

# High-Speed Multi-Line Scan Imaging for Material Inspection

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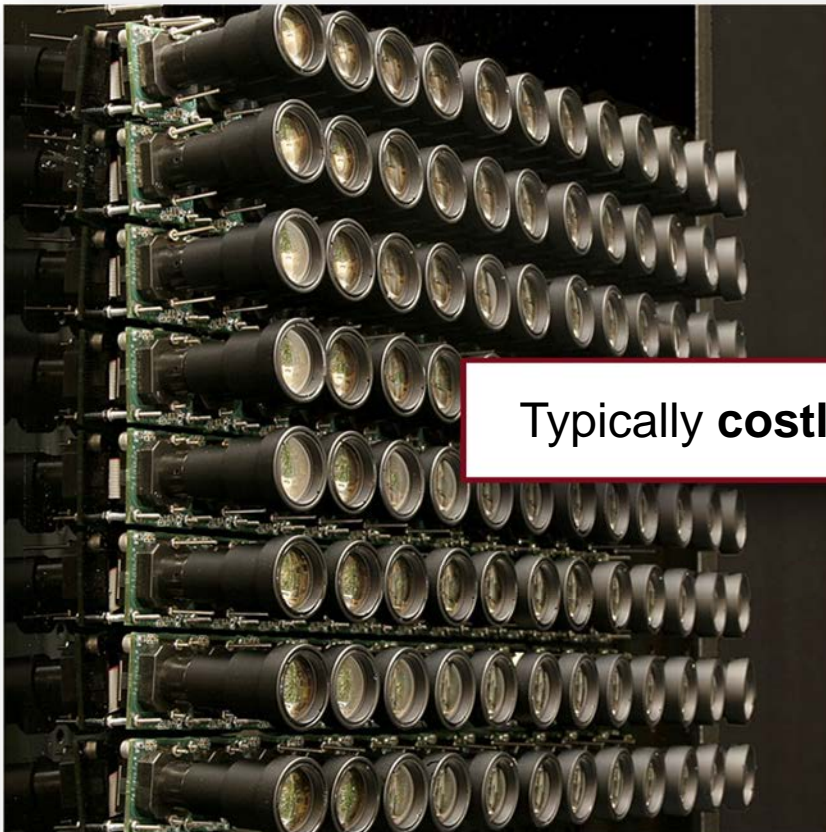
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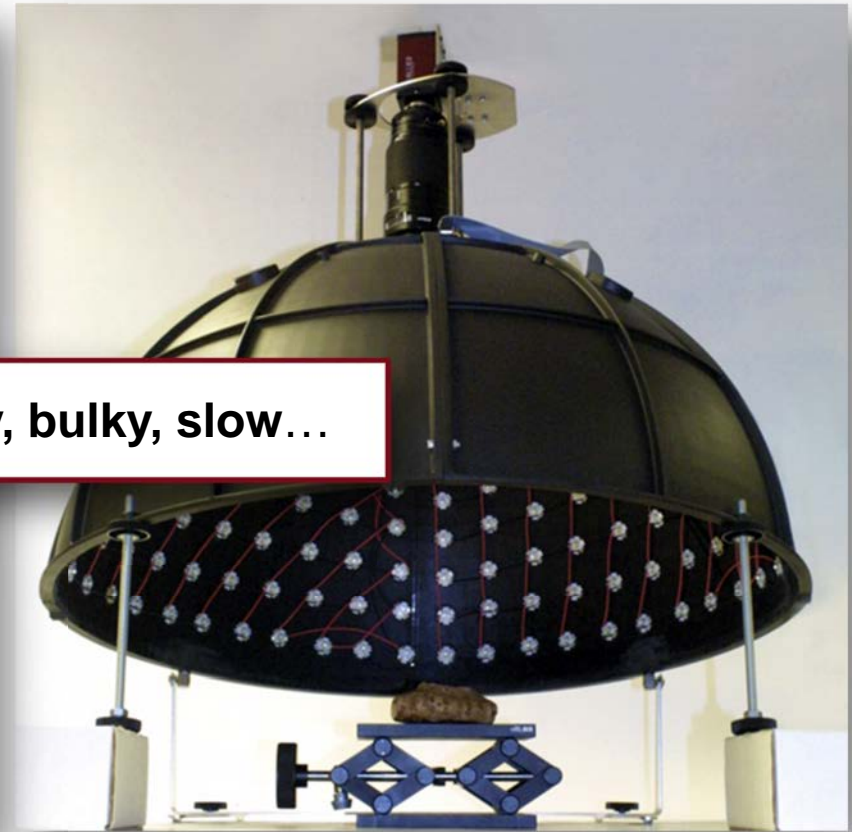
# State of the art: Light field and Photometric stereo systems

