

Image Reconstruction (Comparisons)

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Adobe Photoshop

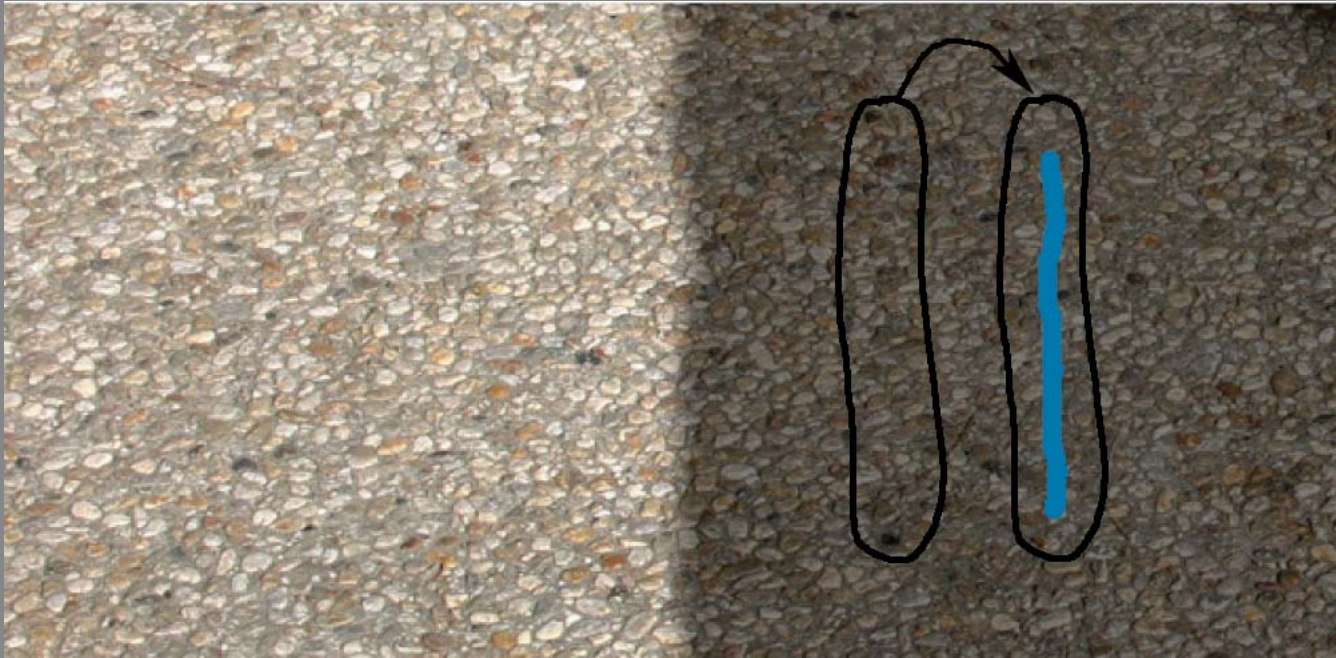
State of the art in Scratch Removal

- Inpainting (2000)
- Poisson Image Editing (2003)
“Poisson Cloning/Blending”
same as Photoshop Healing Brush (2002)

Original



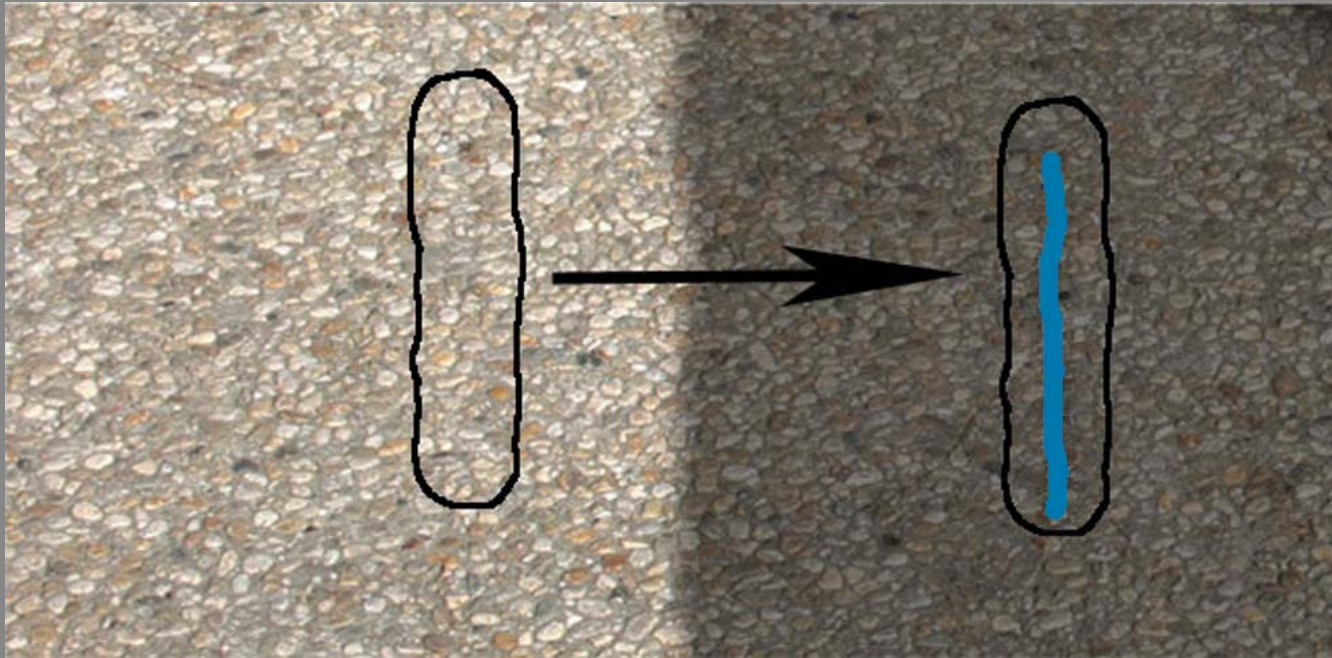
Selection to clone



Poisson Cloning



New selection to clone

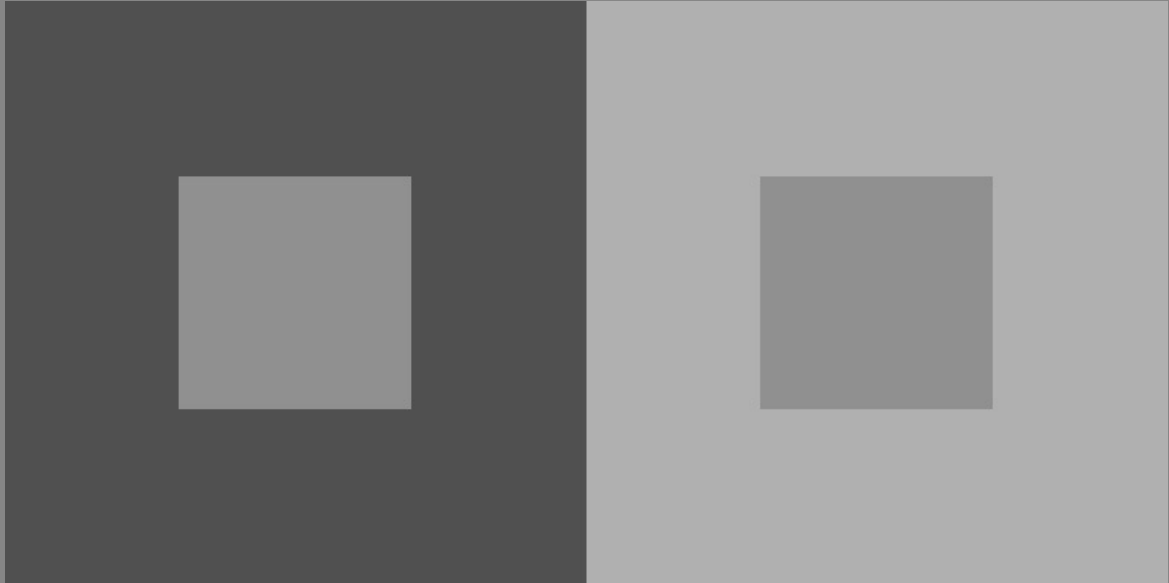


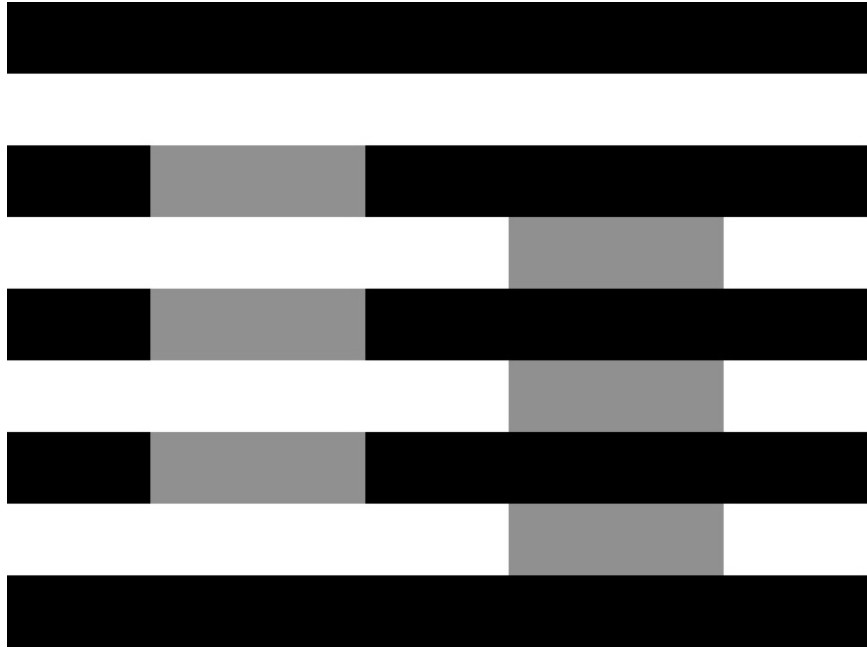
Poisson Cloning

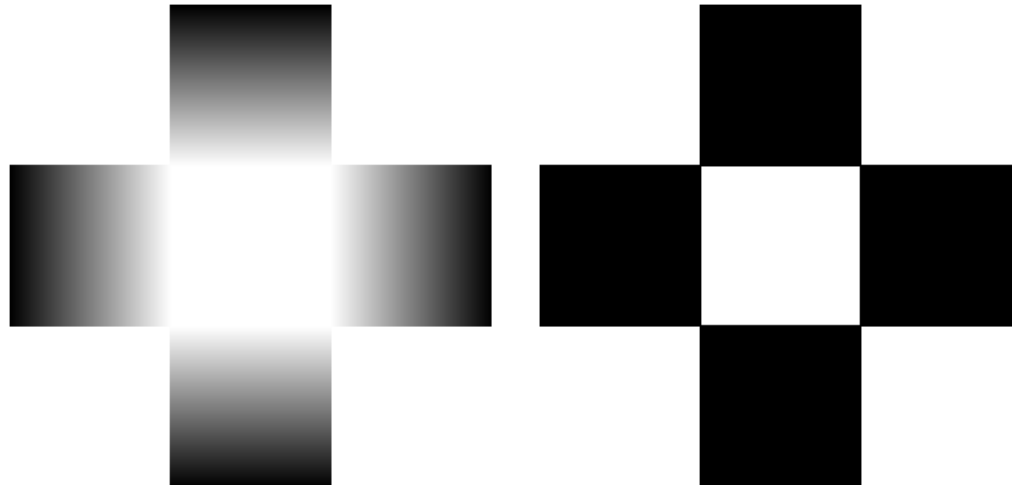


Retina / Cortex Adaptation to Illumination

- The image is *just a record* of pixel values.
- We do not see pixel values directly. *Adaptation*.
- What we see is *an illusion* generated from the above record through internal adaptation of the visual system.







