Development of measurement techniques by image processing for aerospace components inspection

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Supervisor	Prof. Gianluca Rossi

Curriculum	Mechanical Measurement for Engineering and Space
Event	Request of admission to the **third** year of the PhD Course

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Shearography Inspection

- Quantitative defect size and morphology characterization in aerospace composites: **code optimization and validation**

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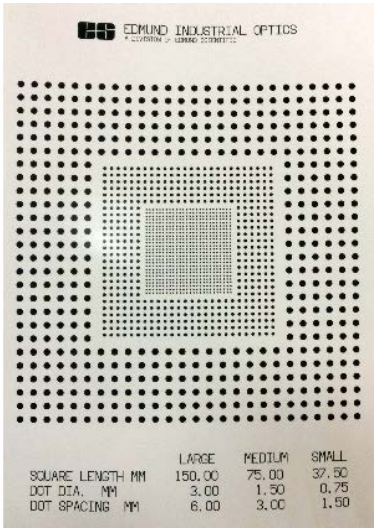
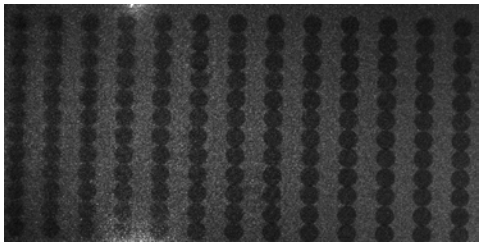
Algorithm developed during the first year of PhD course: a brief recap

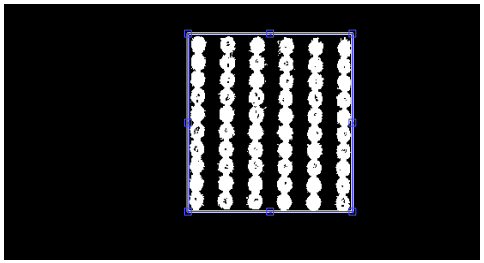
1. Localized shear computation



(1)



(2)

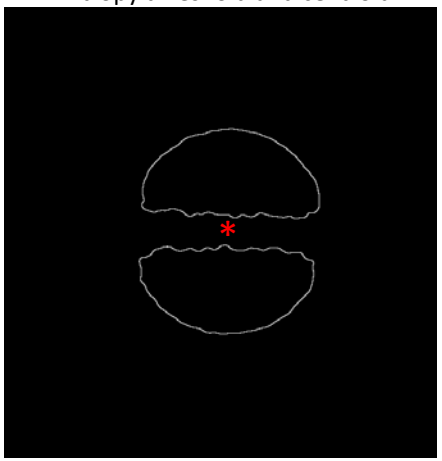


(3)

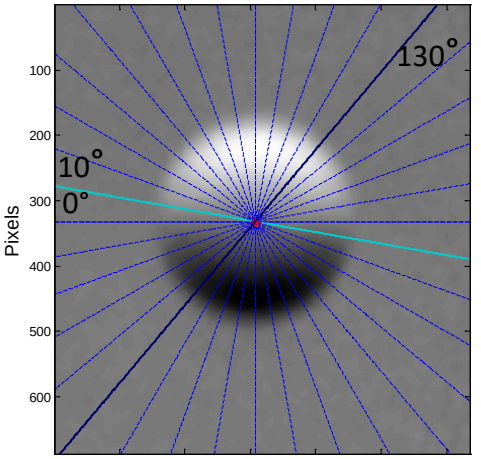
Algorithm developed during the first year of PhD course: a brief recap

2. Wavelet Transform Scanning on the unwrapped phase map
   - Entropy based-threshold for image binarizing and centroid detection
   - Definition of a set of lines passing through the centroid (1 degree-pitch)
   - Deduction of the phase profiles along the scanning lines by a sub-pixel interpolation
   - Computing the wavelet transform for each profile.
   - Extracting the significant singularity of the wavelet representative of the edge of the profile (Mexican Hat Wavelet)

