Multimodal optical device for non-contact skin examination

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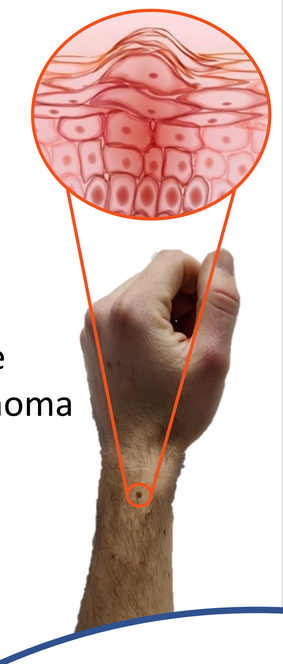
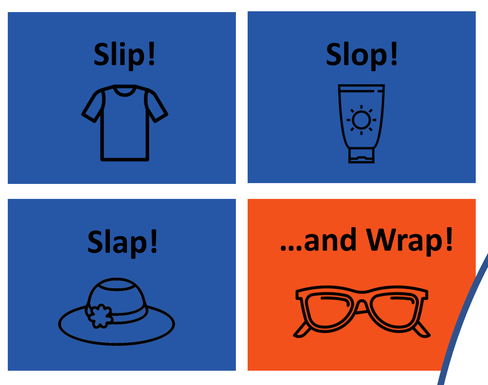
Melanoma

- Melanoma incidence rising for all skin types
- Responsible for 75 % of deaths from skin cancer
- Highly curable at early stages
- Mortality rate of 50 % at later stages
- Subjective diagnosis in Total Body Screening
- ABCDE rule:
  asymmetry, **b**order, **c**olour, **d**iameter, **e**volution
- Goal: improve and objectify the diagnosis by the means of optics for the early detection of melanoma
- iToBoS (Intelligent Total Body Scanner for Early Detection of Melanoma)

