



Photometric Stereo for 3D mapping of carvings and relieves

Summary and recent improvements-



Methods & Case Studies on Prehistorical Art in Sardinia

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The prompt: Documentation of decorations in sardinian Domus de Janas



XXV VALCAMONICA SYMPOSIUM 2013



Difficulty: glancing light
reveals *part* of details.

Many images required



Ambient light disturbs



Surface color also disturbs

Original image with frontal lighting of engravings in Cave's Tomb (Cheremule, Sardinia).



Surface color also disturbs

Same image under right side lighting



Surface color also disturbs

Same image under upper side lighting



3D recording is extremely effective

- It brings the object, in full shape and color, to your desk
- Virtual lighting can be applied at will
- Color can be removed
- The object can be reproduced by 3D printing (a scalable cast)

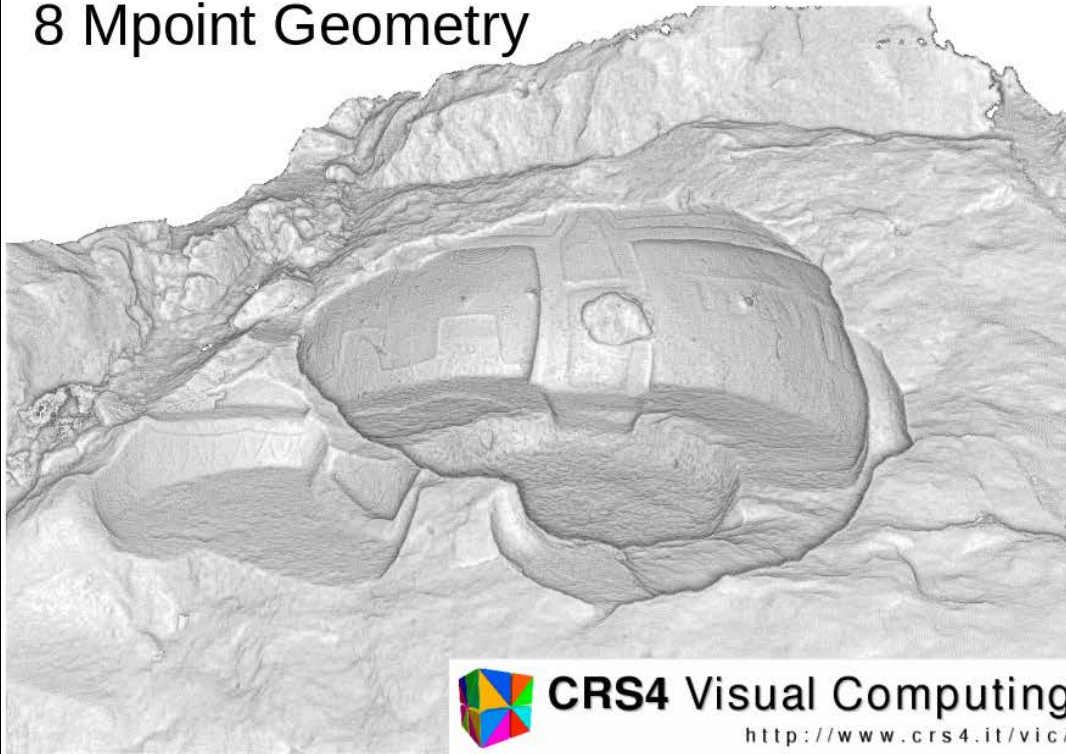
3D reconstruction

3DSurface with albedo

3D reconstruction

3DSurface without albedo

8 Mpoint Geometry



CRS4 Visual Computing
<http://www.crs4.it/vic/>

21 photos



Laser scanning: acquisition and processing time >2 horus

The key point is the acquisition method

It should be:

- Effective
 - for shape recording
 - for color recording
 - for eliminating unwanted shadows and shades
- Fast
- Cheap
- Easy
 - to use
 - to carry
- Scalable
 - good for small details
 - good for large surfaces