Thanks to Jan Koenderink

Covariant Derivative = Perceptual Derivative

$$\frac{\partial}{\partial x} \rightarrow \frac{\partial}{\partial x} + A_x(x, y)$$

$$\frac{\partial}{\partial y} \rightarrow \frac{\partial}{\partial y} + A_y(x, y)$$

Our covariant Laplace equation:

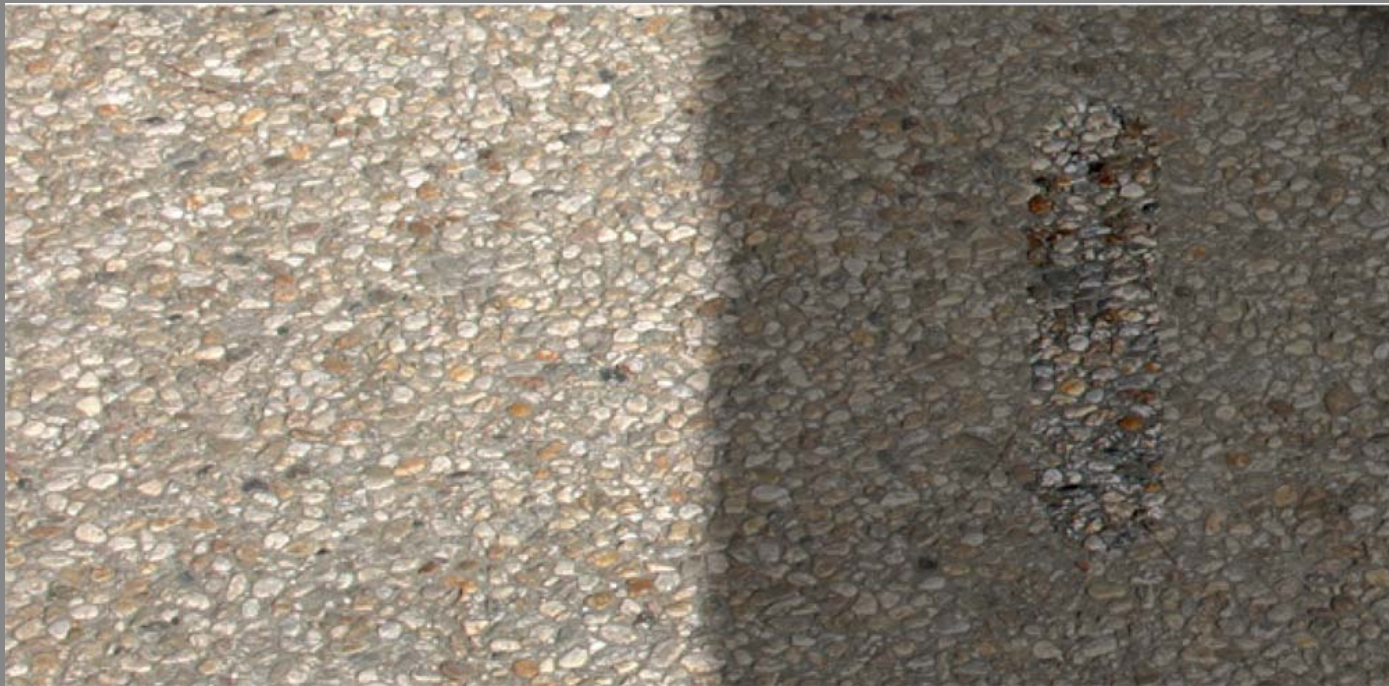
$$\frac{\Delta f}{f} - 2 \frac{\text{grad} f \cdot \text{grad} g}{f g} - \frac{\Delta g}{g} + 2 \frac{(\text{grad} g) \cdot (\text{grad} g)}{g^2} = 0$$

Compare this to **Poisson equation:**

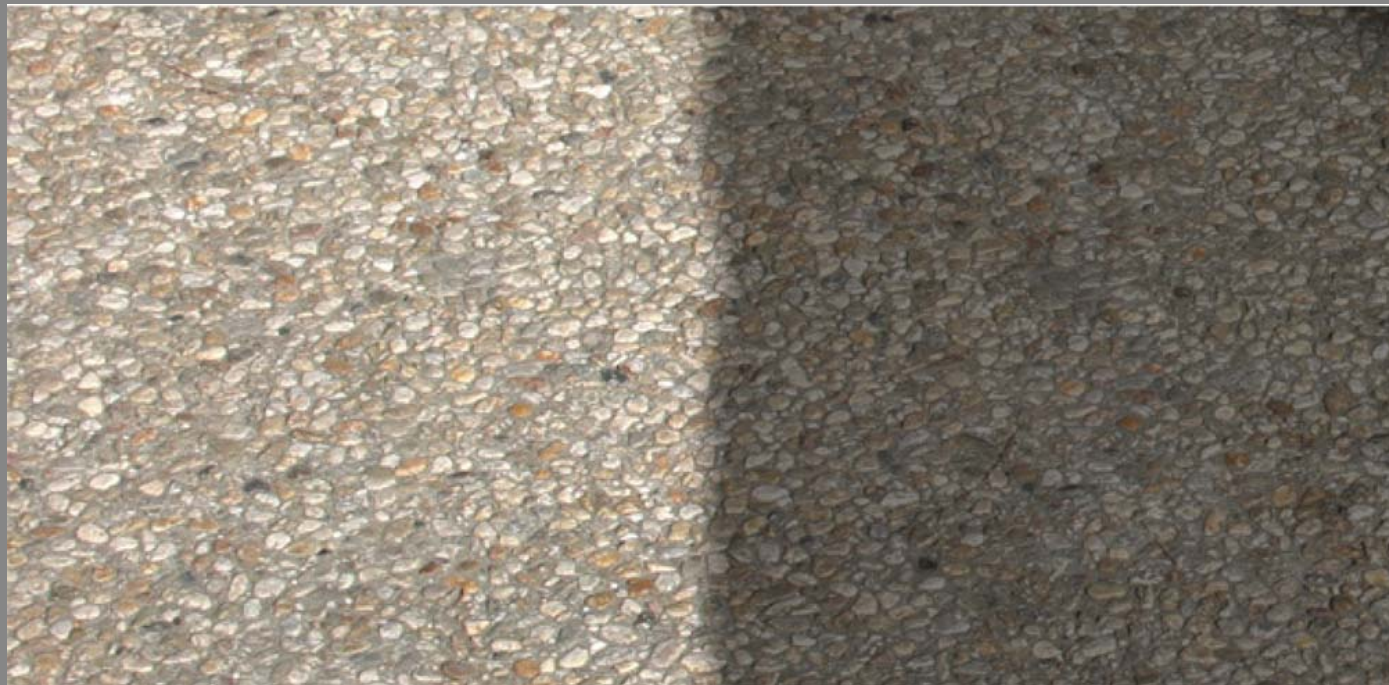
$$\Delta f(x,y) = \Delta g(x,y)$$

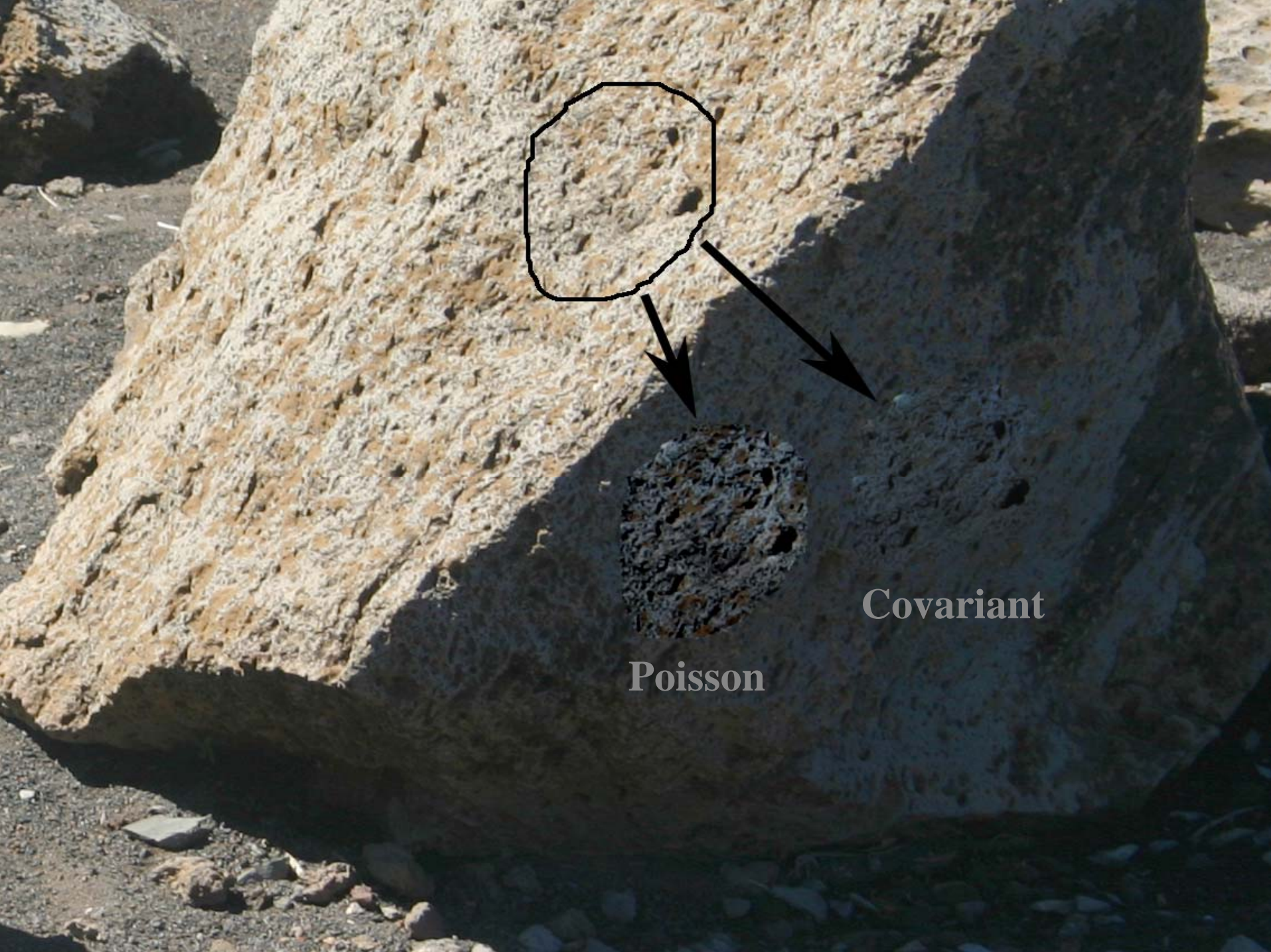
Both define gradient domain cloning. Which one is better?