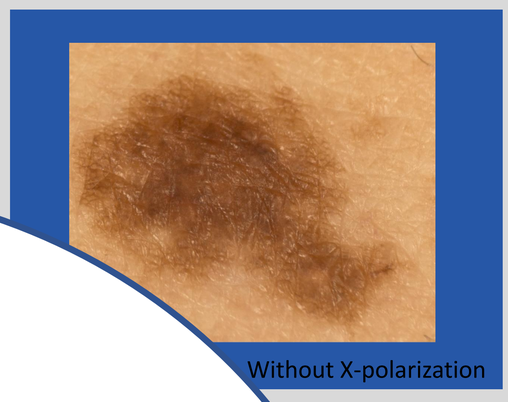


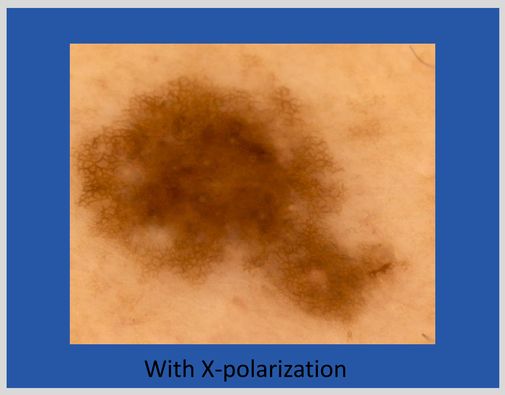
Prevention

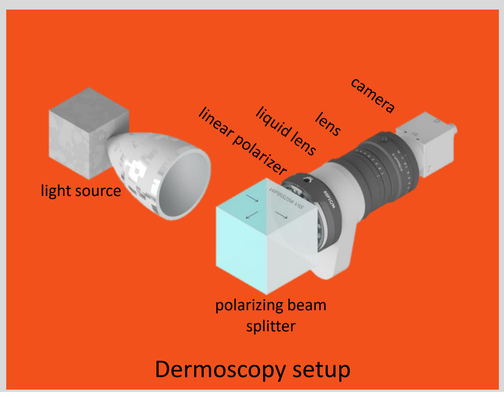


Non-contact dermoscopy

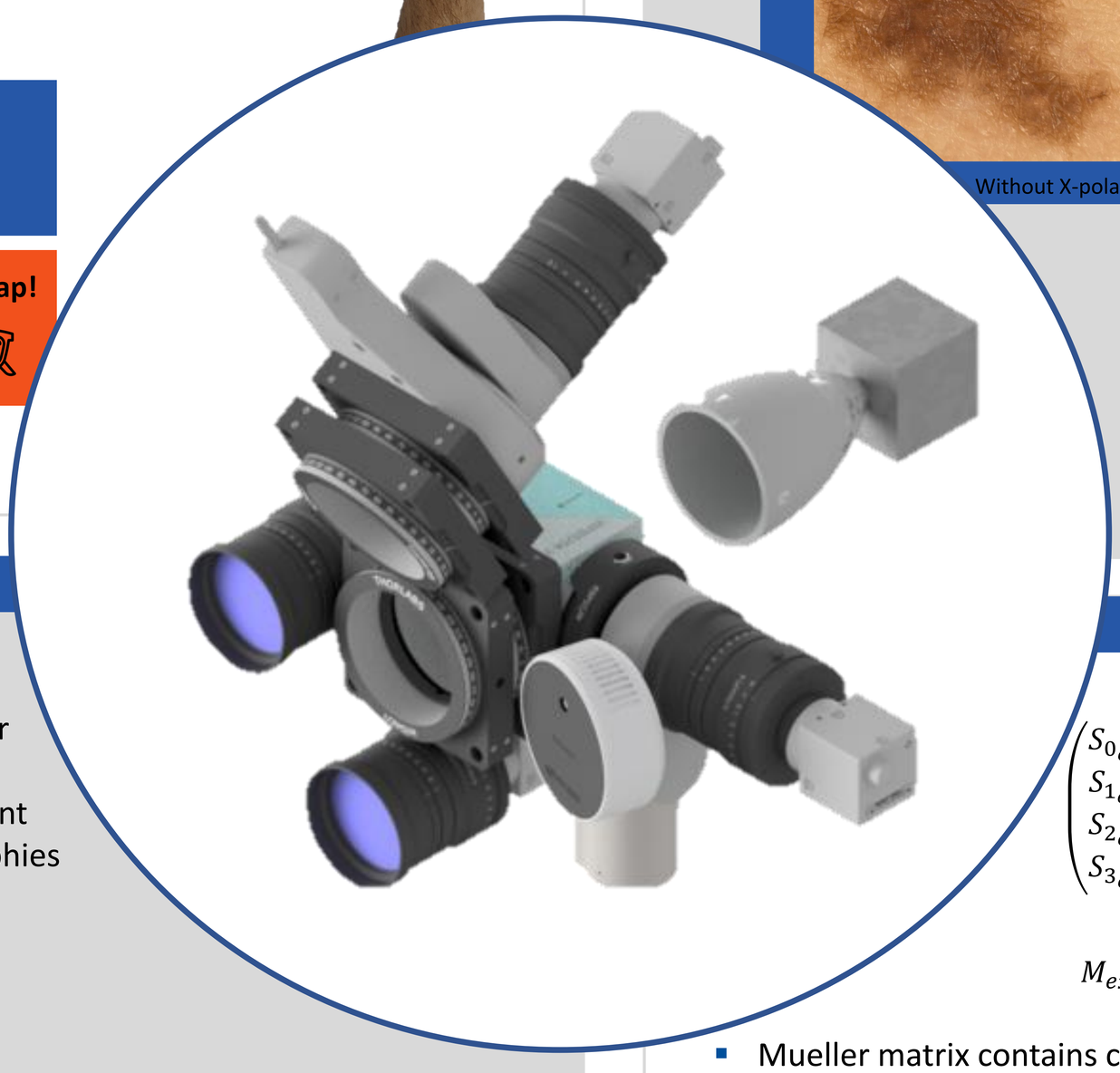
- Non-invasive skin screening
- Natural blood perfusion
- Unaltered colour perception
- Regular skin topography
- X-polarization enables sub-skin-surface imaging
- Focus stacking based on liquid lens for enhanced depth of field
- Automated detection, acquisition and classification
- Clinical decision support


Without X-polarization


With X-polarization



Dermoscopy setup



3D Measurements

Stereo Imaging

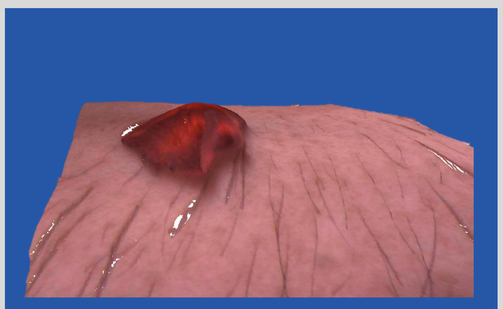
- Skin topography compensation for Mueller Matrix Polarimetry
- Vertical growth assessment
- Disease-specific topographies

