

High Tech in the Food Value Chain

Non-invasive sensing of food quality in manufacturing, distribution and retail

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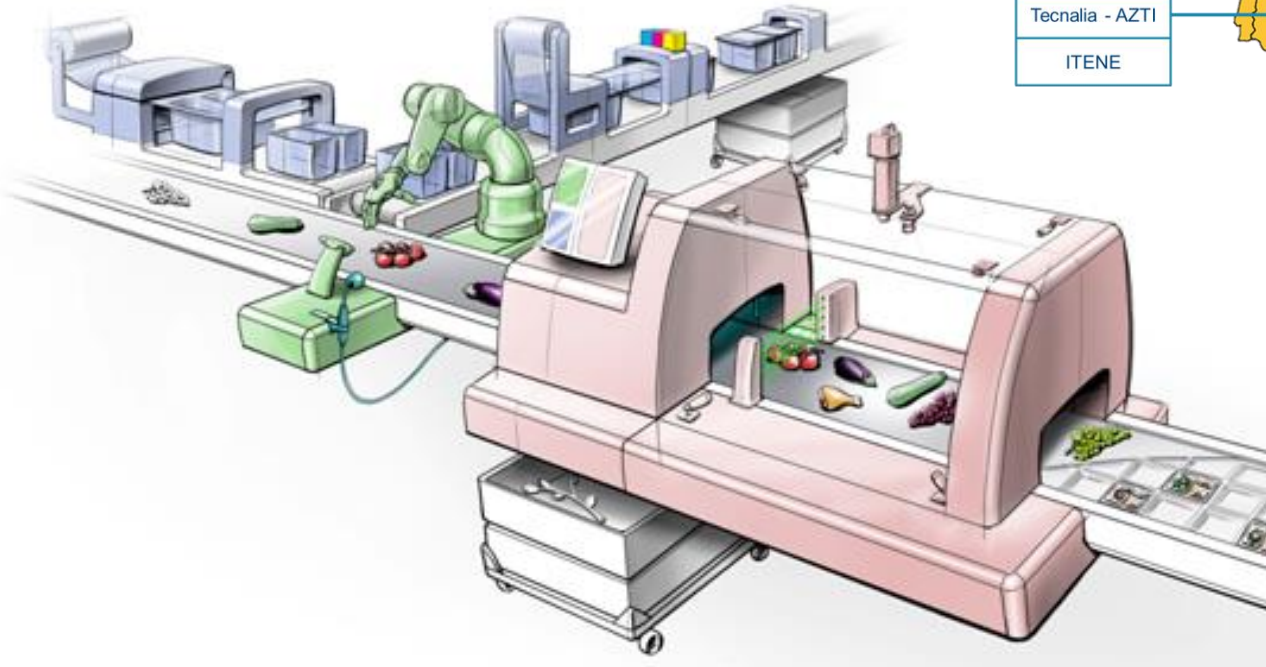
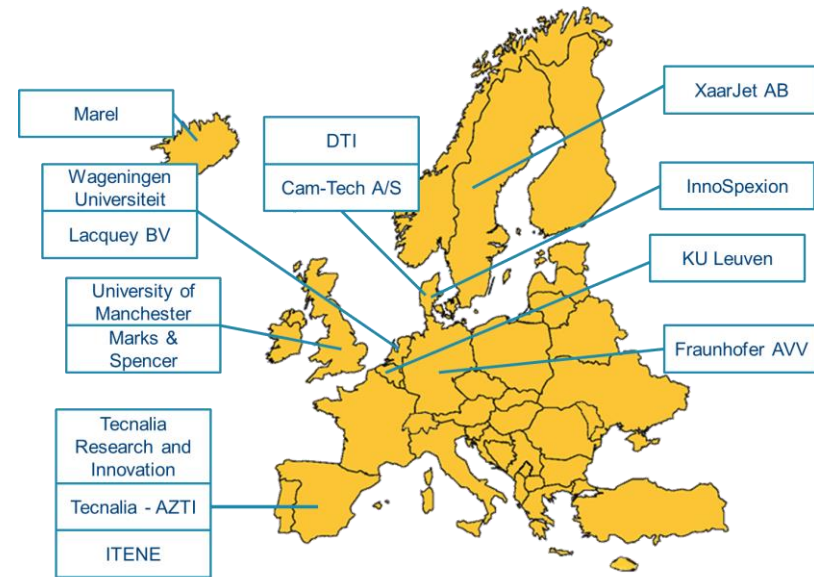


Challenges for automation

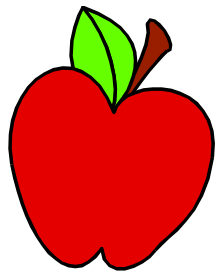
- Hands on the line = Eyes & Brain on the line!
- Flexibility
 - To cope with biological variability
 - Product differentiation
 - Small batches