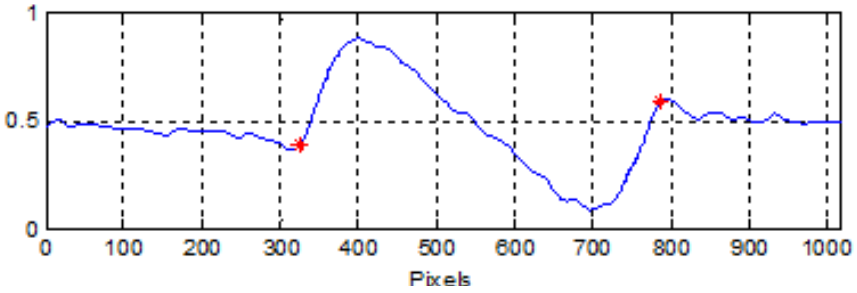
Entropy threshold and centroid



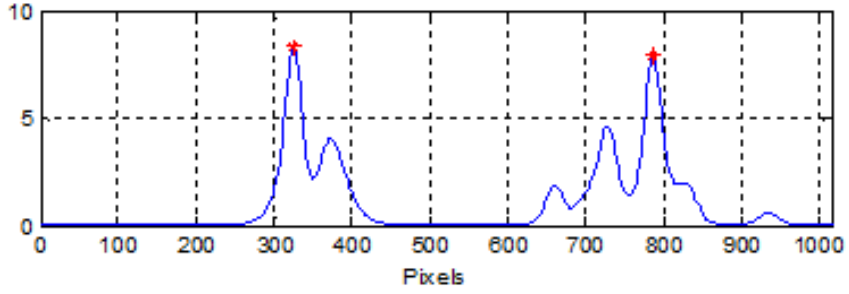
Lines passing through the centroid



Investigated curve



Structural intensity of the estimated wavelet maxima with weight functions



Optimization implemented during the second year of the PhD Course

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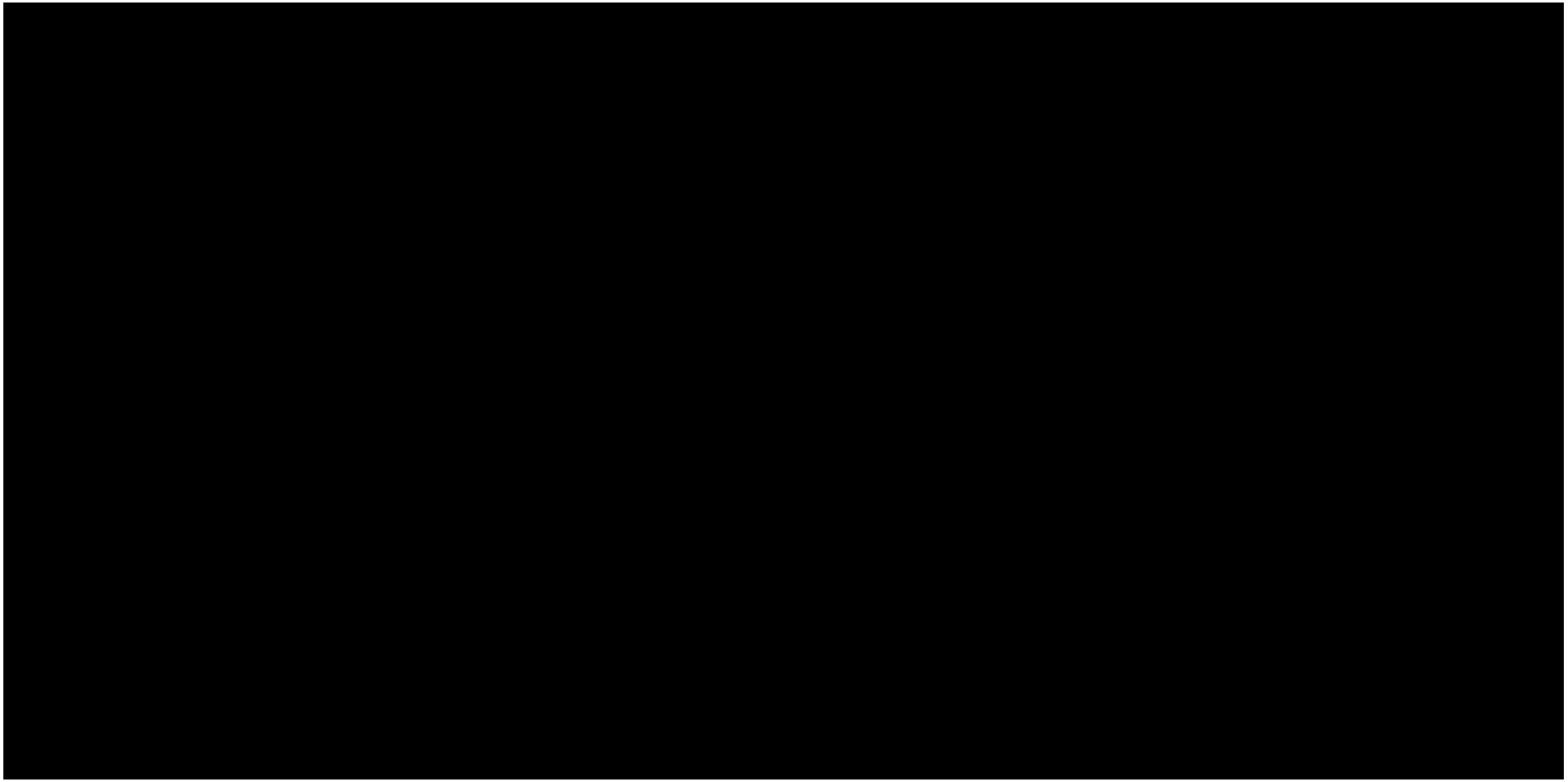

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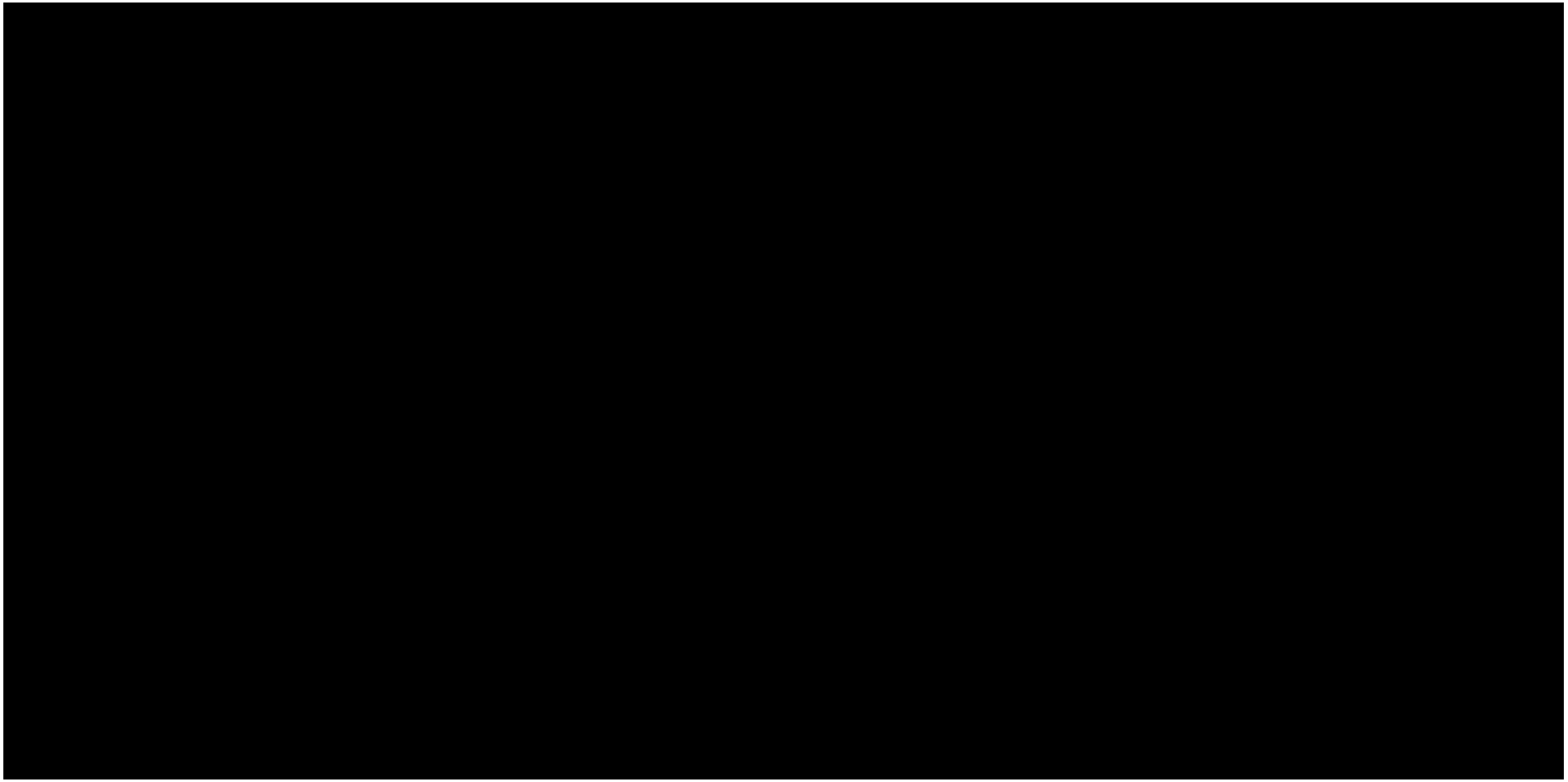

