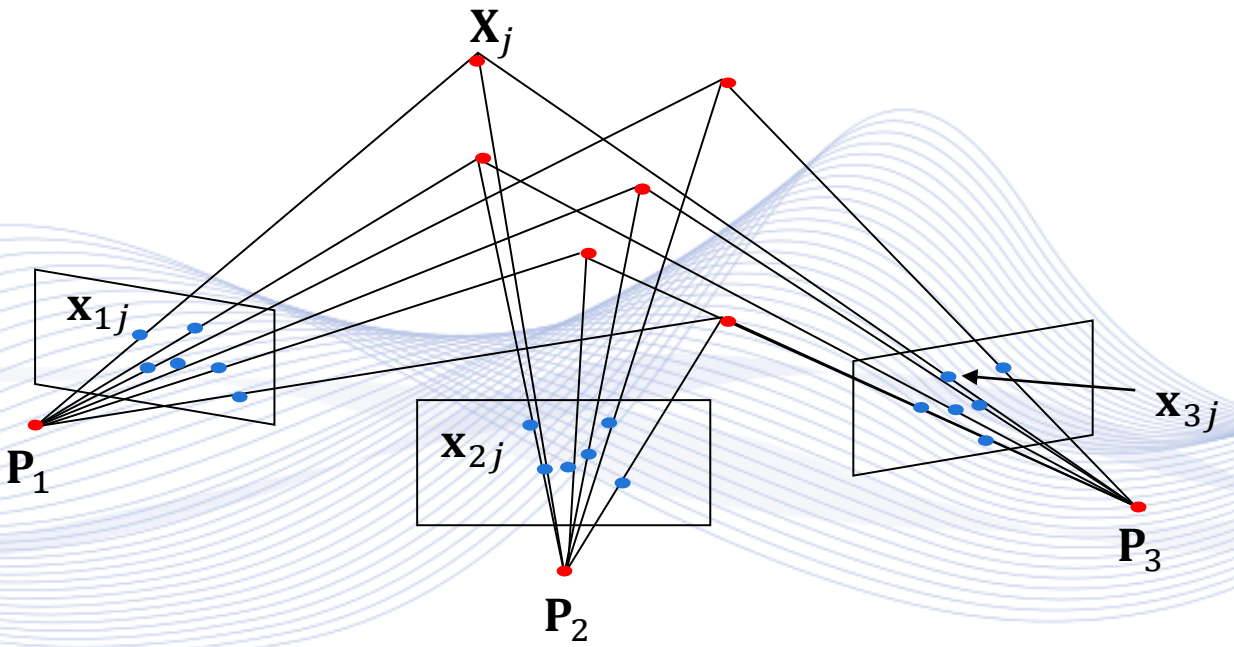
Feature extraction and matching

- Extract keypoints based on local features.
- Common feature extractors are SIFT, SURF, ORB etc.
- The keypoints are matched between images taken from different views.

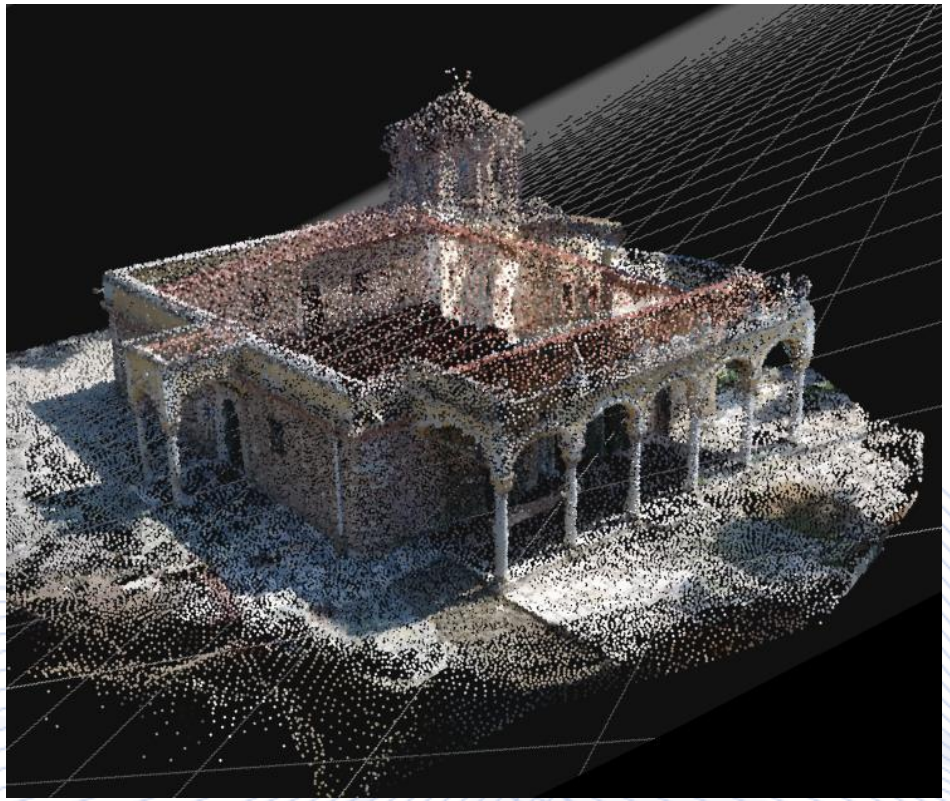
Vlatadon monastery [HEL2002].