The PicknPack project



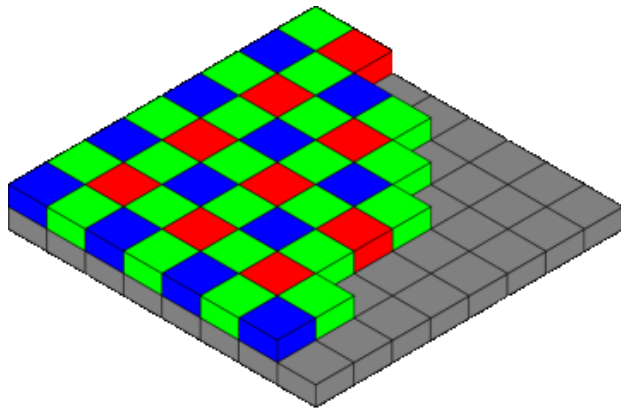
RGB camera vision



Blue stimulus centre

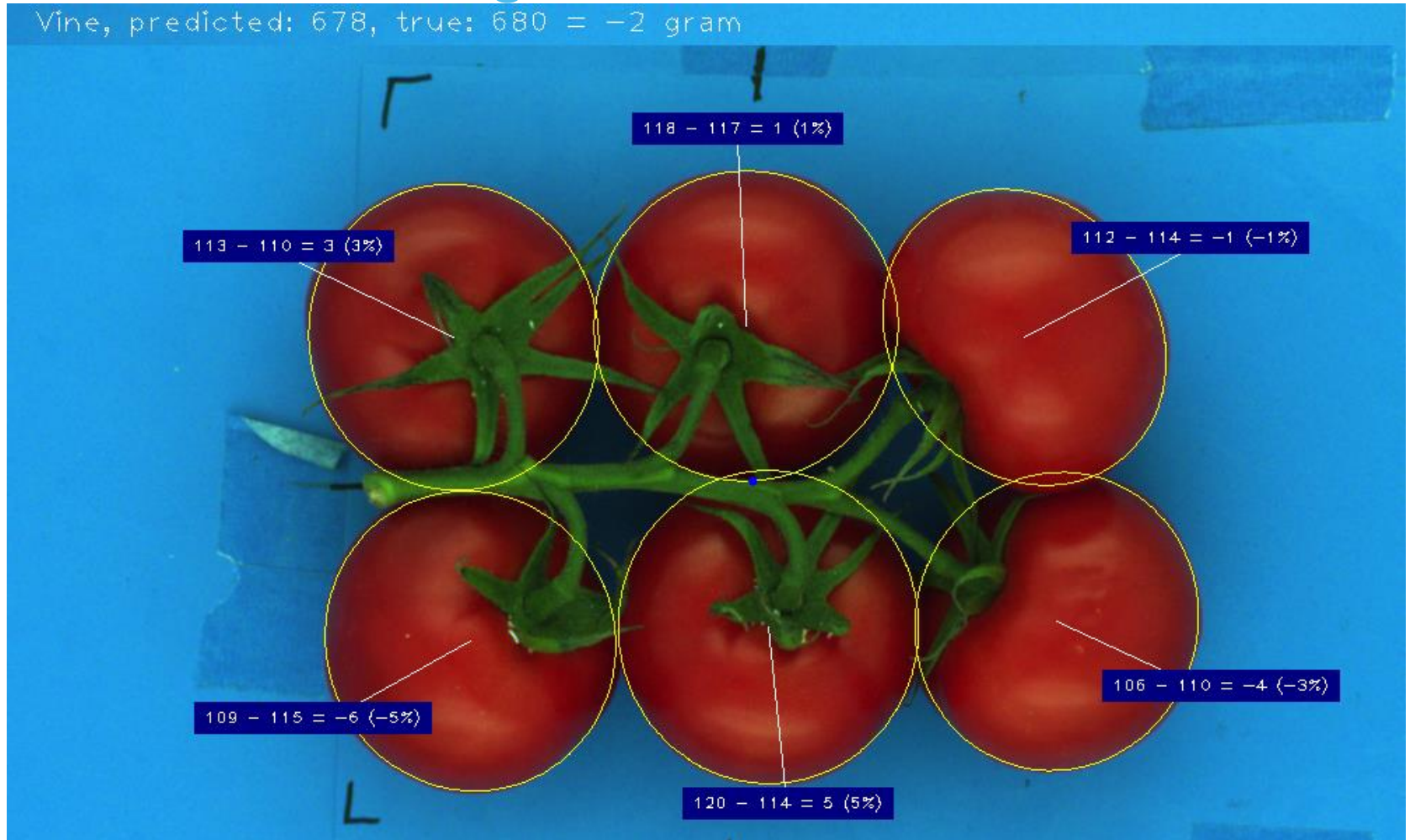
Green stimulus centre

Red stimulus centre

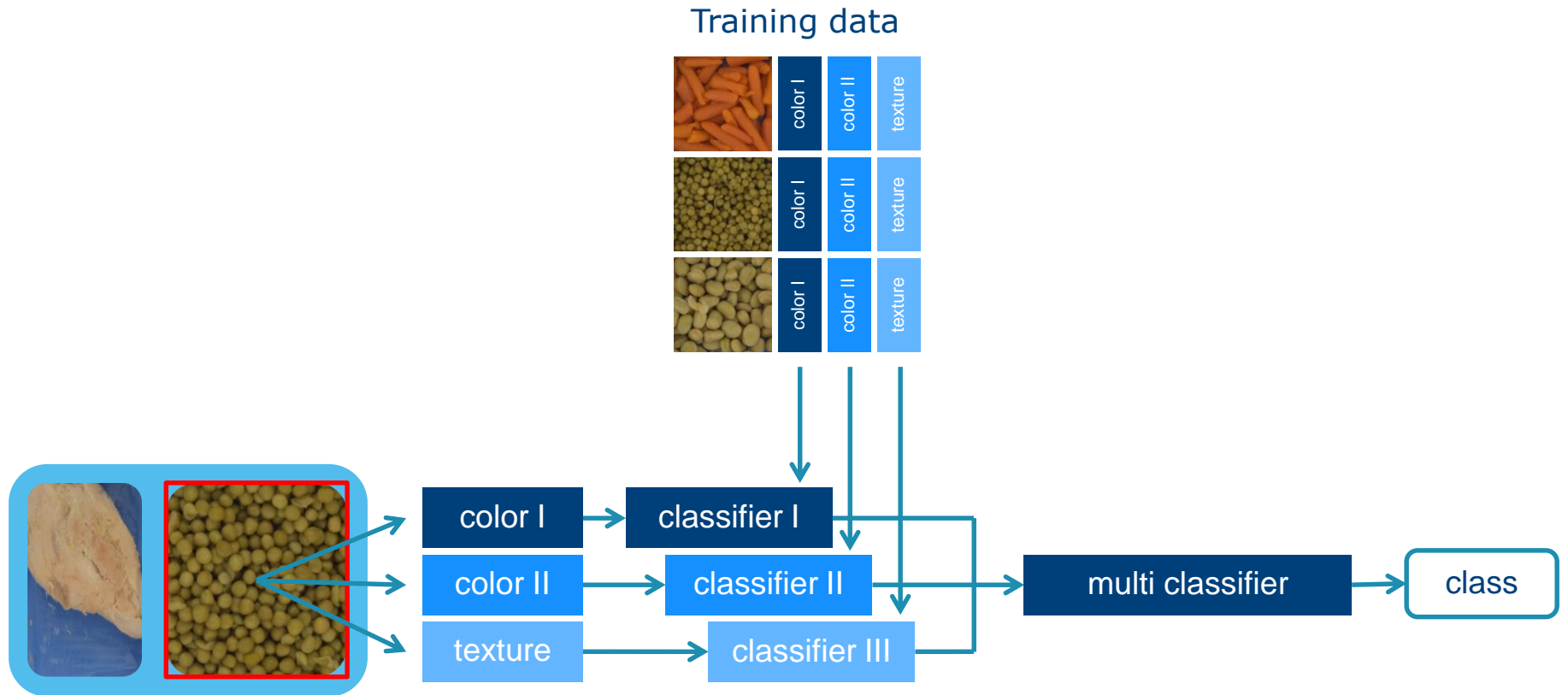


Contactless weight estimation tomato trusses

Vine, predicted: 678, true: 680 = -2 gram

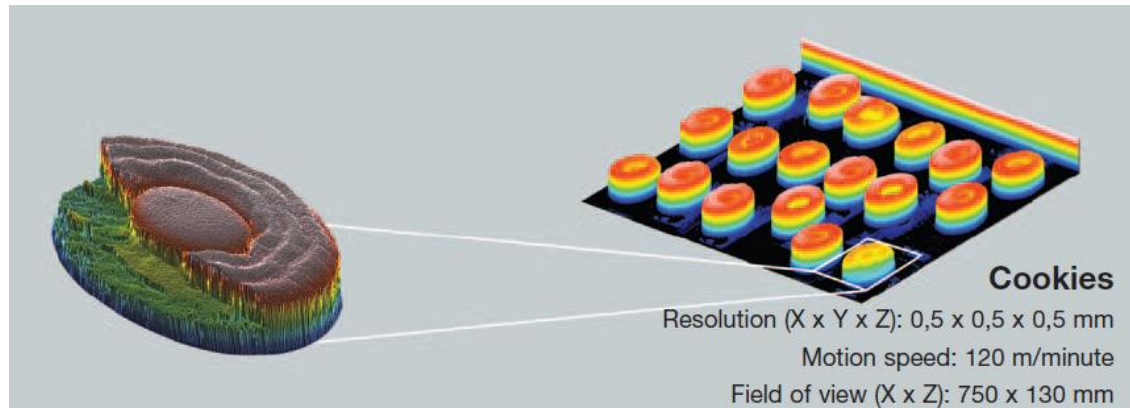
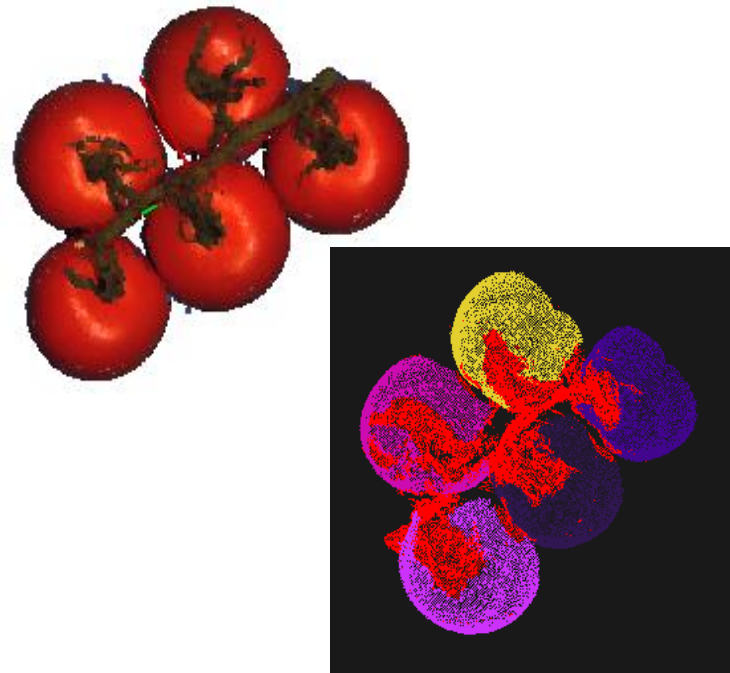


Inspection of ready meals



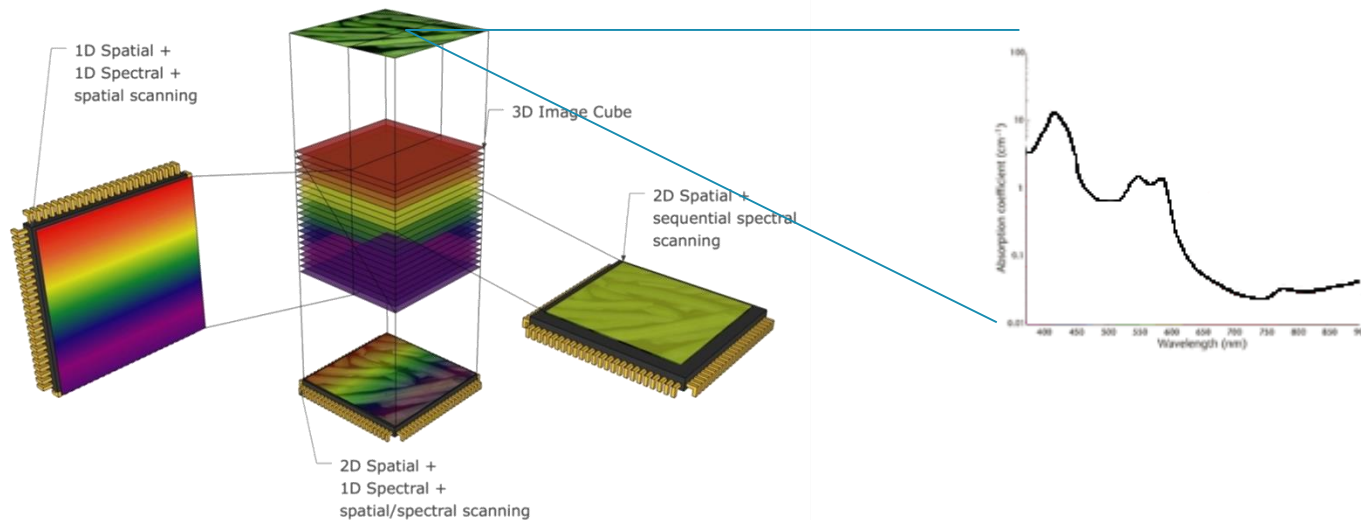
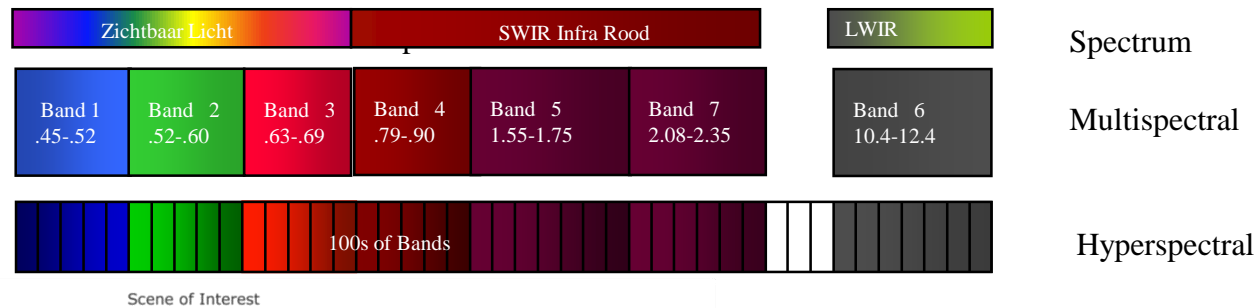
RGB+3D: from surface to volume

- How to determine the distance to an object in the image?
 - Stereovision: disparity between images 2 eyes/camera's
 - Measure distortion of projected pattern
 - Time of Flight of light to object and back