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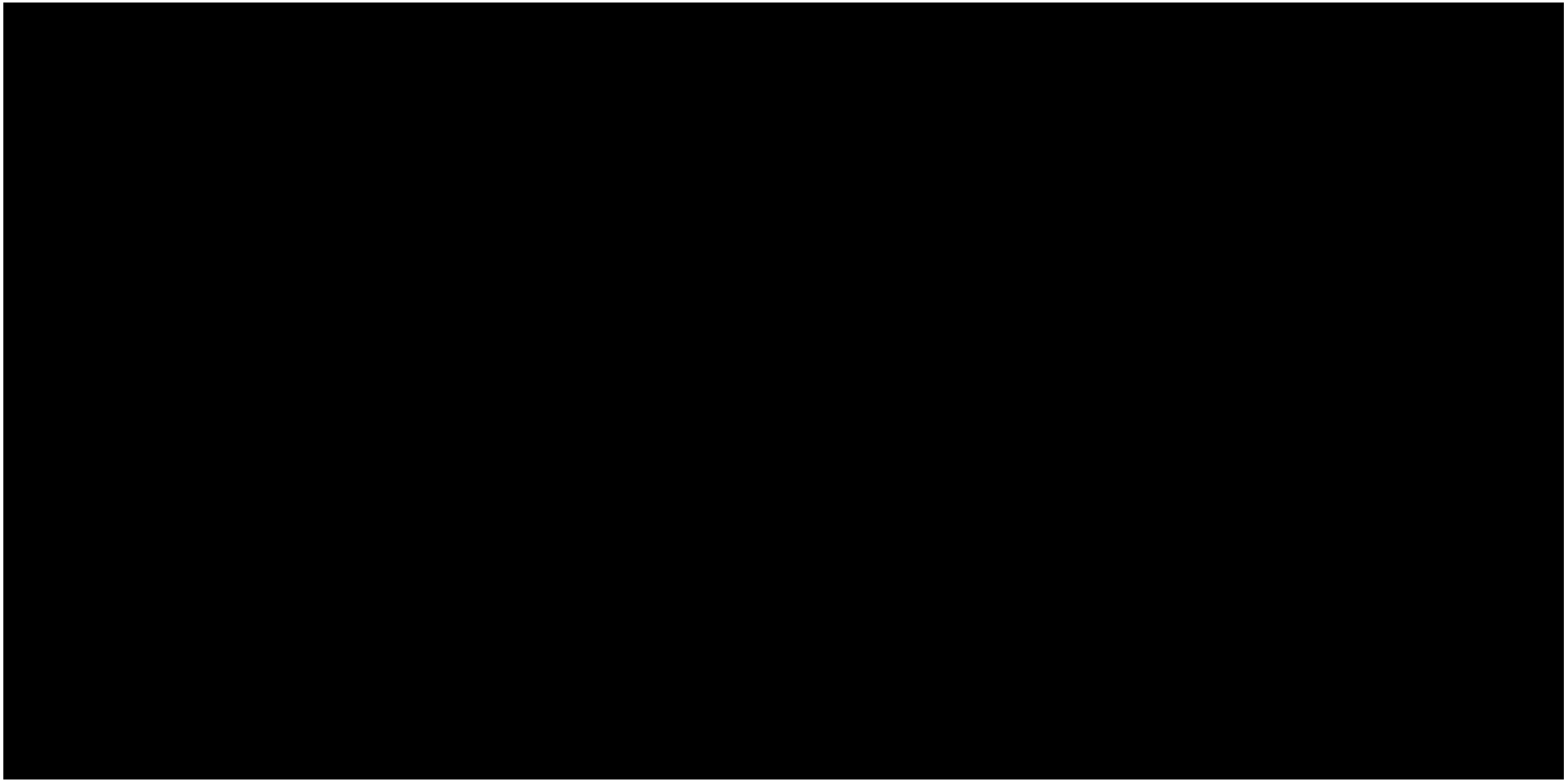

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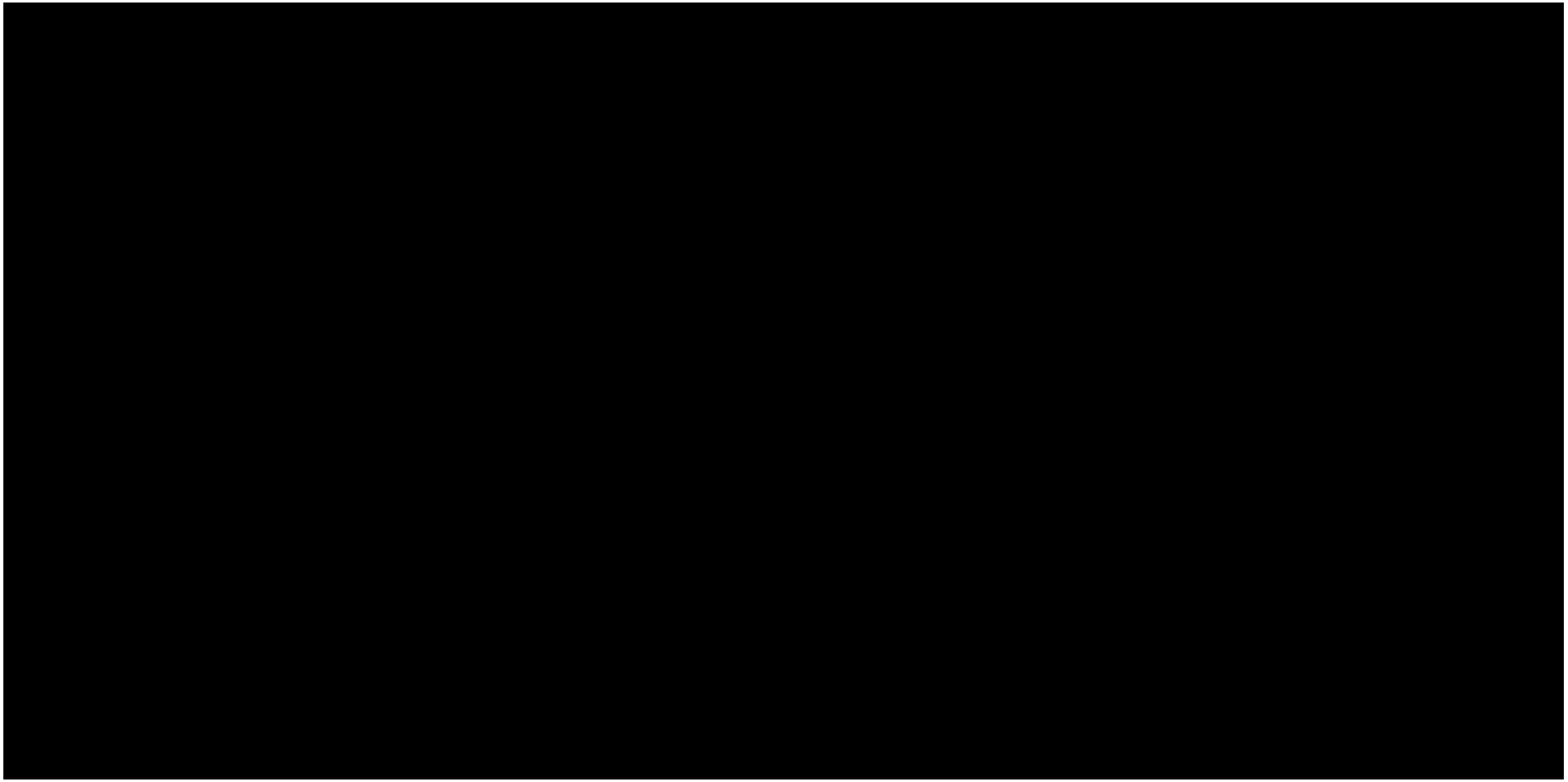
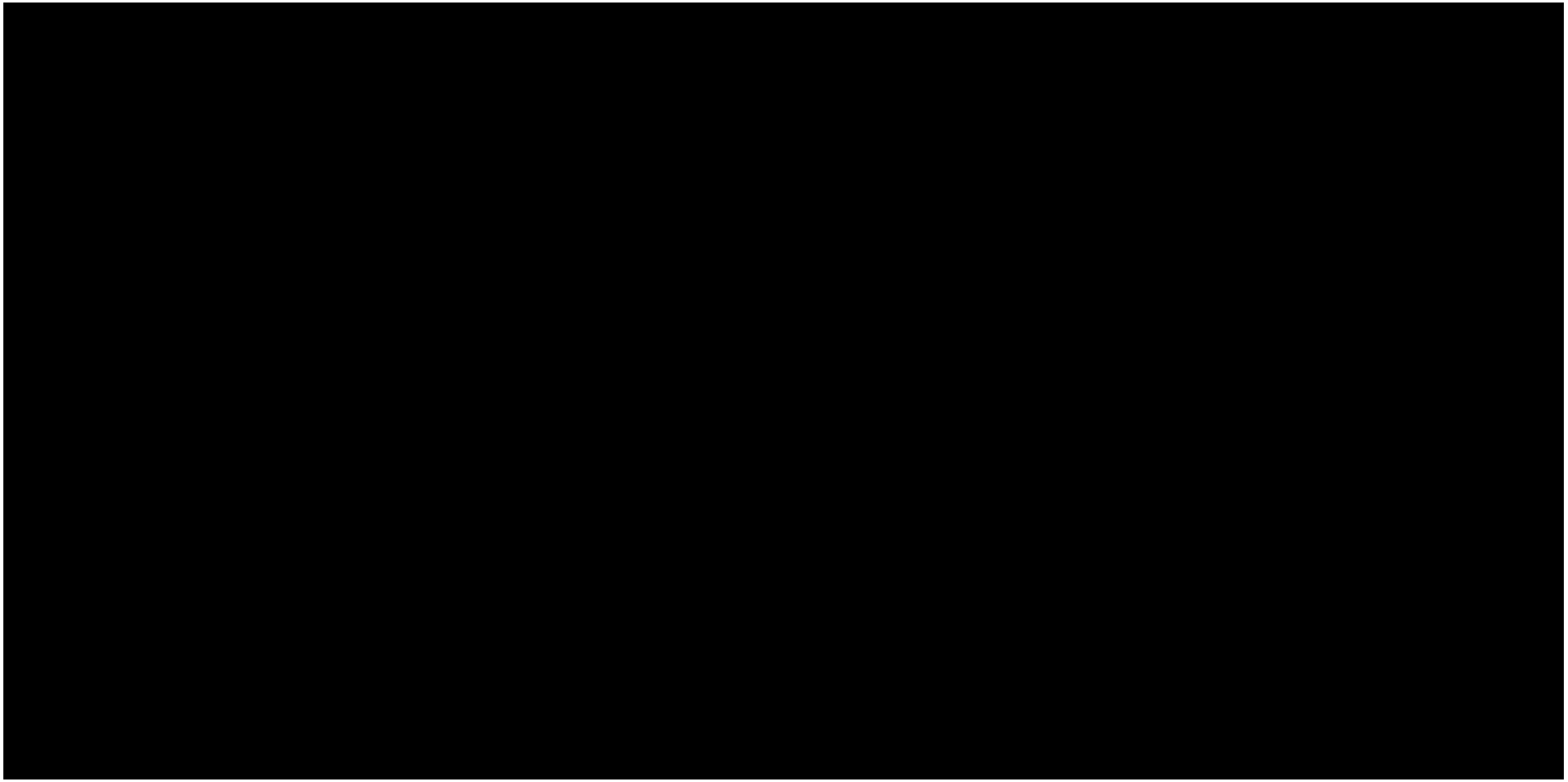