**Light field** for accurate 3D



Stanford (2006)

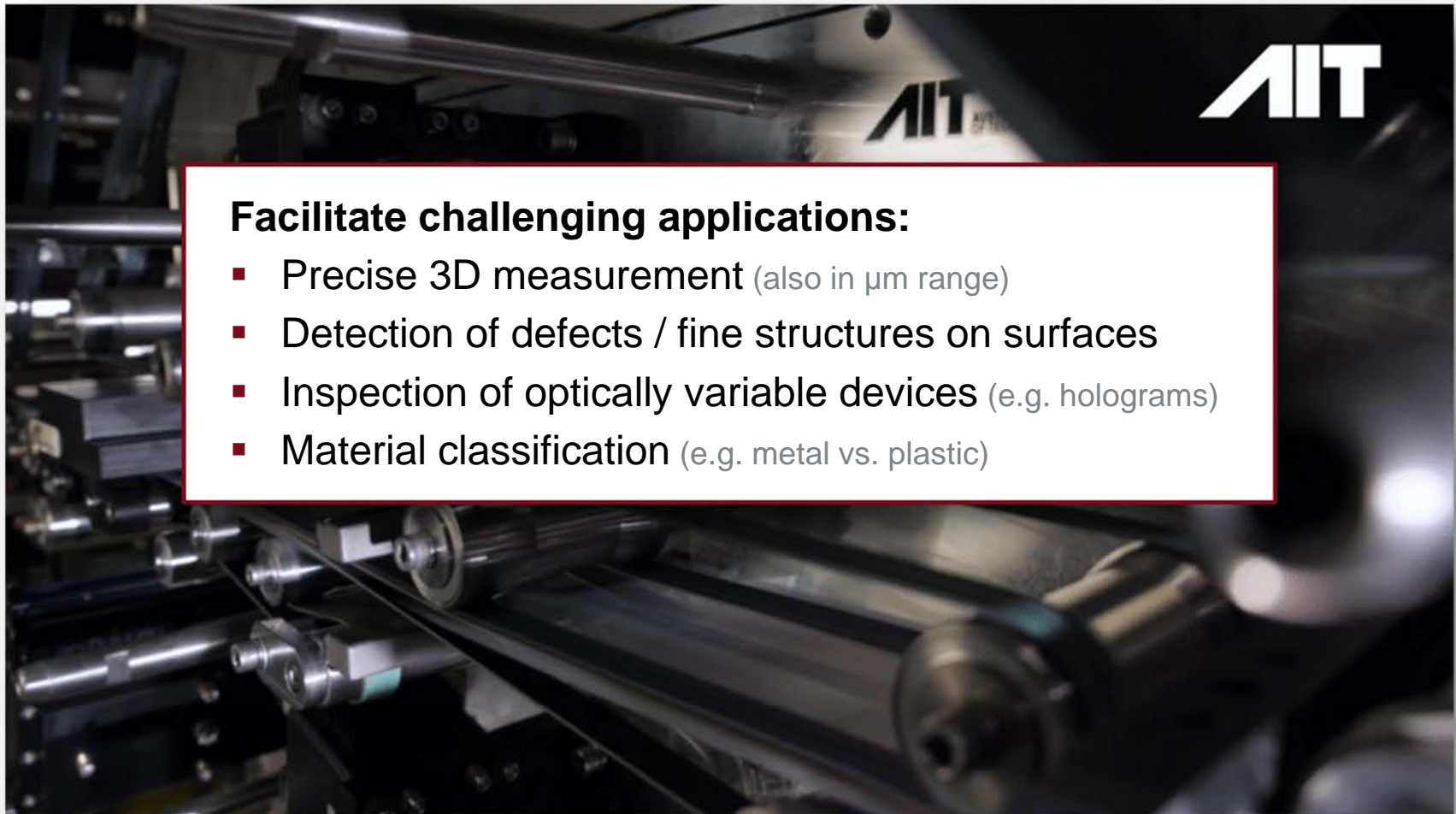
**Photometric stereo** for fine surface detail



KU Leuven (2013)