Photometric Stereo

Shape and light produce shading

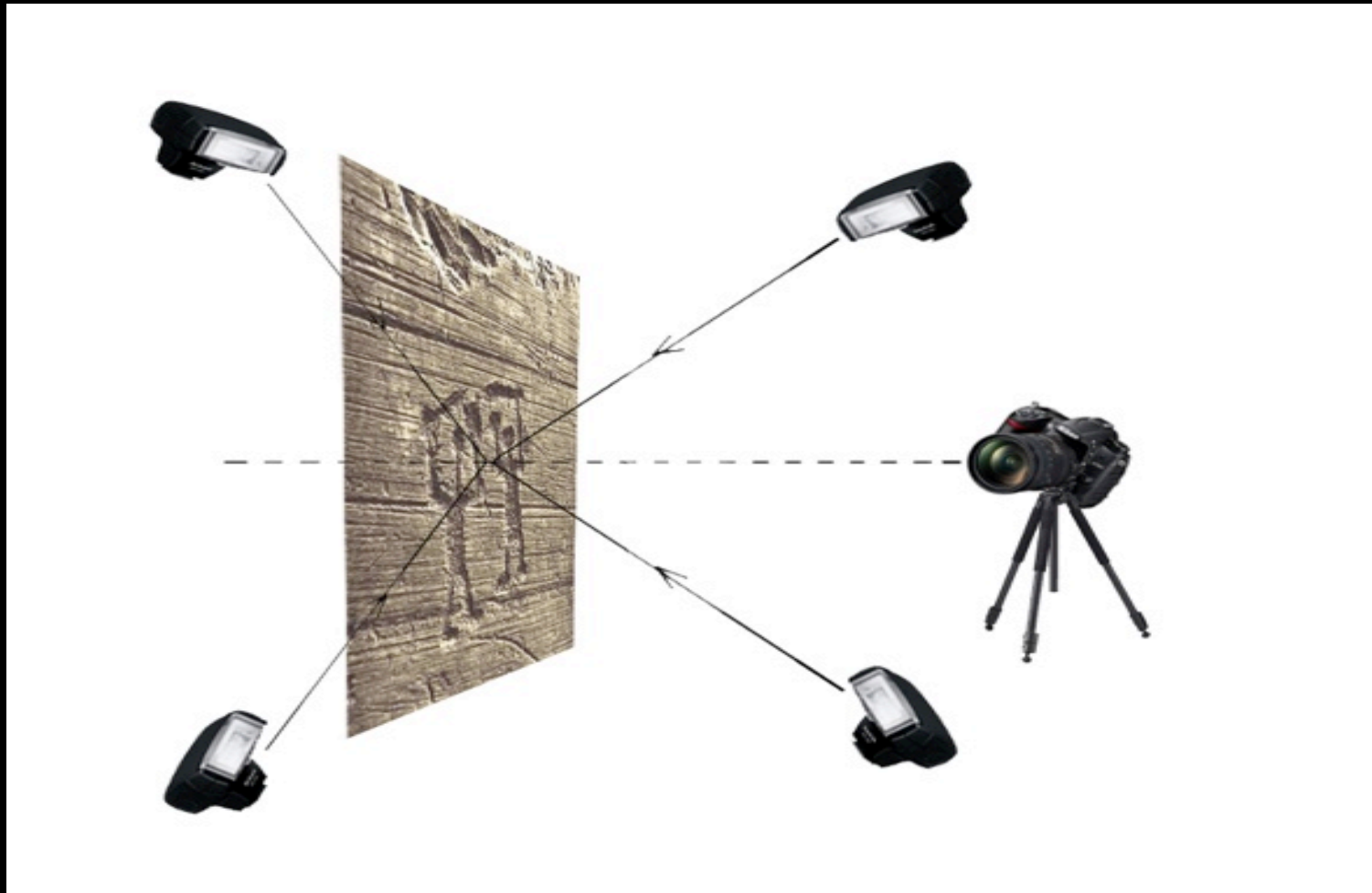


Mathematics teach:

- where to put lights
- how to combine images
 - to reconstruct shape
 - and separate the color

A friendly method:

- Have a camera and hand movable light
- Take 4 pictures...



Data acquisition



That's all!

Montessu – Tomb of Spyrals



One of the original 4 images:
details are nearly invisible under frontal light

First step: checking.

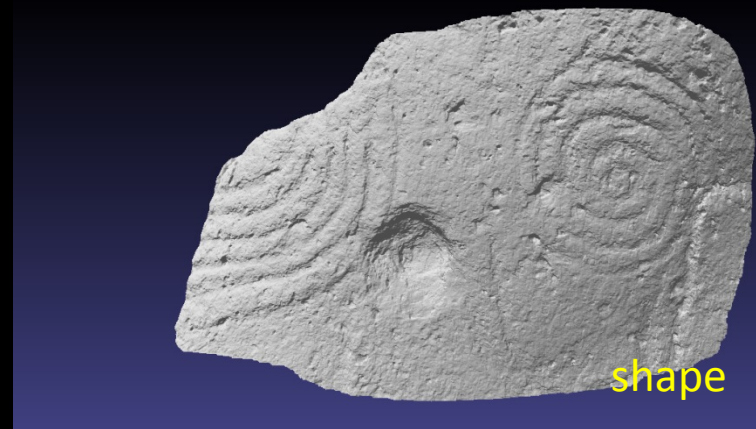
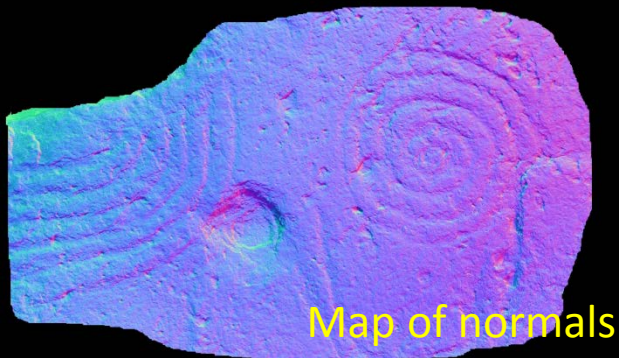
In a few seconds a false-color image removes the color and enhances decorations.