**Poisson
cloning**



**Covariant
cloning**





Covariant

Poisson

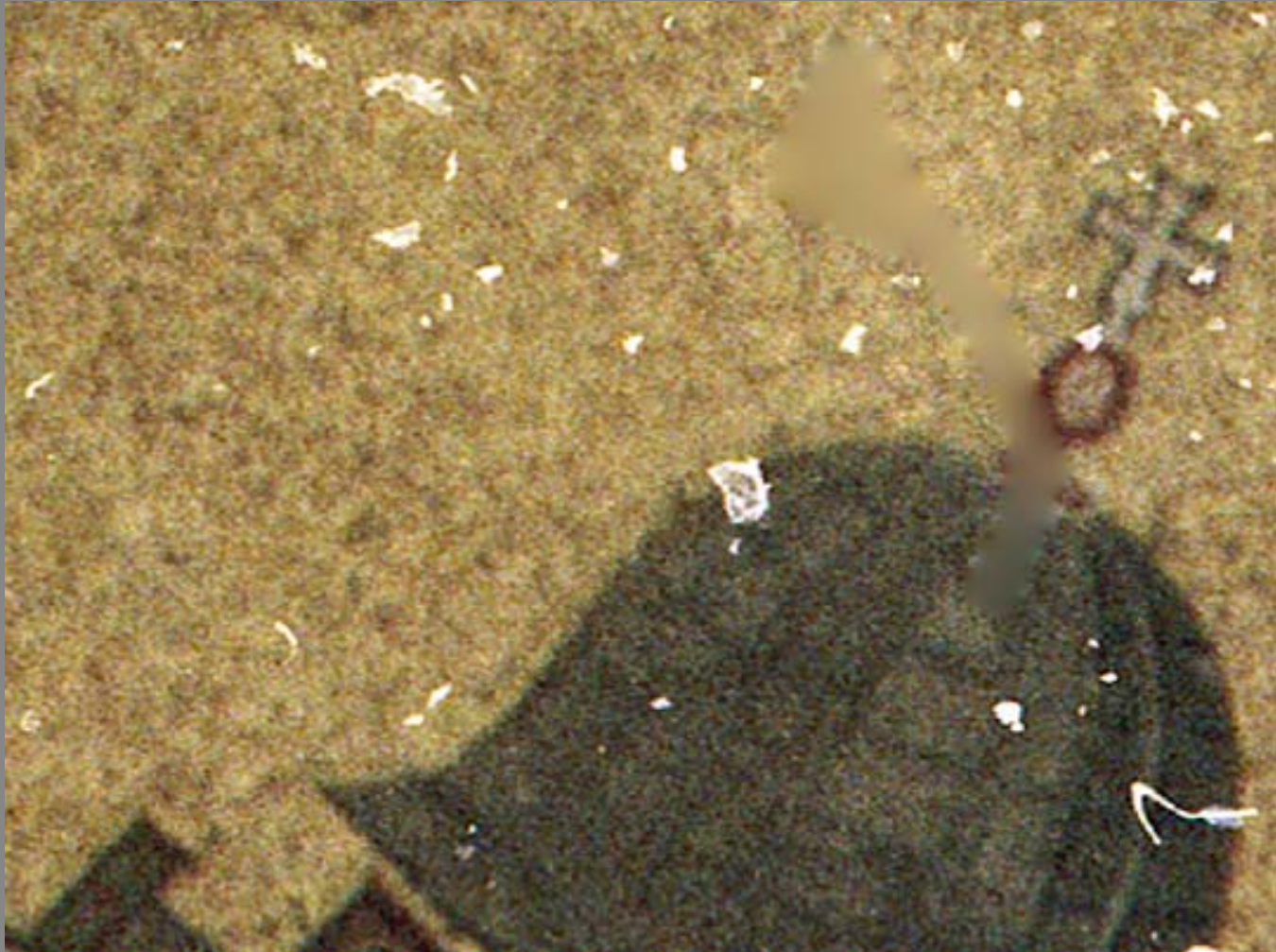
Reconstruction Examples:



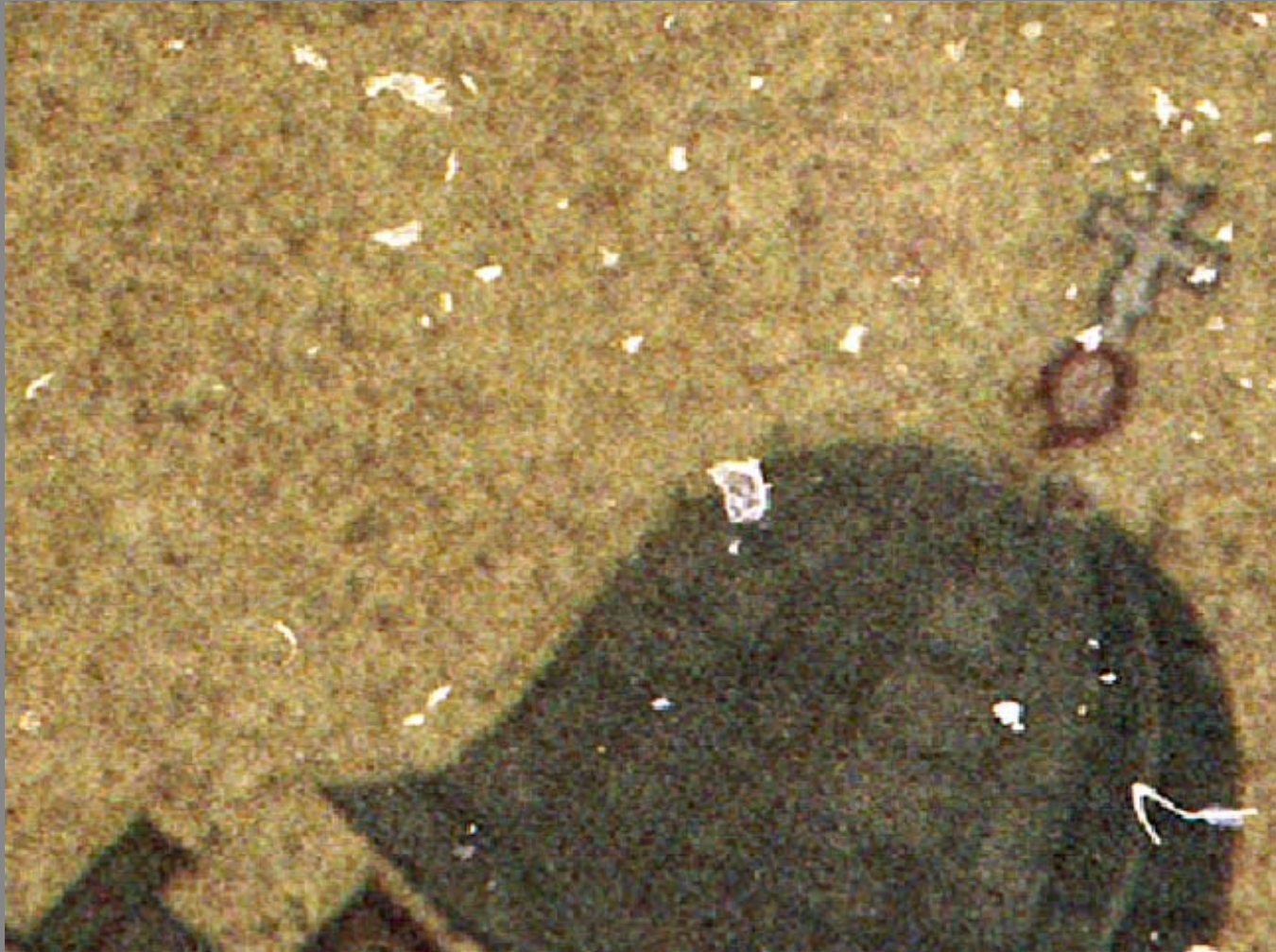
Original Damaged Area



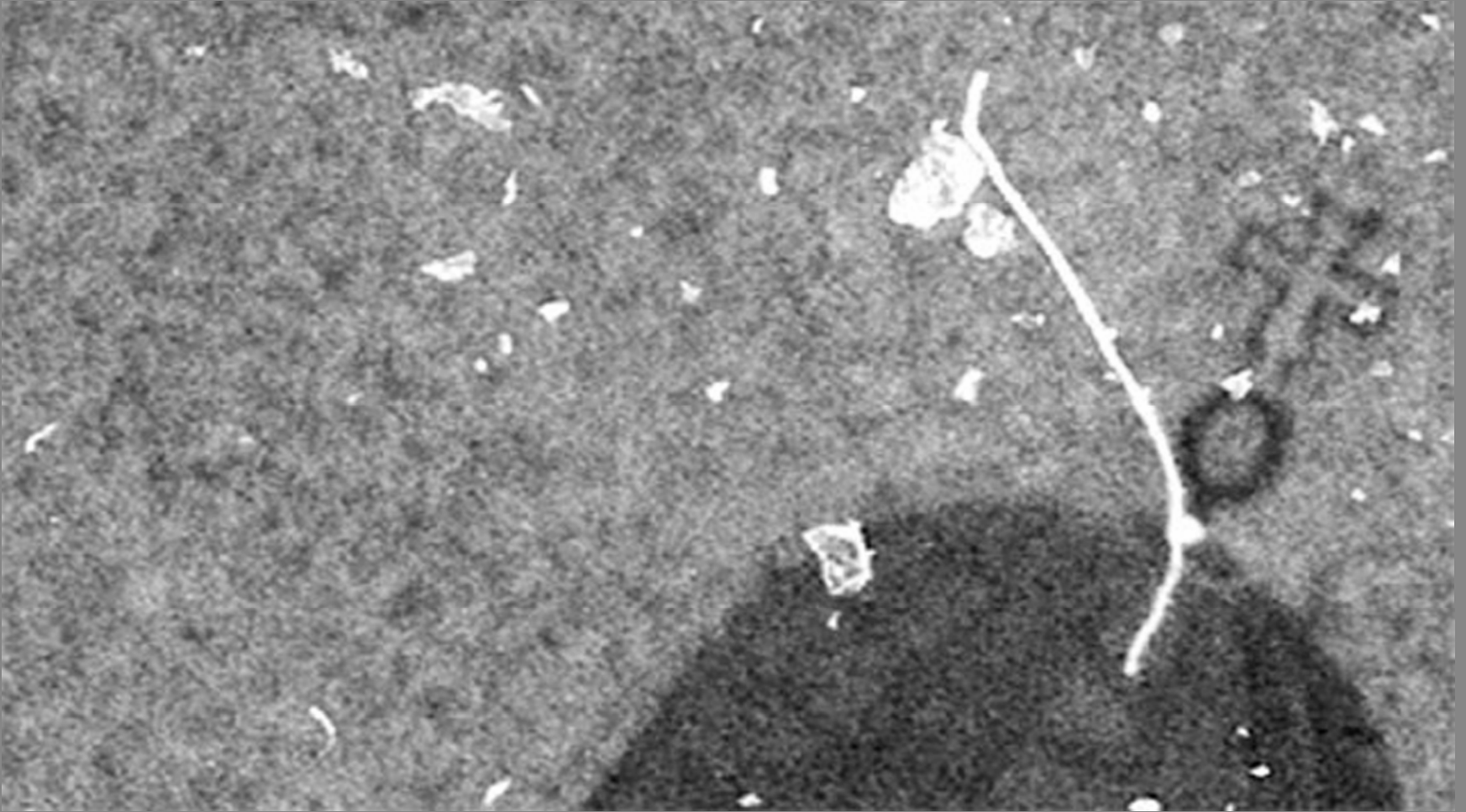
Laplace



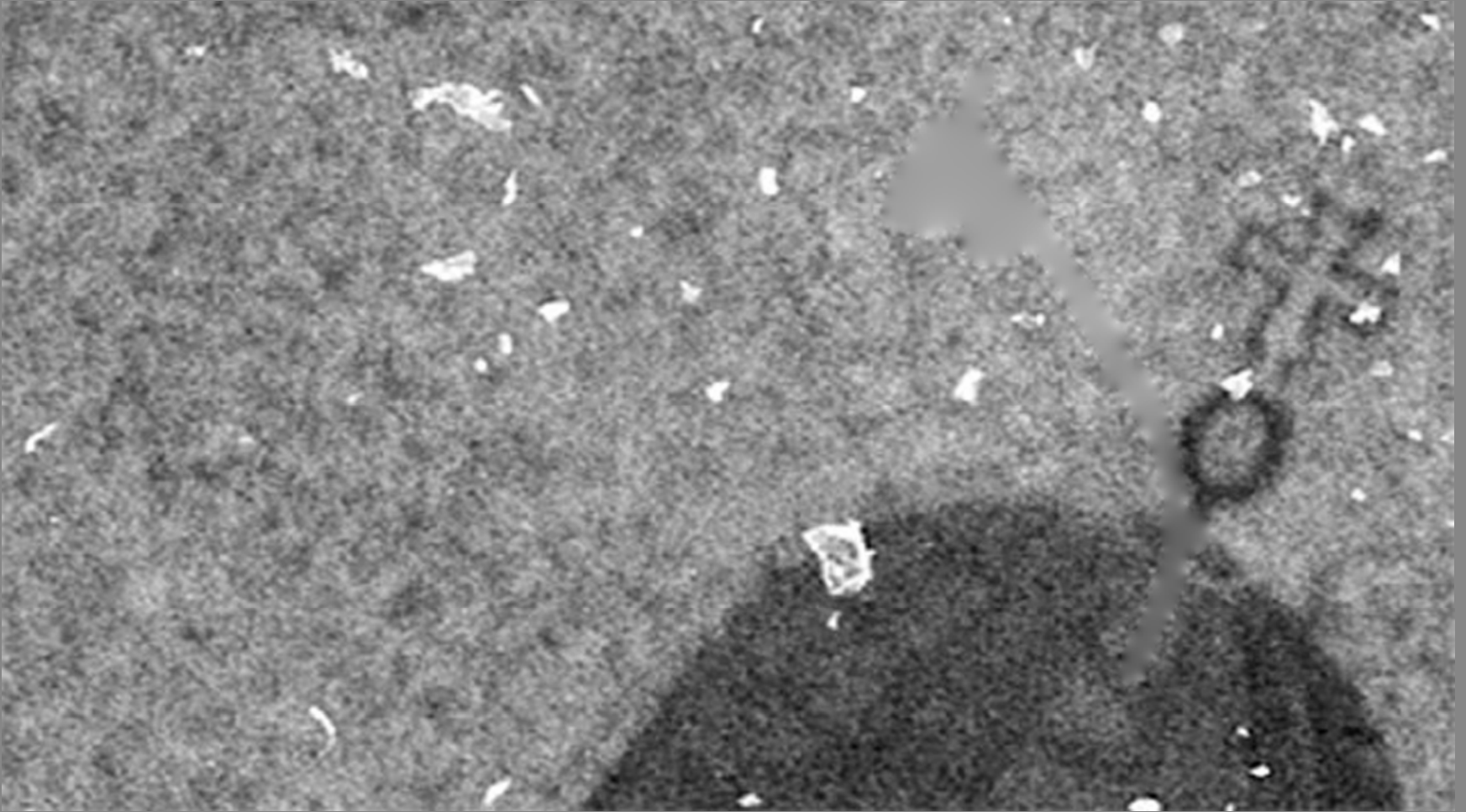
Poisson