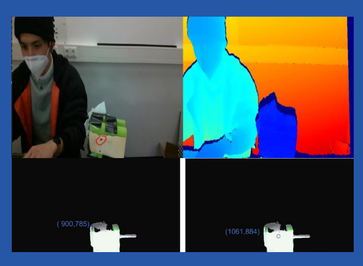
Virtual patient mapping

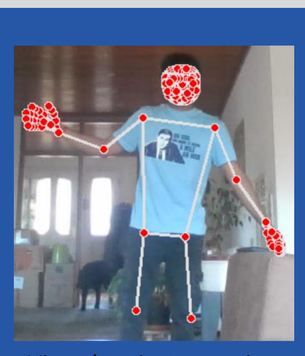
- 3D patient avatar
- Lesion body mapping
- Keypoint-based

LiDAR based autofocus

- 3D point cloud from LiDAR sensor is used for autofocus


Stereo: Pointcloud of nevus phantom


LiDAR: Pointcloud for autofocus


Virtual patient mapping

3D measurement setup

Mueller Matrix Polarimetry

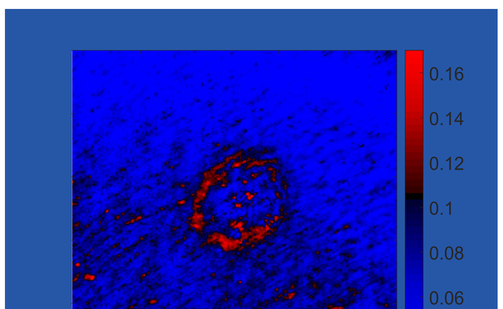
Mueller formalism

$$\begin{pmatrix} S_{0_{out}} \\ S_{1_{out}} \\ S_{2_{out}} \\ S_{3_{out}} \end{pmatrix} = \begin{bmatrix} M_{0,0} & M_{0,1} & M_{0,2} & M_{0,3} \\ M_{1,0} & M_{1,1} & M_{1,2} & M_{1,3} \\ M_{2,0} & M_{2,1} & M_{2,2} & M_{2,3} \\ M_{3,0} & M_{3,1} & M_{3,2} & M_{3,3} \end{bmatrix} \begin{pmatrix} S_{0_{in}} \\ S_{1_{in}} \\ S_{2_{in}} \\ S_{3_{in}} \end{pmatrix}$$

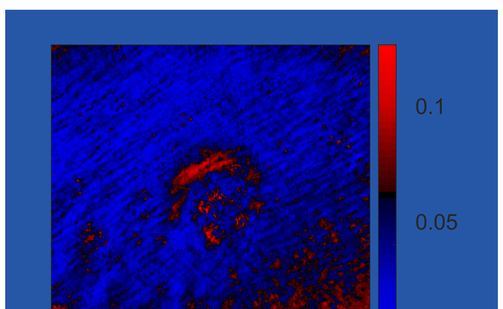
Polar decomposition

$$M_{exp} = M_R M_P M_\Lambda$$

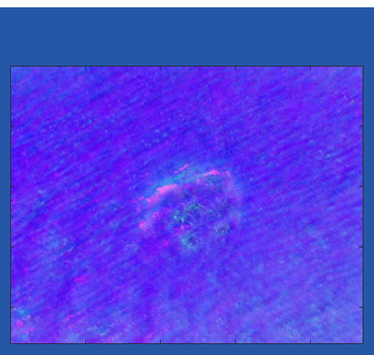
- Mueller matrix contains complete polarization information
- Decomposition reveals physical properties of the sample
- Polarization stain imaging as a visualization technique
- Machine learning for classification

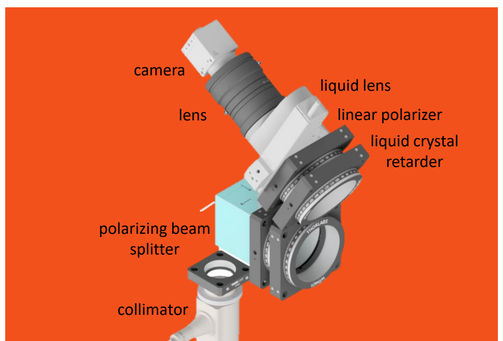


Spatially resolved diattenuation of a nevus



Spatially resolved polarizance of nevus


Polarization staining image of nevus



Polarimetry setup

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iToBoS

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HOT Optical Technologies.

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