Not yet 3D, but data can be safely recorded for a good second step



Second step: reconstruction

Shape without color and color without shape (albedo) are obtained



Third step: rendering

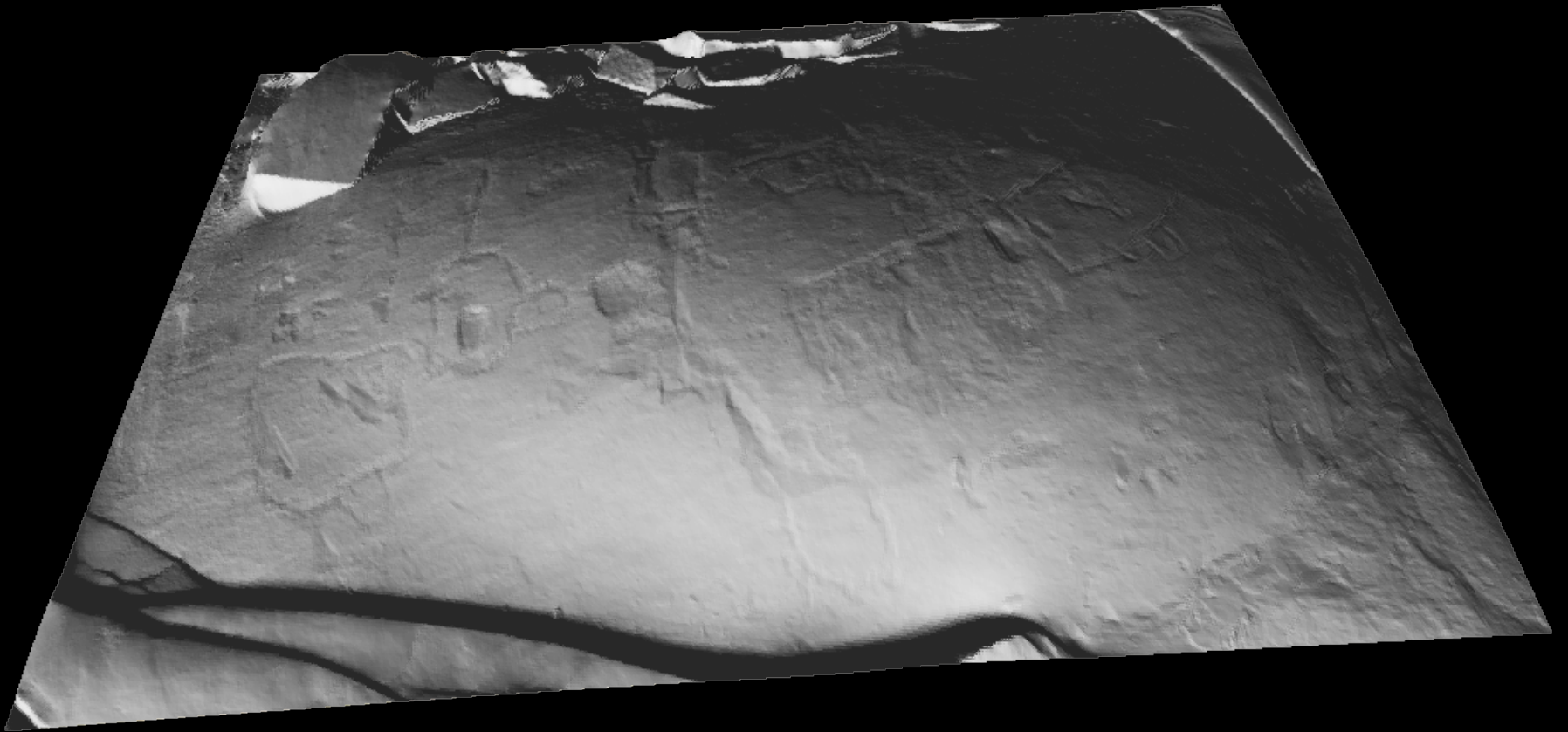
Shape and color are merged in a virtual 3D replica of the original



Other recent results: Village map (Anela)



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Other recent results: Cheremule



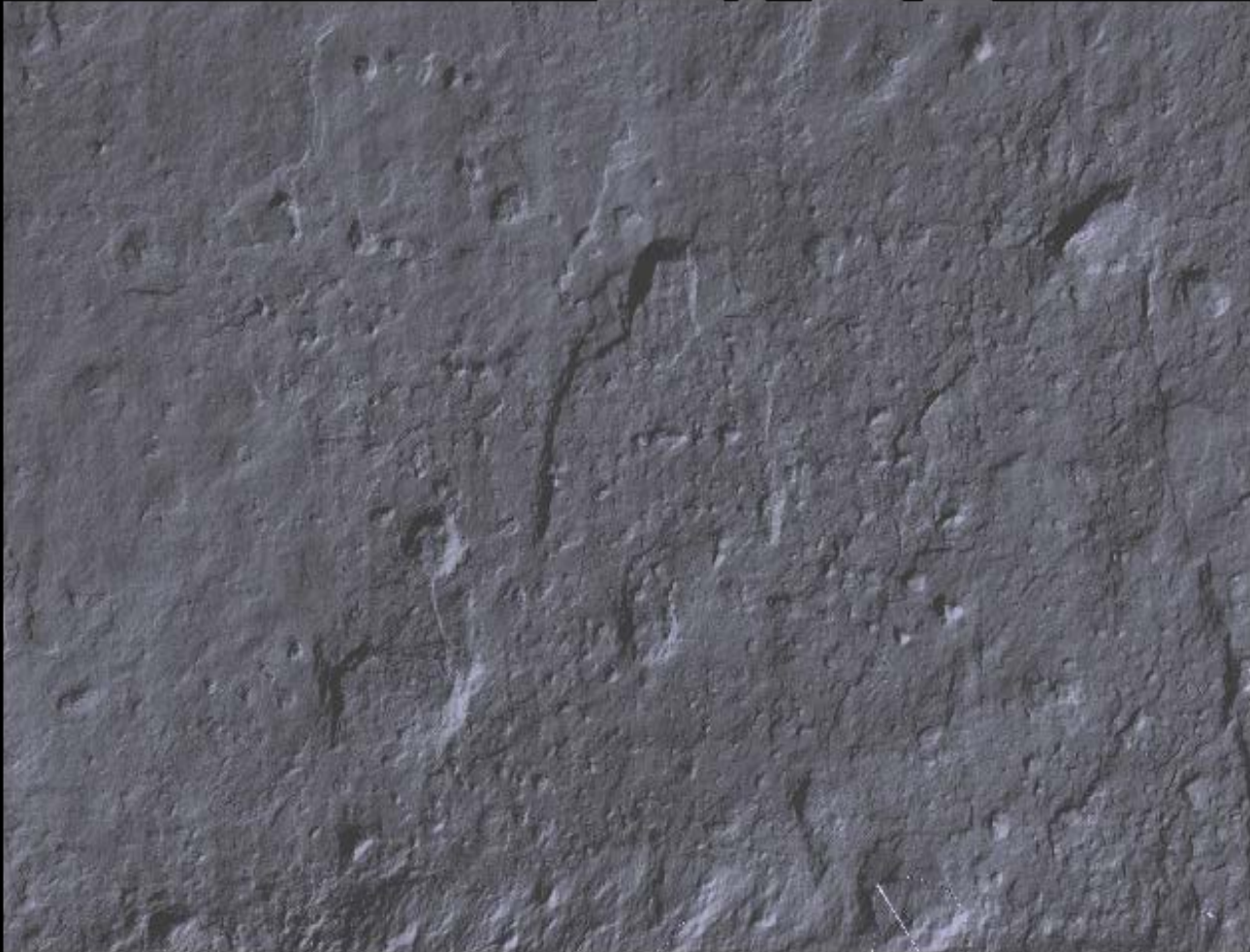
Other recent results: Cheremule



Other recent results: Mother Goddess (Montessu)



Other recent results: Mother Goddess (Montessu)



Considerations

- **What are the peculiarities of Photometric Stereo?**
- **Is Photometric Stereo perfect?**
- **Recent improvements**

What are the peculiar features of Photometric Stereo?