Typically **costly, bulky, slow...**

## **Our goal:** Enable Light field and Photometric stereo for industrial inline quality inspection

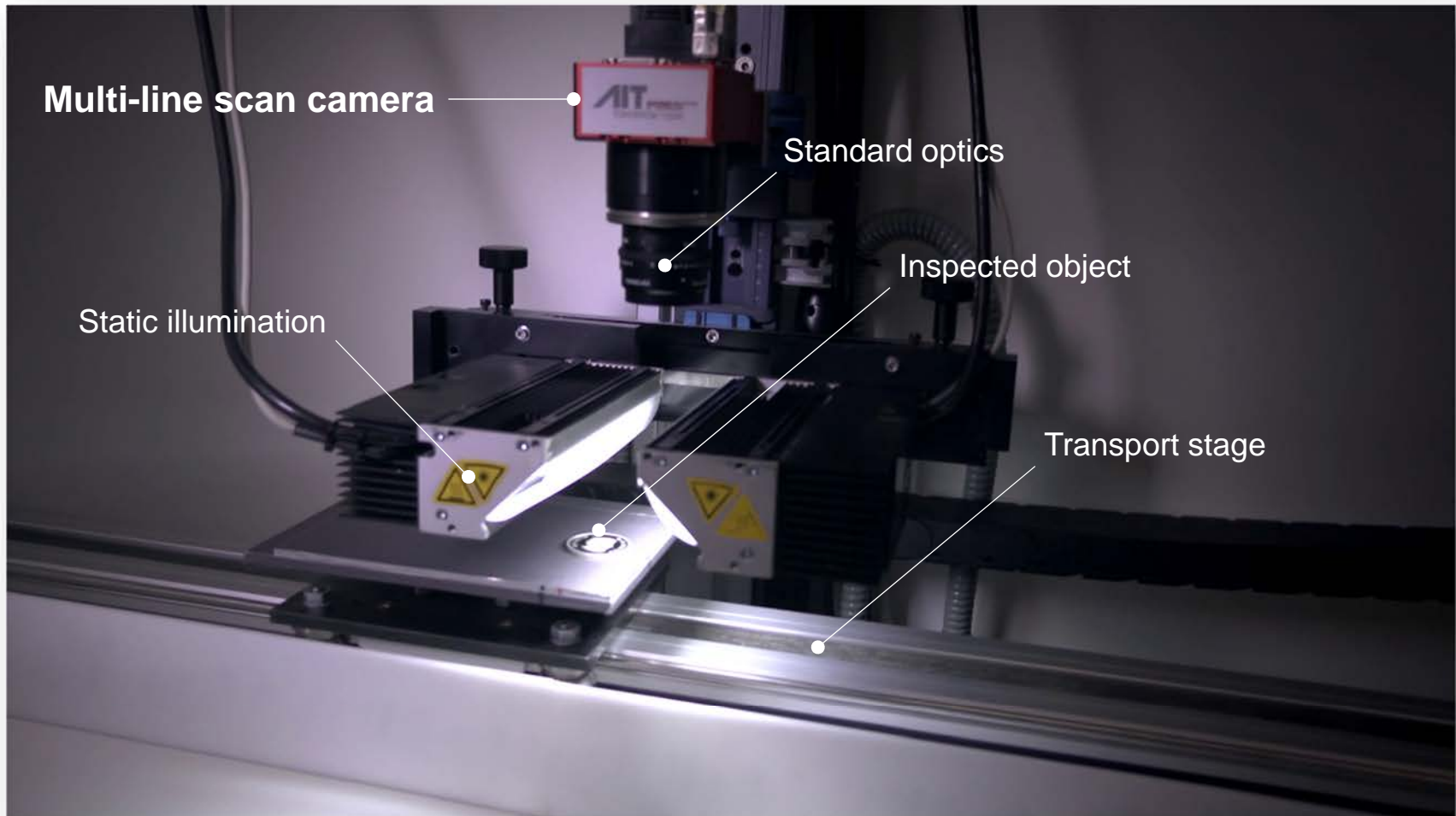


### **Facilitate challenging applications:**

- Precise 3D measurement (also in  $\mu\text{m}$  range)
- Detection of defects / fine structures on surfaces
- Inspection of optically variable devices (e.g. holograms)
- Material classification (e.g. metal vs. plastic)

