Thermographic Super Resolution Using Structured 1D Laser Illumination and Joint Sparsity


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1. Motivation: The resolution problem in fields of thermography

<table>
<thead>
<tr>
<th>Scanning methods</th>
<th>a) Laser array</th>
<th>b) Single laser</th>
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</thead>
<tbody>
<tr>
<td>Irradiance</td>
<td>70 W/cm²</td>
<td>8 kW/cm²</td>
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<tr>
<td>Focus</td>
<td>Wide</td>
<td>Narrow</td>
</tr>
<tr>
<td>Scanning steps</td>
<td>Few</td>
<td>Many</td>
</tr>
</tbody>
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Problem: Find a method that increases spatial resolution which is limited by diffusive nature of heat conduction
Solution: Multiple measurements at different positions with a) random illumination patterns or b) single laser line (randomization in signal processing) - Reconstruction algorithm: nonlinear iterative joint sparsity (IJOSP)

2. Methodology: Realization of blind structured illumination

a) Experiment
Laser illuminates sample with multiple random patterns
- Front view of sample (shown as a model)
- Blind illumination with laser array
- Rear view of sample (IR camera view)
- Temperature distribution only in defect region

b) Reconstruction [1]

1. Transform measured temp. matrix to virtual wave matrix
2. 1st reconstruction with Frequency domain Synthetic Aperture Focusing Technique (F-SAFT) for every single measurement
3. Iterative joint sparsity reconstruction algorithm with reconstr. data

3. Results

a) Laser array
Sample: aluminium foil glued on a 3 mm steel sheet, slit pairs are cut in the aluminium foil
- Silt distance for each slit pair (left to right): 0.6, 0.9, 1.3, 2, 3 mm
- Difficult to resolve the red area with laser array

b) Single laser with different excitation pulse lengths

4. Conclusion

- Laser array allows to reduce the measuring time
- Small focus beam allows to resolve slits with 0.6mm distance (see 3 b))
- 10 ms excitation pulse: increase of spatial resolution by a factor of 8
- Fields of application: NDT, medicine: cancer detection
- Vision: 2D and 3D reconstruction with virtual wave approach

5. References