

(R)-EVOLUTION IN THE IMPLEMENTATION OF PHOTOMETRIC STEREO IN ARCHAEOLOGY

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PHOTOMETRIC STEREO (PS)

- Estimate surface normals and albedo from $m \geq 3$ photographs taken from the same viewpoint but under m non-coplanar light sources
- The only photographic 3D reconstruction method capable of estimating albedo
- Pixel-level 3D reconstruction
- Knowledge of m light sources can be difficult under complex lighting conditions
- Bad knowledge of lighting can induce low frequency bias in reconstruction

3D RECONSTRUCTION METHODS



Normal field of a Cypriot calathos head. From left to right: photogrammetry, calibrated PS, scene-calibrated PS.

LAMBERTIAN ASSUMPTION

Lambertian model: $I_j^i = \rho_j \mathbf{n}_j \cdot \mathbf{s}^i$ (1)

- I_j^i : grey level of pixel j in image i
- ρ_j, \mathbf{n}_j : albedo and normal of pixel j
- \mathbf{s}^i : lighting for image i , assumed uniform

Assumption for both photogrammetry (implicitly) and photometric stereo (explicitly)

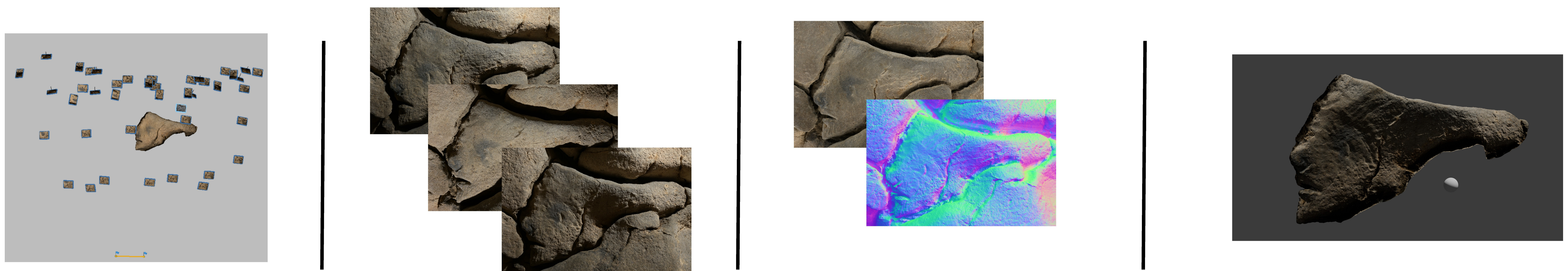
SCENE-CALIBRATION OF THE LIGHTING

Over the scene, ρ_j is unknown, \mathbf{n}_j is approximated by photogrammetry

Reformulation of (1): $I_j^i \frac{1}{\rho_j} - \mathbf{n}_j \cdot \mathbf{s}^i = 0$ (2)

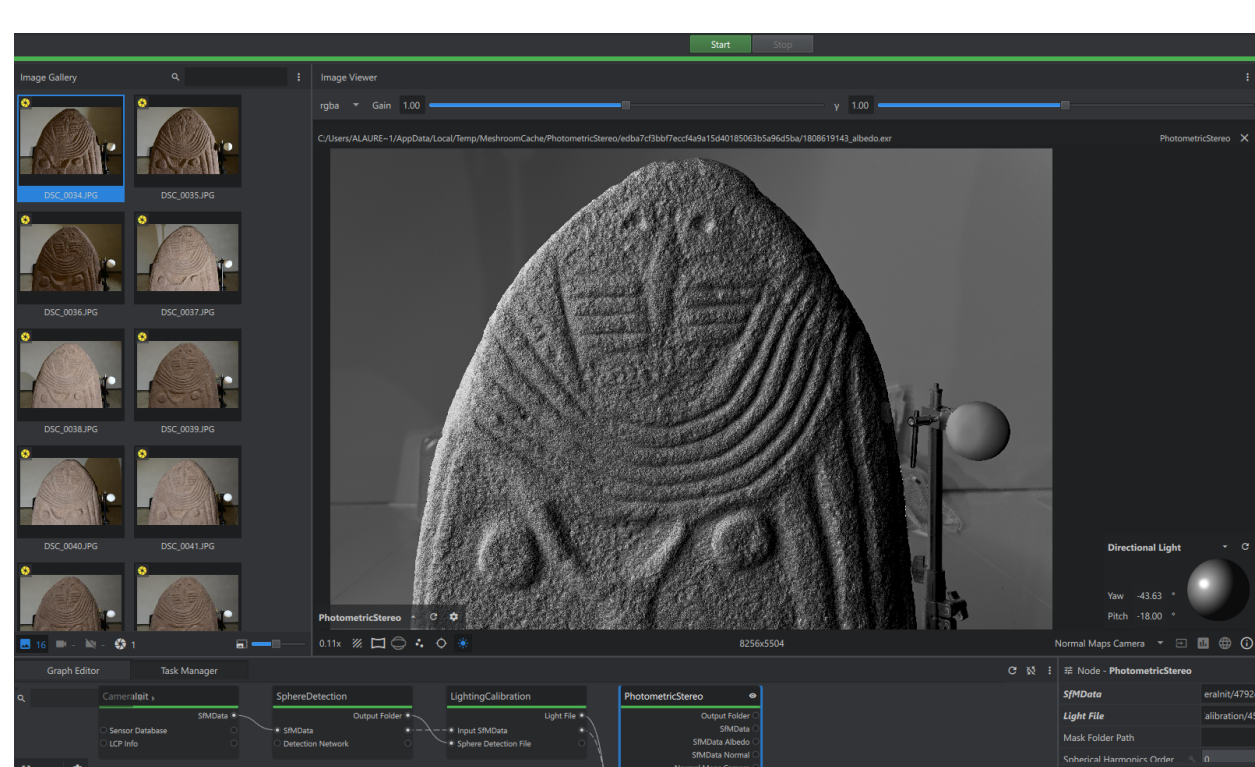
- Unknowns: p values $\frac{1}{\rho_j}$ and m vectors $\mathbf{s}^i \in \mathbb{R}^3$
- System of pm linear equations in $(\frac{1}{\rho_j}, \mathbf{s}^i)$
- Well-constrained if $pm \geq p + 3m$

ACQUISITION PIPELINE



Mas d'Azil cave (Ariège, France). From left to right: photogrammetric acquisition; multi-lighting acquisition; albedo and normals estimated by PS; relighting of the mapping of normals onto the 3D mesh.

IMPLEMENTATION



Relighting the result of calibrated PS in AliceVision/Meshroom

CONCLUSION AND PERSPECTIVES

- Light estimation without calibration pattern
- Simplification of acquisition protocol
- Perspectives: implementation of scene-calibrated PS and multi-view PS in AliceVision/Meshroom