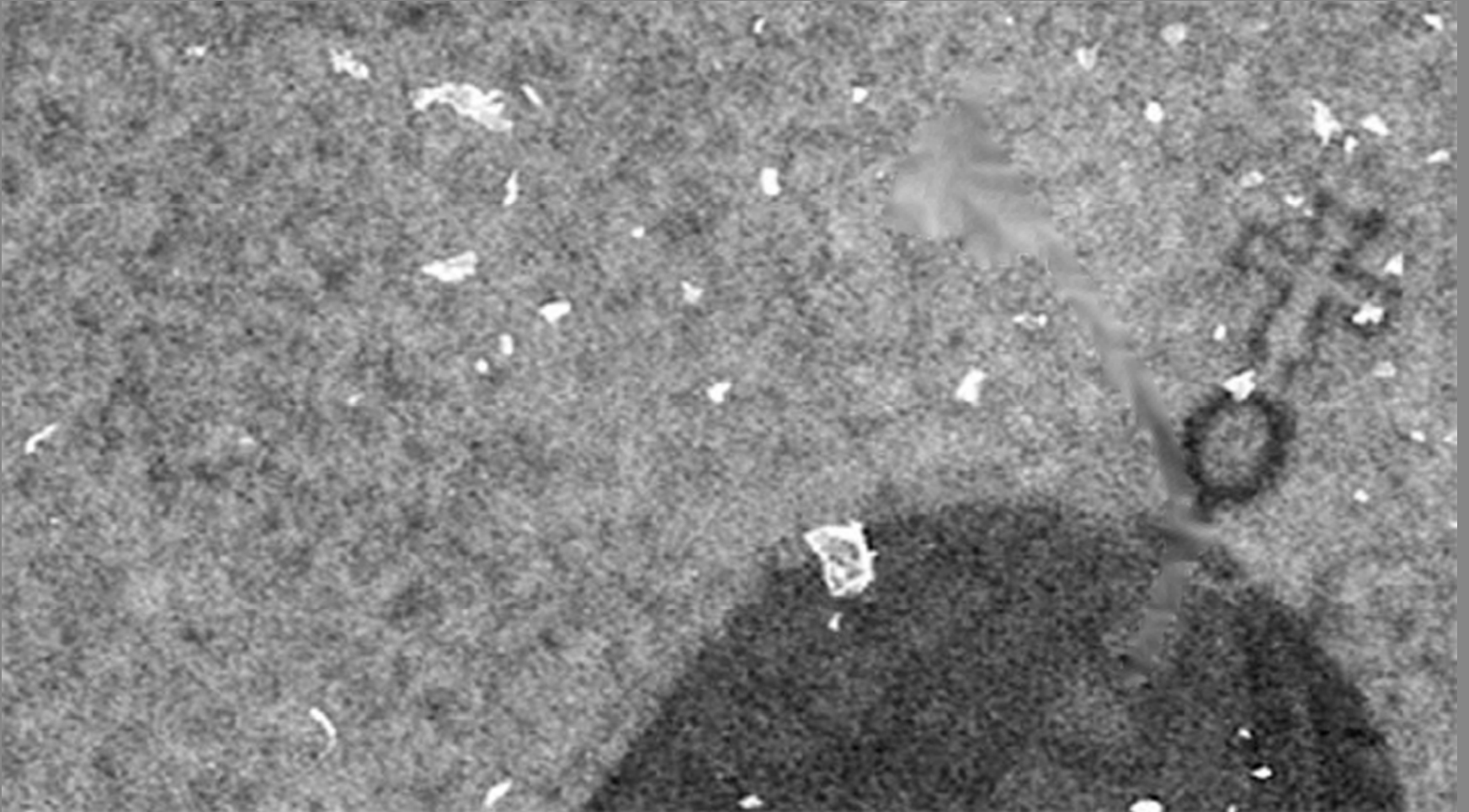
Original



Laplace

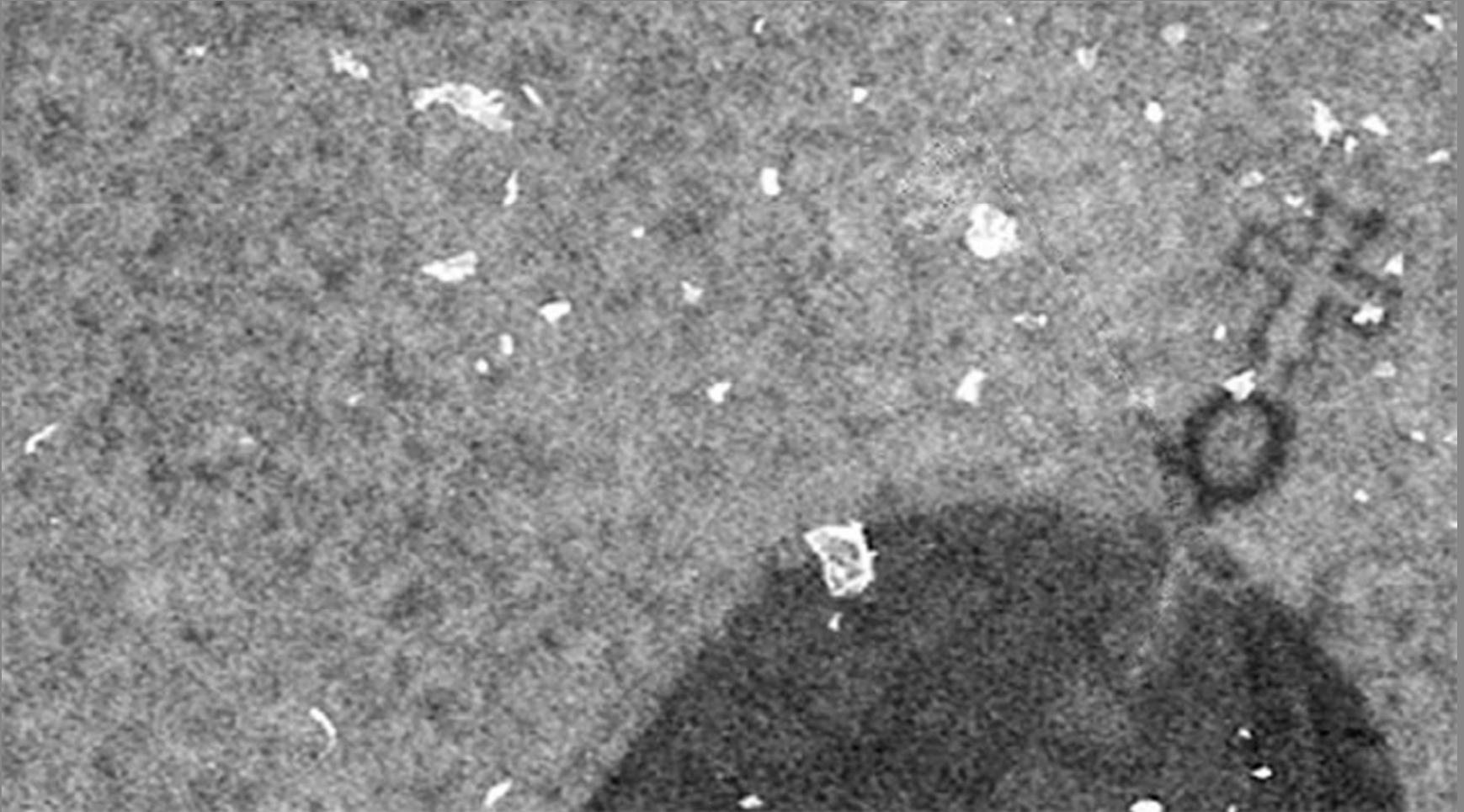


Inpainting



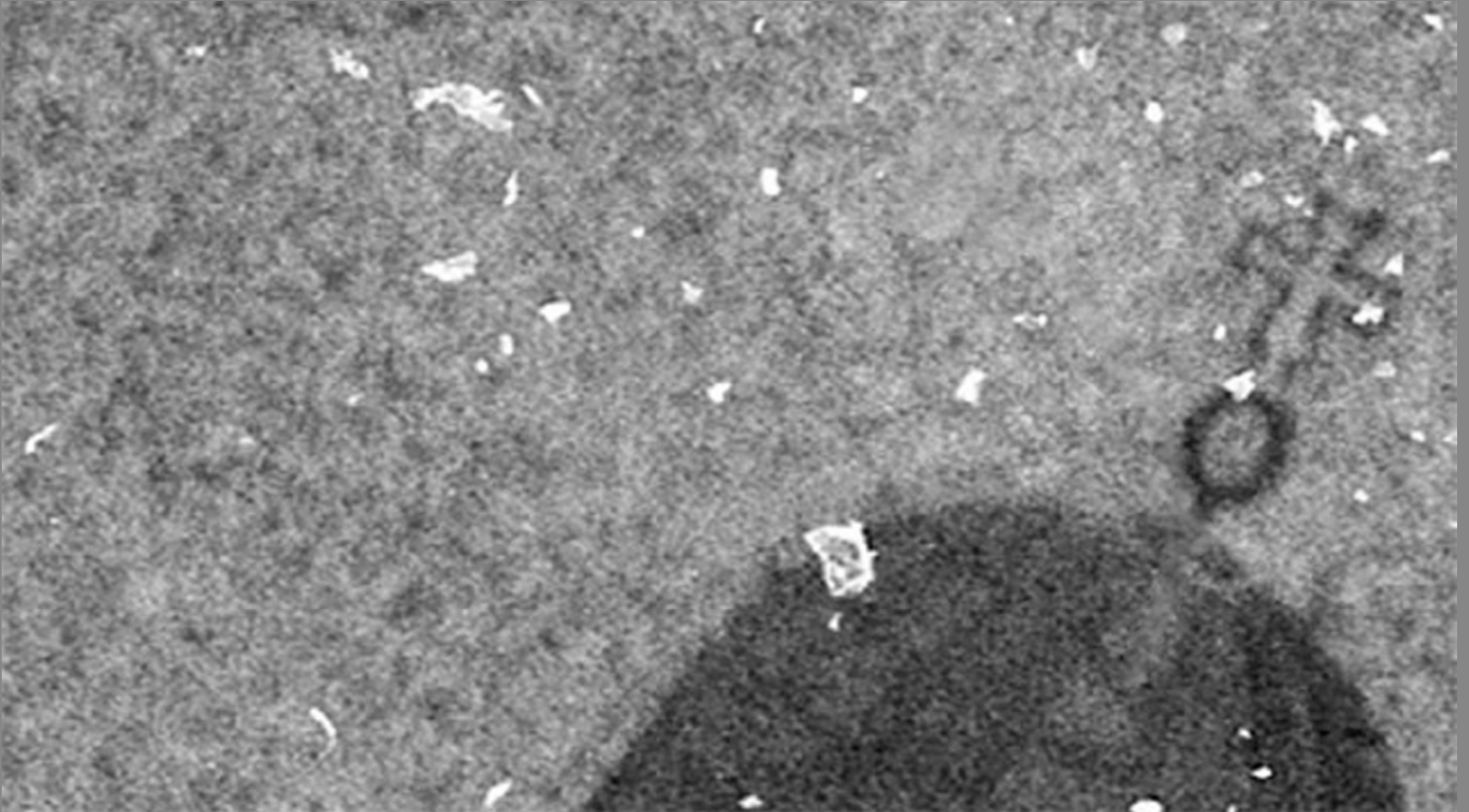
Thanks to Guillermo Sapiro and Kedar Patwardhan