Code validation and comparison with prior code version results



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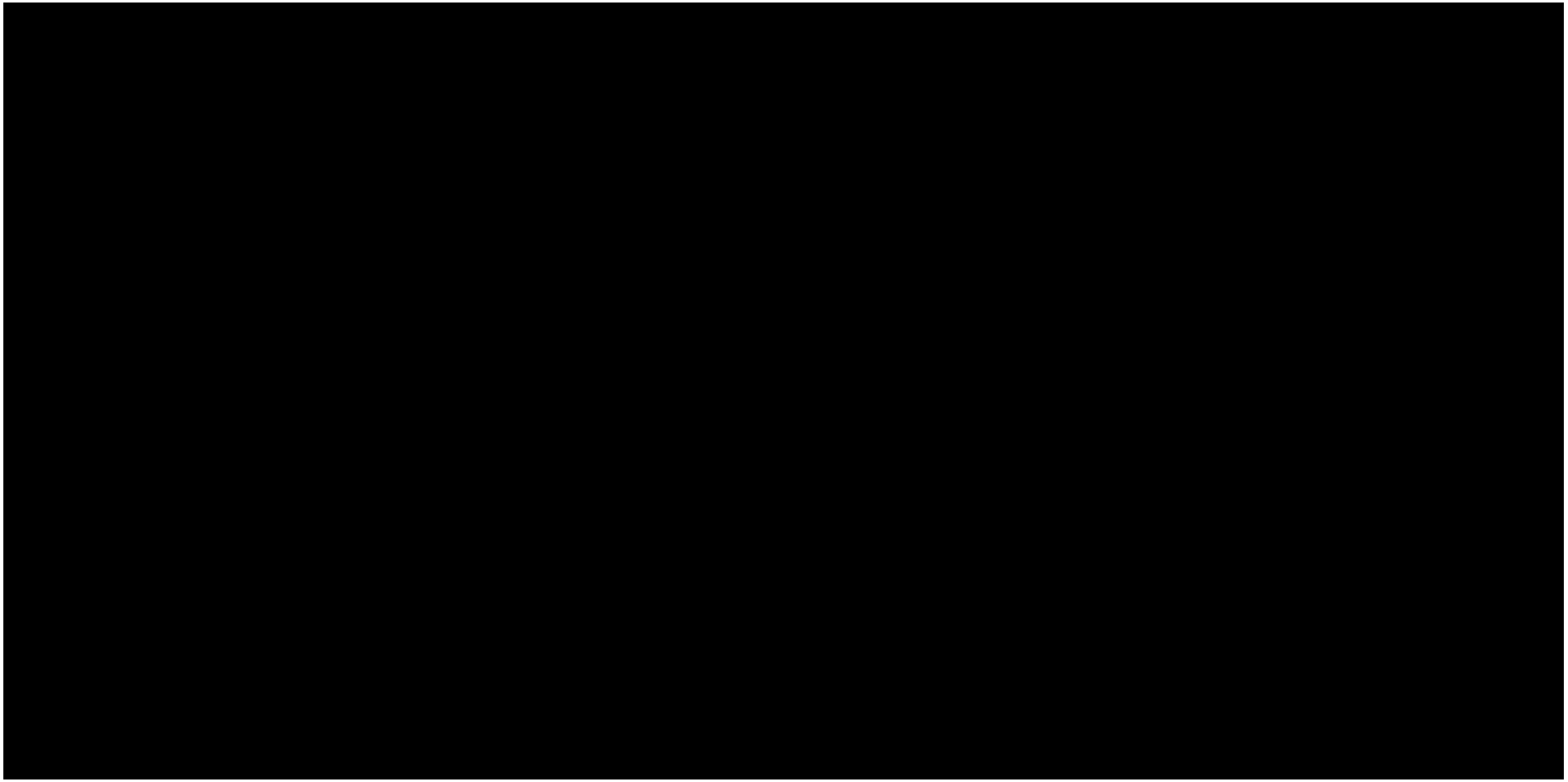