Hyperspectral camera's

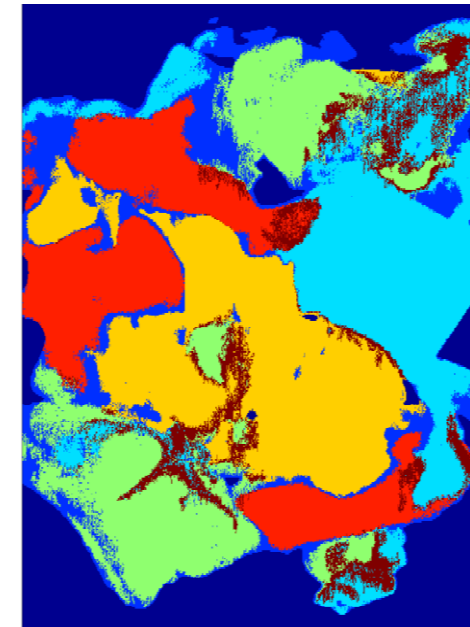
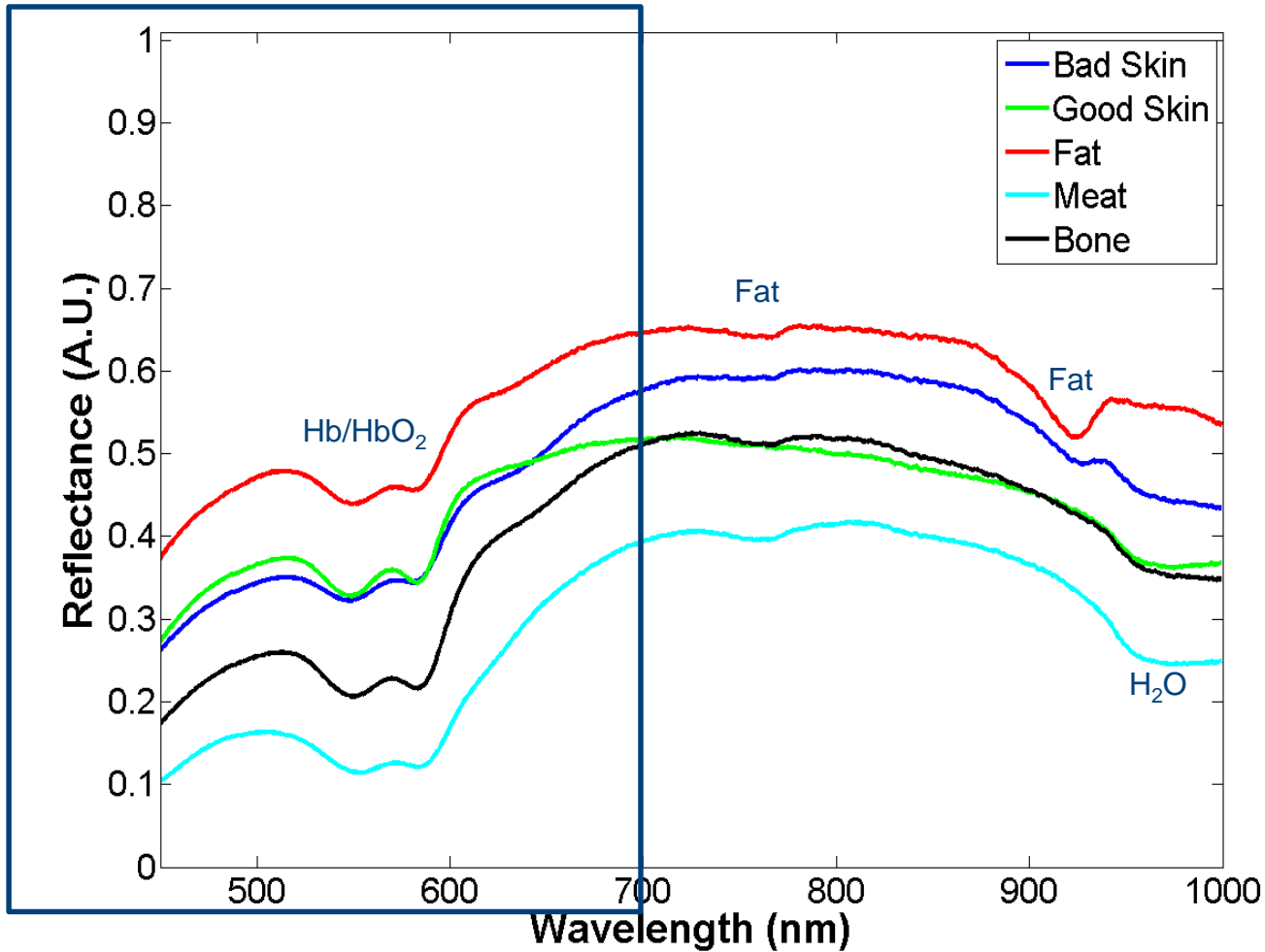
- Differentiate products with similar colour
- Assess surface and subsurface quality



Spectral
“signature” for
every pixel in
the image

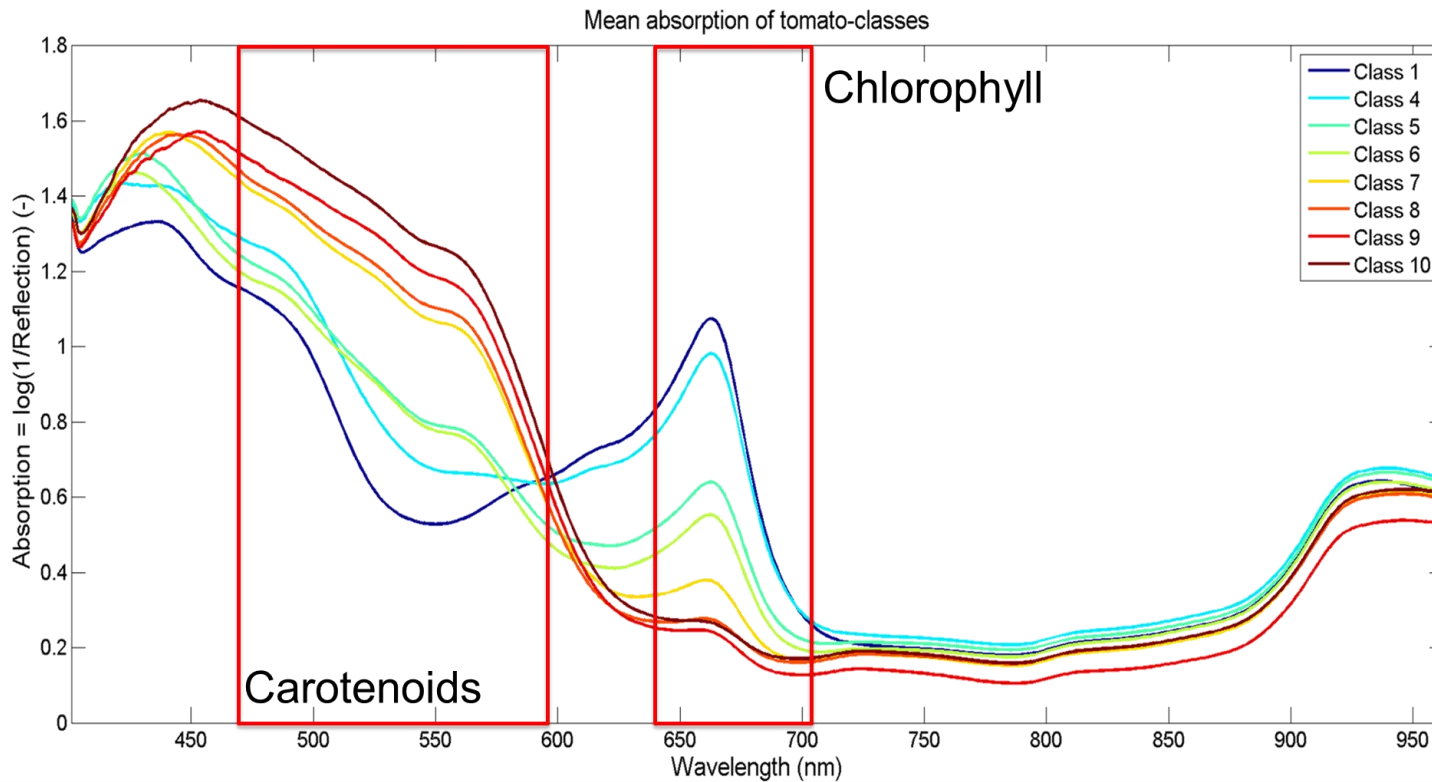
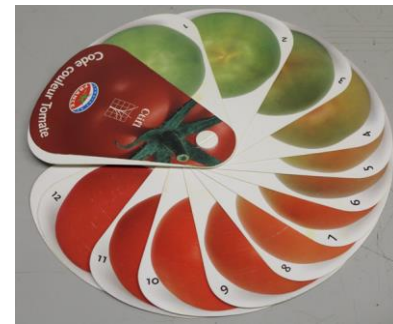
Classification in carcass deboning

RGB



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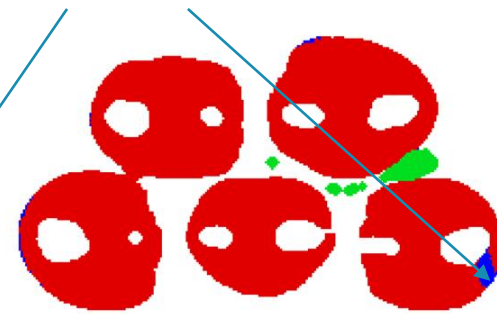
Ripeness of tomatoes



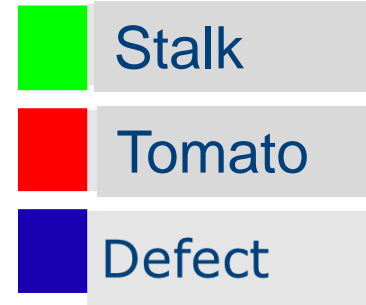
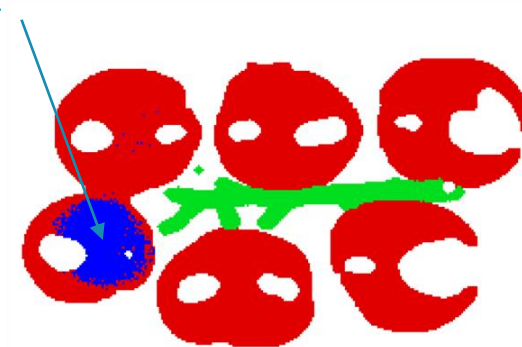
Defect detection in tomatoes