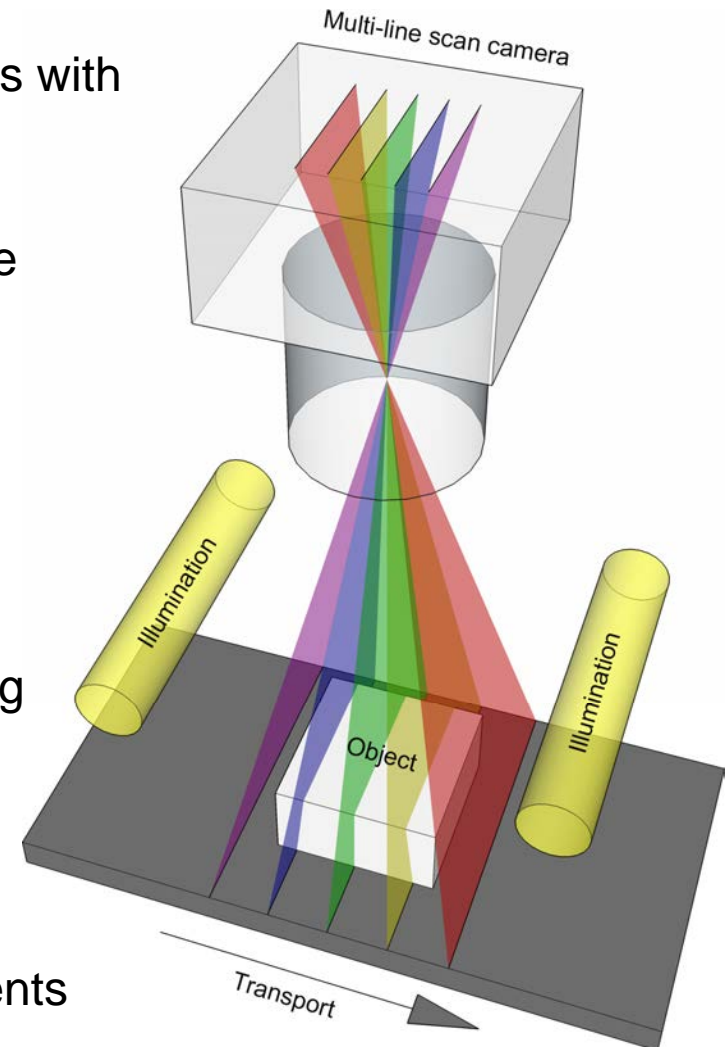
# AIT Multi-Line Scan Imaging

# AIT multi-line scan imaging system



## AIT multi-line scan imaging advantages

- Multiple viewing & illumination perspectives with a single camera and static illumination (no strobing nor multiple exposures required)
- Sensitive in both large-scale as well as fine surface details
- Allows computational imaging for:
  - precise 2.5/3D surface reconstruction
  - increased signal-to-noise ratio
  - extended depth of field
  - extended dynamic range
  - adaptive dark-field / bright-field imaging
- Suitable for high-speed inline applications
- Flexible choice between accuracy and speed (can be chosen dynamically)
- Technology protected by a number of patents



## Multiple viewing & illumination perspectives



# Computational Imaging using AIT Multi-Line Scan Approach

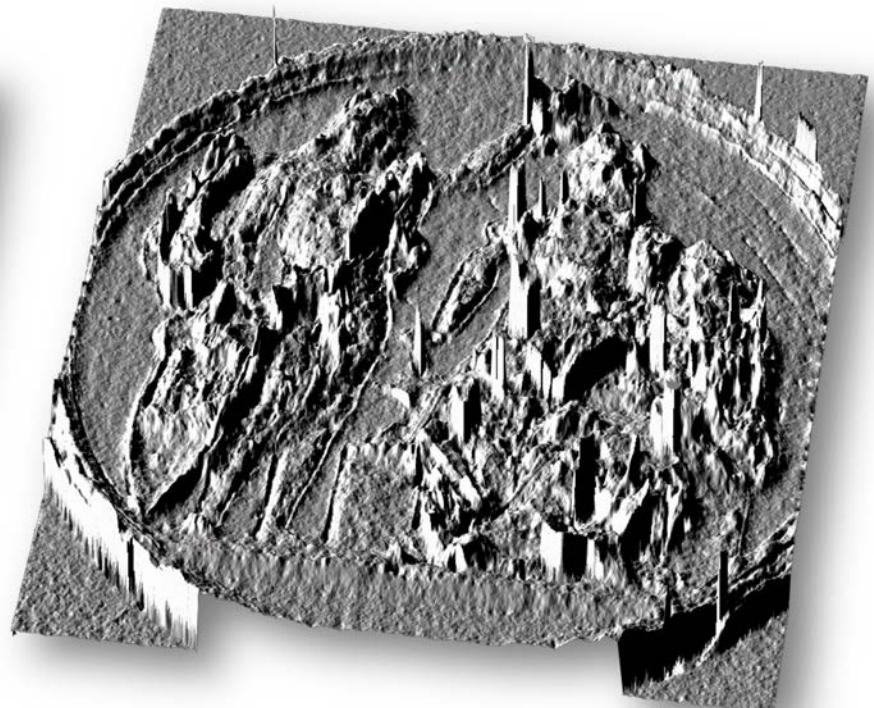


## 3D reconstruction using Light field vs. Conventional stereo

Light field (11 views)



Conventional stereo (2 views)