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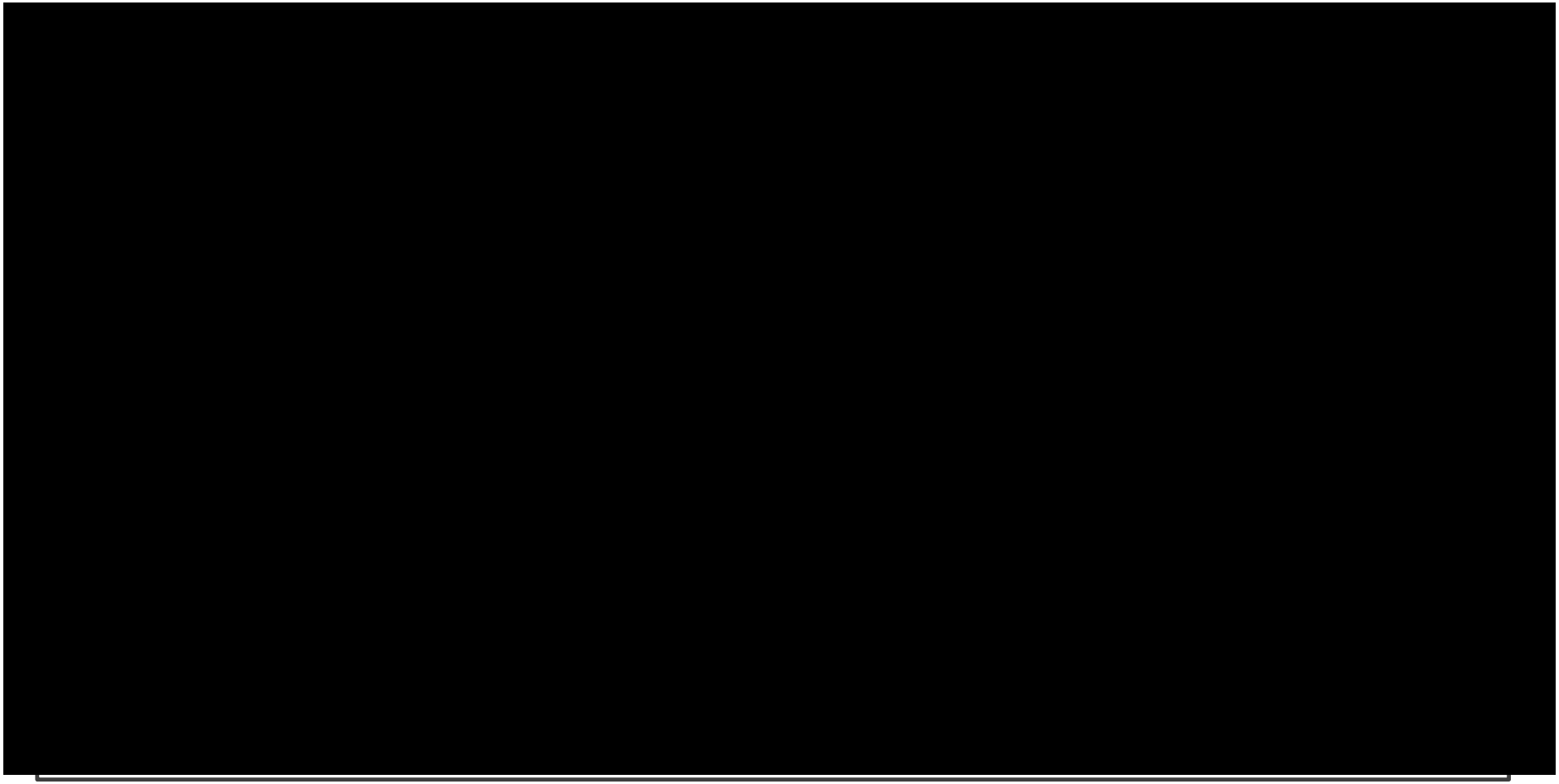
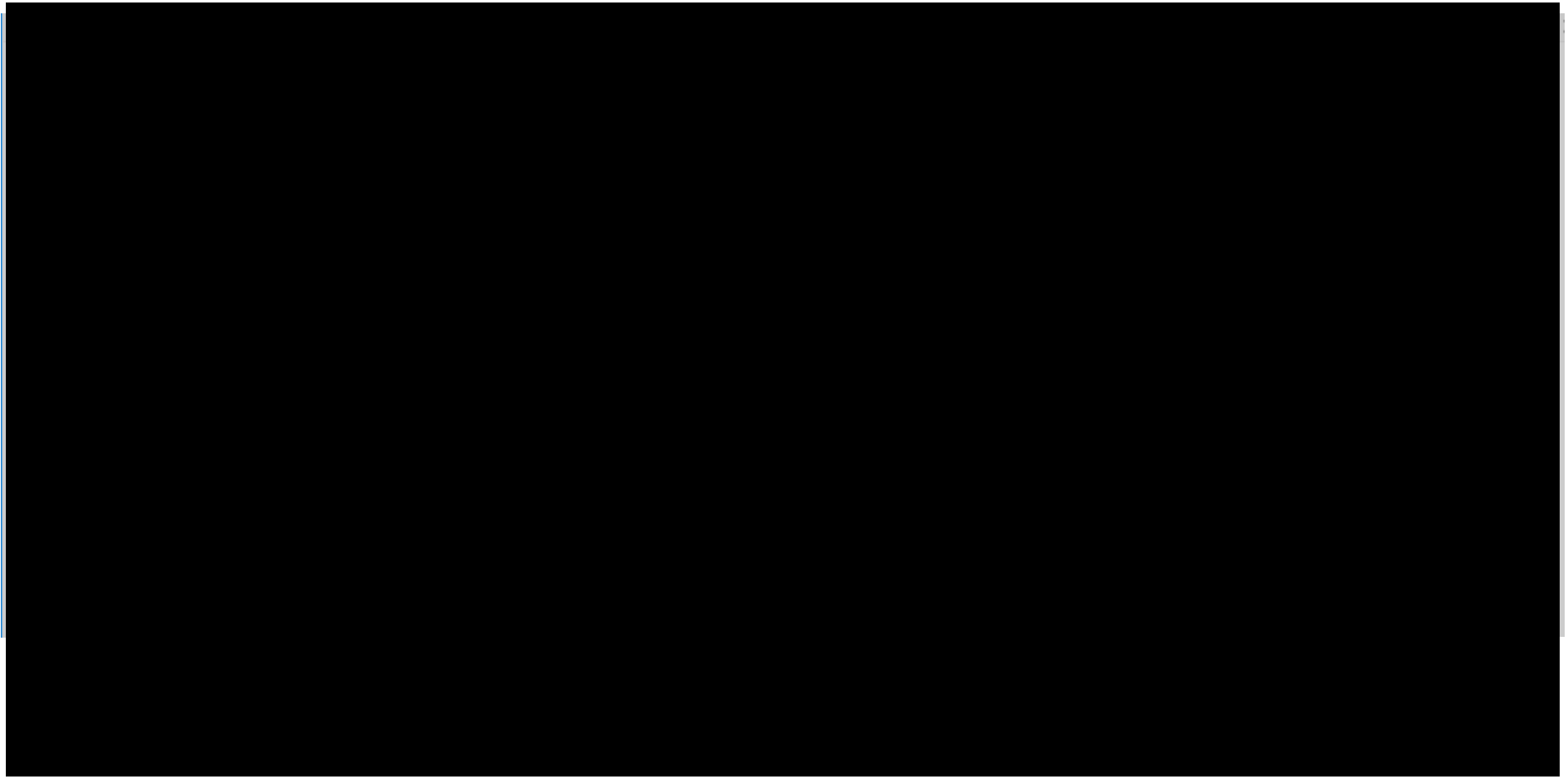