Puncture damage

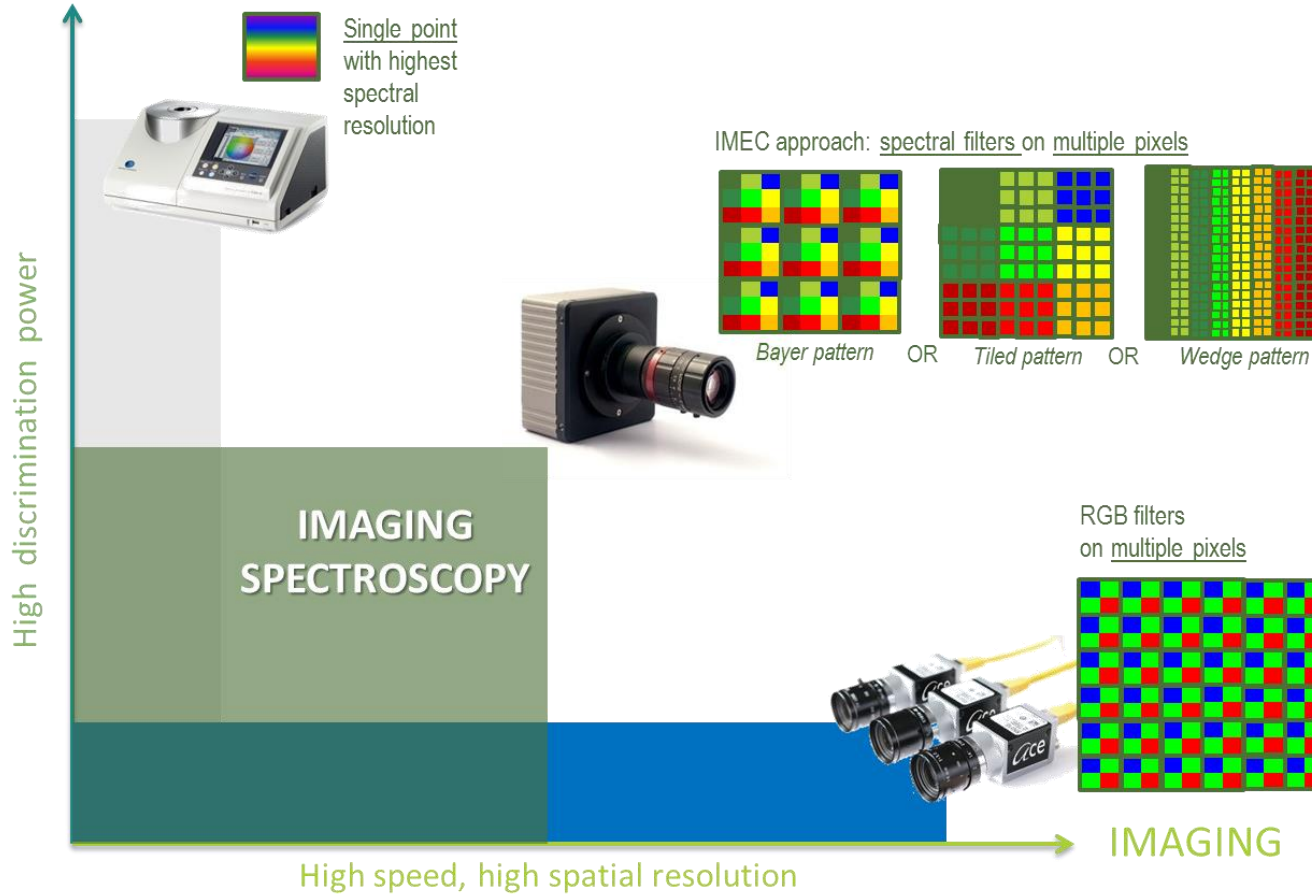


Discoloration



Spectral camera's in the factory

SPECTROSCOPY



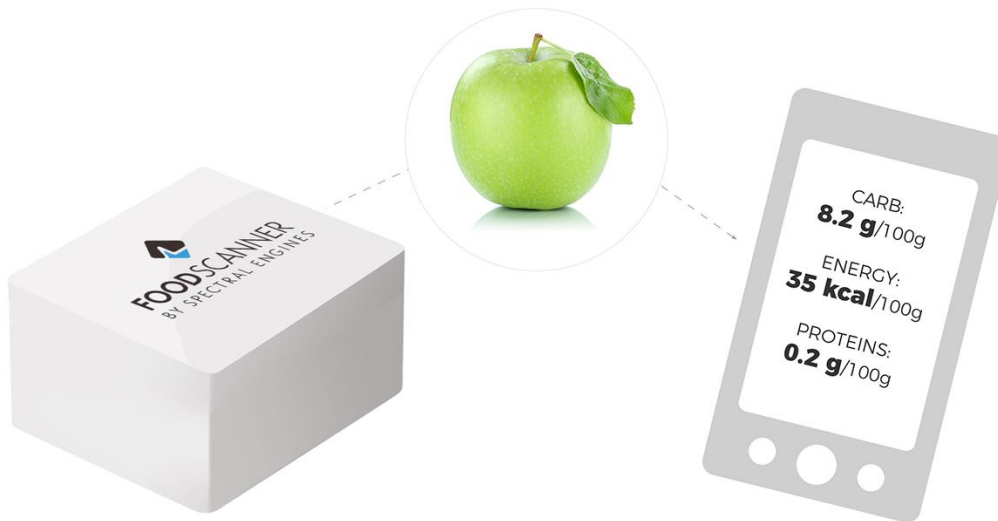
Spectral sensors in the factory

- From: Sampling – Transport to the lab – Scanning in the lab
- To: Bringing sensors to the samples for
 - At line
 - On line
 - In line



Spectral sensors for consumers

- Democratization of spectral sensors
- Connection to smartphone
- Data processing in the cloud
- 'Food scanners'
 - Product identification vs. quantification
 - Be careful for over-ambitious claims!



Interaction of light with turbid food matrices

- Light = Electromagnetic spectrum

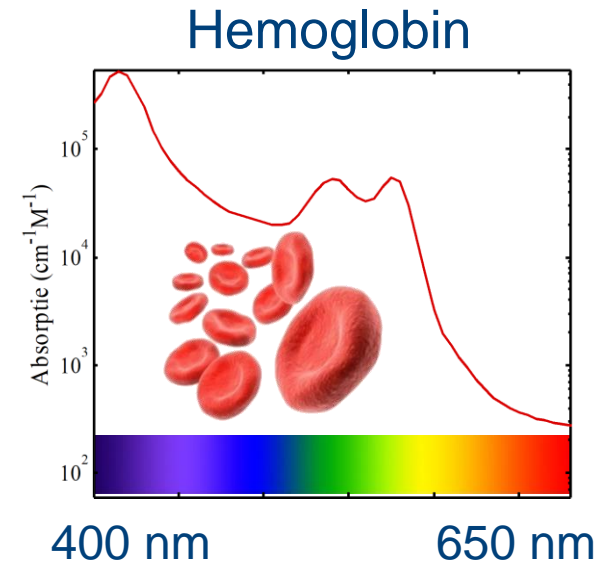
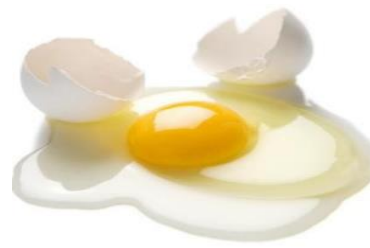
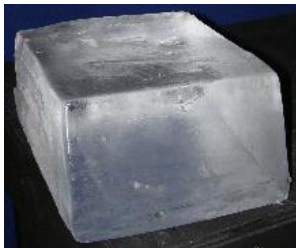


1. Absorption (μ_a)

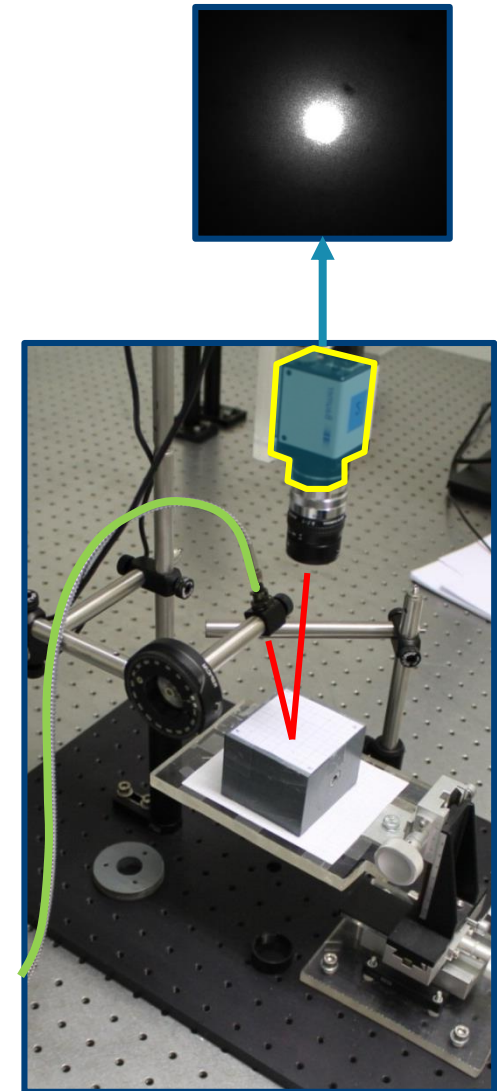
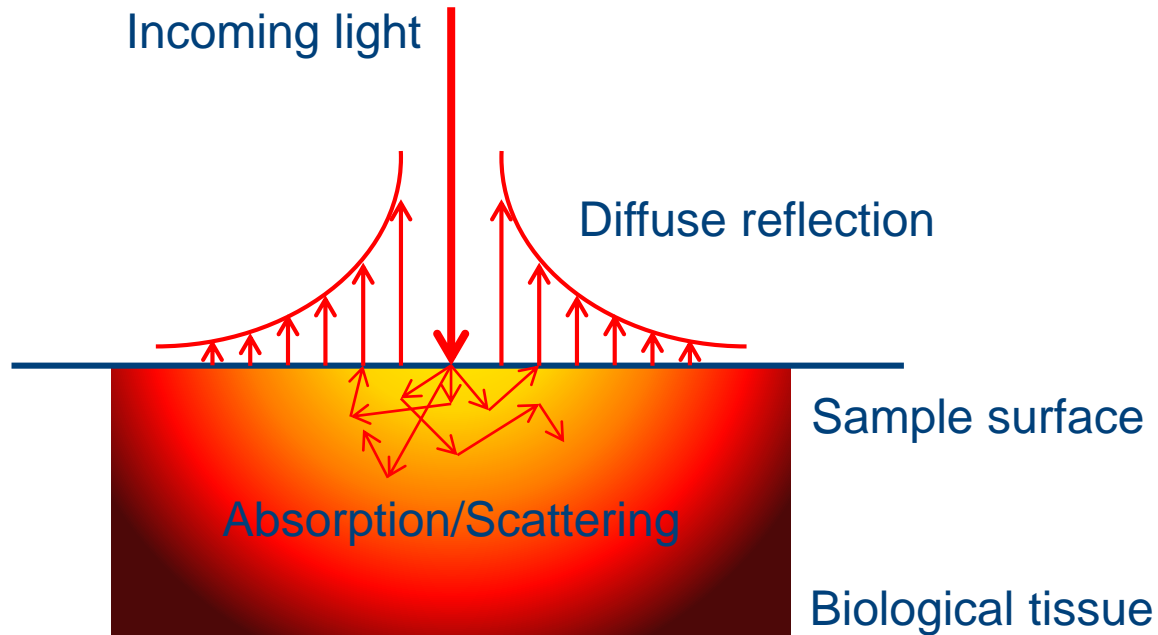
- Chemical properties

