

Layered Surface Detection in Micro-CT Tetra Pak Data

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Publication date:
2015

Document Version
Peer reviewed version

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Citation (APA):
Dahl, V. A. (2015). Layered Surface Detection in Micro-CT Tetra Pak Data [Sound/Visual production (digital)]. ERF, Lund, Sweden, 07/10/2014

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Layered Surface Detection in Micro-CT Tetra Pak Data

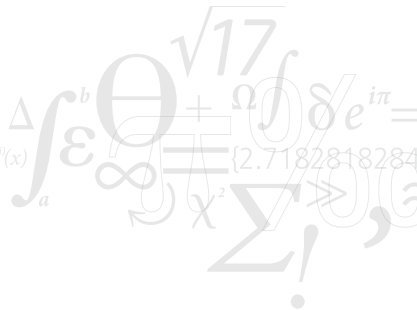
Vedrana Andersen Dahl, DTU Compute

Industrial CT scanning Erfa-group meeting, 7. October 2014

$$f(x+\Delta x) = \sum_{i=0}^{\infty} \frac{(\Delta x)^i}{i!} f^{(i)}(x)$$

Focus on...

- ▶ Image analysis. Principles, challenges, opportunities...
- ▶ One surface detection algorithm

$$f(x+\Delta x) = \sum_{i=0}^{\infty} \frac{(\Delta x)^i}{i!} f^{(i)}(x)$$


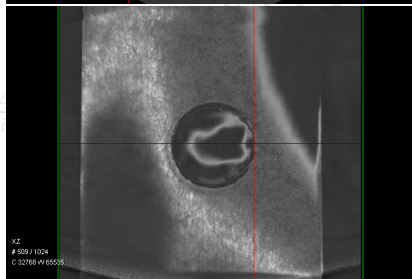
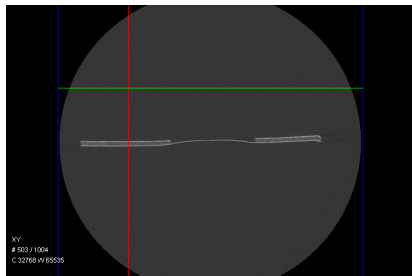
Data collection

Carsten Gundlach, DTU Physics

Three settings

- ▶ Objective: LFOW,
Pixel size: 21.2 μm
- ▶ Objective: 4X
Pixel size: 4.7 μm
- ▶ Objective: 10X
Pixel size: 1.9 μm

Voltage 40 kV
Power 10 W
Filter AIR
Exposure: 5 s, 5s, 25 s.



Data collection

Carsten Gundlach, DTU Physics

Three settings

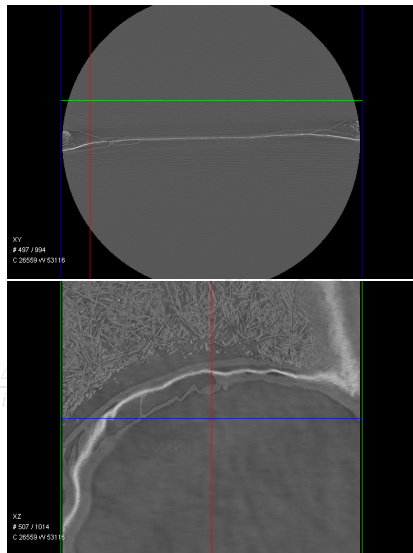
- ▶ Objective: LFWO,
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Pixel size: 4.7 μm
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Power 10 W

Filter AIR

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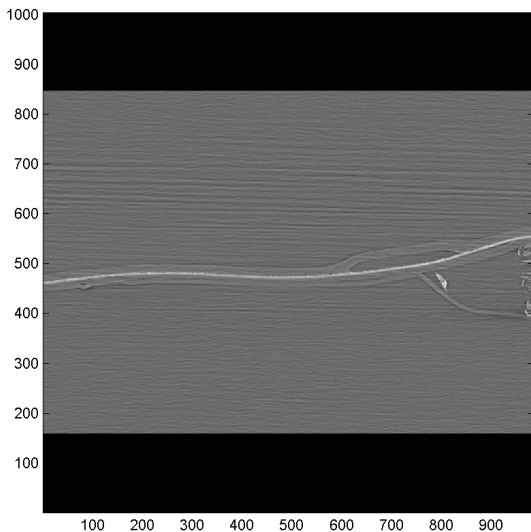
The nature of data