Triangulation and Bundle Adjustment

- Bundle adjustment and triangulation are the final steps to estimate the camera parameters and create an accurate point cloud.
- Further techniques are used to make the point cloud denser and to reconstruct surface based on it.



Triangulation and Bundle Adjustment



3D model of Vlatadon monastery.

Structure from Motion

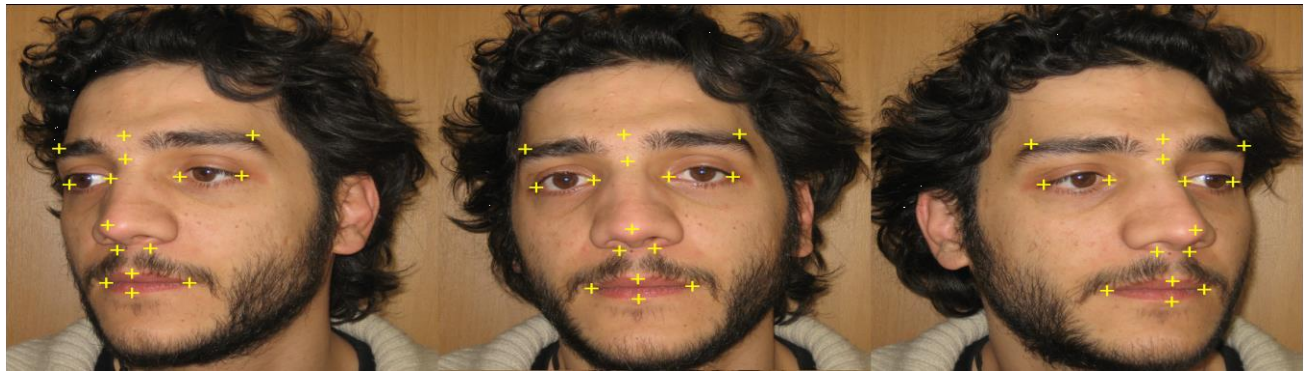
Bundle Adjustment:

- Initial SfM stages end up providing an accurate initial guess to non-linear re-projection error optimization:

$$\underset{\boldsymbol{\mathcal{P}}_i, \mathbf{P}_j}{\operatorname{argmin}} \sum_{i,j} v_{ij} \left\| \mathbf{p}_{ij} - \boldsymbol{\mathcal{P}}_i \mathbf{P}_j \right\|^2.$$

- $\boldsymbol{\mathcal{P}}_i$: projection matrix of camera i.
- $\mathbf{P}_j$: world coordinate point $\mathbf{X}_j$ (homogeneous coordinates).
- $\mathbf{p}_{ij}$: projection $\mathbf{x}_{ij}$ on camera i plane (homogeneous coordinates).
- $v_{ij} = \{0,1\}$: it denotes if point j is visible on camera i.

