

XPOSURE – MORE THAN JUST THE FASTEST LINE-SCAN CAMERA

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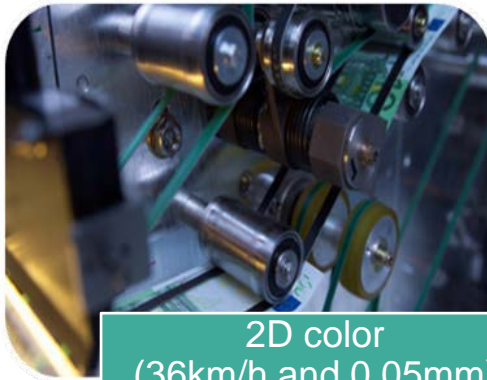
Stuttgart, 7.11.2018



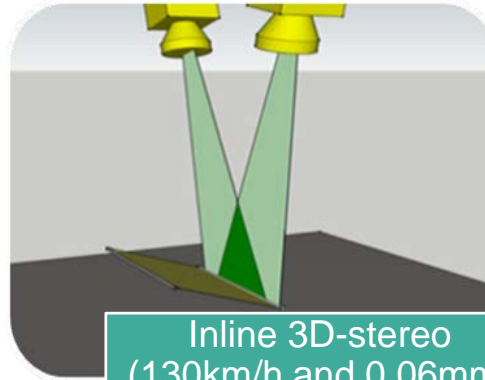
MOTIVATION

- We believe: Today, inline inspection systems have to do far more than just 2D surface scanning - we have to scan a bundle of physical surface properties to get the required inspection quality
- We observe: CMOS-technology-based image sensors and cameras have made a tremendous technological progress as for speed, data throughput and image quality, but line-scanning imagers for inline scanning lag far behind
- We propose: fast and flexible multi-line-scan camera technology with low NRE for easy adaption to specific inline inspection application
- You get: several application examples of a fast and flexible multi-line-scan technology

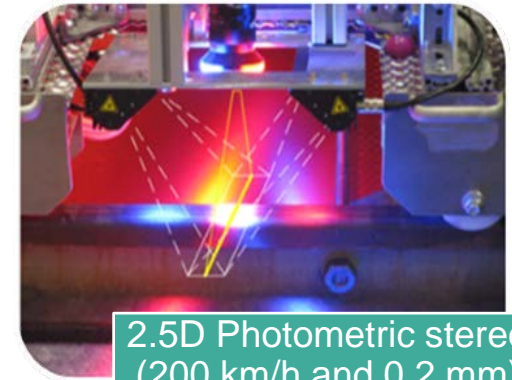
NEED FOR INLINE ACQUISITION OF VARIOUS PHYSICAL SURFACE PROPERTIES



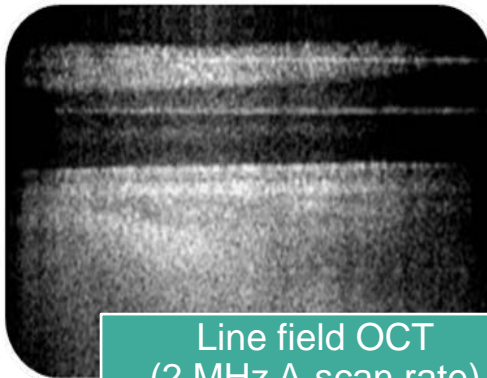
2D color
(36km/h and 0.05mm)
High-resolution color



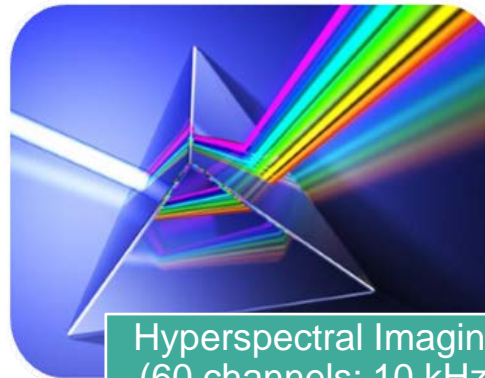
Inline 3D-stereo
(130km/h and 0.06mm)
Depth map



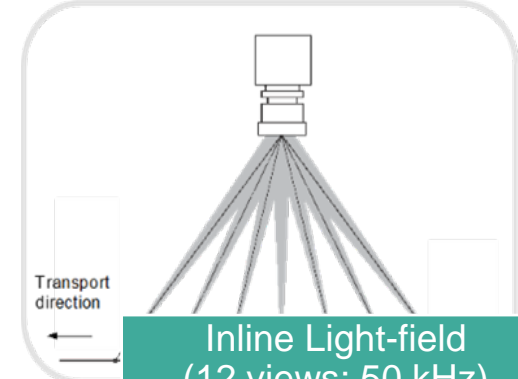
2.5D Photometric stereo
(200 km/h and 0.2 mm)
Surface curvature