“Structure and Texture” Inpainting

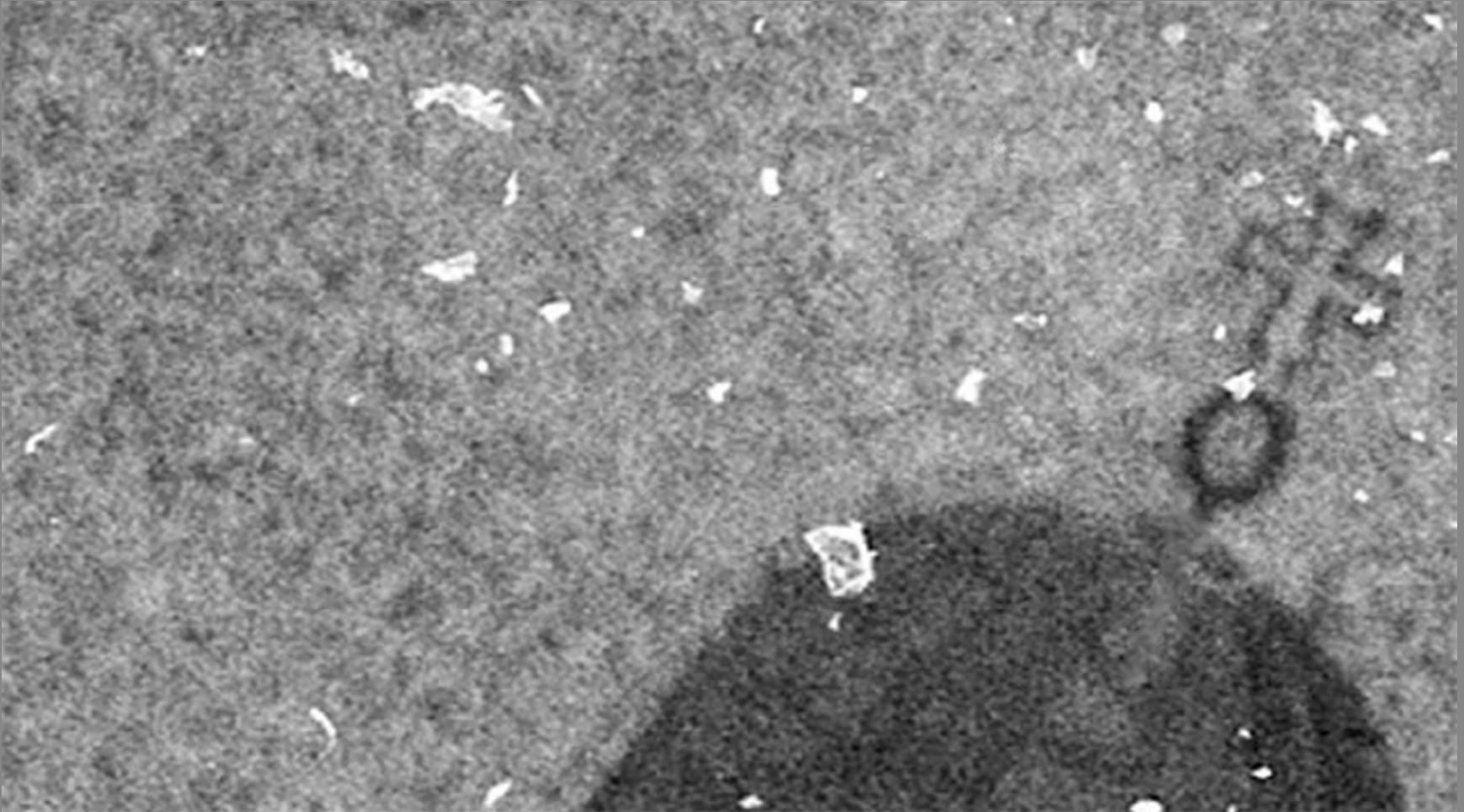


Bertalmio – Vese – Sapiro – Osher method

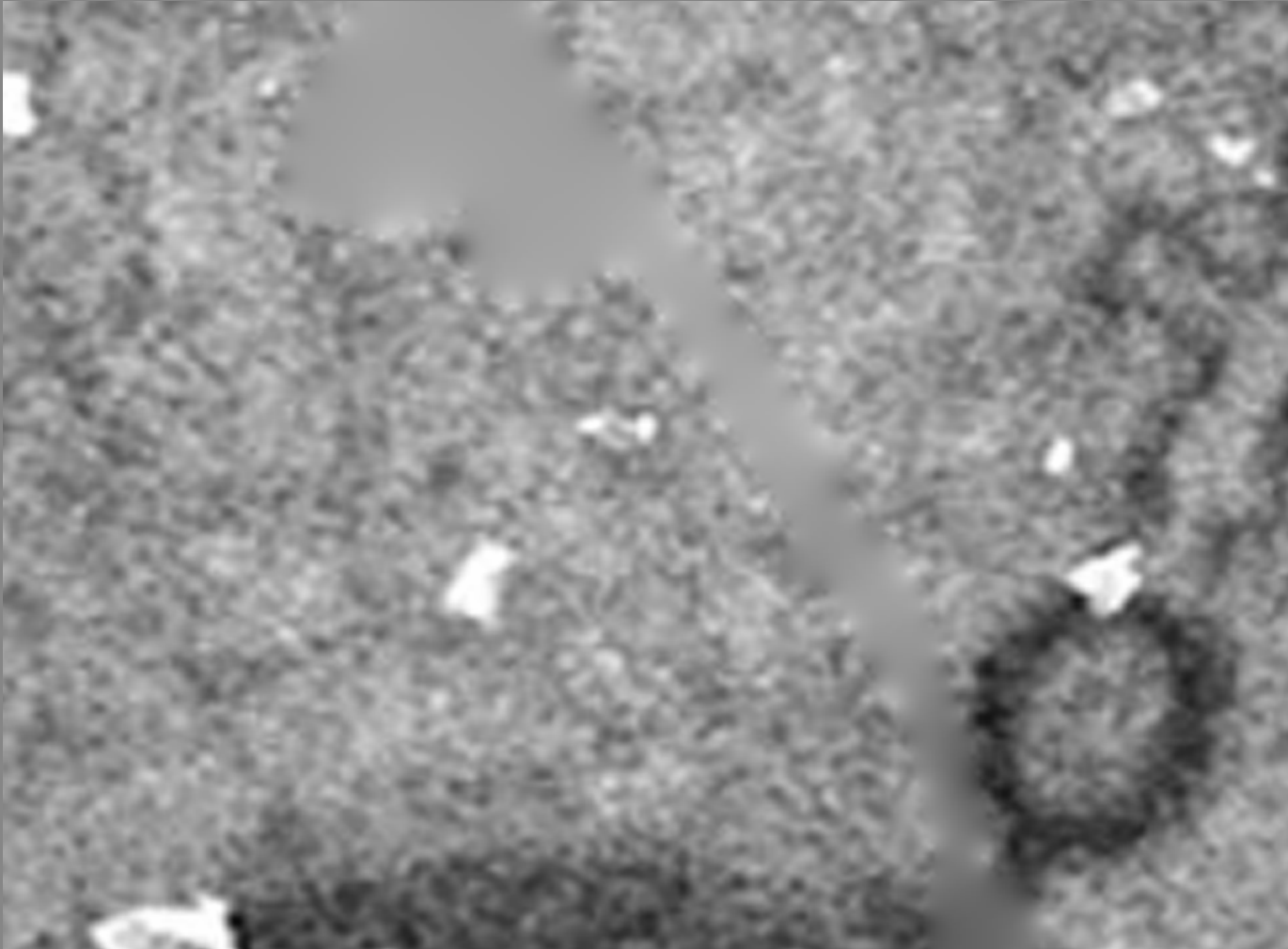
Poisson



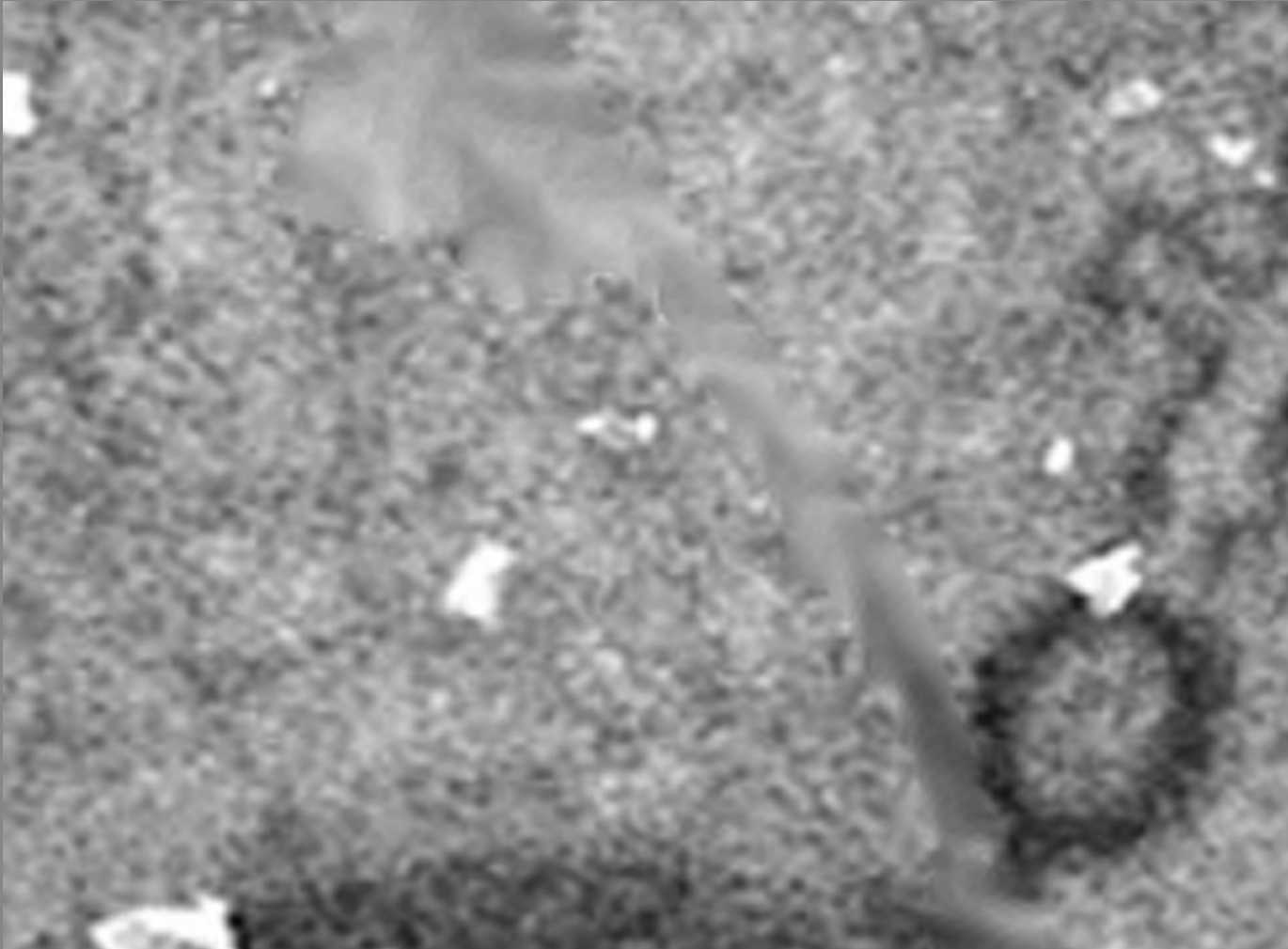
Covariant



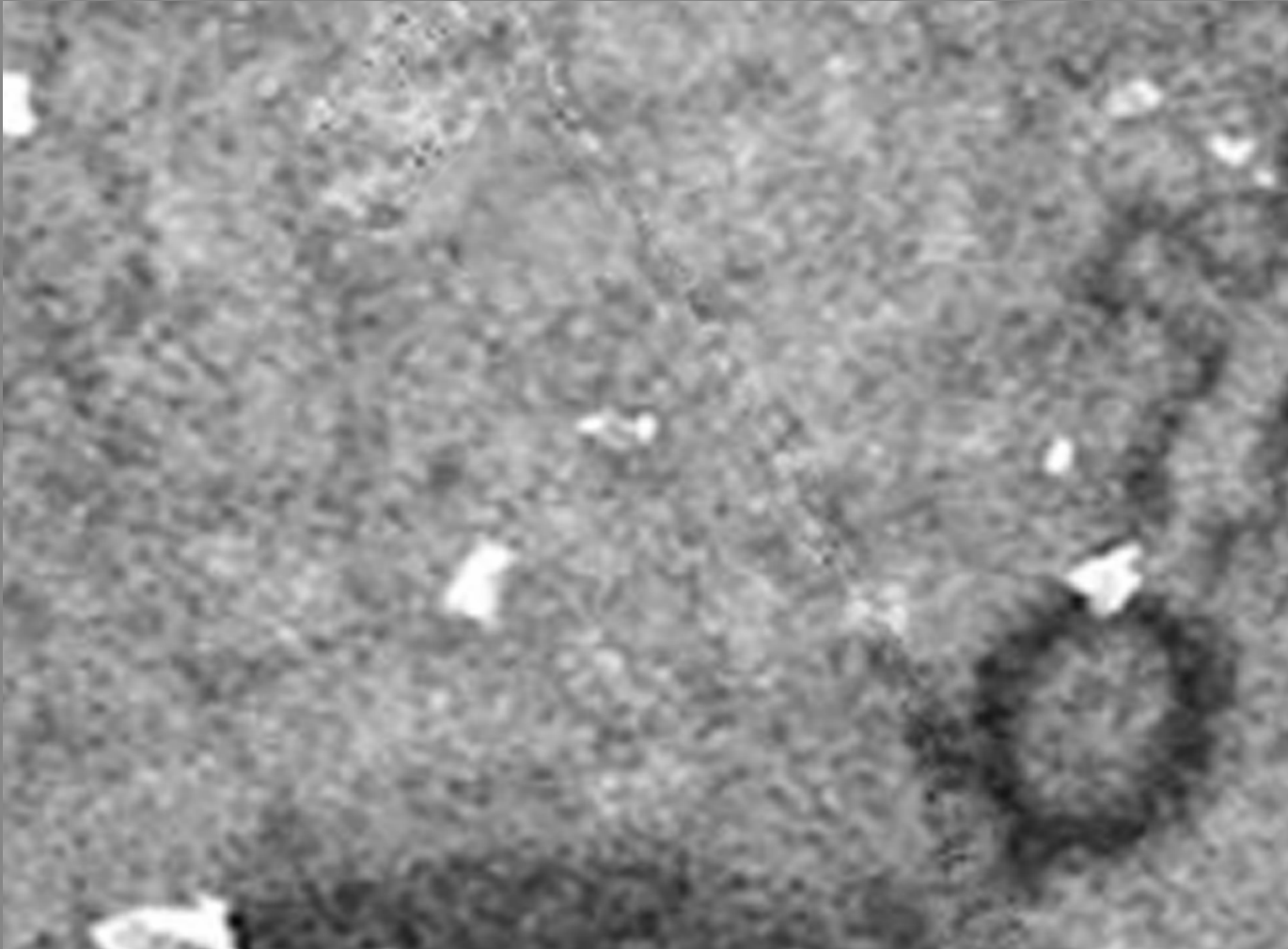
Laplace



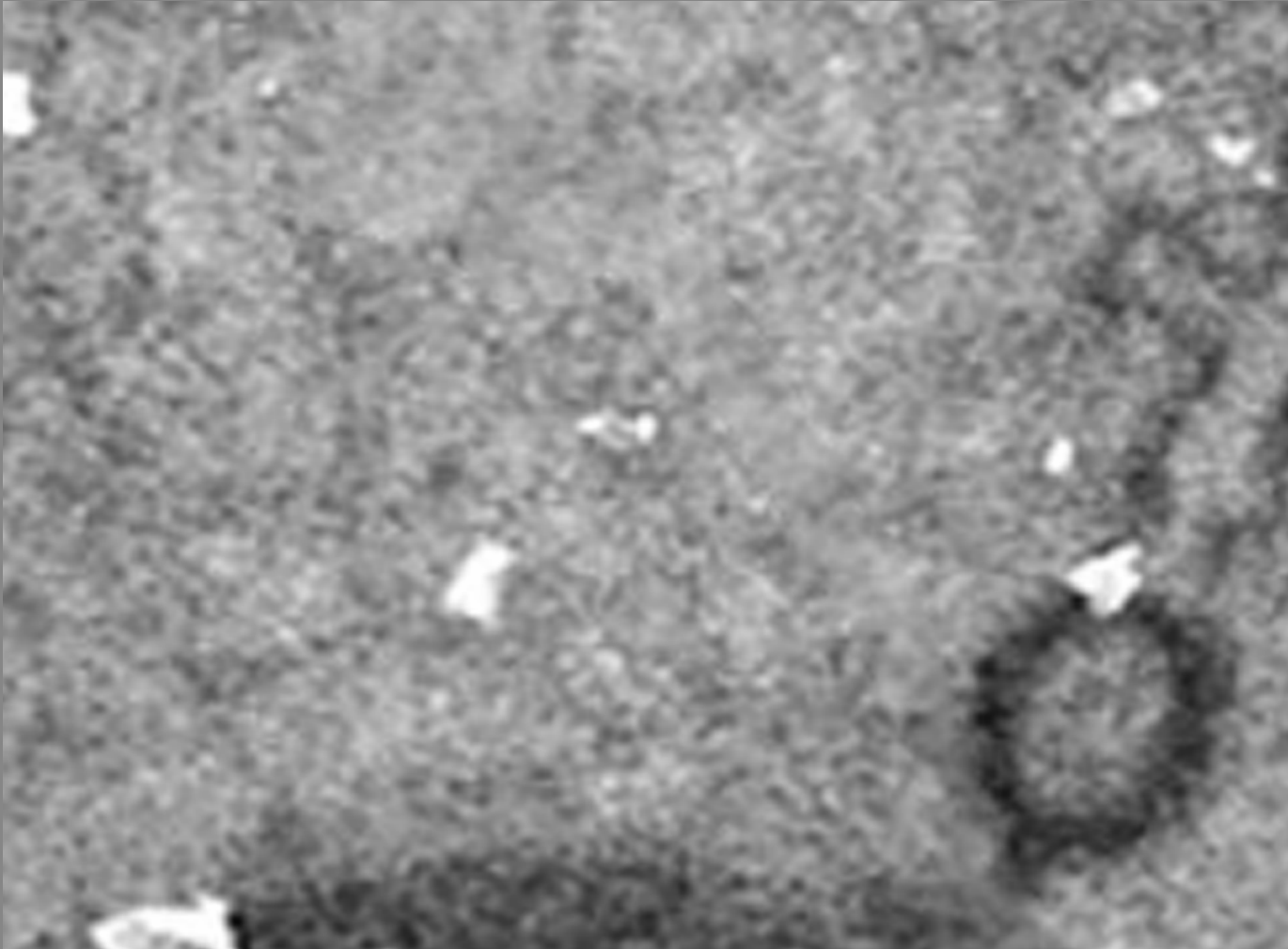
Inpainting



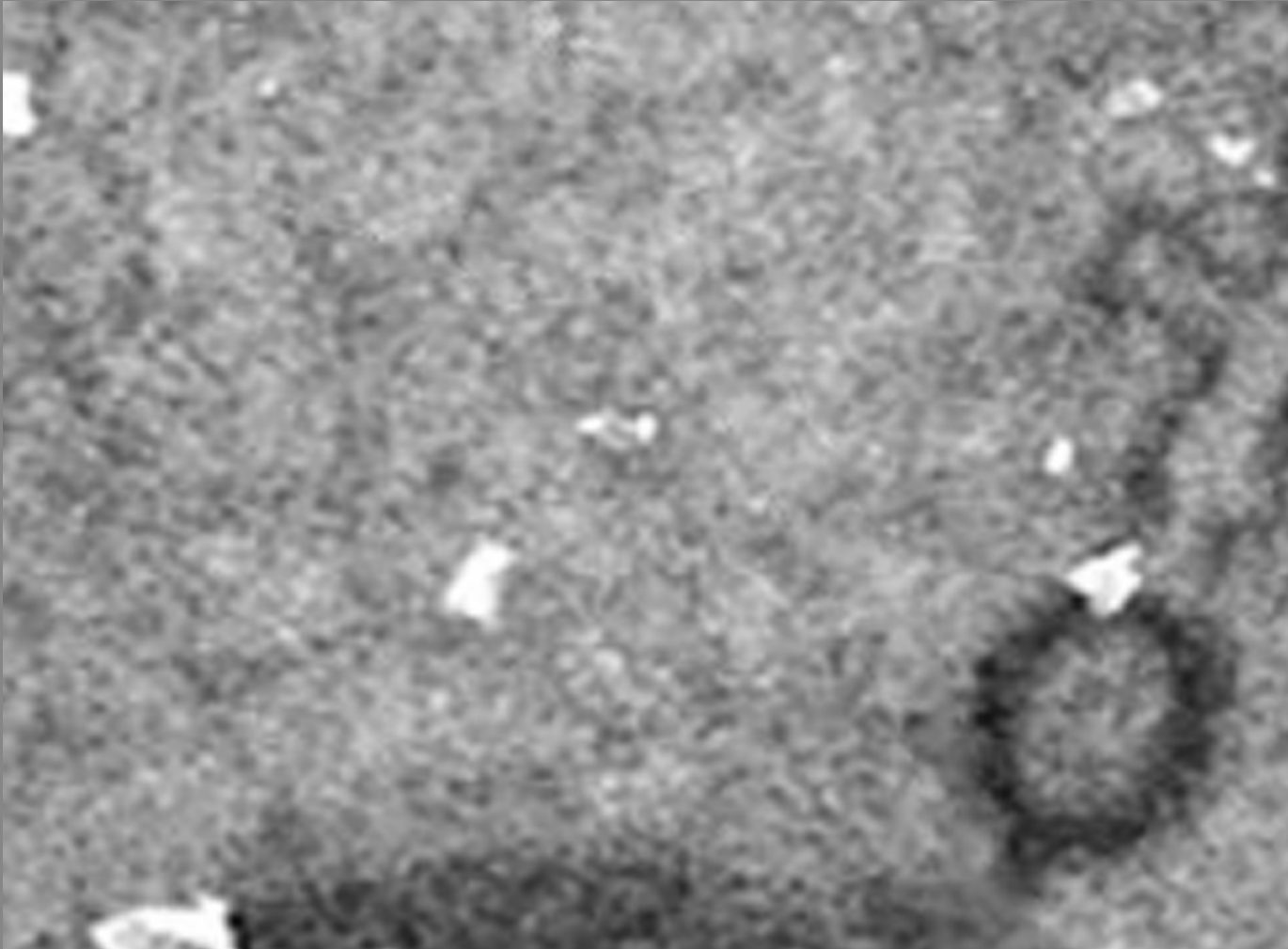
Structure and Texture Inpainting



Poisson



Covariant



Conclusion:

The covariant (adapted) derivative provides a way to perform *perceptual image processing* according to how images are *perceived* as opposed to - how images are *recorded* by a camera. It explicitly takes into account changes of retina sensitivity due to adaptation to illumination conditions.