2. Scattering (μ_s)

- Physical (micro)structure

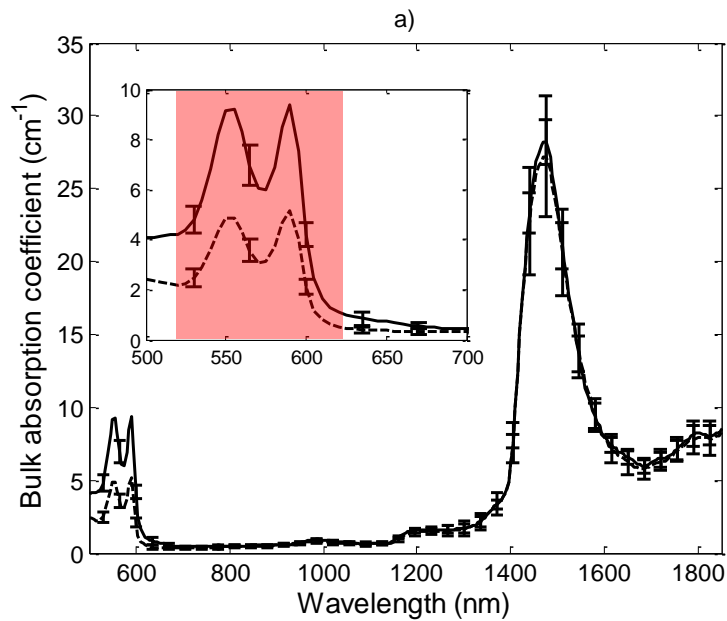


Spatially Resolved Spectroscopy for microstructure characterization



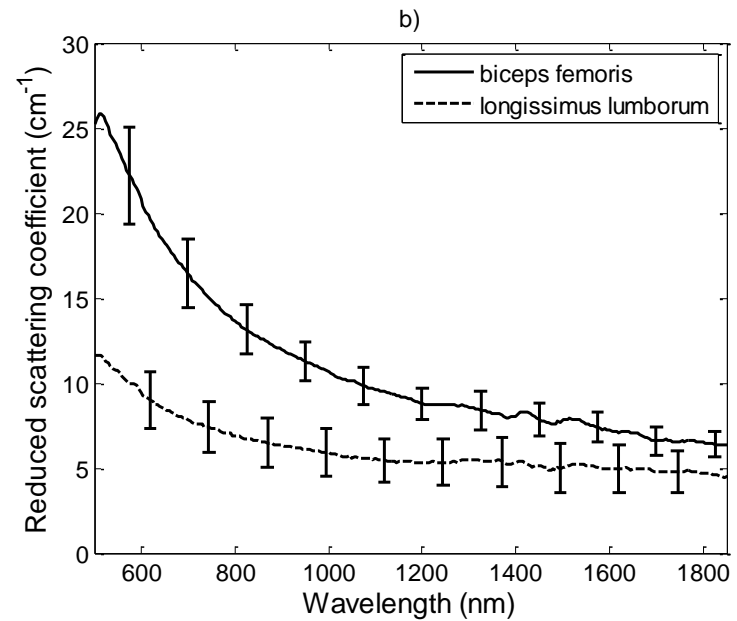
Bulk optical properties of two bovine muscles

Bulk absorption coefficient μ_a

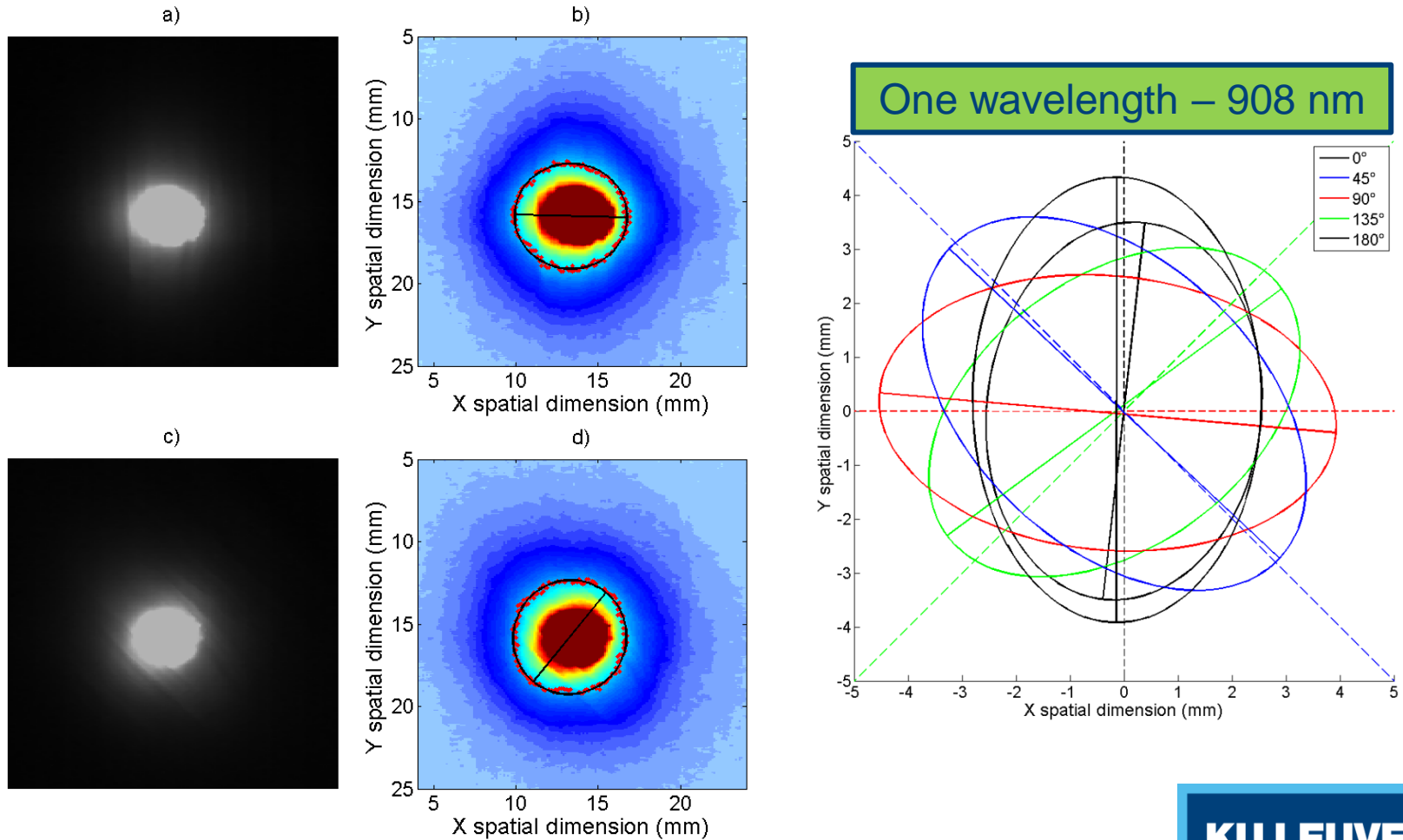


oxymyoglobin

Reduced scattering coefficient μ_s'

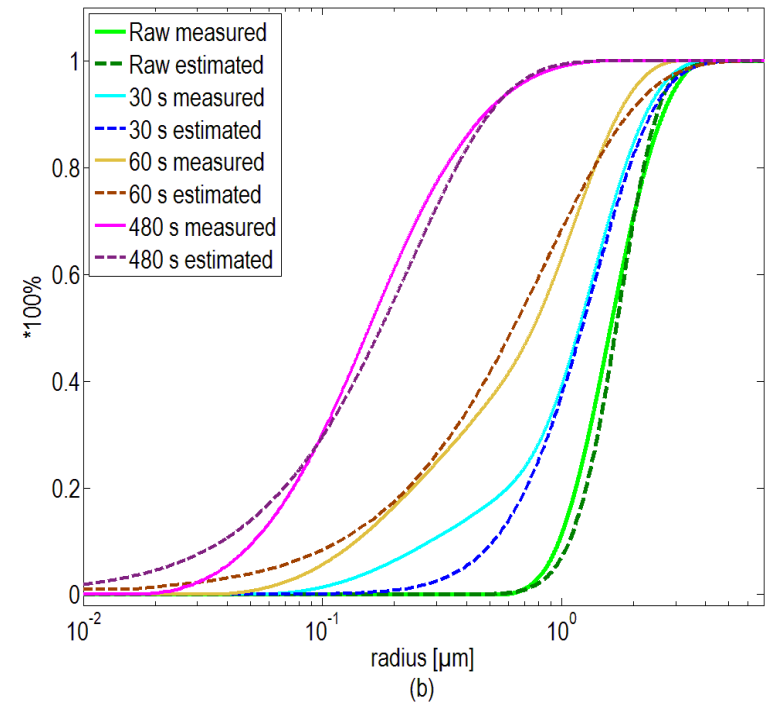
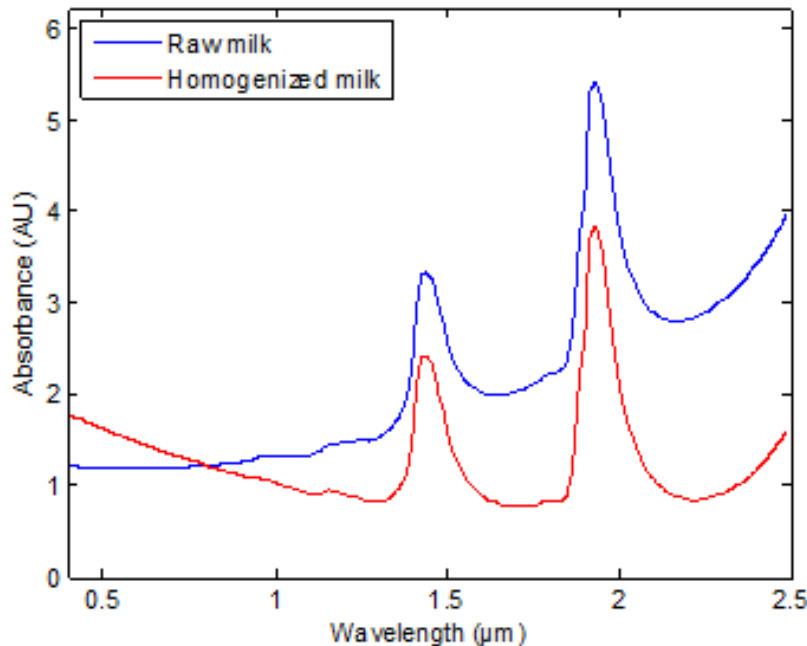