- ▶ Data is noisy, including projection data. Reconstruction data cannot be less noisy without assumptions.
- ▶ All image/volume segmentation is based on assumptions.
- ▶ Our interpretation of data depends on assumptions made under analysis – also in cases where those assumptions are implicit.

$$f(x+\Delta x) = \sum_{i=0}^{\infty} \frac{(\Delta x)^i}{i!} f^{(i)}(x)$$

Surface detection, initial analysis

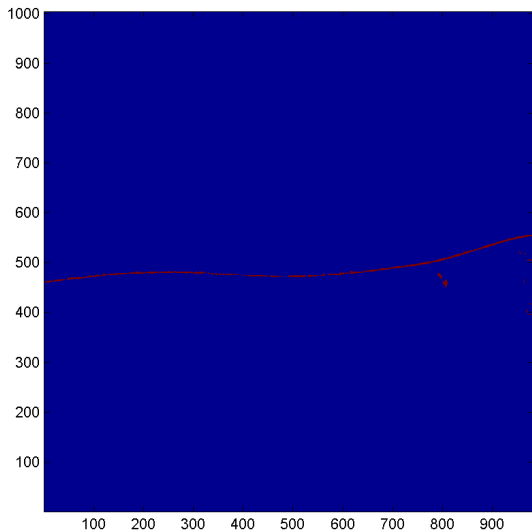
Example slice, volume dimensions $980 \times 984 \times 1004$ voxels