SfM in 3D Face Reconstruction

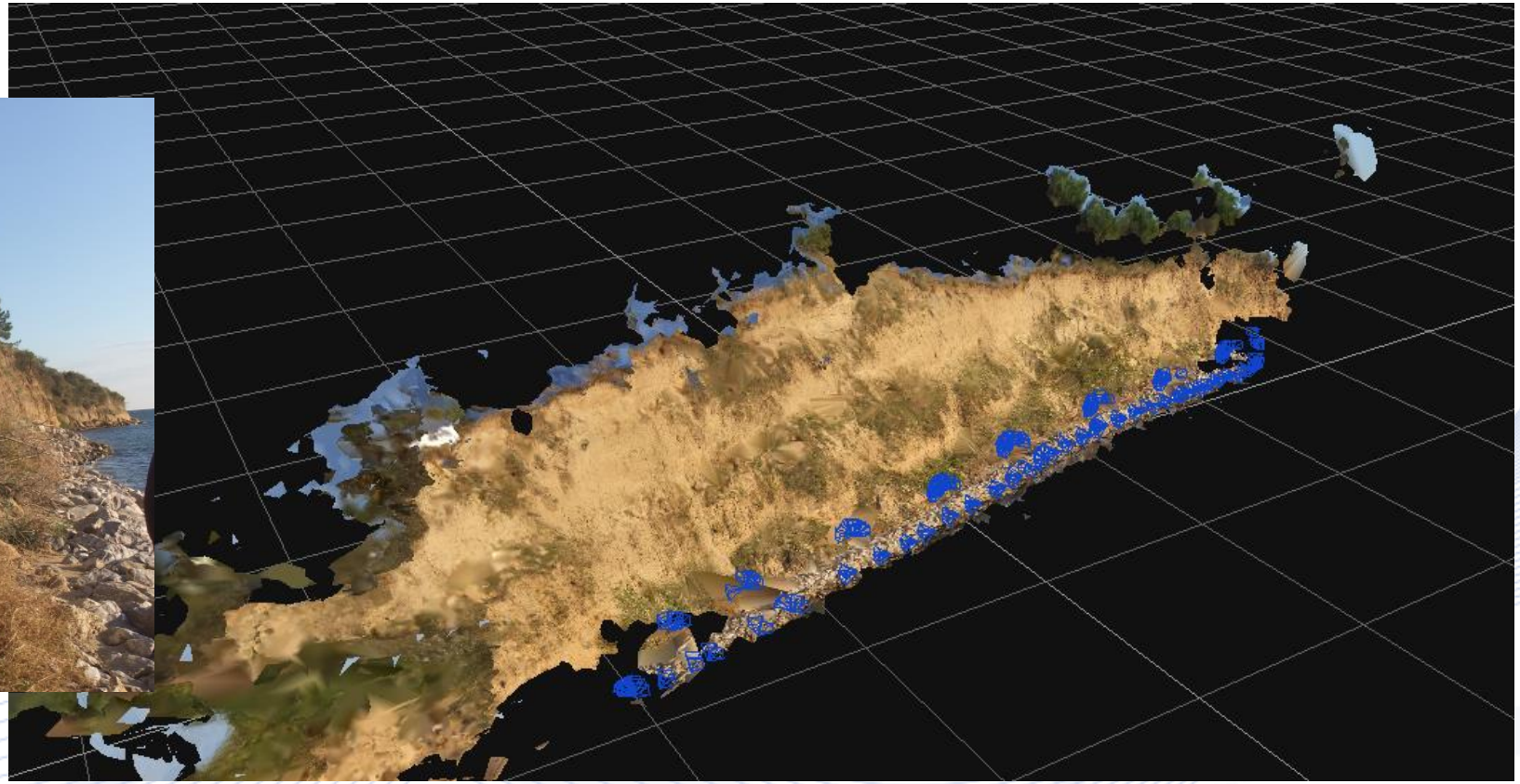


Selected features

CANDIDE grid reprojection