Line field OCT
(2 MHz A-scan rate)
Layer structure of tissue



Hyperspectral Imaging
(60 channels: 10 kHz)
Material properties



Inline Light-field
(12 views: 50 kHz)
Denser sampling BRDF

FAST AND FLEXIBLE MULTI-LINE-SCAN TECHNOLOGY AND ITS VALUE FOR VARIOUS APPLICATIONS

- 2D high-speed line-scan -> high-resolution color images
- Inline 3D inspection -> high-resolution depth map
- 2.5D Photometric stereo -> detailed surface curvature
- Line field OCT (> 2 MHz A-scan rate) -> Volume scan of tissue
- Multi-spectral imaging with far more than 3 spectral bands
-> robust material classification
- Multi-line-scan light-field imaging for versatile inline inspection tasks
-> more stable acquisition of surfaces with “difficult” reflection
properties by exploiting the 4D nature of the light field

2D COLOR PRINT INSPECTION @ 10 M/S – BOOST RESOLUTION



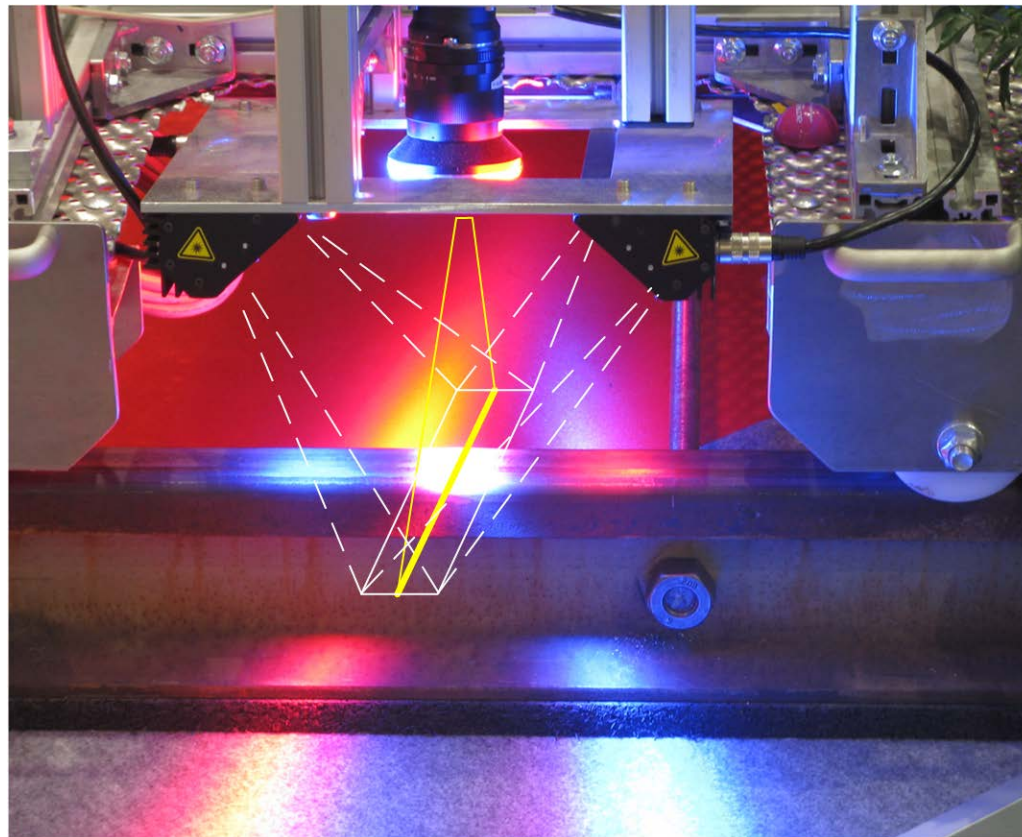
state of the art
0,20 mm



goal
0,05 mm

2.5D RAIL INSPECTION WITH PHOTOMETRIC STEREO

- Resolution 0,2 mm – 2 color channels
- scanning speed: 200 km/h
- → 300 kHz line rate (RB)