$$7e^{i\pi} = 18284$$

Surface detection, initial analysis

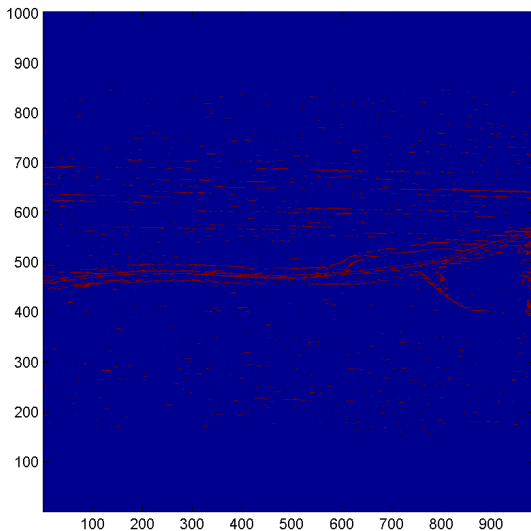
Thresholding aluminium foil – ok



$$7 e^{i\pi} = 18284$$

Surface detection, initial analysis

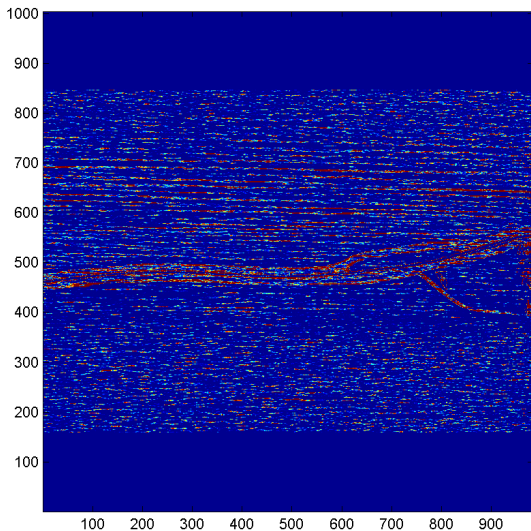
Thresholding plastic membrane – noisy



$$7 e^{i\pi} = 18284$$

Surface detection, initial analysis

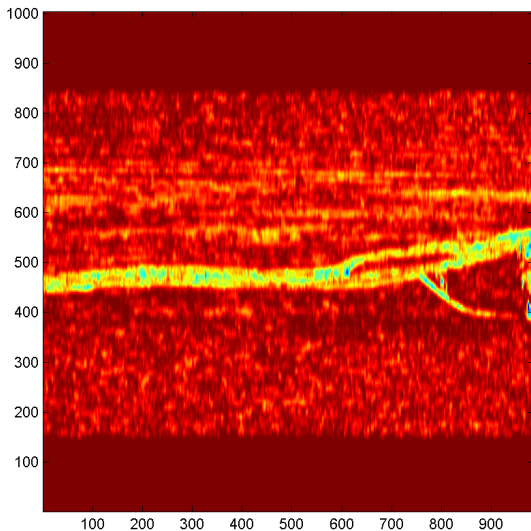
Relaxed plastic membrane response



$$7 e^{i\pi} = 18284$$

Surface detection, initial analysis

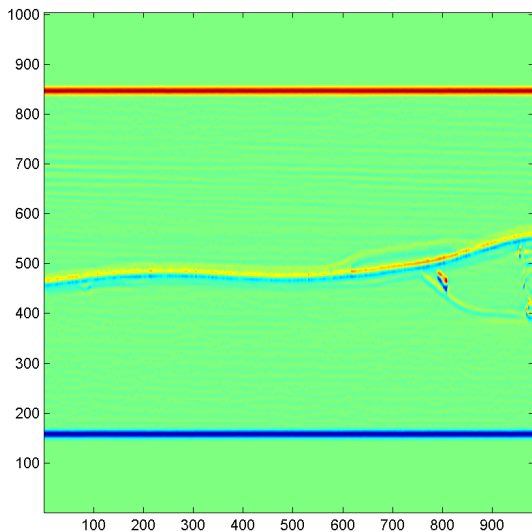
Averaged relaxed plastic membrane response – a useful contribution



$$7e^{i\pi} = 18284$$

Surface detection, initial analysis

Edge response – a useful contribution



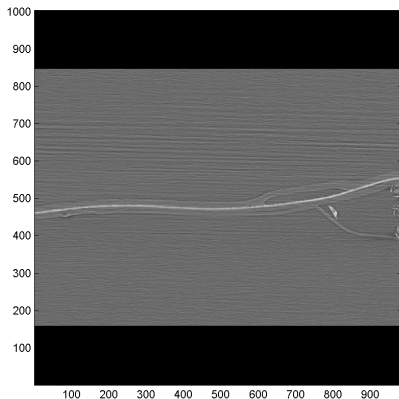
$$7 e^{i\pi} = 18284$$

Surface detection, initial analysis

- ▶ Challenges: data size, presence of noise.
- ▶ Conclusion: We need to choose a model, including an appearance model and a geometric model.

$$f(x+\Delta x) = \sum_{i=0}^{\infty} \frac{(\Delta x)^i}{i!} f^{(i)}(x)$$

Surface detection, suggested geometric model



- ▶ Terrain-like surfaces

$$z = f(x, y)$$

- ▶ Smoothness

$$|f(x + n, y) - f(x, y)| < \Delta$$

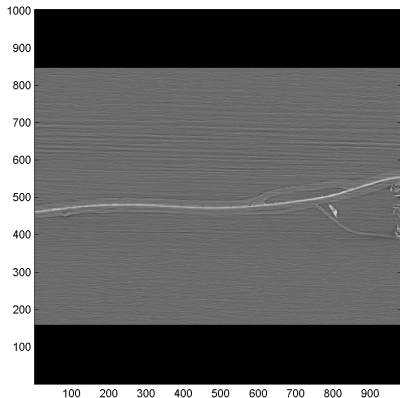
$$|f(x, y + n) - f(x, y)| < \Delta$$

- ▶ Optimality

$$\min_{x, y} \sum c(x, y, f(x, y))$$

- ▶ Initial focus on three surfaces:
aluminium foil, lowest edge,
highest edge.

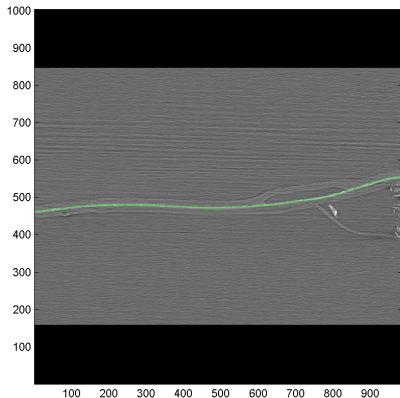
Surface detection, suggested appearance model



- ▶ Aluminium foil:
 - ▶ binary aluminium foil response
- ▶ Lowest and highest edge, a weighted sum of four contributions:
 - ▶ relaxed plastic membrane response
 - ▶ edge response
 - ▶ repulsion from aluminium foil (limited range)
 - ▶ cumulative term (first strong occurrence)

$$f(x) = \sum_{i=0}^{\infty} \frac{(\Delta x)^i}{i!} f^{(i)}(x)$$

Surface detection, pipeline

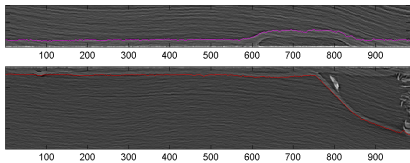


Ordering

1. aluminium foil
2. lowest plastic edge and highest plastic edge in sampled images
3. plastic edge transformed back