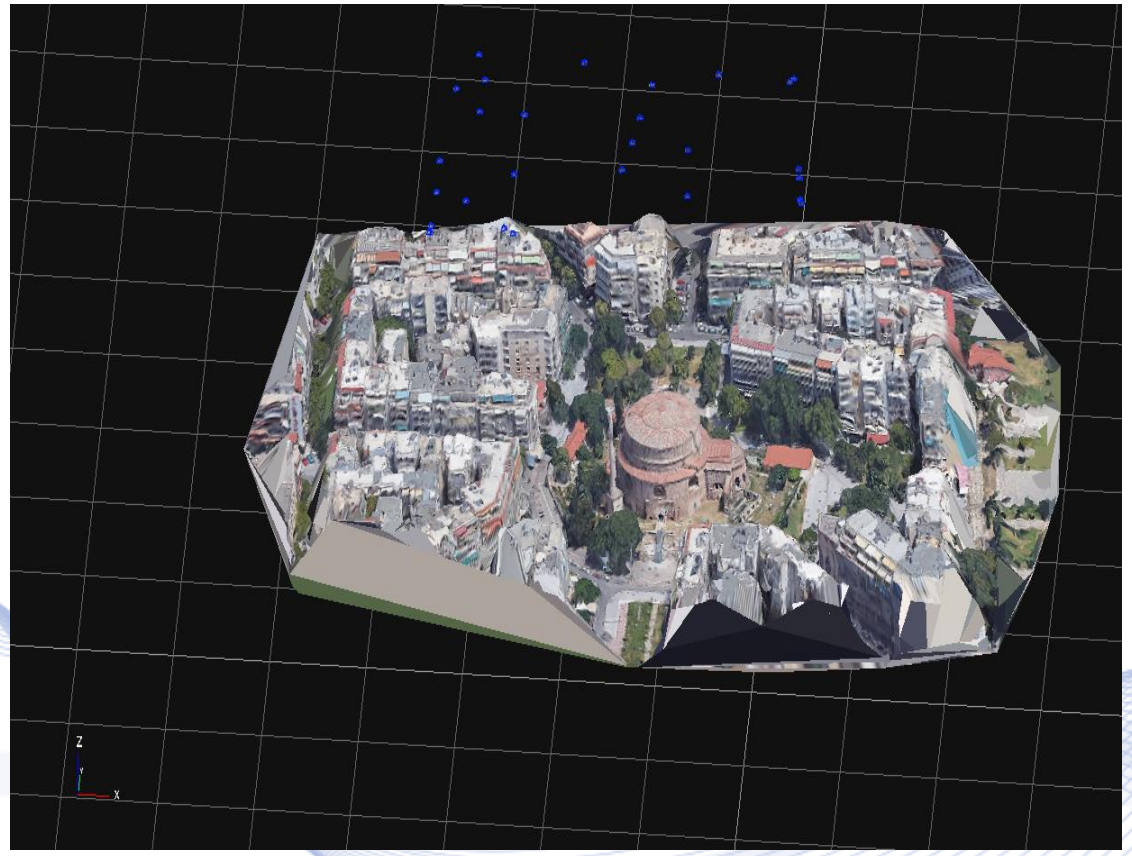
3D face reconstruction

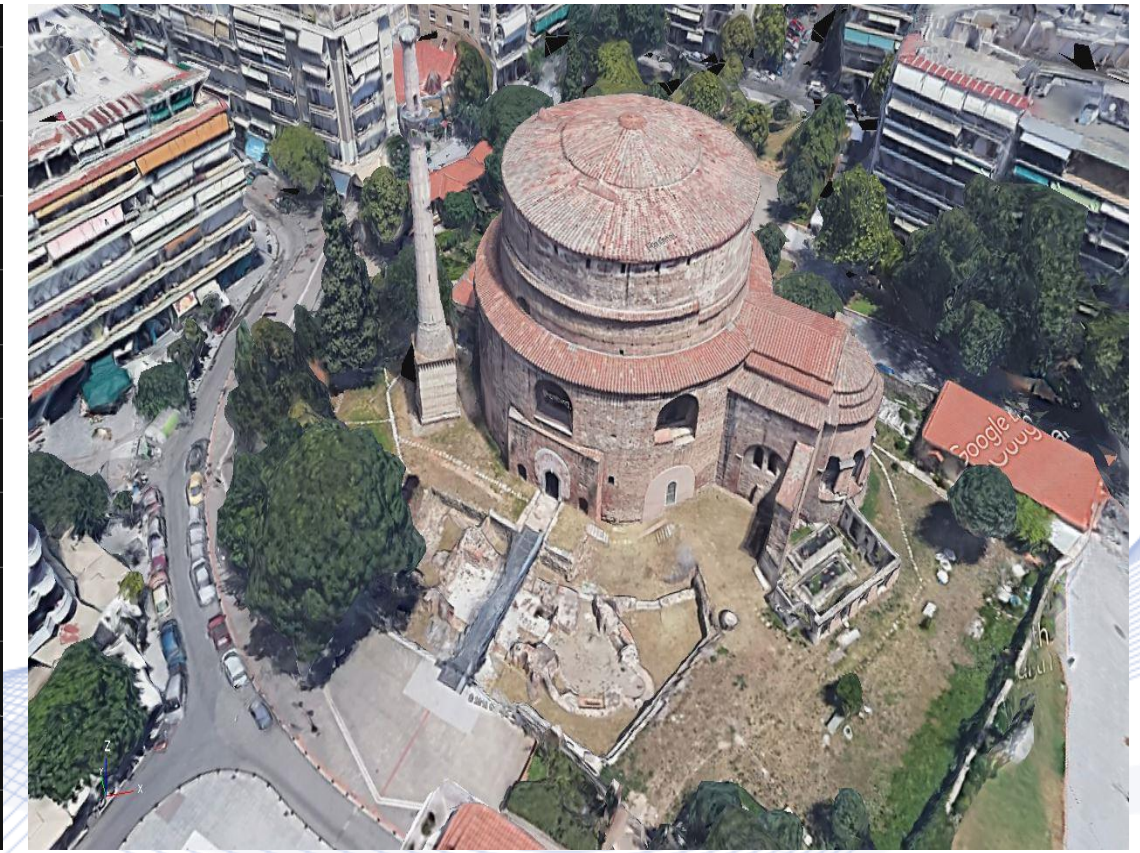
SfM in 3D landscape reconstruction