3D ROAD SURFACE INSPECTION

- 2 exposure cameras 3D stereo
- 60 μm resolution
- 130 km/h for highways



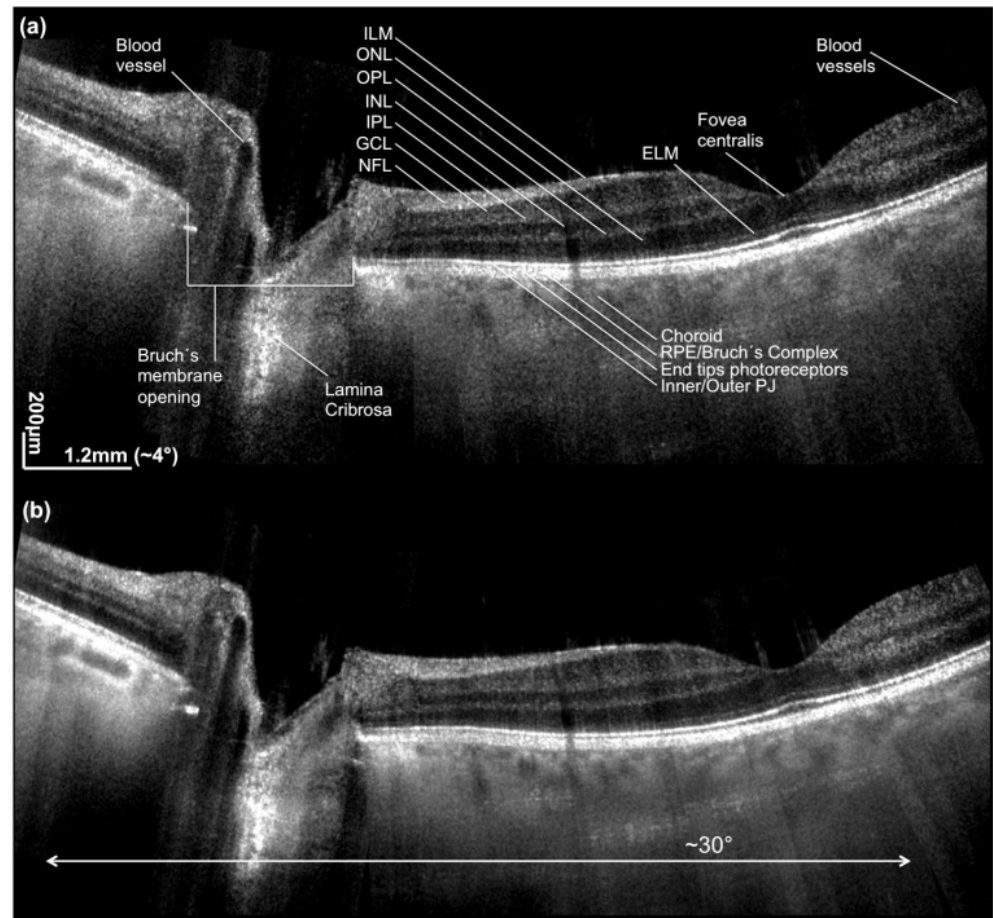
METAL SURFACE INSPECTION – FINDING A NEEDLE IN A HAY STACK

- Defects in micrometer range
- Hundreds of square meters

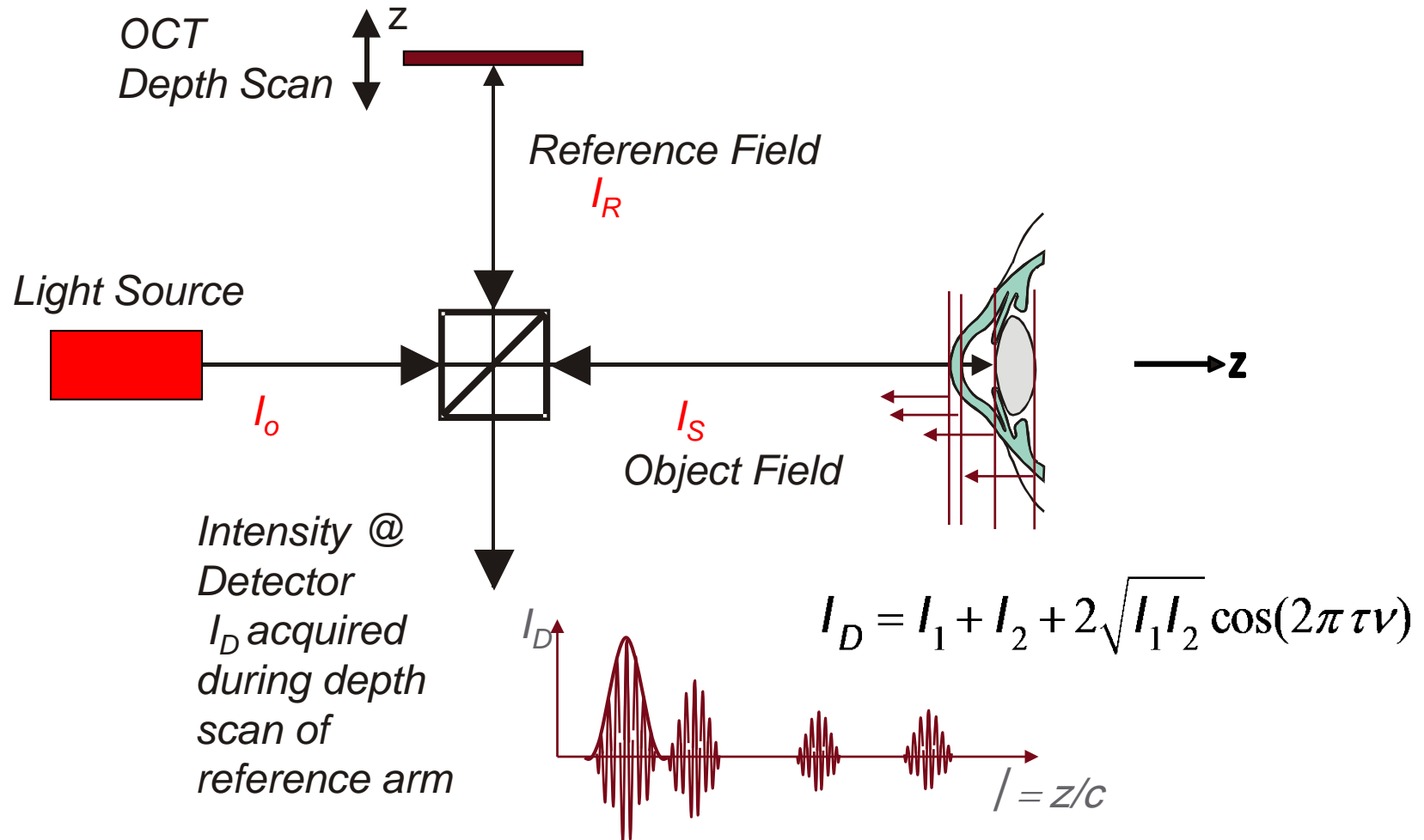