$$f(x) = \sum_{i=0}^{\infty} \frac{(\Delta x)^i}{i!} f^{(i)}(x)$$

Surface detection, pipeline

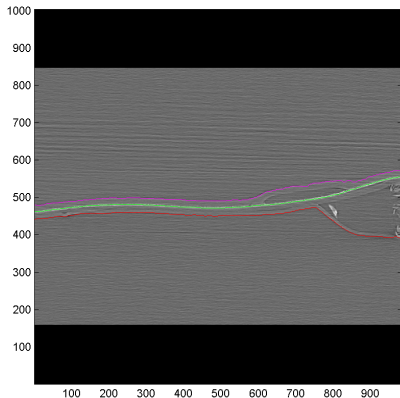


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Surface detection, pipeline

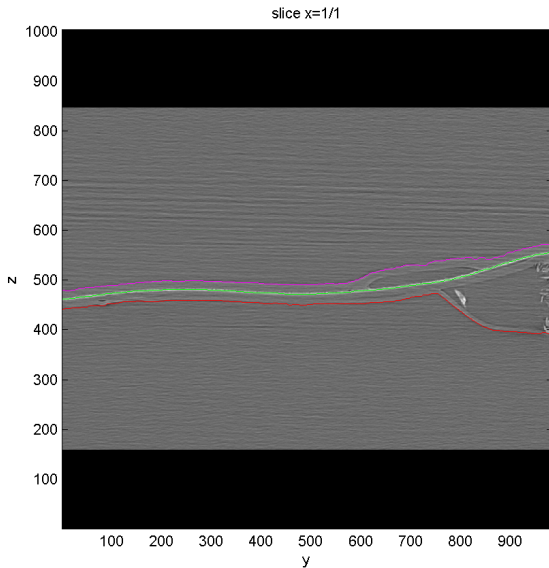


Ordering

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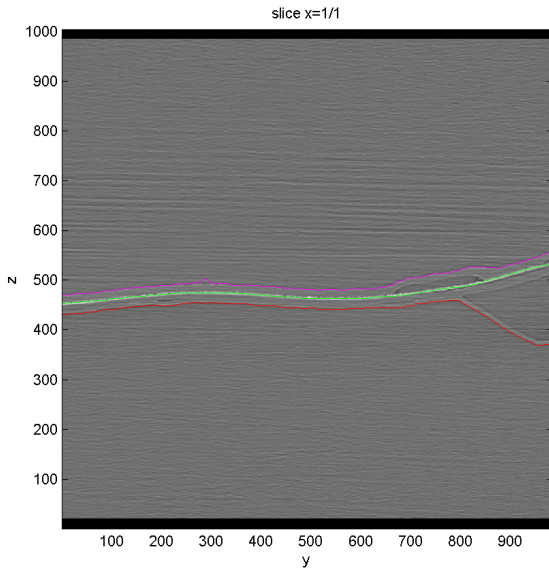
$$f(x) = \sum_{i=0}^{\infty} \frac{(\Delta x)^i}{i!} f^{(i)}(x)$$