- Fast acquisition and elaboration (seconds)
- Cheap (some hundreds euros)
- Light and small equipment
- Suitable also under strong sun light
- Engravings overlapping studies
- Working also under non-ideal conditions
 - Free hand light positioning
 - Impossibility to position one of the four lights

Is Photometric Stereo perfect?

No:

1. surfaces are distorted because of non – ideal lights



Is Photometric Stereo perfect?

No:

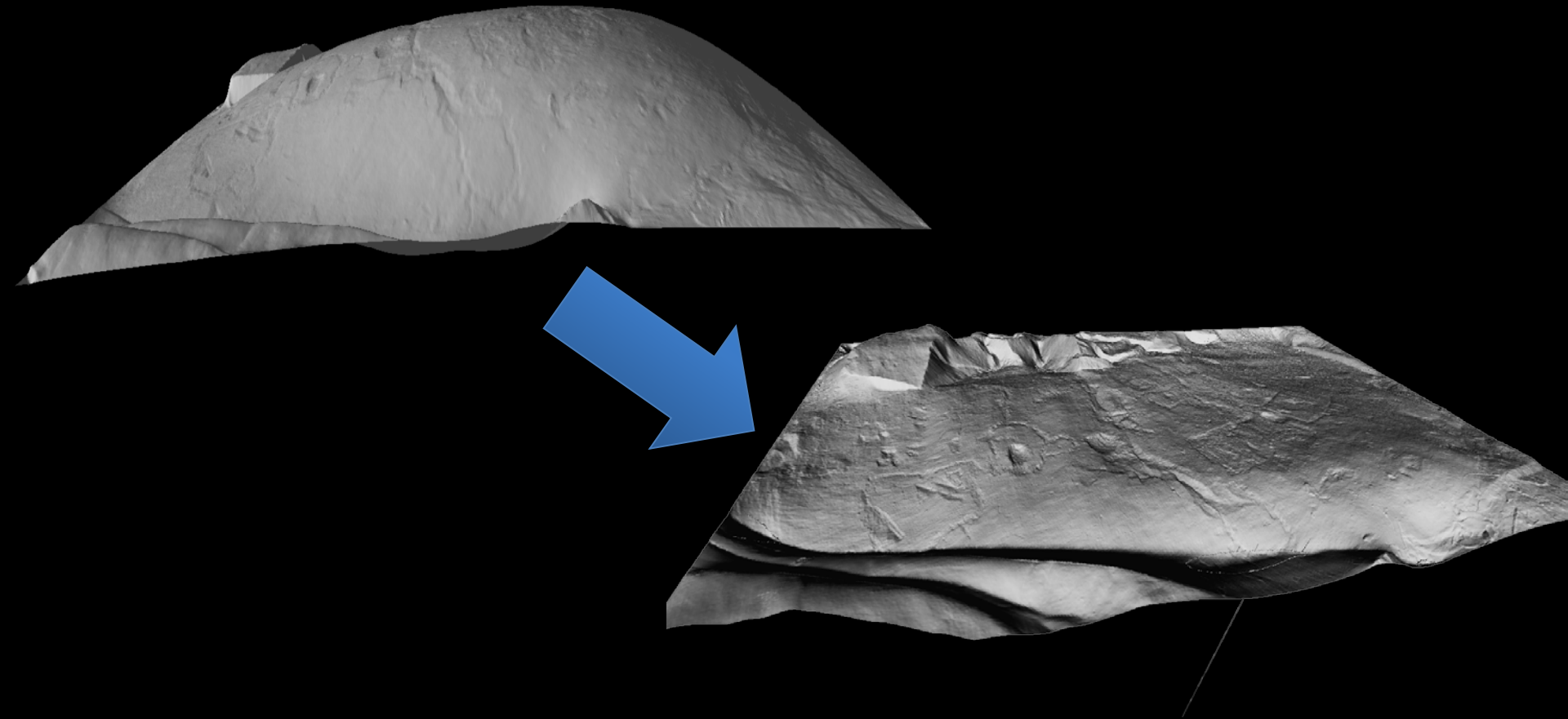
2. Elaboration time is long...

| | |
|----------------------|------------|
| Acquisition | 1 minutes |
| 3D Processing | 18 minutes |
| Export File | 90 minutes |

... or at least, it was up to few months ago

Recent improvements

1. Mathematical surface stretching fixes distortion



Recent improvements

2. New algorithms dramatically reduces the elaboration time

| | Some months ago | Now |
|----------------------|------------------------|------------|
| Acquisition | 1 minutes | 1 minutes |
| 3D Processing | 18 minutes | 7 seconds |
| Export File | 90 minutes | 8 seconds |