3D VOLUME SCAN WITH OPTICAL COHERENCE TOMOGRAPHY

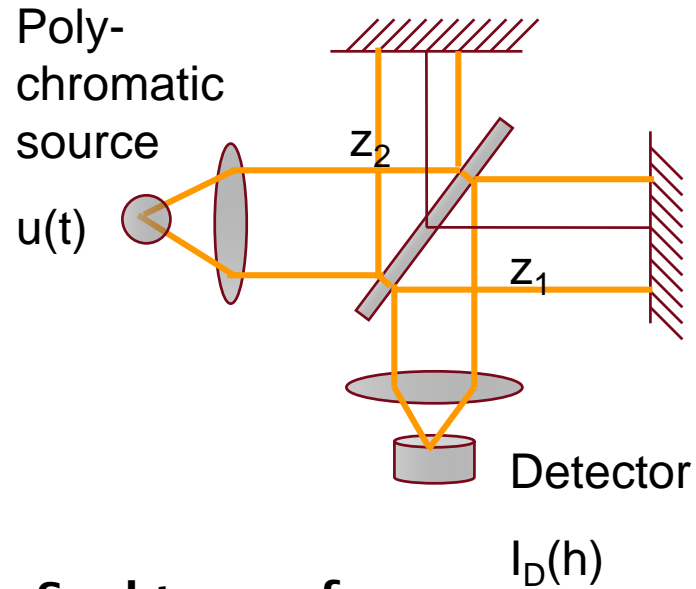
- Swept-source line-field OCT
- Biomedical (eye, skin)
- > 2 MHz A-scan rate



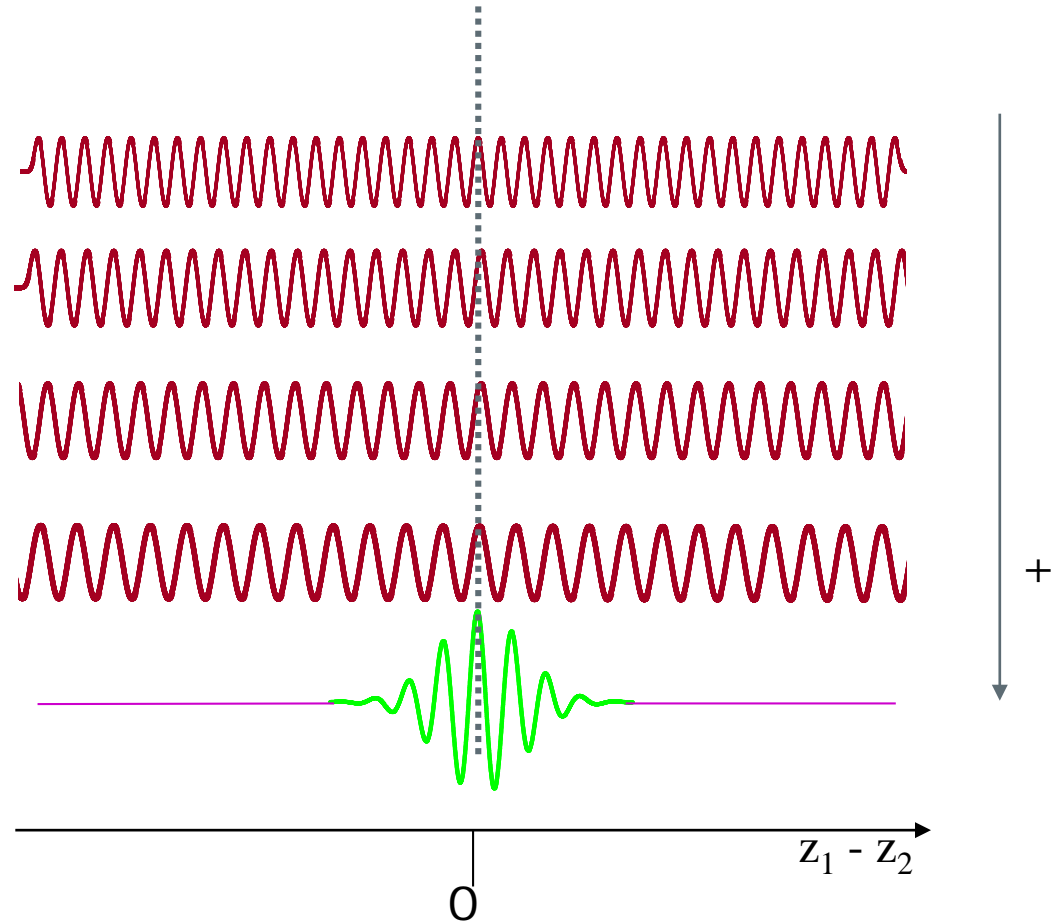
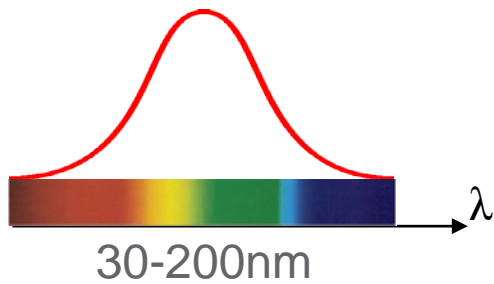
WHITE LIGHT INTERFEROMETRY