- 3D cliff surface reconstruction

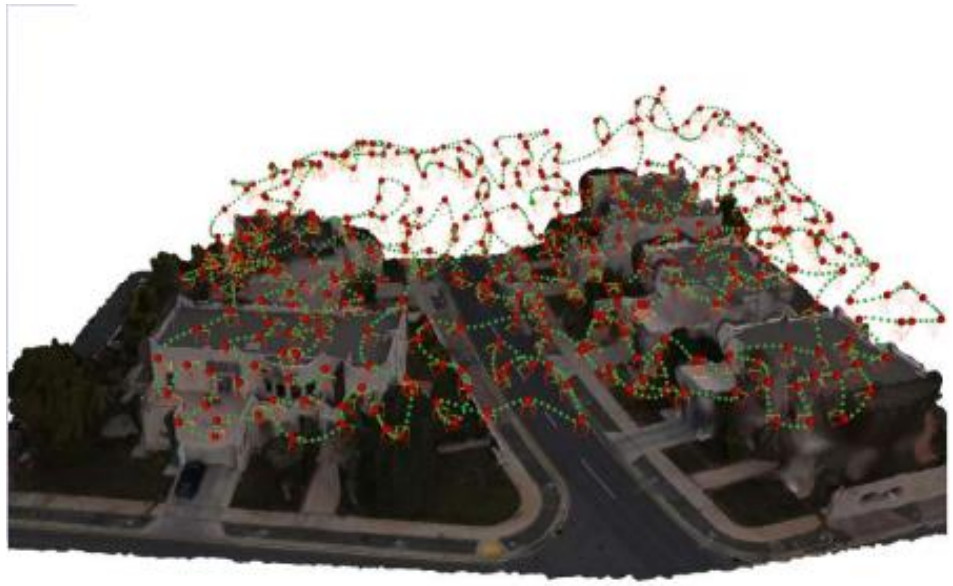
SfM in 3D monument reconstruction