- Resolution: 855x1287 pixels

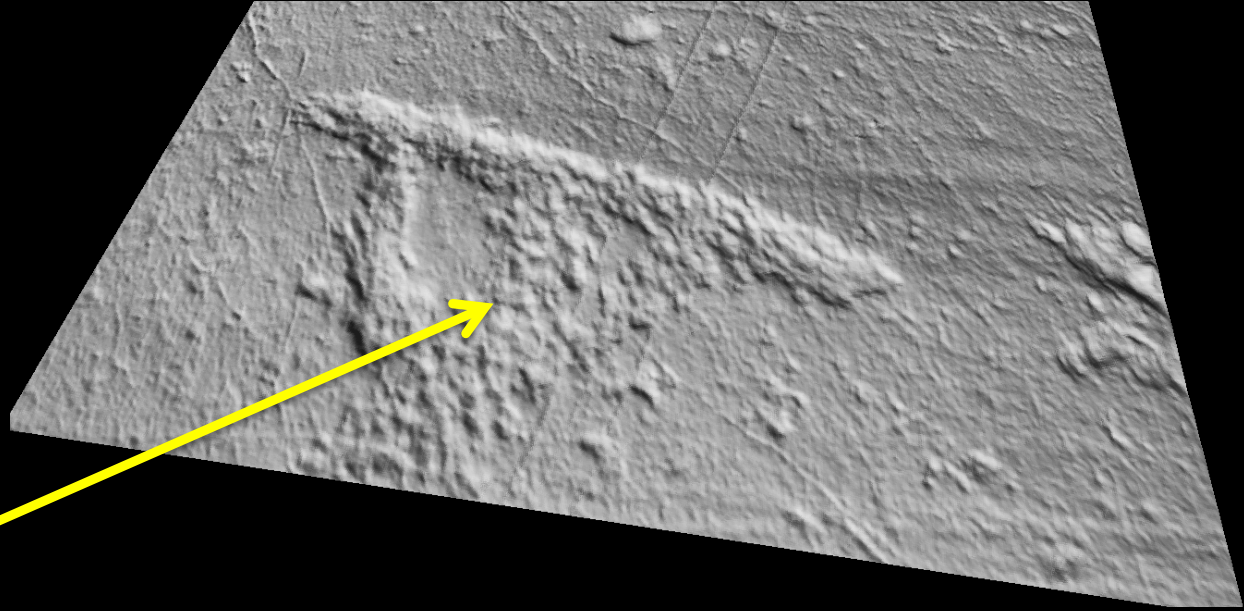
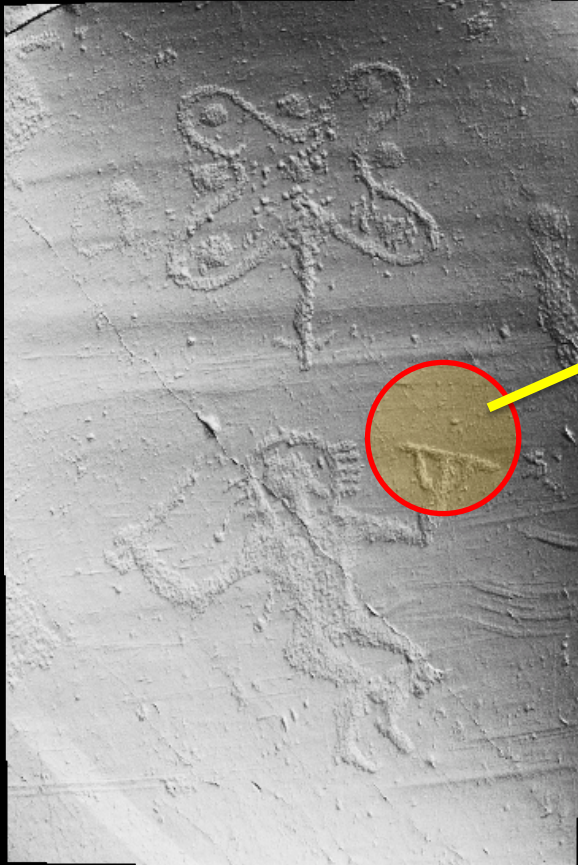
Latest achievements: overlapping

Zoom in: spidery writing
overlaps other engravings
(Breno, Valcamonica)