Surface detection, results



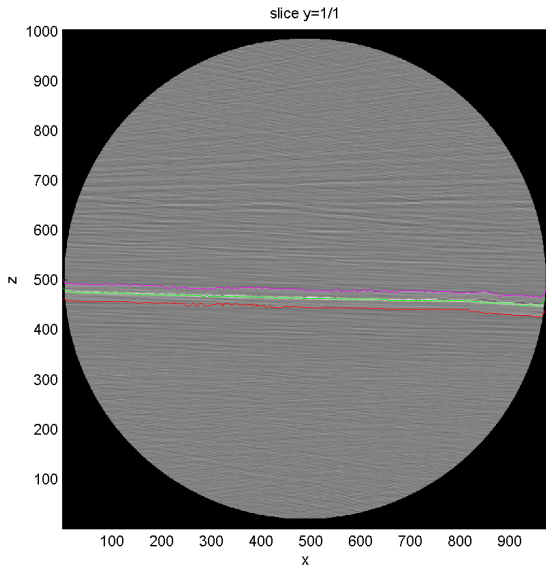
$$7e^{i\pi} = 18284$$

Surface detection, results



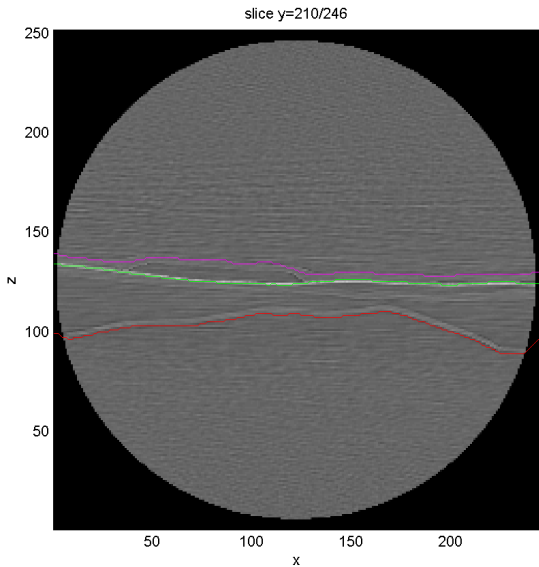
$$7e^{i\pi} = 18284$$

Surface detection, results



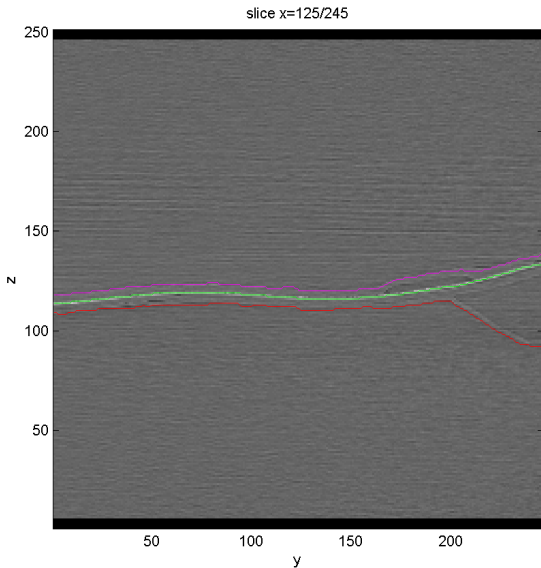
$$7e^{i\pi} = 18284$$

Surface detection, results



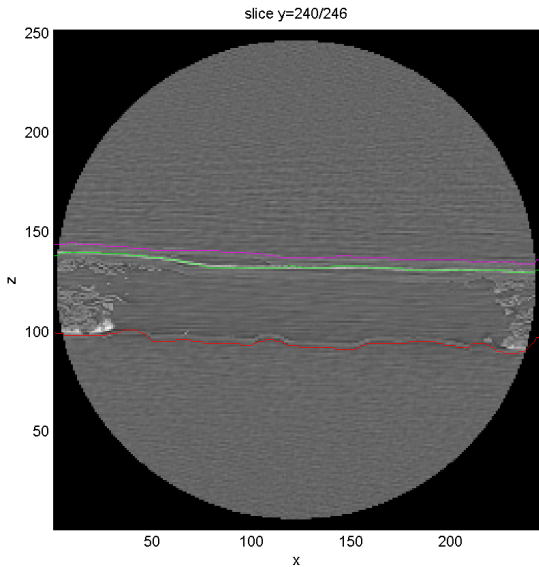
$7e^{i\pi} = 18284$

Surface detection, results



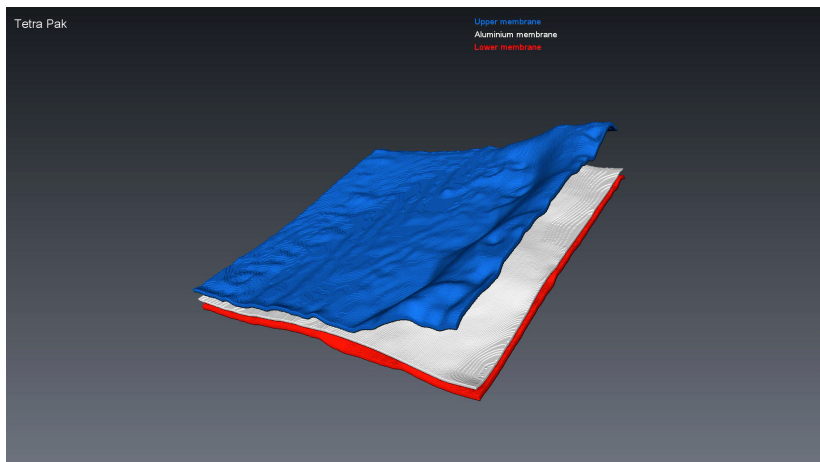
$$7e^{i\pi} = 18284$$

Surface detection, results



$$7e^{i\pi} = 18284$$

Results



Carsten Gundlach, DTU Physics

Thank you!