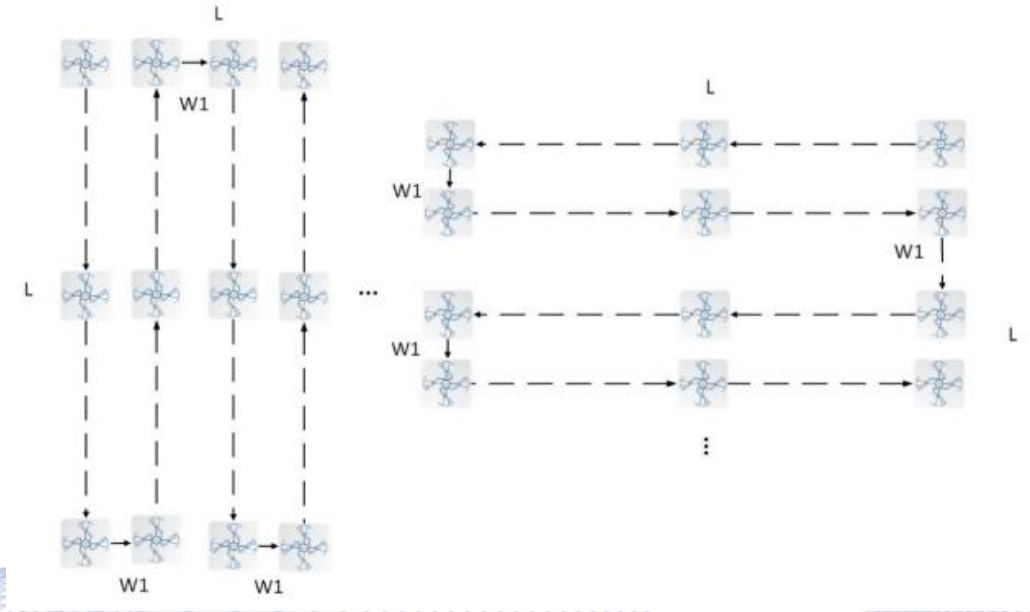




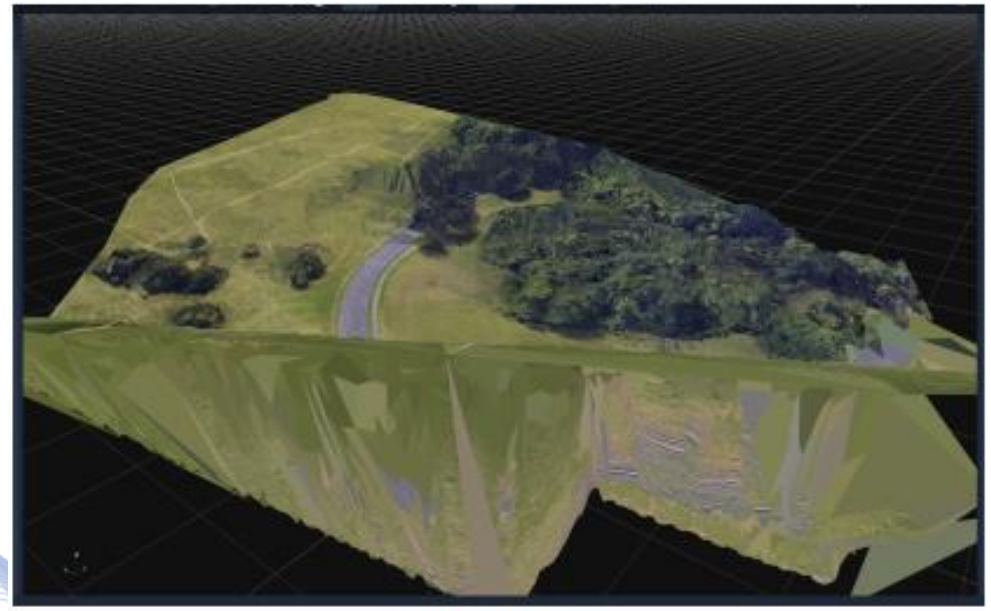
Rotonda monument, Thessaloniki, Greece.