Laser scatter imaging for fiber orientation in meat



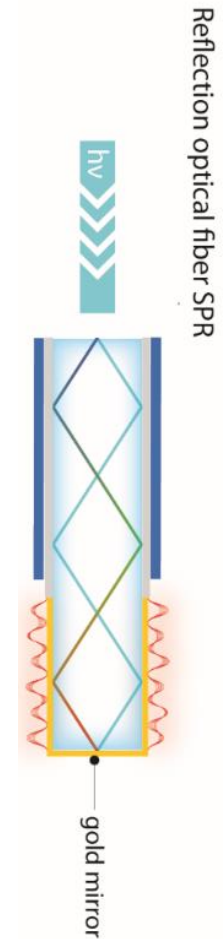
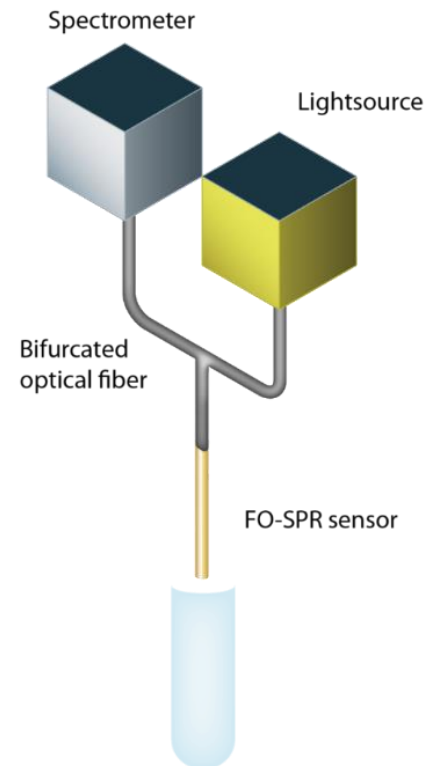
Fat globule size estimation in milk

- Inversion of light propagation models to determine
 - Scatter coefficient spectra from SRS measurements
 - PSDs from Scatter coefficient spectra

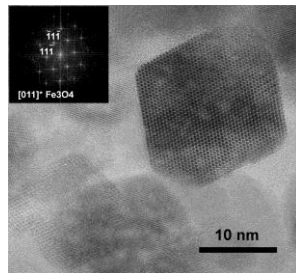
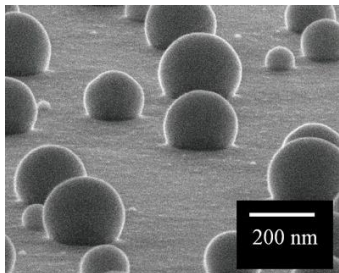
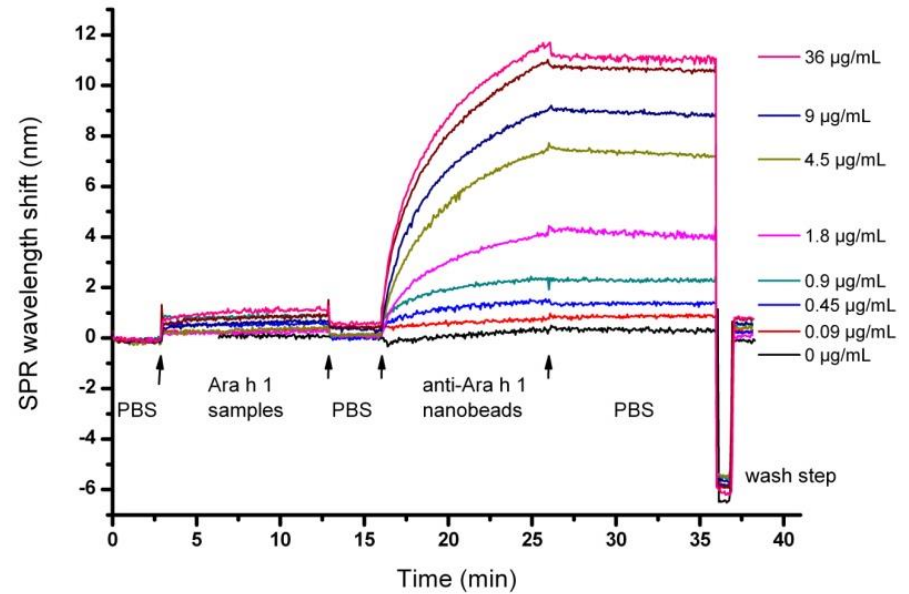
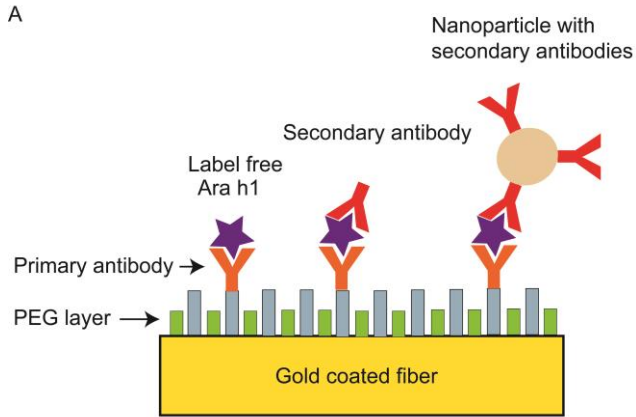


Fiber optics based biosensors

- Robust optical equipment
 - Multimodel optical fiber
 - VNIR spectrometer (400-1000 nm)
- Increased sensitivity
 - Surface plasmon resonance
- Increased specificity
 - Functionalization
- Easy use
 - Dip probe
- Wide range of applications
 - Proteins
 - DNA
 - Cells - bacteria
 - Small molecules

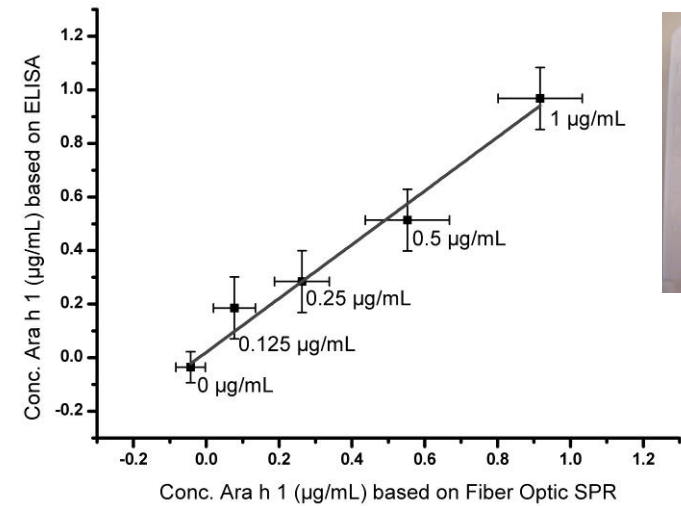
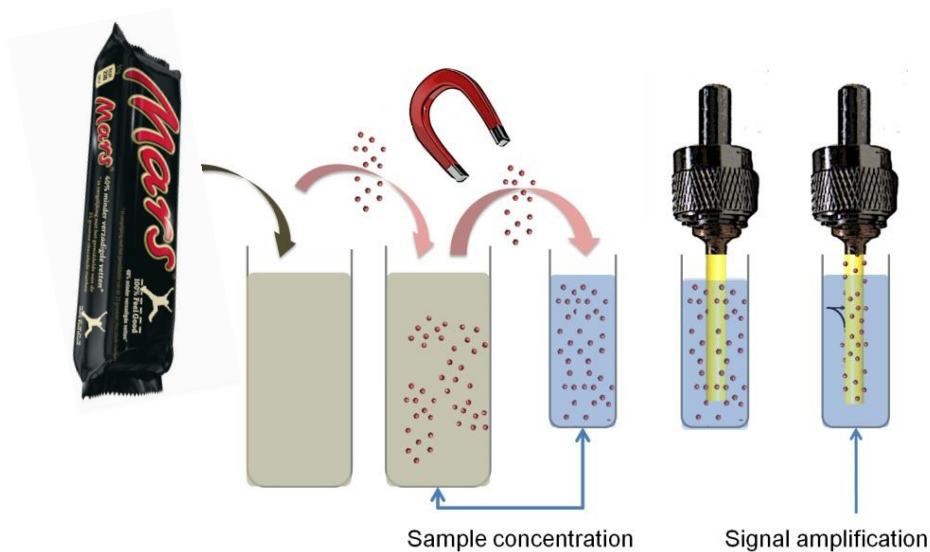


Detection of allergens

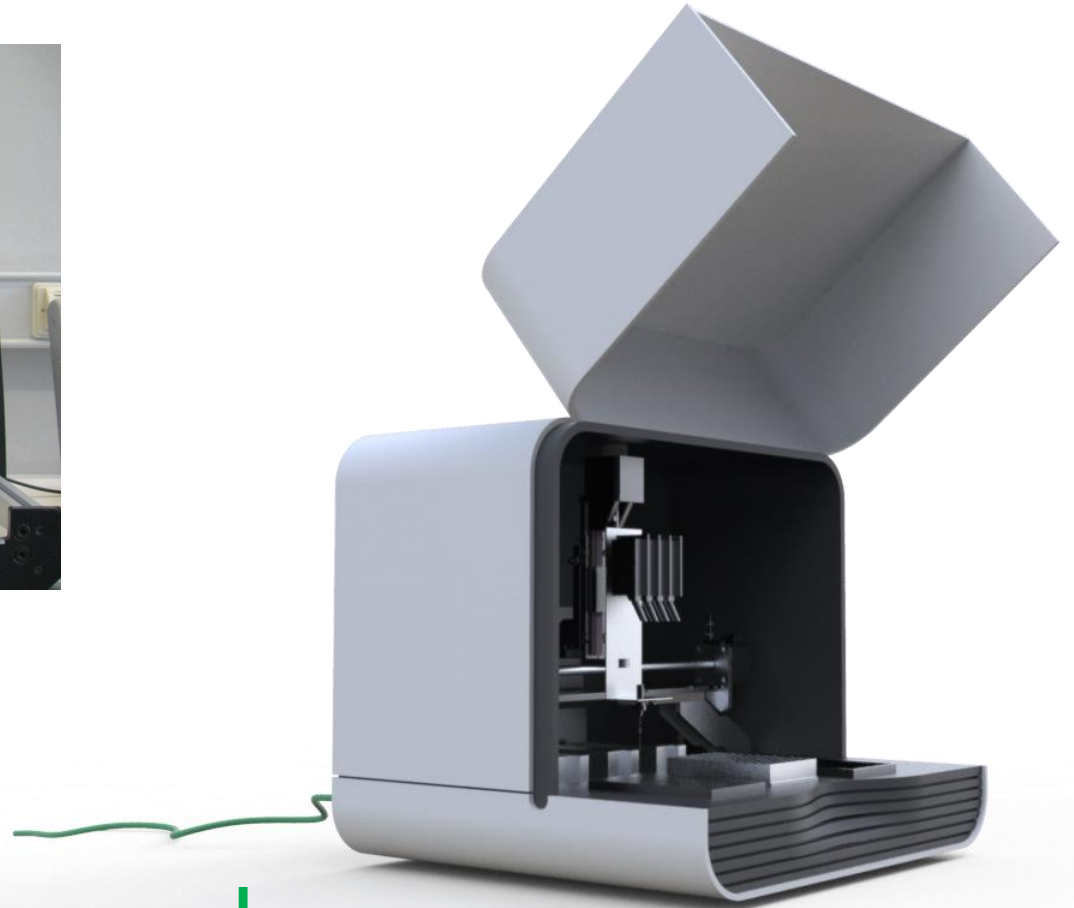
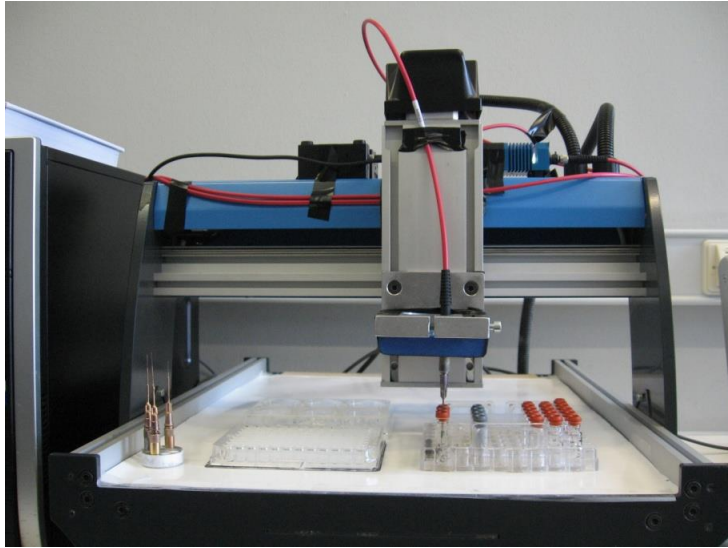