Implementation of a Matlab application



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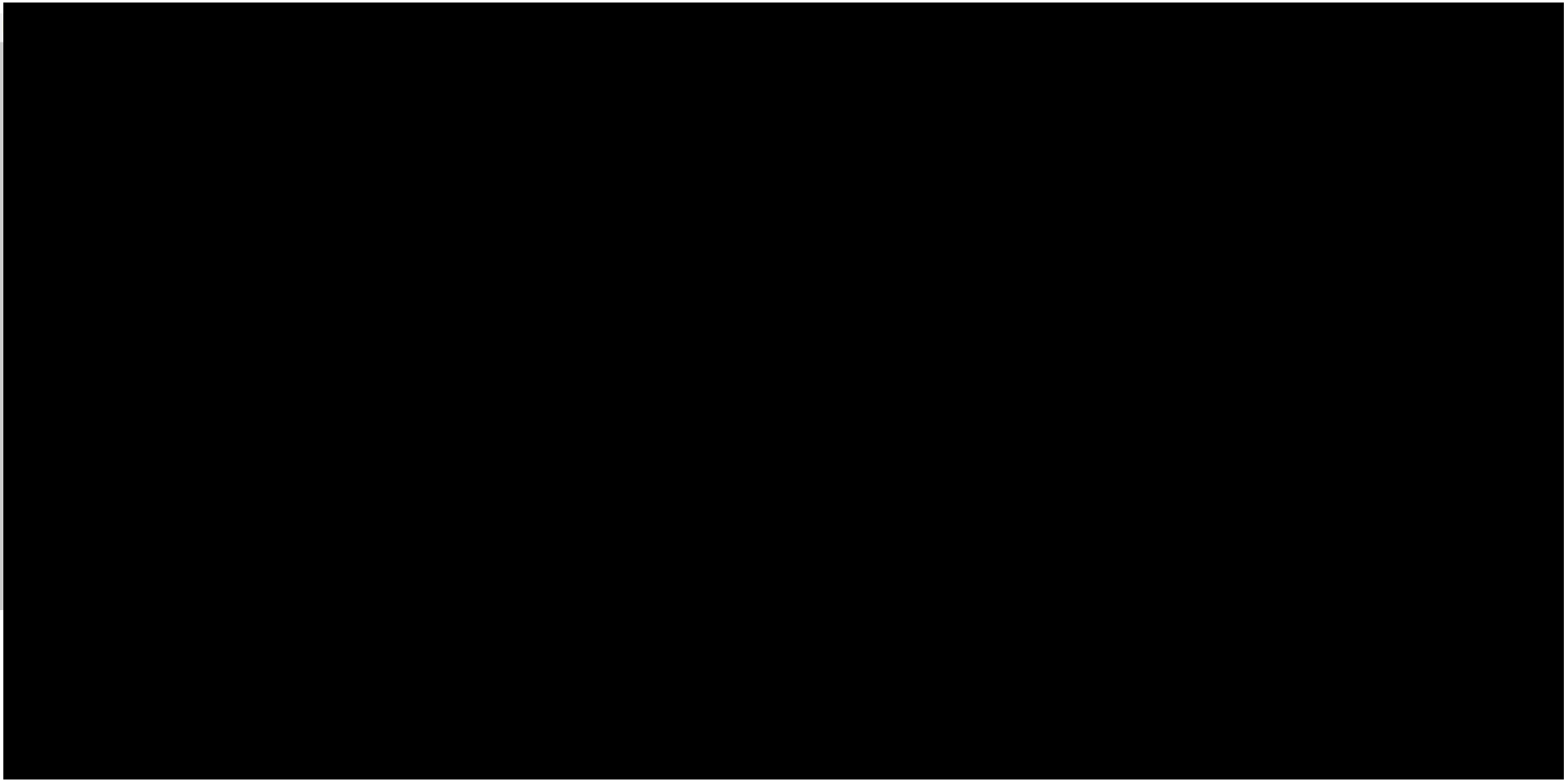

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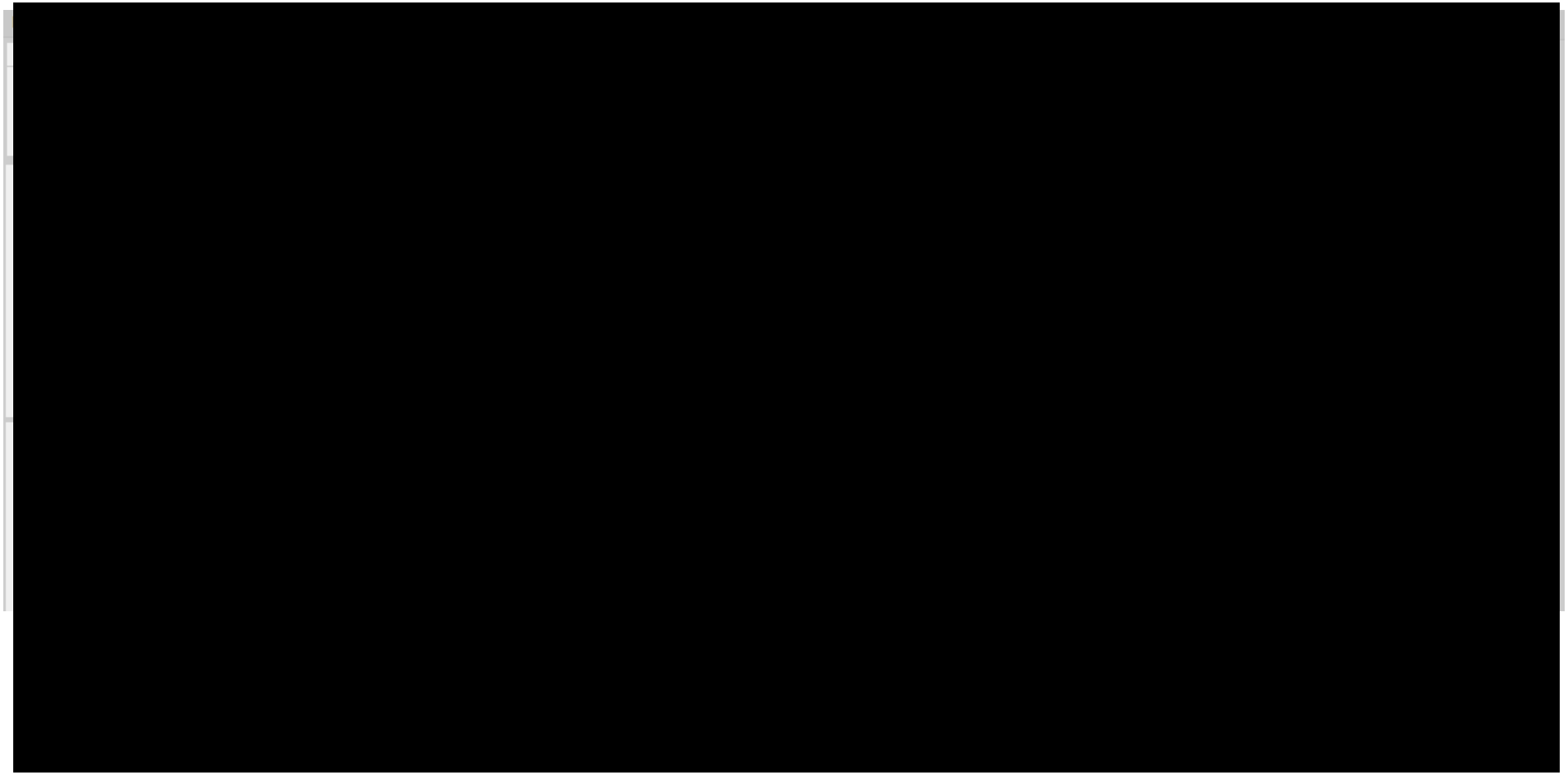