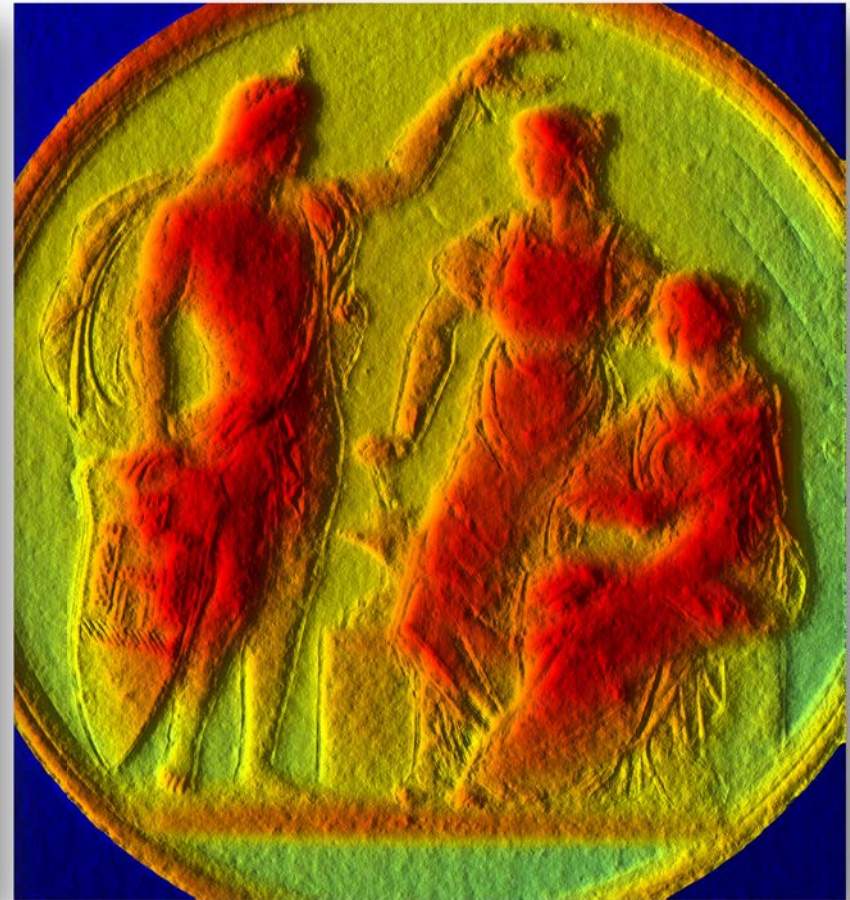
- For robustness with different materials, we perform variational multi-view stereo matching powered by the CRF method (<https://arxiv.org/pdf/1601.06274.pdf>)