Detection of allergens

- Benchmarking against ELISA



From prototype tot product and spin-off



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Making biomolecular research tools accessible

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Inspection of internal quality

- Horticultural products can develop a number of internal defects

During growth



During storage

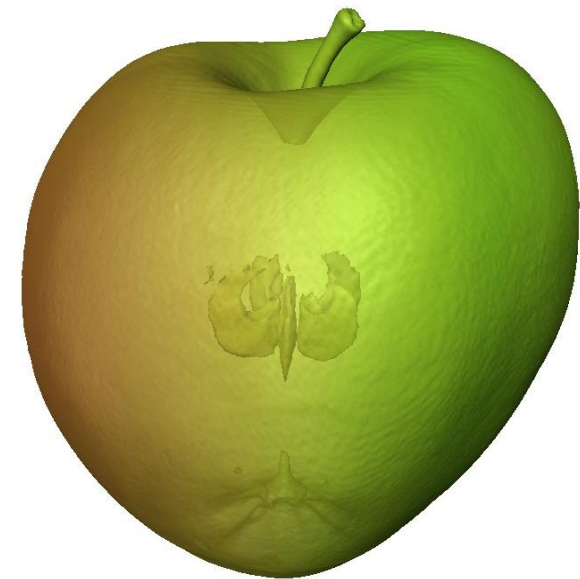
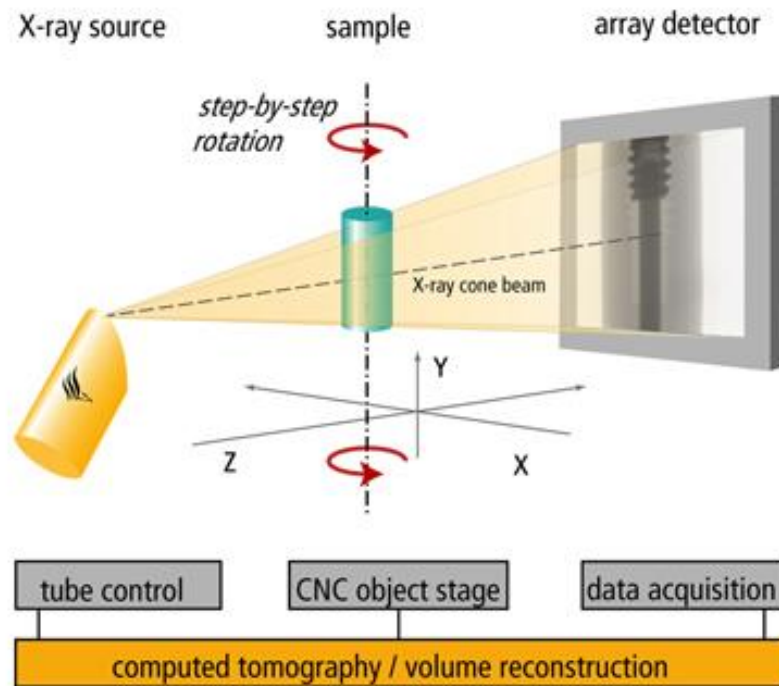
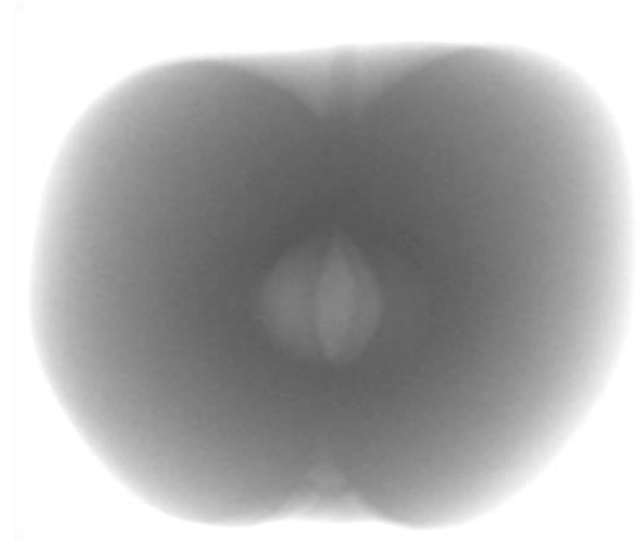


Which apple will you buy?



X-ray imaging

- Radiography (2D)
- Tomography (3D)



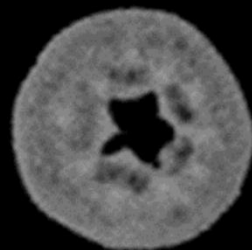
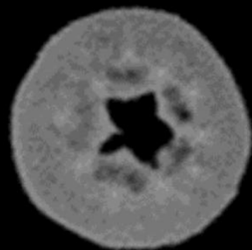
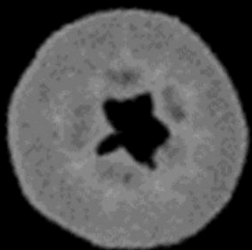
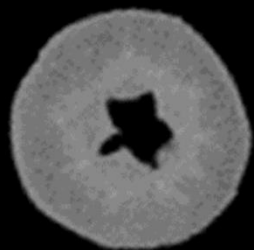
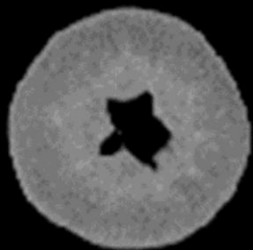
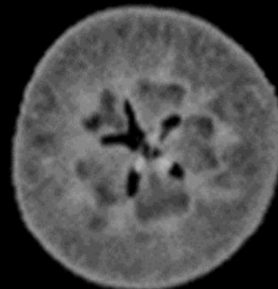
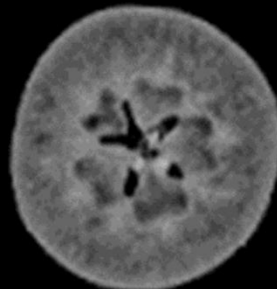
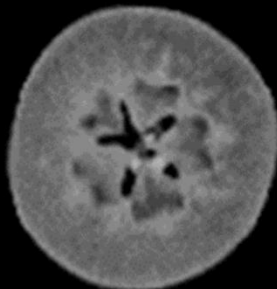
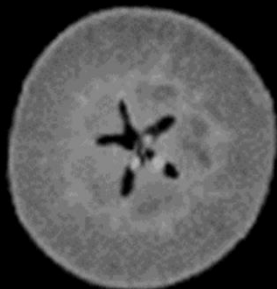
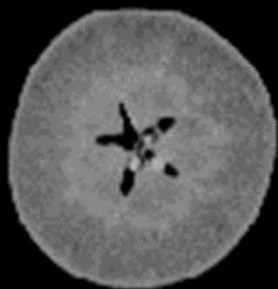
26/11/2014