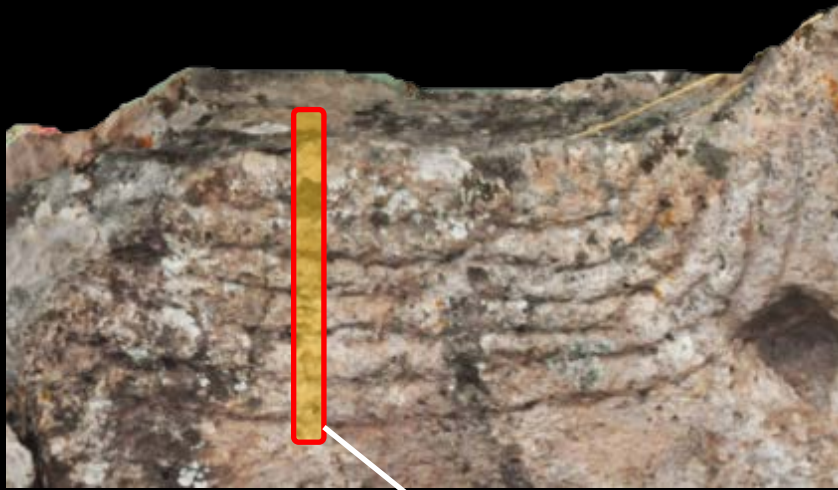
Overlapping

Zoom in: spidery writing overlaps other engravings



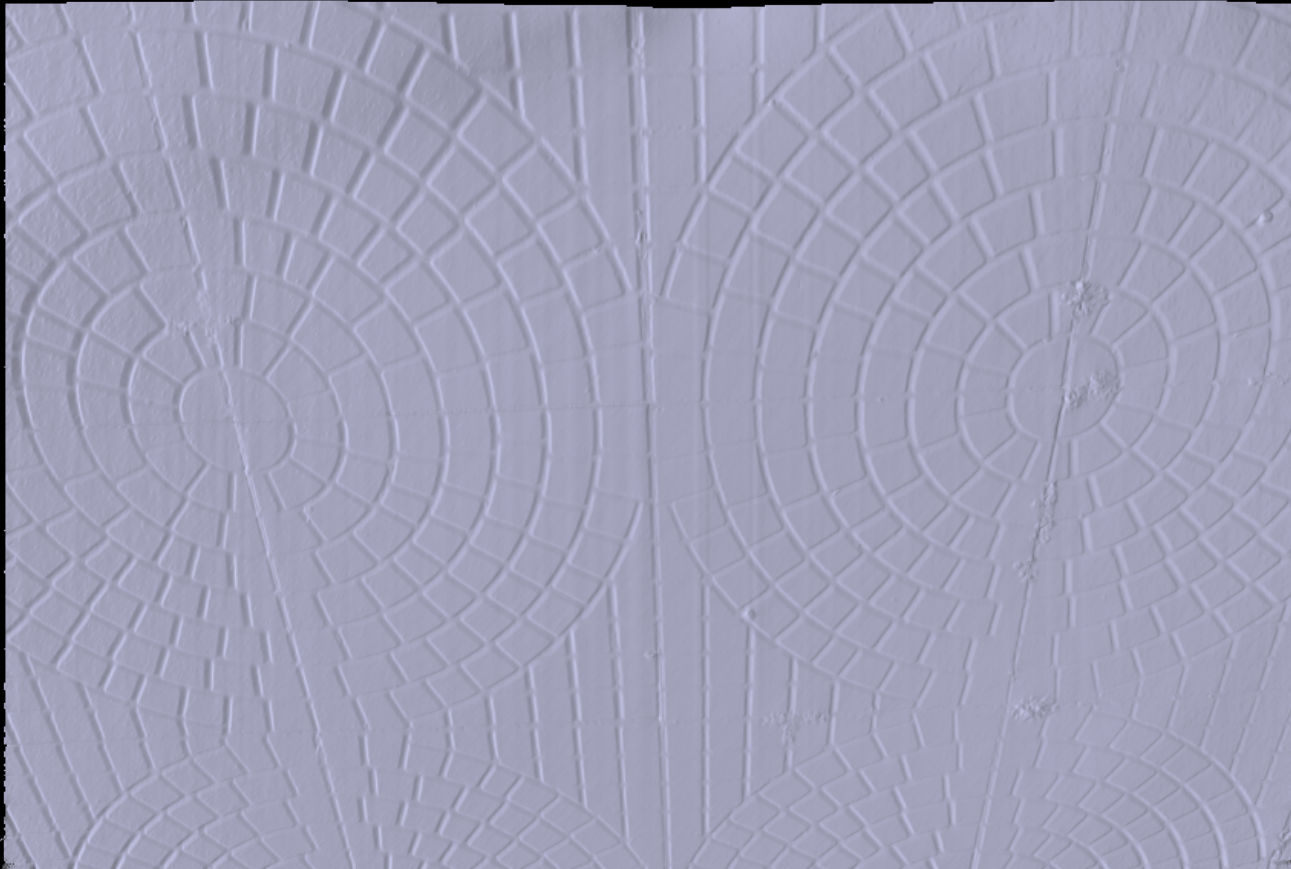
Latest achievements: tool shape

Relief extraction and drawing: from the engravings to the chisel's shape



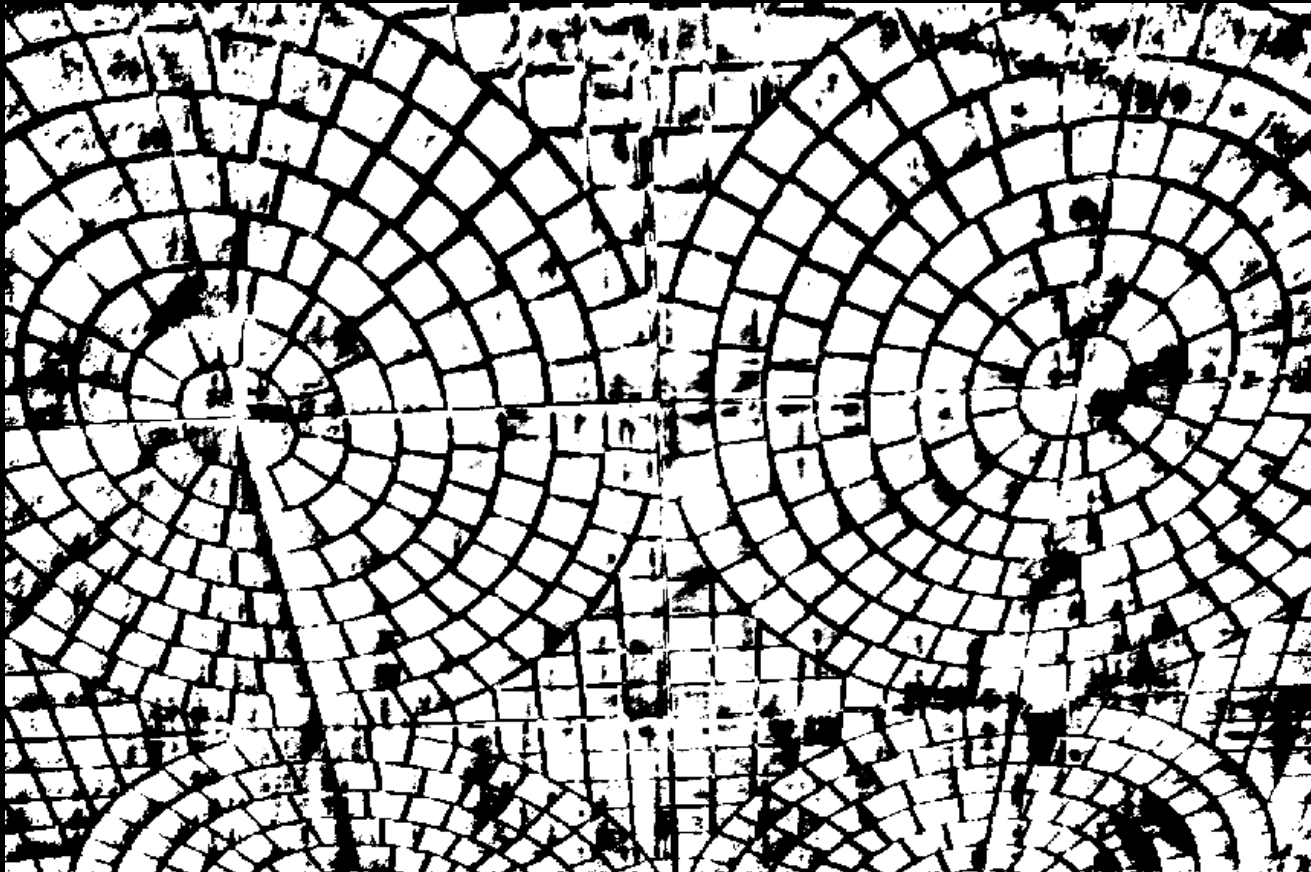
Latest achievements: automated sign

- This process will allow us to extrapolate the draw of engravings from the rocks