Optimal UAV Flight Trajectory

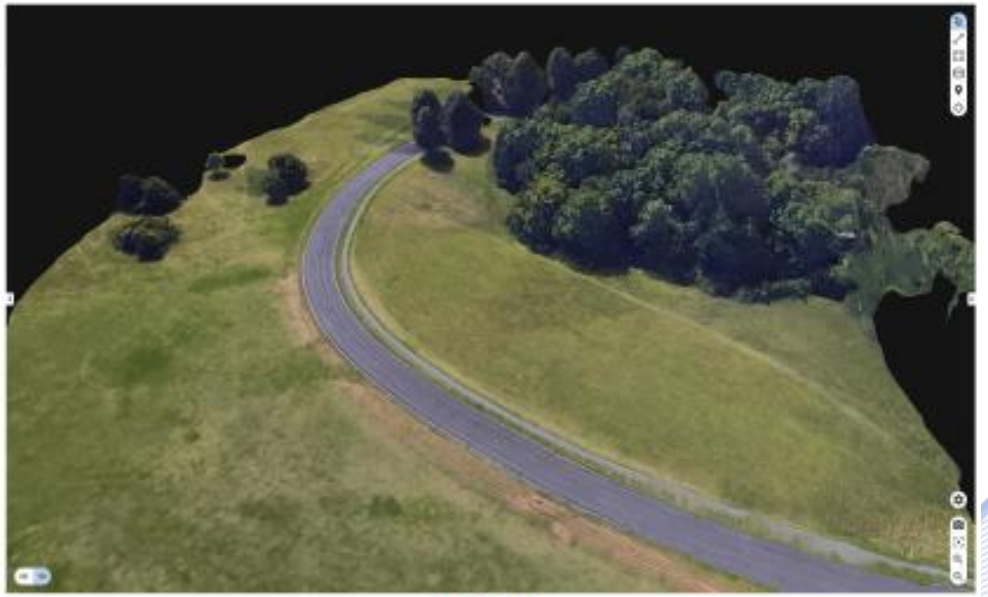




Photogrammetry Reconstruction



3DF Zephyr



Pix4D

Flat Surface Smoothing

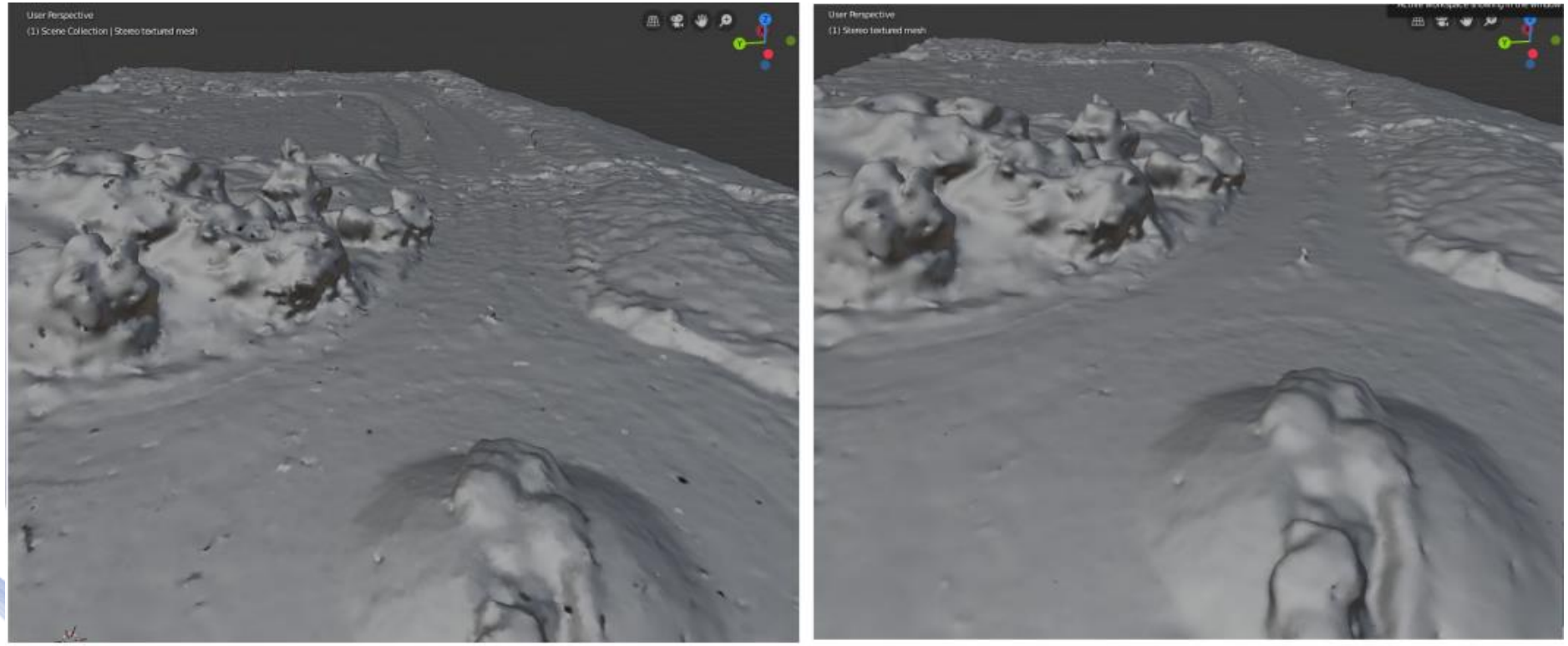


Figure: An example of Smoothing. (Left) The initial 3D model structure. (Right) The processed 3D model structure after Smoothing.

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Q & A

Thank you very much for your attention!

Contact: Prof. I. Pitas
pitas@csd.auth.gr