Covariant (perceived) gradient domain.

Scratch Removal is only one application.

Comparison of different reconstruction equations

Laplace $\Delta f = 0$

Poisson $\Delta f = \Delta g$

Directed diffusion $\frac{\Delta f}{f} - \frac{\Delta g}{g} = 0$

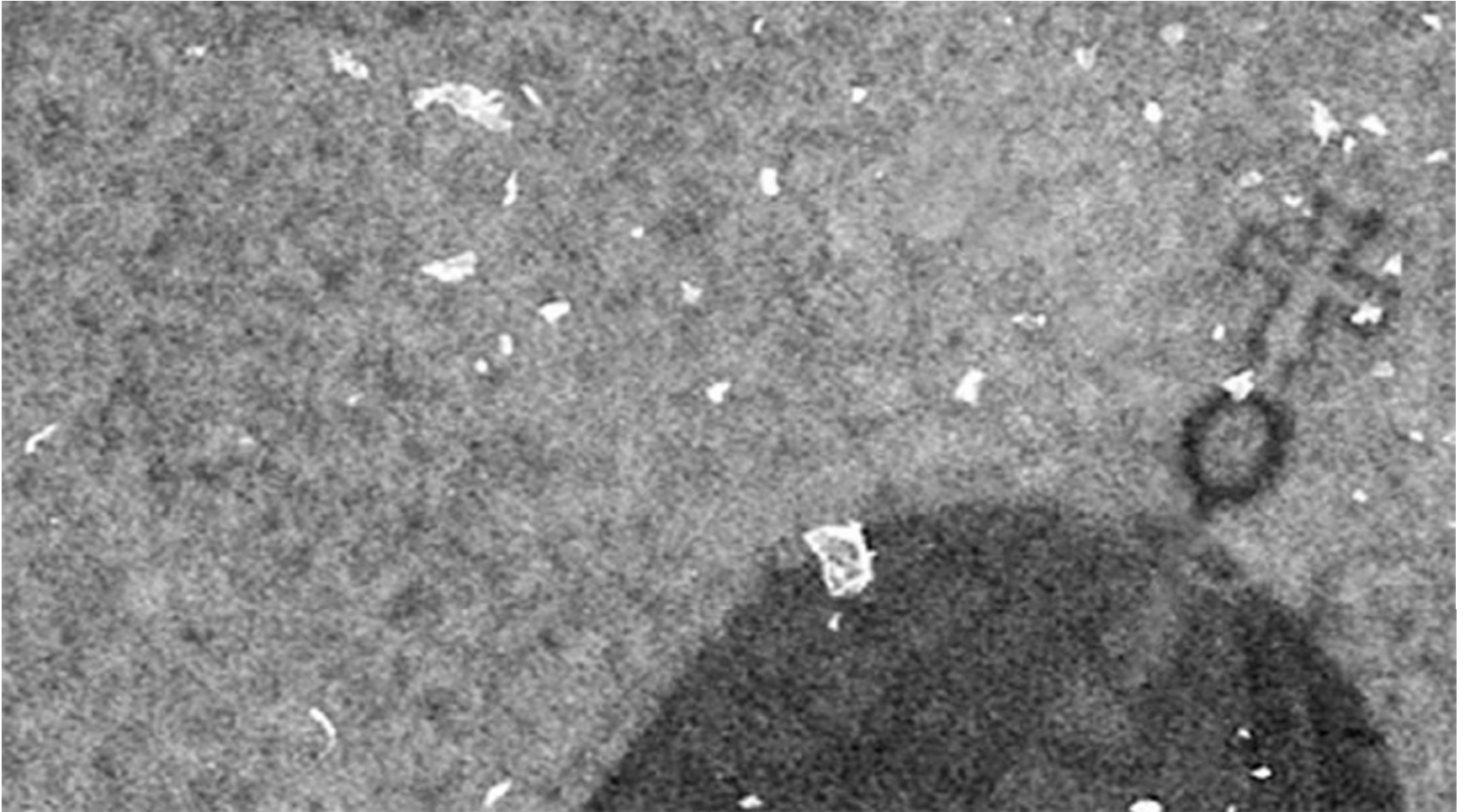
Logarithmic $\frac{\Delta f}{f} - \frac{(\text{grad} f)^2}{f^2} - \frac{\Delta g}{g} + \frac{(\text{grad} g)^2}{g^2} = 0$ $\Delta(\ln f - \ln g) = 0$

Covariant Laplace $\frac{\Delta f}{f} - 2 \frac{\text{grad} f}{f} \frac{\text{grad} g}{g} - \frac{\Delta g}{g} + 2 \frac{(\text{grad} g)^2}{g^2} = 0$ $\Delta \frac{f}{g} = 0$