Thermography Inspection

- Feasibility study of Thermoelastic technique on a 3D printed- titanium alloy bracket
- Stress analysis (TSA)
- **Displacement and strain field analysis (Optical Flow)**

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Optical Flow Analysis

- The hypothesis of brightness constancy is not valid!!!

$$\Delta s = \frac{I_0(x_j, y_k) - I(x_j, y_k, t)}{|\nabla I_0|}$$

I_0: mean image

I: frame at istant t

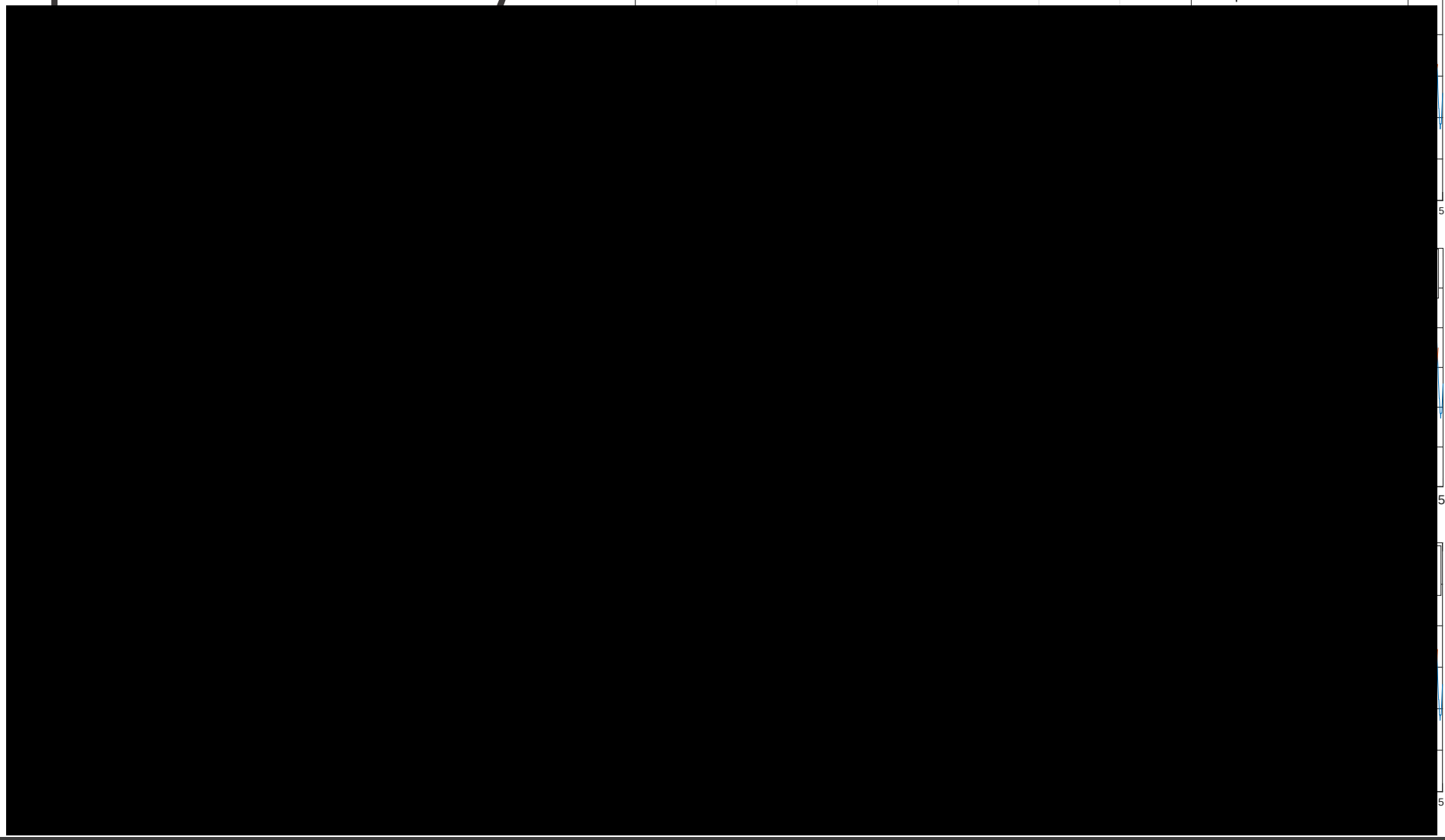
I: frame at istant t

Δs: gradient oriented - displacement

- The formula must be evaluated frame by frame (no mean image!)

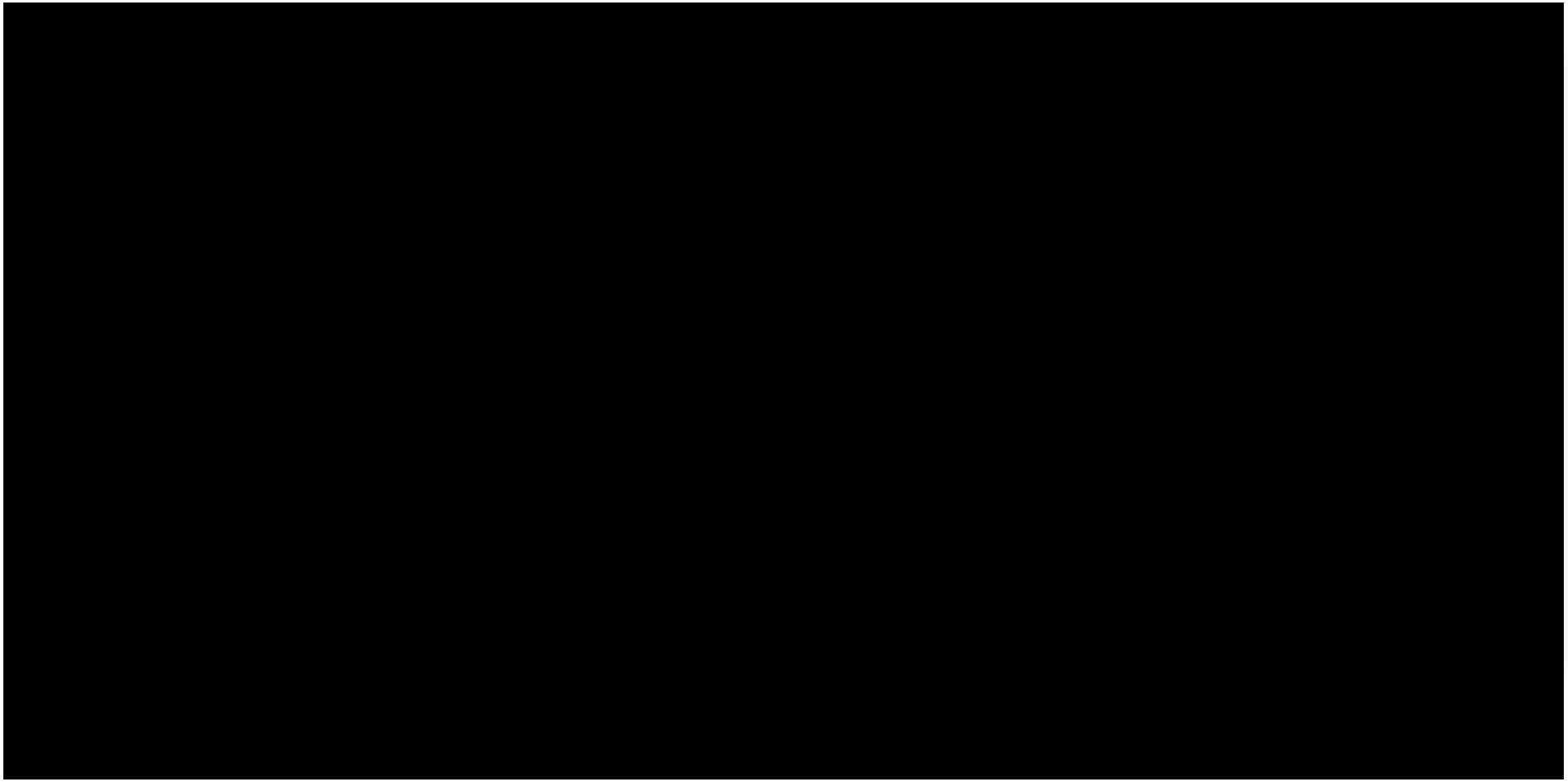
  - Selection of a Region Of Interest (ROI)
  - Evaluation of *mm/pixel* ratio
  - Frequency extraction
  - Displacement calculation by Horn-Schunck optical flow