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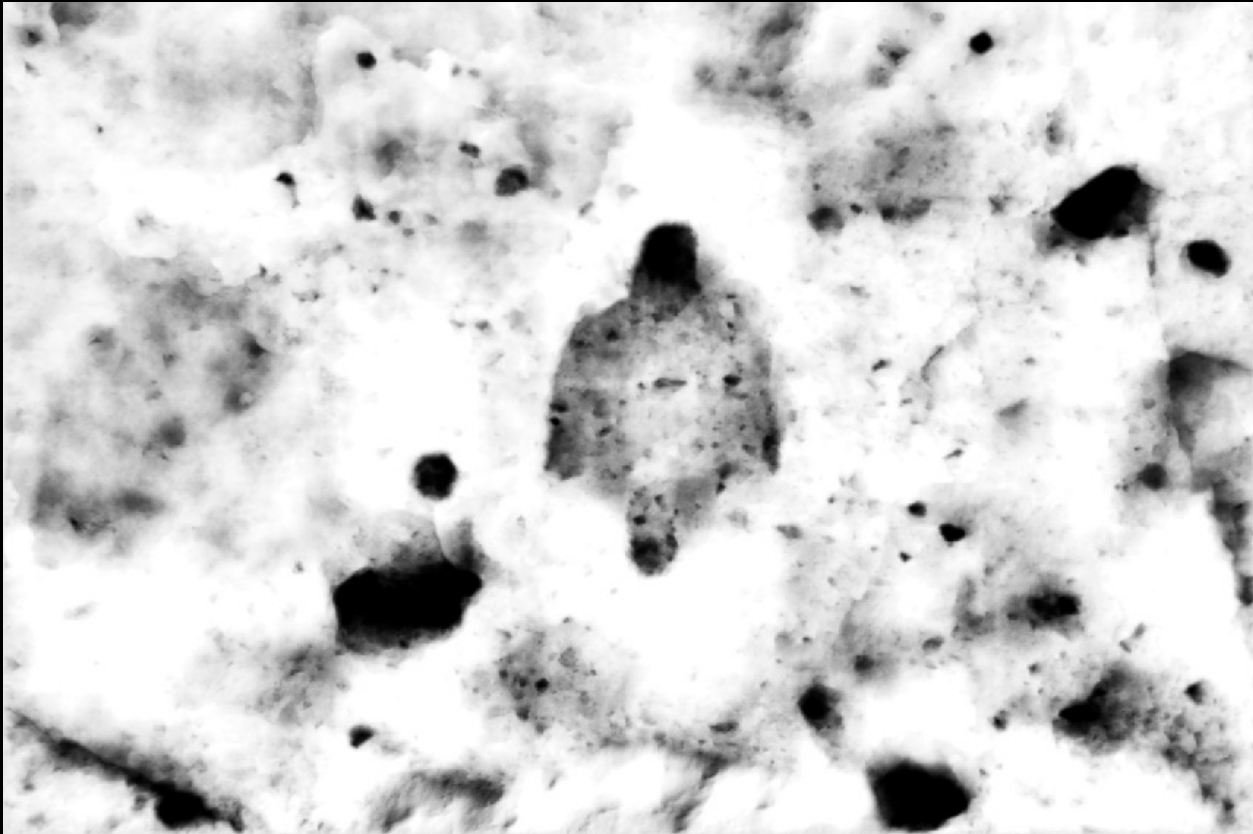
Latest achievements: automated sign