19/01/2015

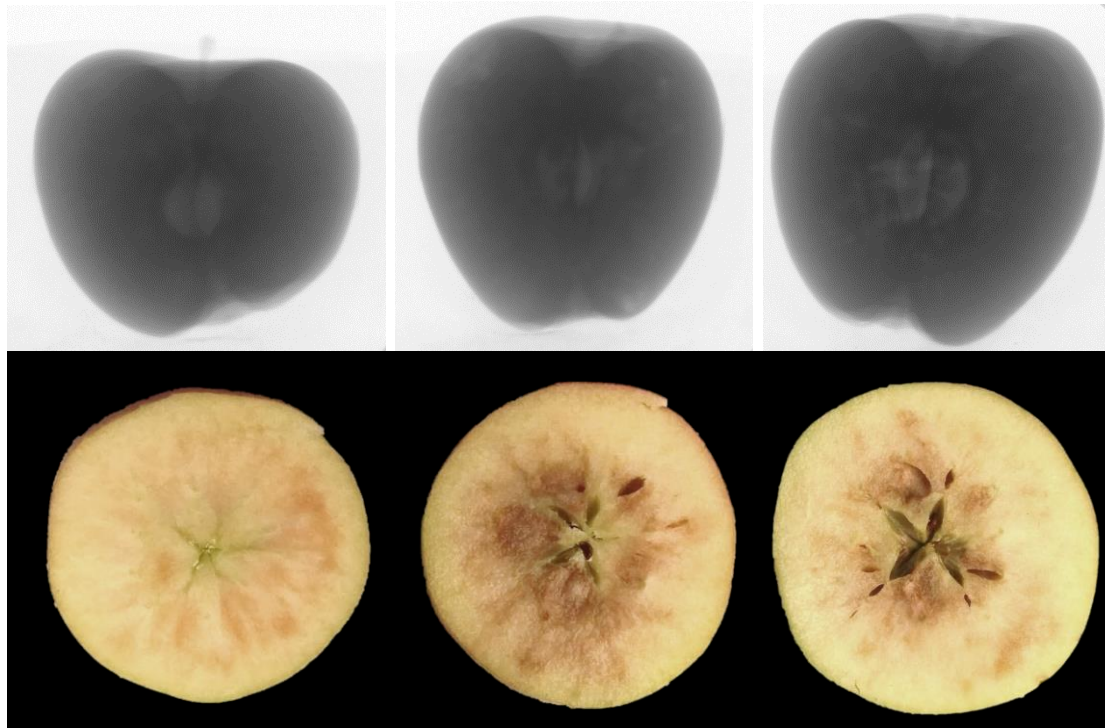
02/03/2015

20/04/2015

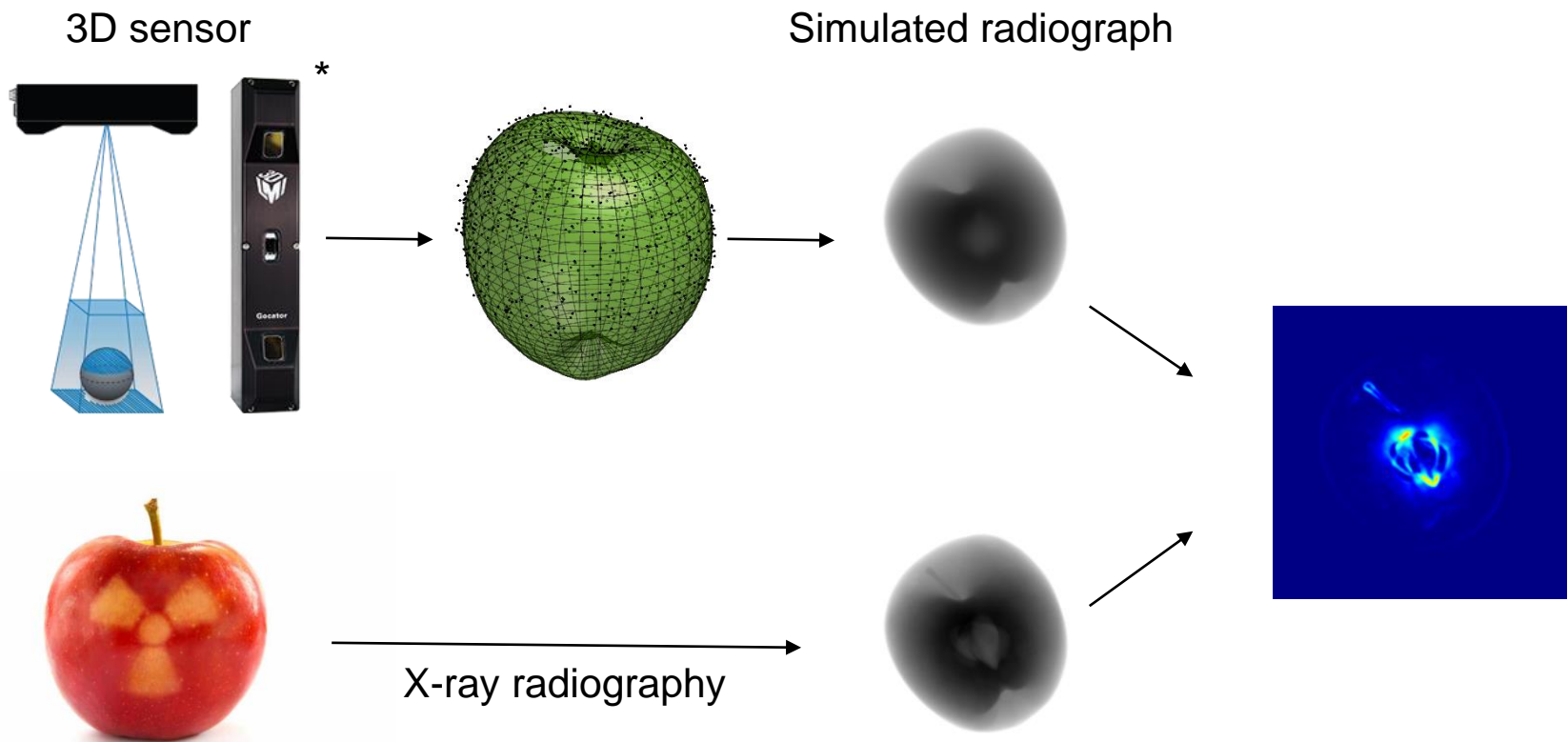
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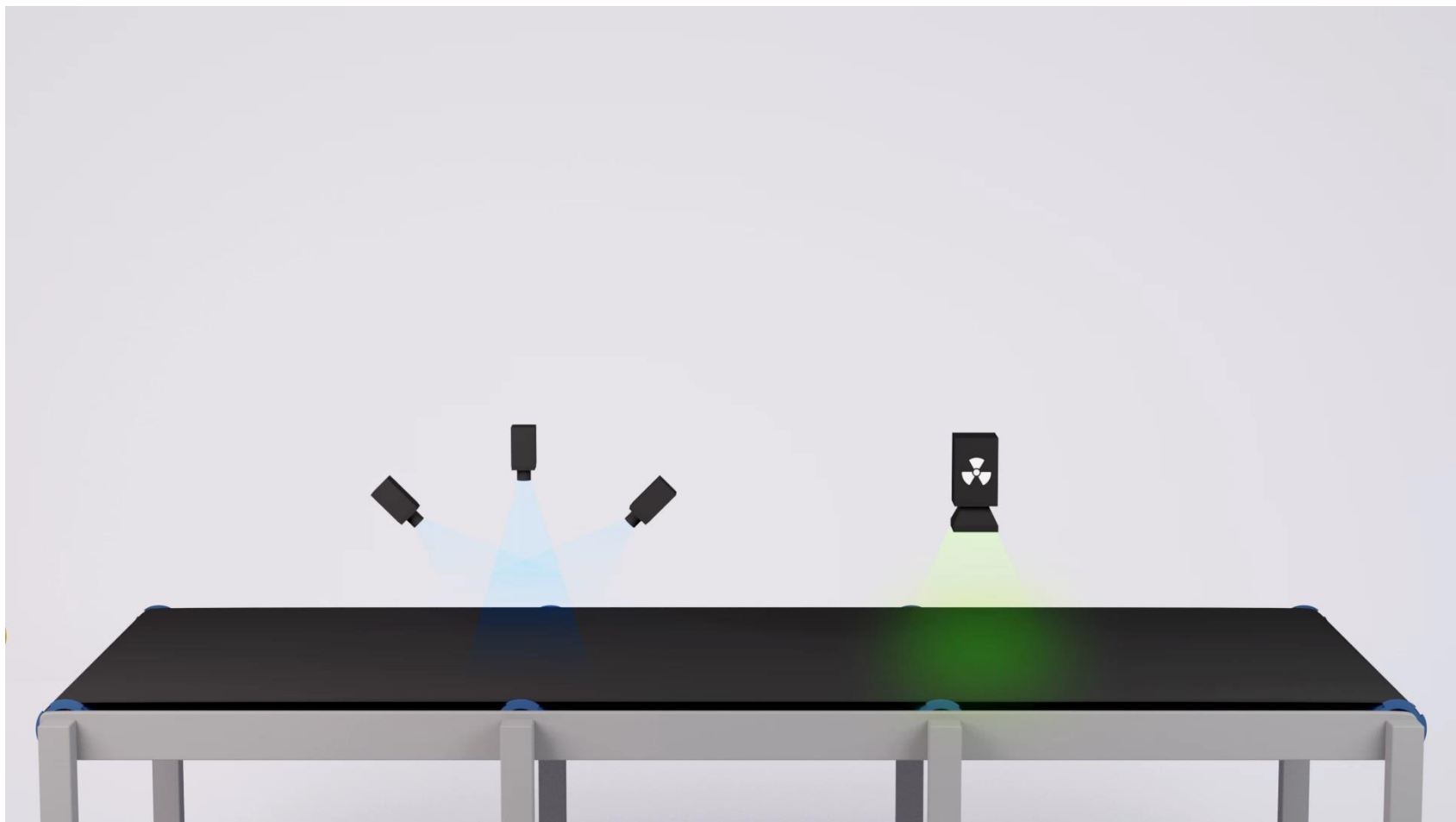


But not all types of defects can be detected like this.



Normalize X-ray radiography for contrast generated by sample shape

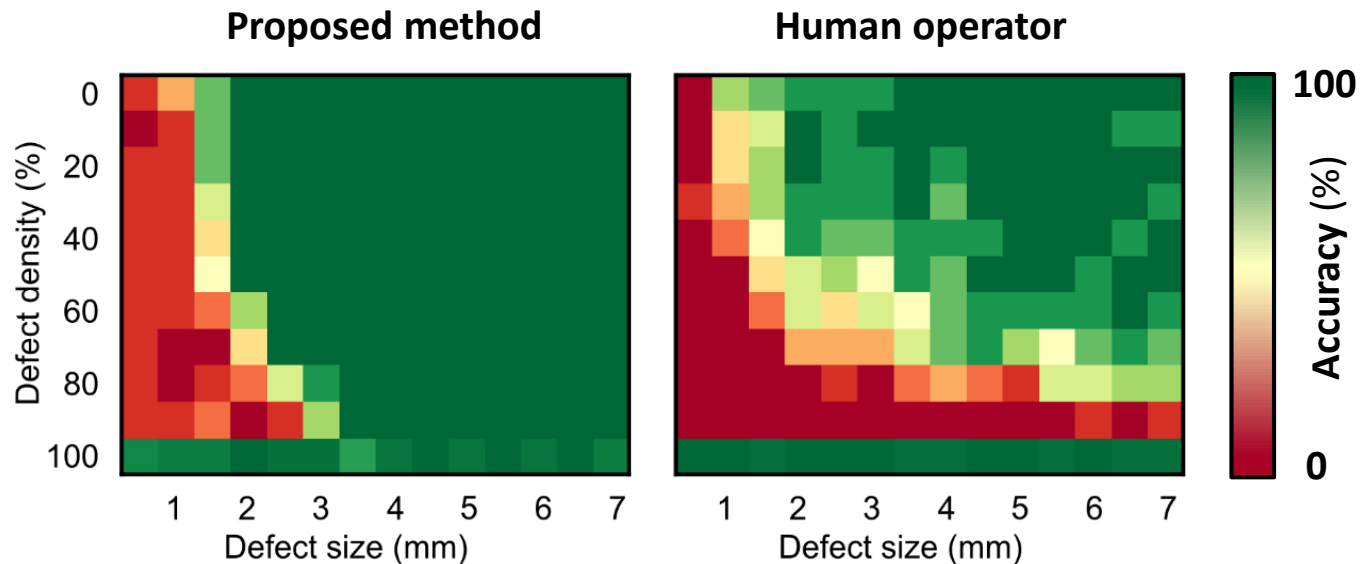




3D sensor

X-ray radiography

Multisensor inspection outperforms a human operator visually inspecting the X-ray radiograph



Conclusions

- Labor shortage demands for automation and robotisation.
- Hands on the line = Eyes and Brains on the line.
- To guarantee customer satisfaction the external and internal quality of every individual product should be inspected
- Rapid developments in photonics technology create many opportunities
- Successful implementation requires domain knowledge

- Do we provide our students with the right skills to realize this potential?