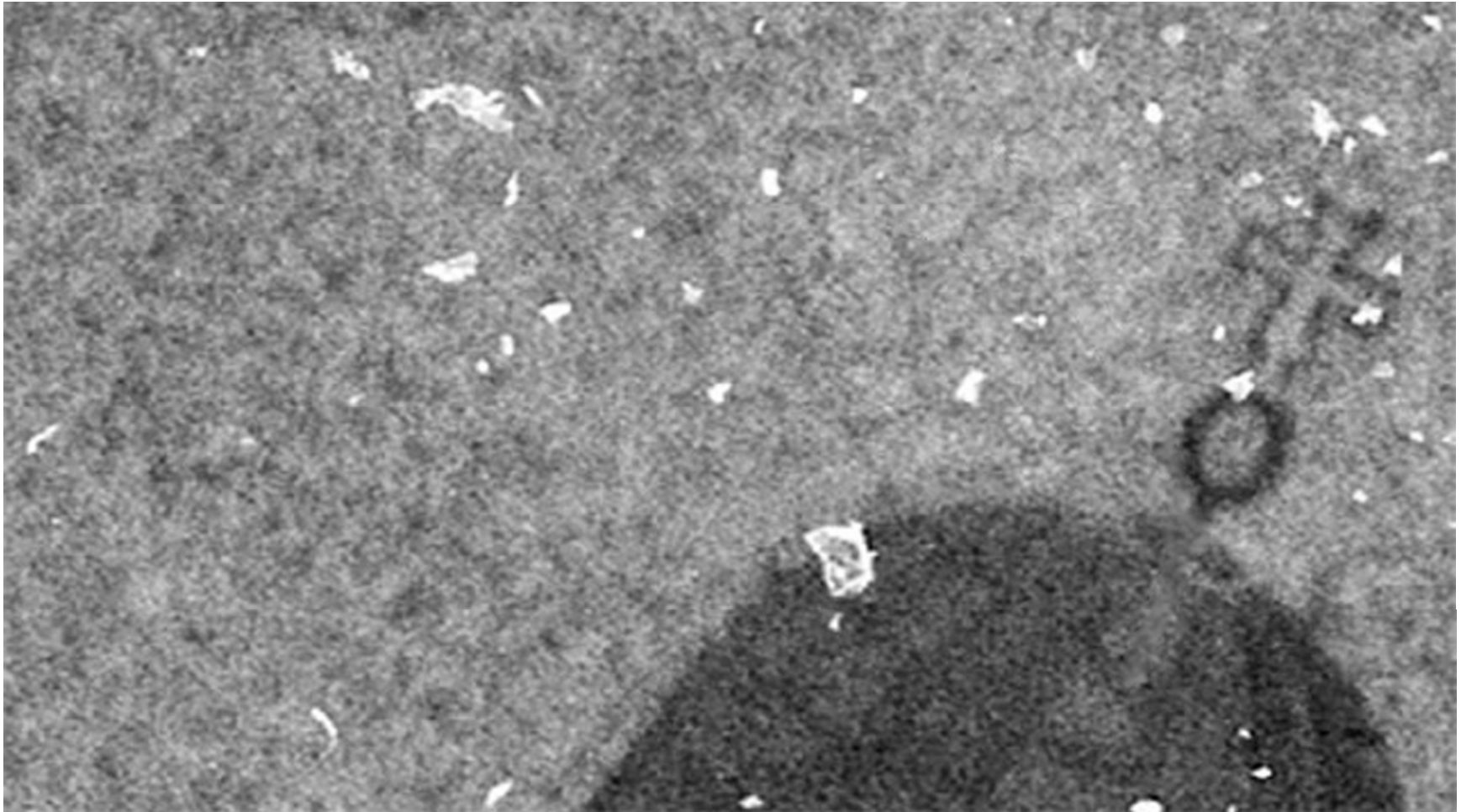
Inpainting $\nabla^\perp f \cdot \nabla \Delta f = 0$

Textured Inpainting *... too complex to write*

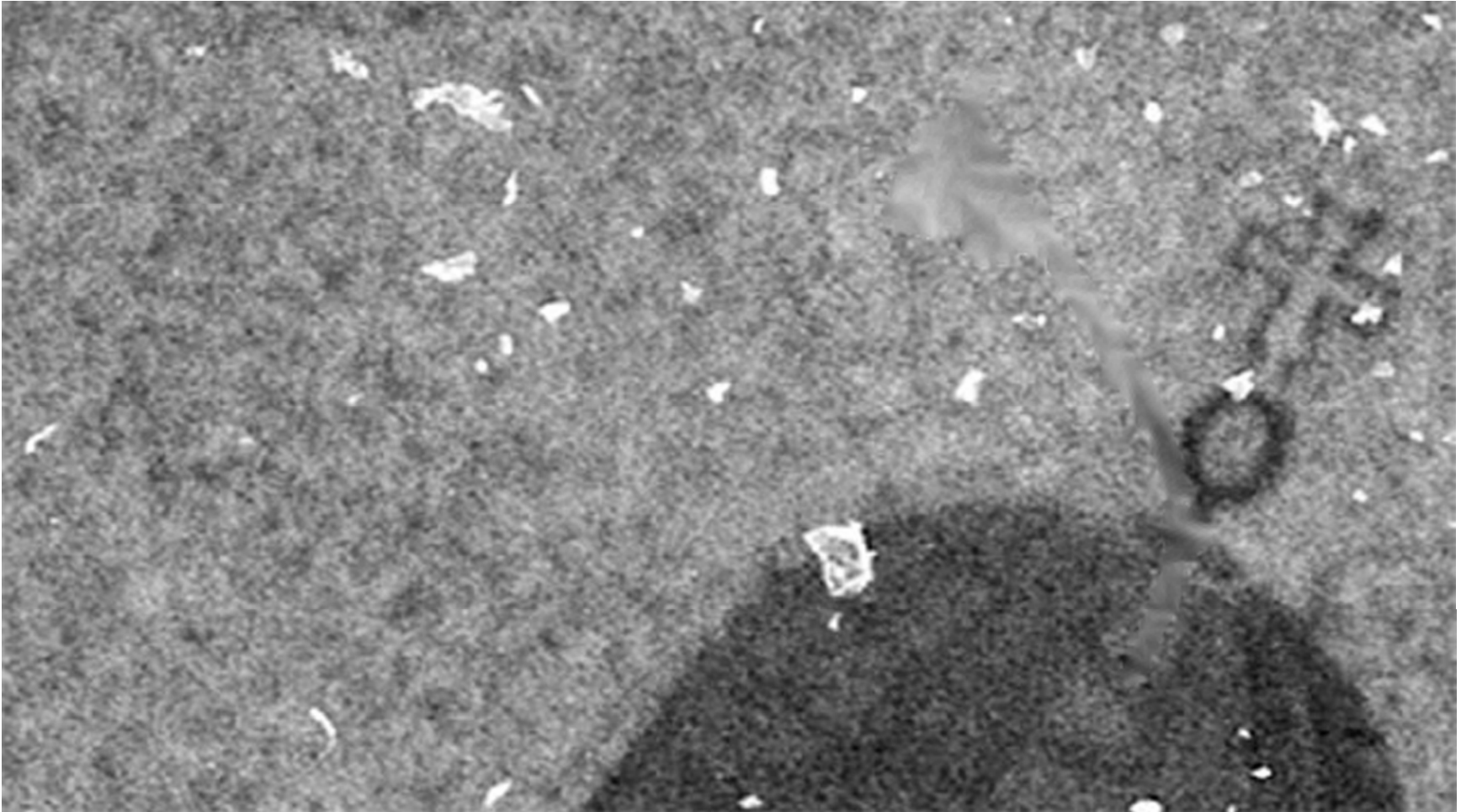
Poisson



Covariant Laplace

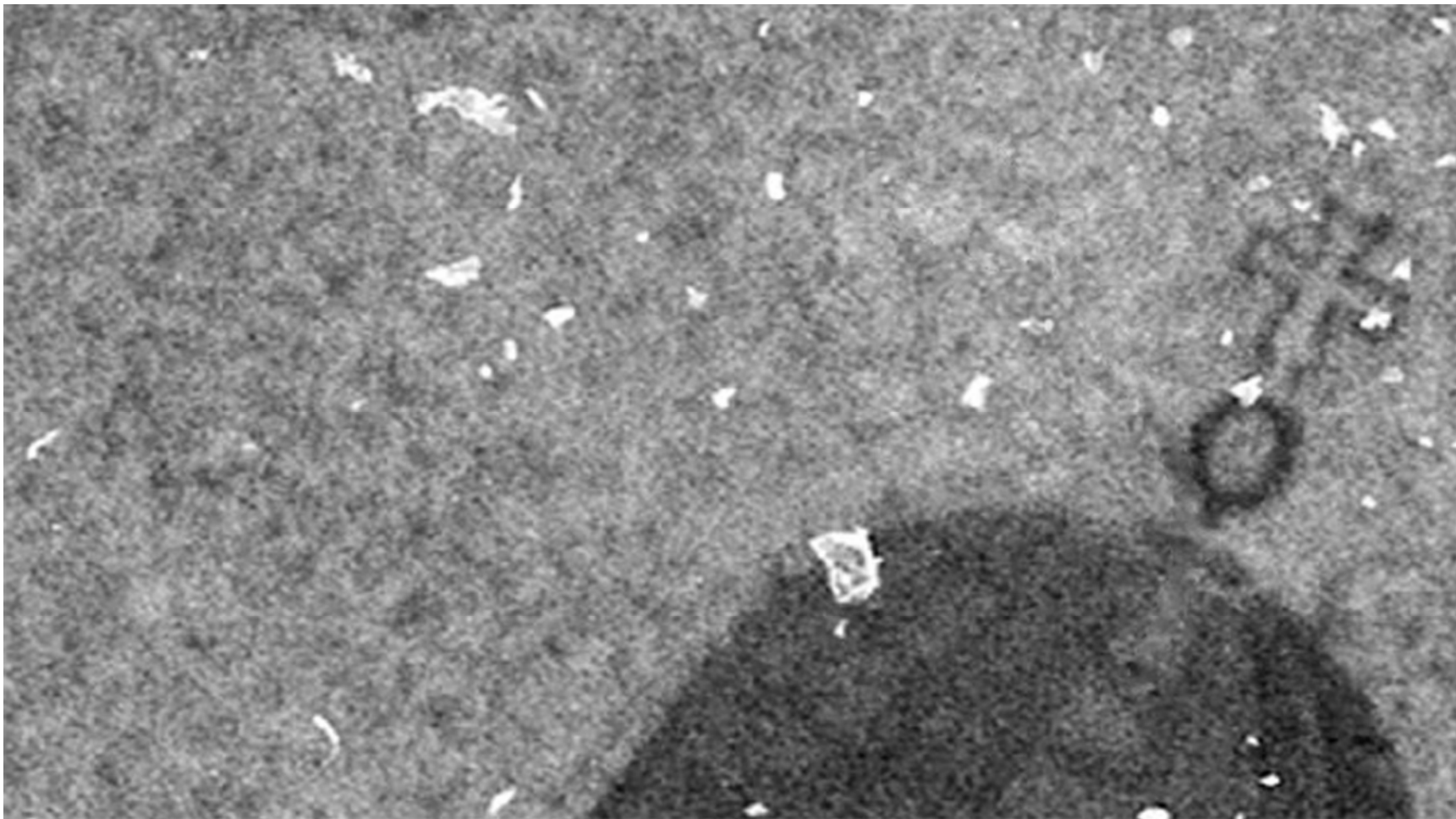


Inpainting



Thanks to Guillermo Sapiro and Kedar Patwardhan

Covariant Inpainting



Other experiments

Reconstruction is not just “scratch removal”















Conclusion:

The covariant (adapted) derivative provides a way to perform perceptual image processing according to how we see images as opposed to - how images are recorded by the camera.

HDR and reconstruction/healing are only 2 of the applications.