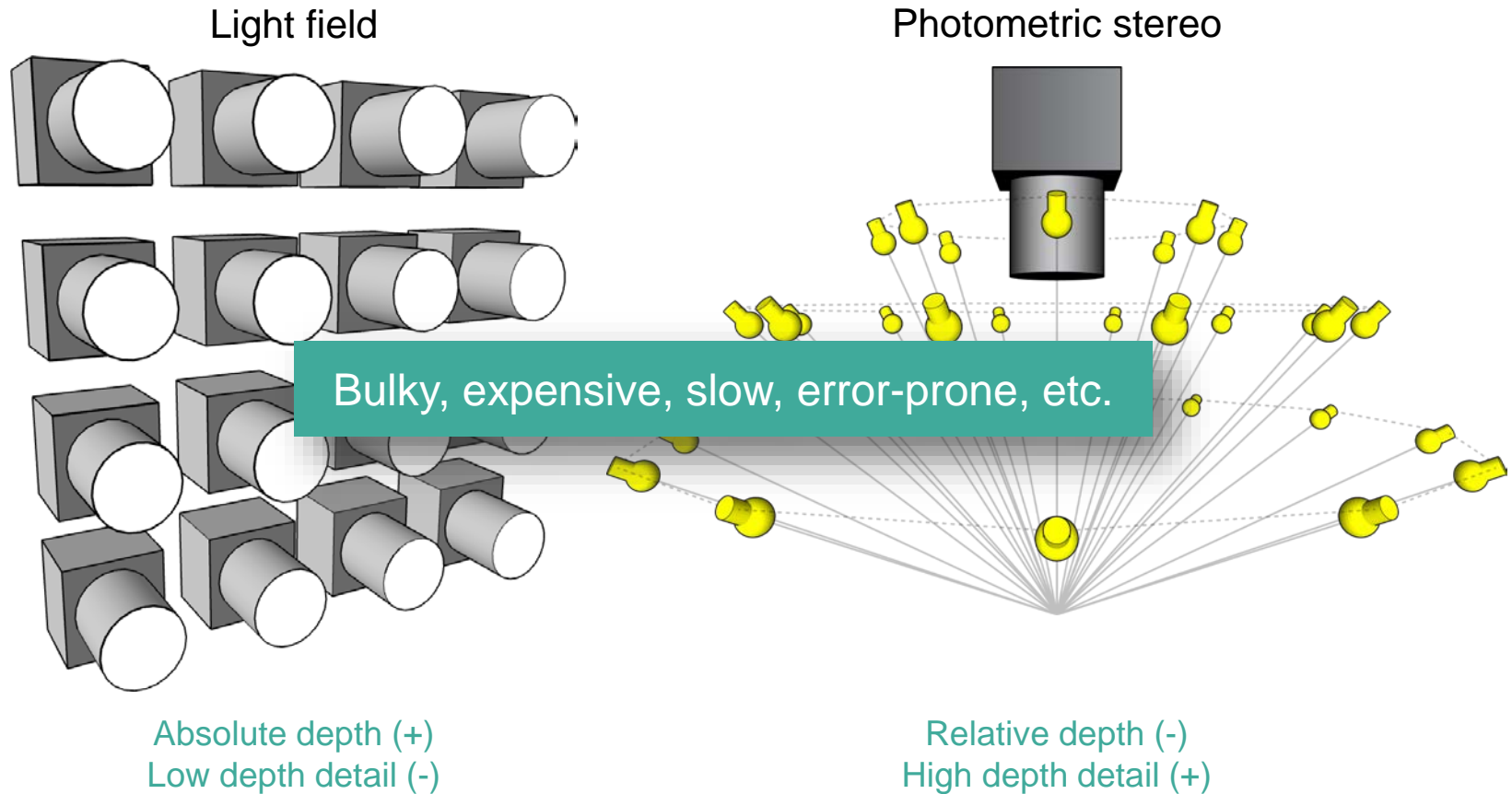
WIDE-BAND LIGHT SOURCE



Spektrum of wavelengths