# High detail with combined Light field & Photometric stereo

Light field & Photometric stereo



Light field only

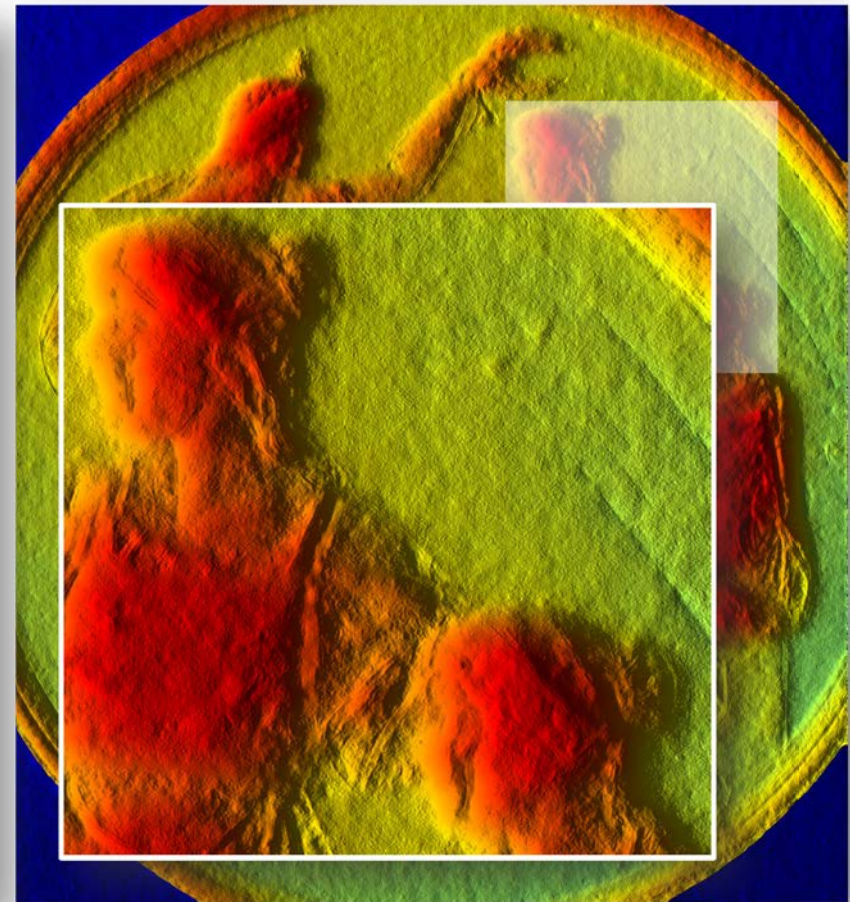


# High detail with combined Light field & Photometric stereo

Light field & Photometric stereo



Light field only

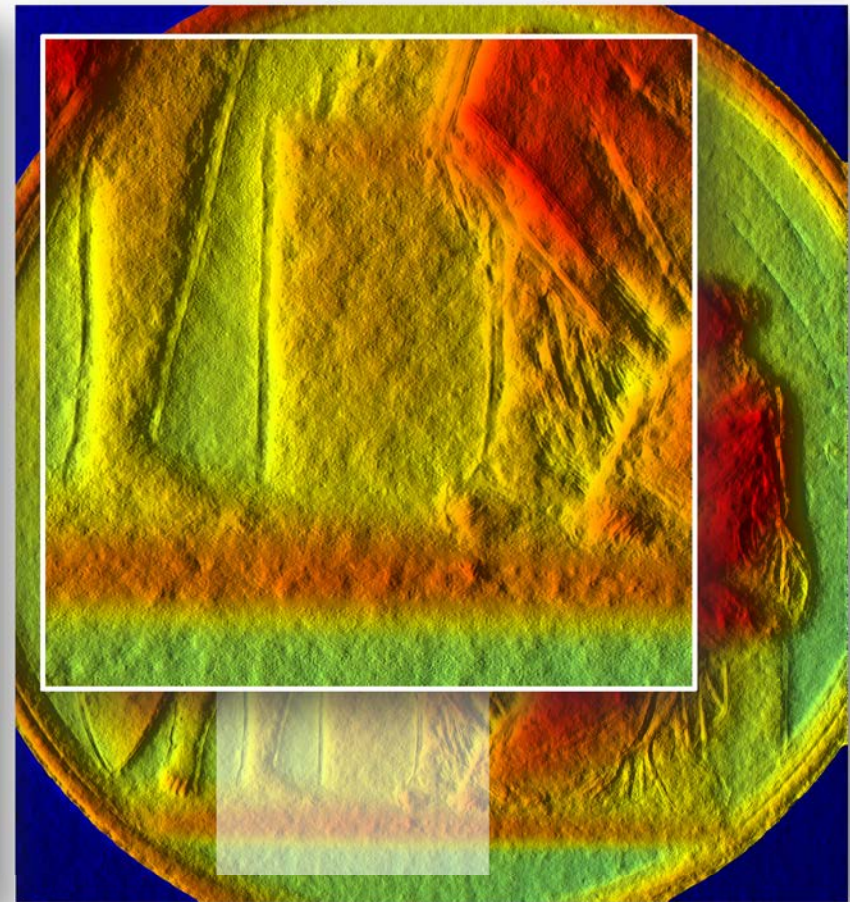


# High detail with combined Light field & Photometric stereo

Light field & Photometric stereo



Light field only



## All-in-focus imaging for increased signal-to-noise ratio

All-in-focus (extended DoF / 3D TDI)



Full aperture (TDI-like)