- Other result



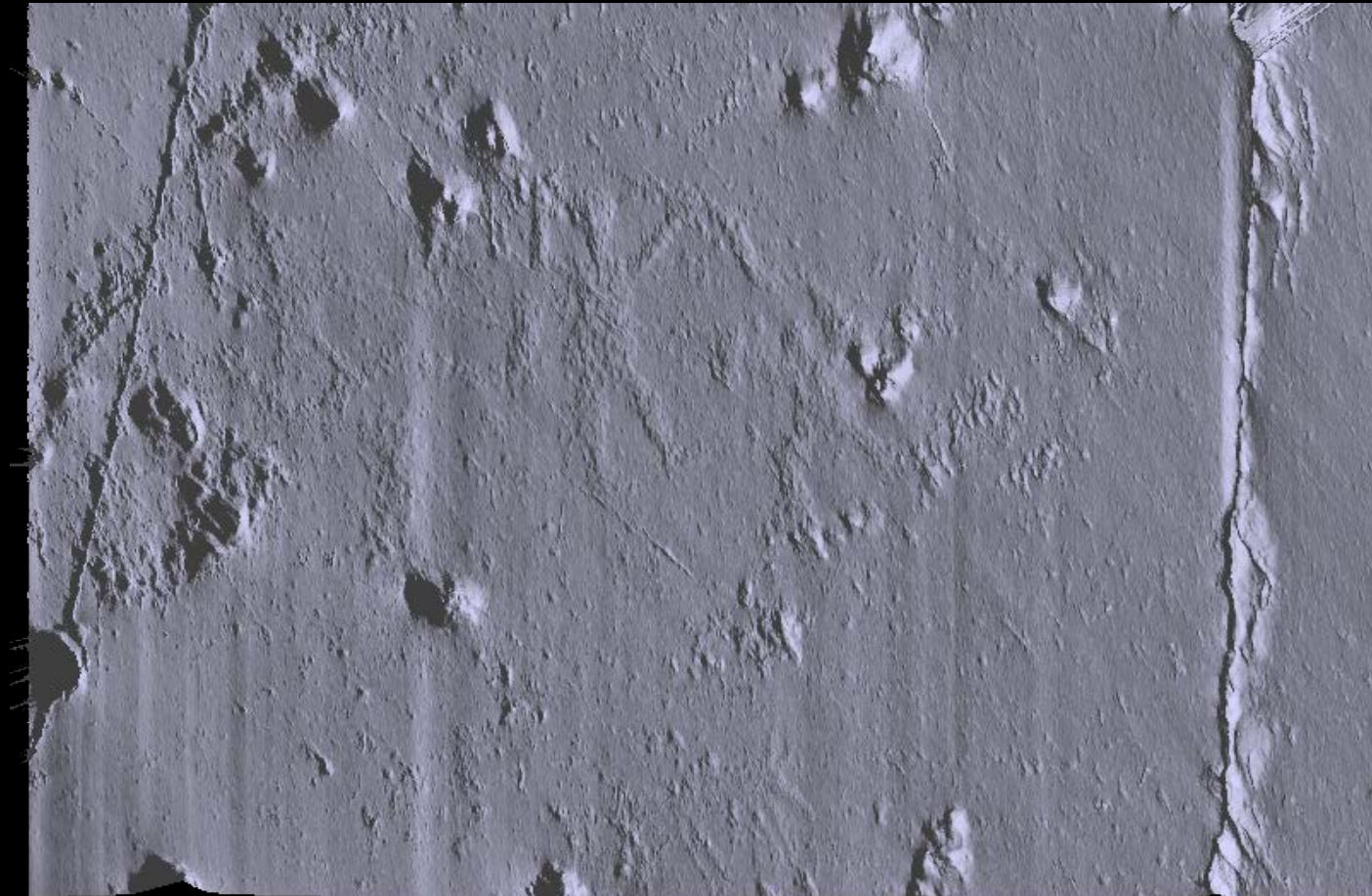
Latest achievements: automated sign

- Other result



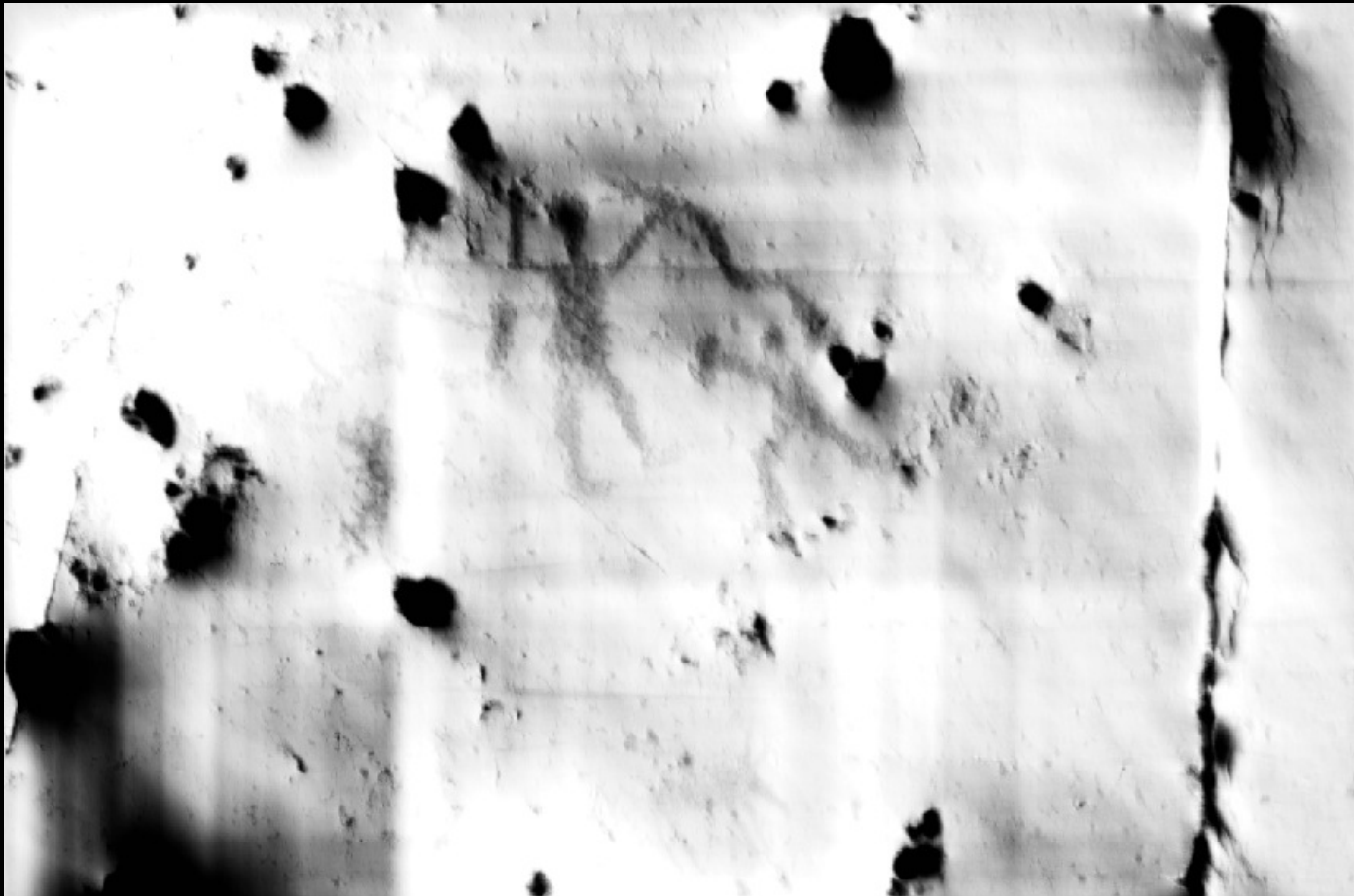
Latest achievements: automated sign

- Other result



Latest achievements: automated sign

- Other results



Conclusions

Photometric Stereo is:

- Fast
- Cheap
- Effective
- Robust

But the best way is to see how it works