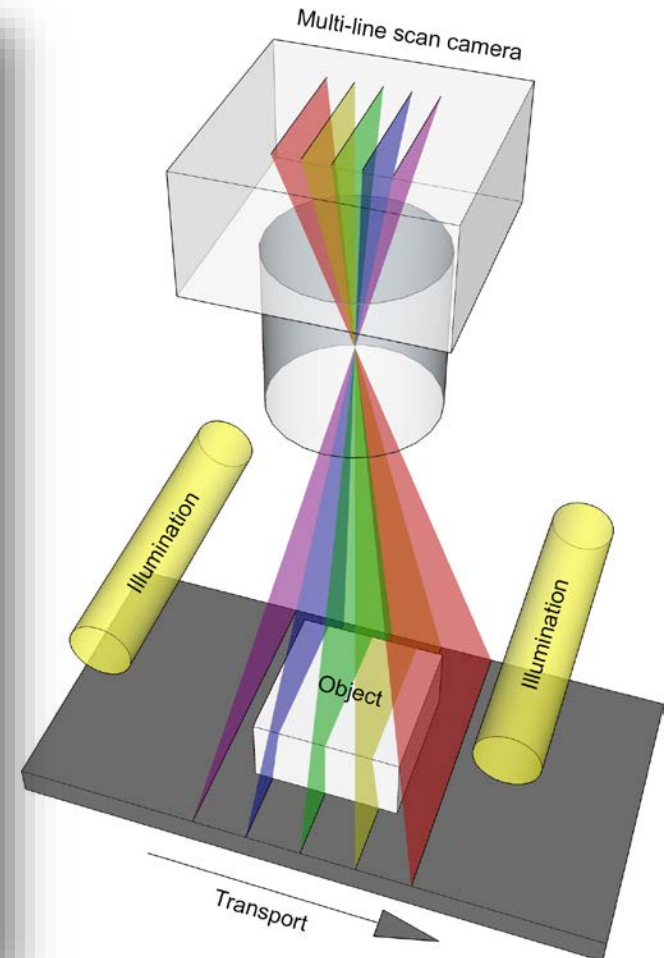
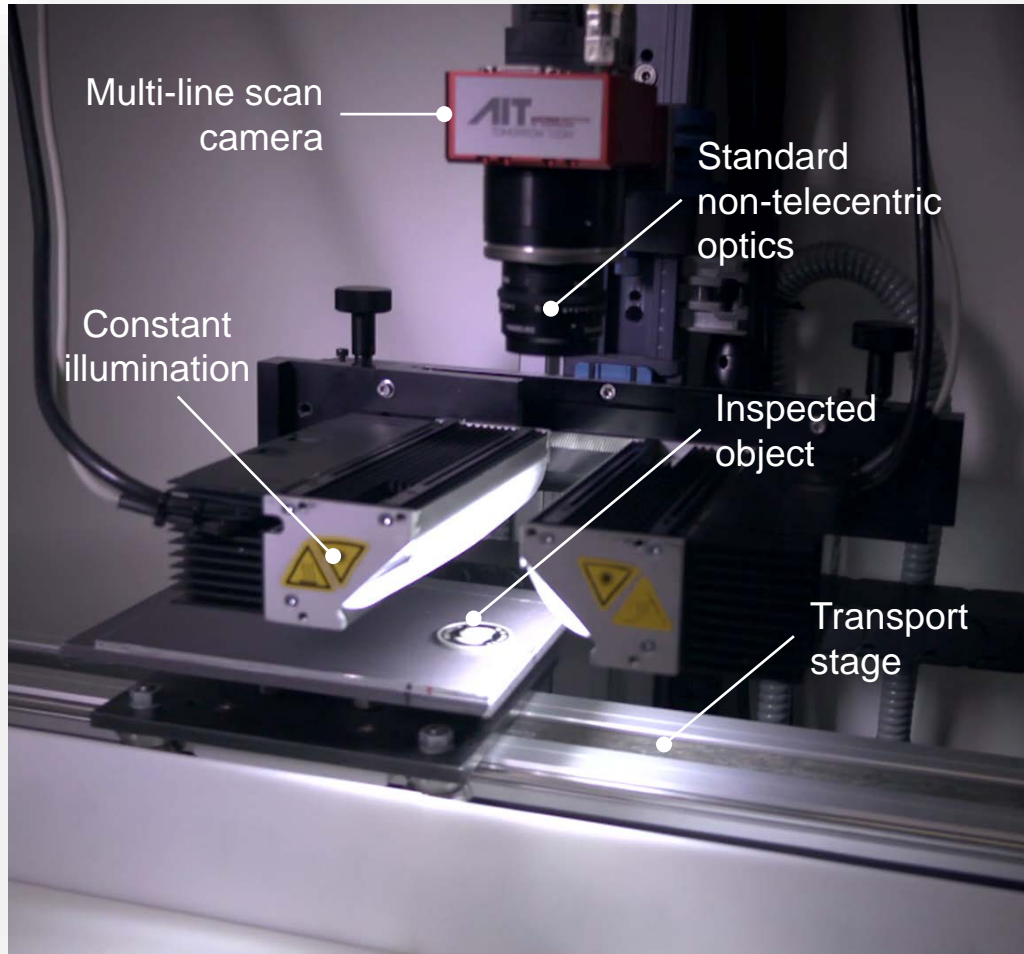