## Adaptive dark-field / bright-field imaging

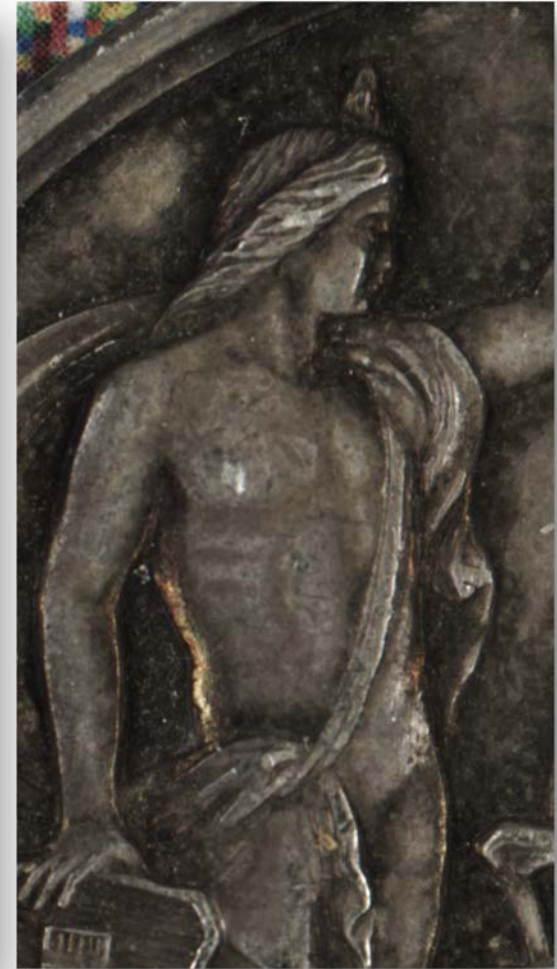
High gloss



Medium gloss



Low gloss

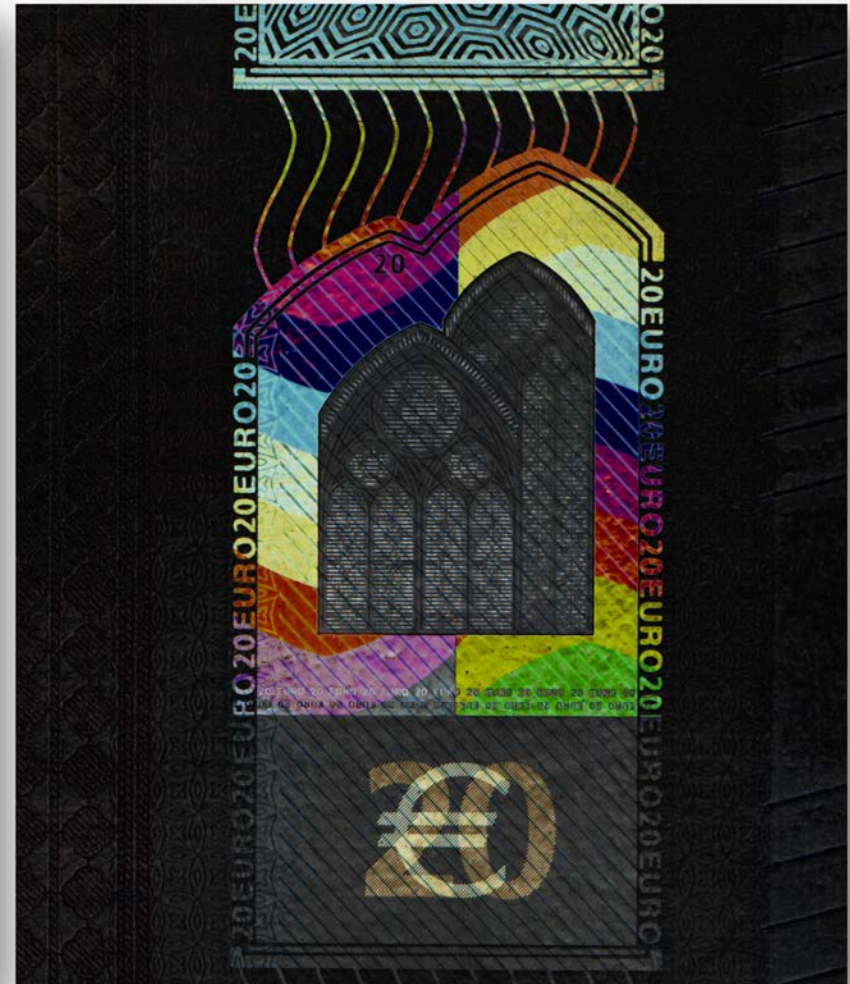


# Computational OVD detection in security printing

Multiple light field views



Detected OVD feature

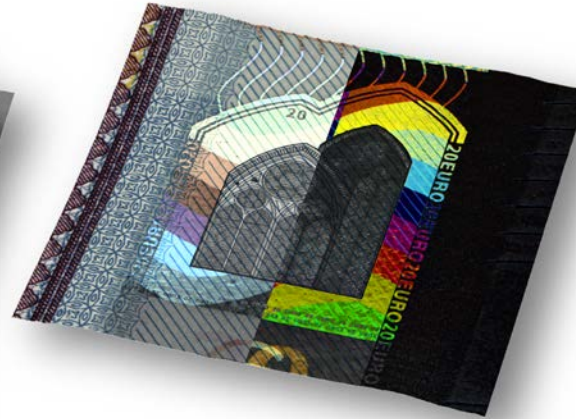


## Further use cases

Coins / Metal objects



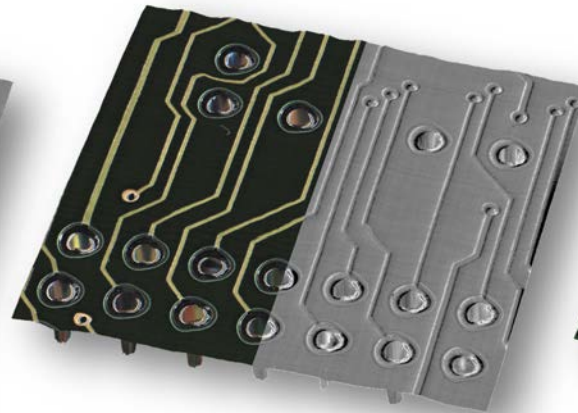
Security print



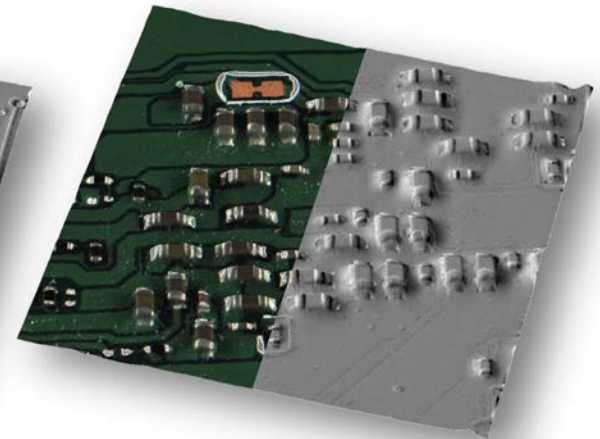
Packaging with Braille



Bare PCBs



PCBs with components



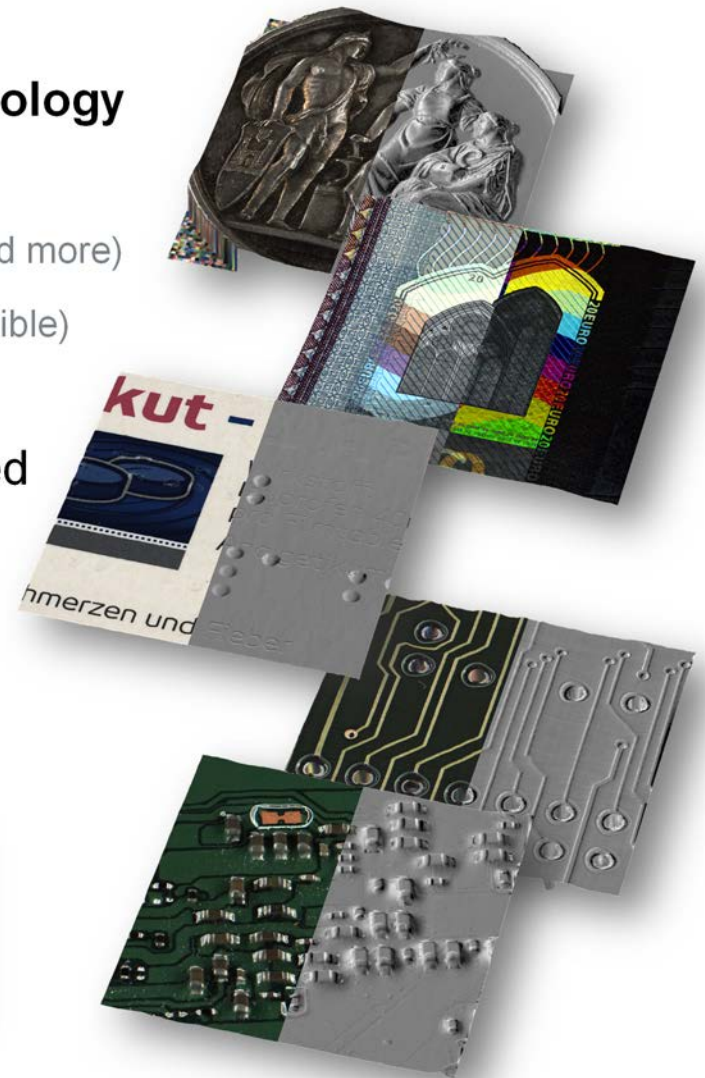


# Conclusions

## Advantages of the AIT multi-line scan technology

- Compact setup (only few components needed)
- Enables computational imaging (for 2D, 3D, and more)
- Inline applicable (with exposure 50 kHz line rate feasible)
- Combines Light field & Photometric stereo
- Flexible choice between accuracy and speed
- Works with many different materials
- Allows for advanced material analyses
- Protected by a number of patents

For more details, welcome to see our  
**Inline Computational Imaging demo!**



# AIT Austrian Institute of Technology

your ingenious partner

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