Optical Flow Analysis



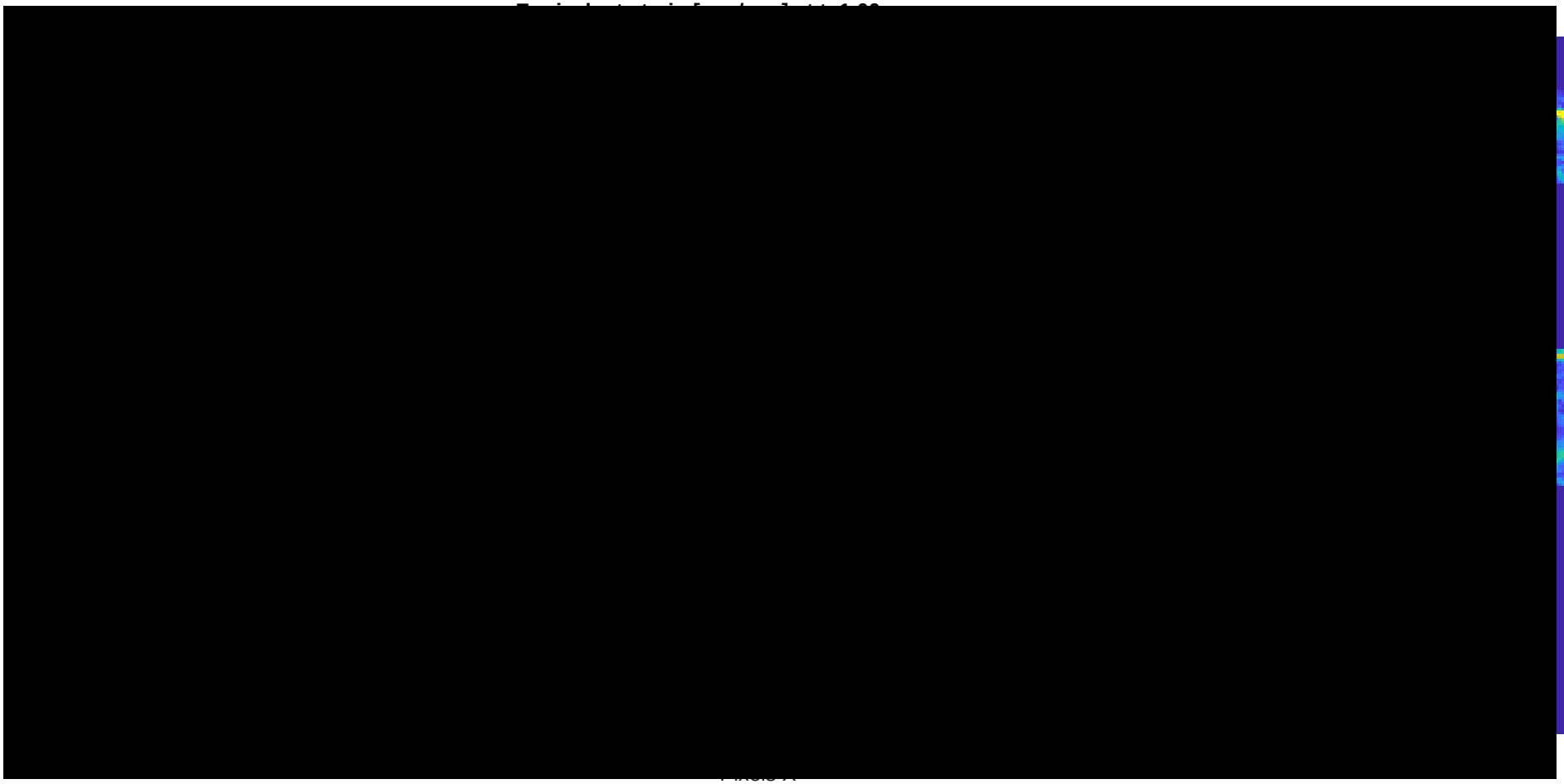
Optical Flow vs FEM Analysis

Displacement fields

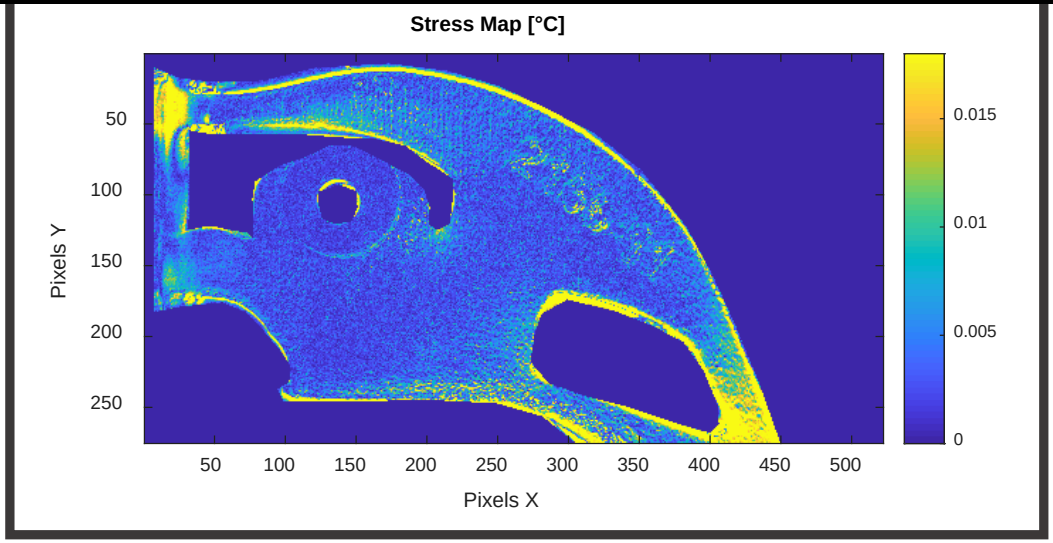


Optical Flow Analysis

The highest equivalent strain is revealed in the layer where the component usually breaks!



Optical Flow Analysis



Future work

Shearography

- Matlab application completion
- Other test campaigns on different materials to furtherly check the code performances

Thermal Imaging

- Optical Flow method enhancement and validation on a basic component
- Stress calibration
- Other test campaigns on different conditions to furtherly check the code performances

Thanks for your attention

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