STATE OF THE ART LIGHT FIELD TECHNOLOGY IS NOT INLINE COMPATIBLE



AIT INLINE COMPUTATIONAL IMAGING (1/2)

[Štolc S. et al., JEI 2014]



AIT INLINE COMPUTATIONAL IMAGING (2/2)

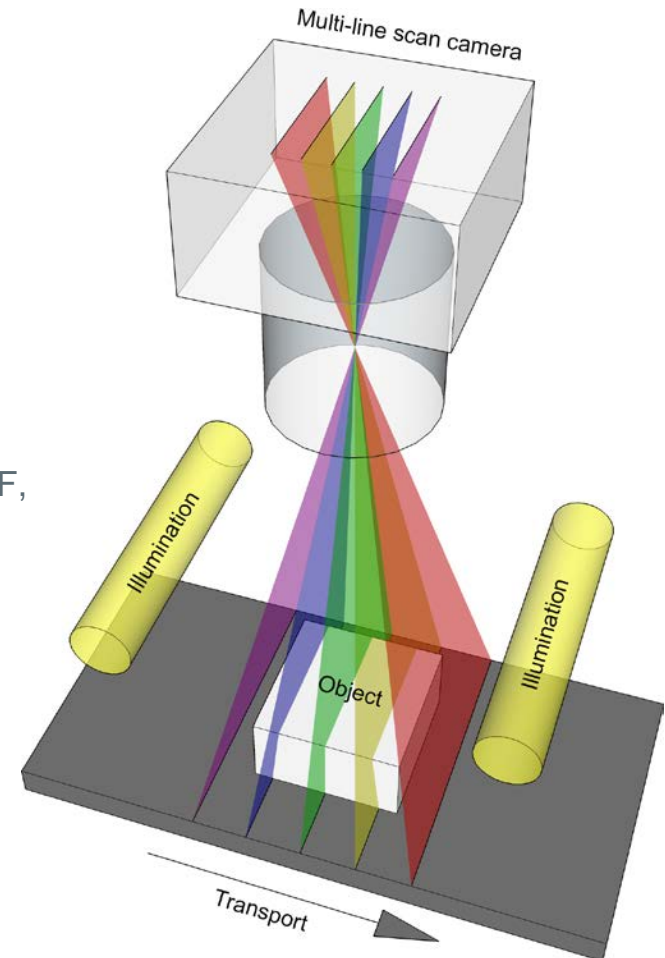
[Štolc S. et al., JEI 2014]

Opportunities

- Single multi-line scan camera / constant illumination
(low system complexity)
- Joint multiplexing of viewpoint and light direction
(i.e. light field & photometric stereo; neither strobing nor multiple exposures are required)
- Allows for computational imaging
(depth reconstruction, refocusing, increased SNR, extended DoF, super-resolution, etc.)
- Suitable for high-speed inline applications

Limitations

- Small stereo baseline \Rightarrow limited depth resolution
(can be increased using photometric stereo)
- Requires precise transport control
(can be compensated computationally)

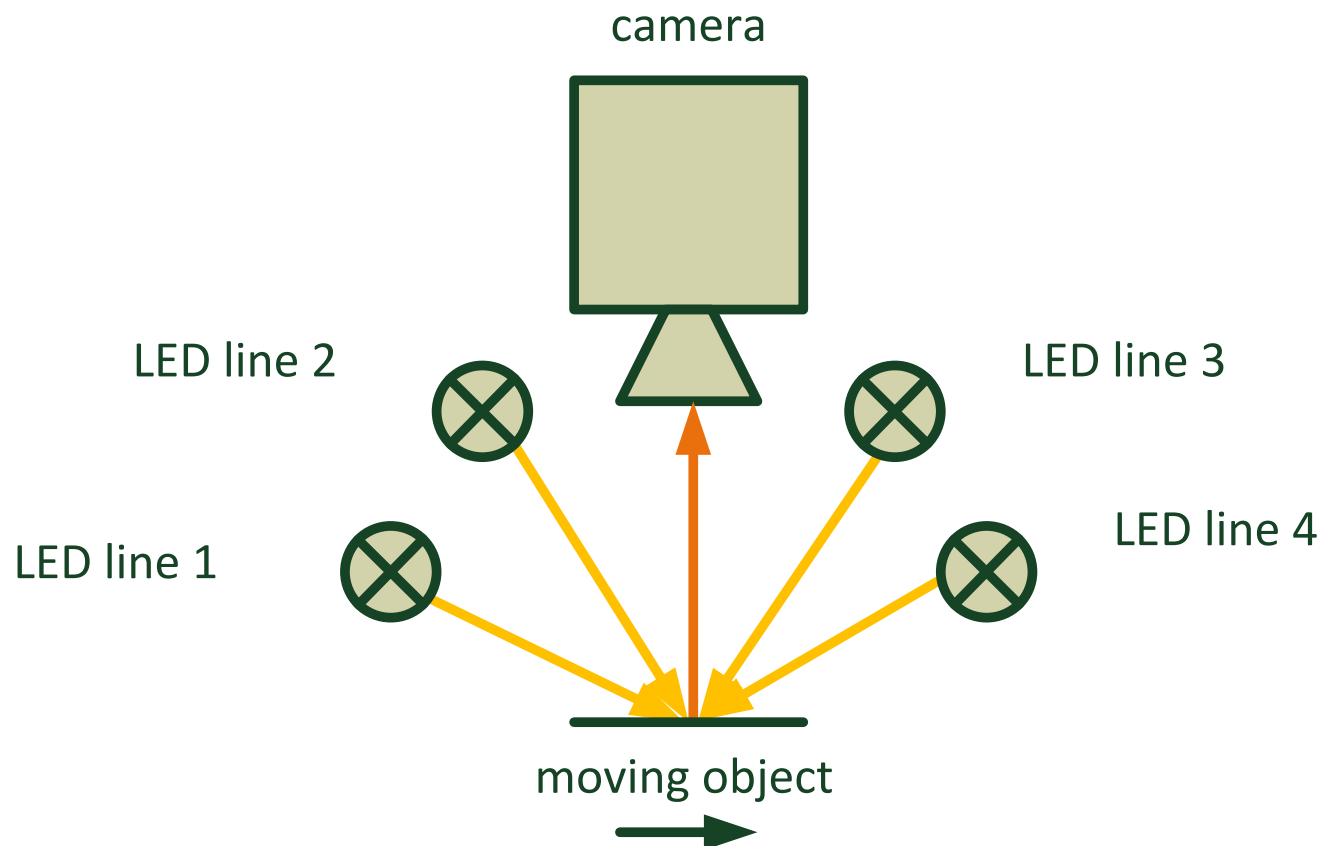


VIEWPOINT AND LIGHT DIRECTION MULTIPLEXING WITH AIT INLINE COMPUTATIONAL IMAGING (ICI)



INLINE PHOTOMETRIC STEREO

- AIT's xposure camera with up to 600 kHz line-rate
- 4strobed LED lines illuminating for different directions
- -> inline photometric stereo with 150 kHz line-rate



AIT XPOSURE CAMERA - A PROTOTPYE OF A FAST AND FLEXIBLE MULTI-LINE-SCAN CAMERA

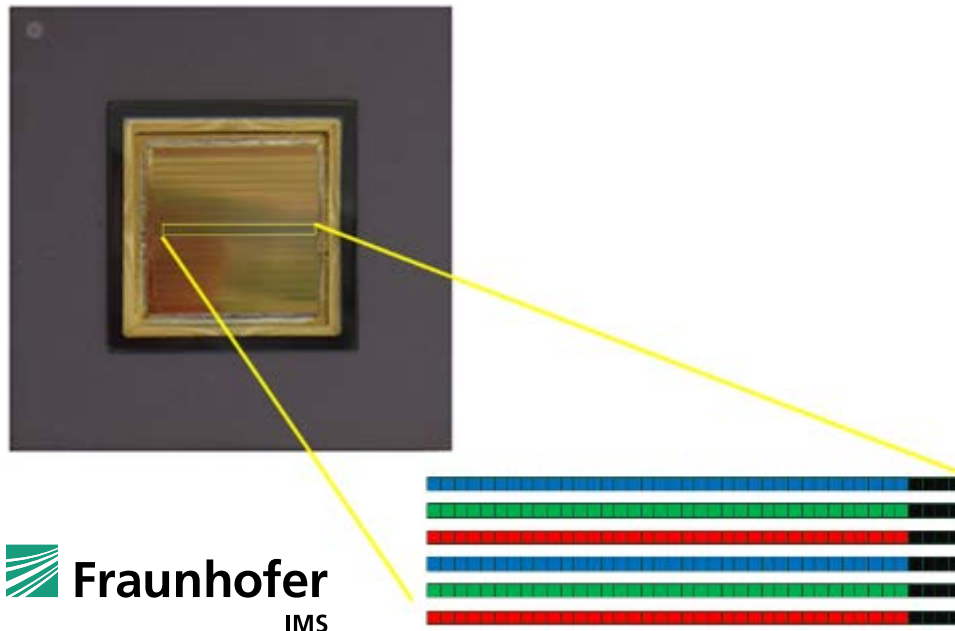
➔ New type of scanning device

- fast
- sensitive/low noise (short exposure time)
- flexible



Flexible switching between readout modes, e.g.

- 600.000 fps single line
- 300.000 fps RB color
- 200.000 fps RGB color
- 100.000 fps 6 color channels
- 10.000 fps 60 color channels



CONCLUSION

- Today scanning of different physical surface properties is necessary
- Technological progress of line-scanning devices lags far behind area scanning devices
- Gap is closed by a fast and flexible multi-line-scan technology ...
- ... that can easily adapt to a variety of inline inspection situations
- There are several applications benefiting from a fast and flexible multi-line-scan technology

REFERENCES

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THANK YOU!

www.ait.ac.at/hpv

