Sensor Advances for Optical Patient Surface Tracking

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Outline

- Practical Requirements
- Measuring Methodologies
- Advanced sensor

Practical Requirements

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Measuring motion and deformation of the body surface

Non-contacting:	NO targets
Precision:	≤ 0.5 mm Δ(x,y,z)
Latency:	≤ 20 ms
Speed:	≥ 20 Mio. (x, y, z) points/s
Completeness:	≥ 75% of FoV
Low viewing angle:	≤ 15°
Surface tolerance:	skin color, clothes, accessories
Usability:	normal room light, 24/7, adaptive, …
Added value:	patient setup, …

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Methodologies

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Requirements	Passive Stereo-Vision (COR)	Random Pattern Projection (COR)	sin Fringe Projection (PHASE)
Non-contacting			
High speed			
Low latency			
High precision			
Low angle			
Completeness			
Surface tolerance			
Usability			
Added value			
.....			

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Fringe Projection - Phase Measurements

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a) project fringes on surface

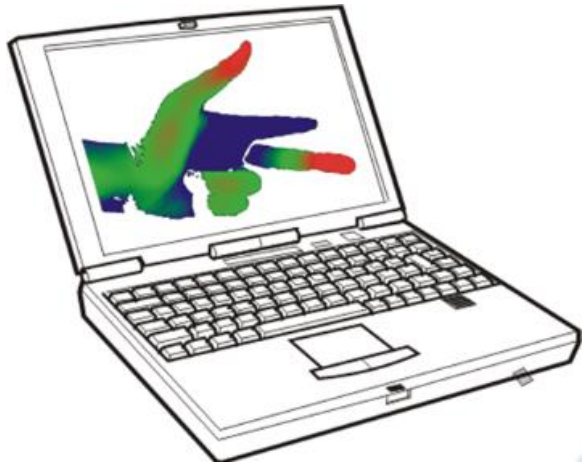
$$I_{ij}^{project} = I^0 (1 + V \cdot \cos(\Phi_{ij} + \psi_m))$$
$$m = 1 \ldots P$$

b) record fringes by camera

$$I_{ij}^{record}, \quad m = 1 \ldots P$$

c) calculate x,y,z for each pixel

$$\Phi_{ij} = \tan^{-1} \frac{\sum_{m=1}^{P} a_m \cdot I_{ij}^{record}(m)}{\sum_{m=1}^{P} b_m \cdot I_{ij}^{record}(m)} + N \cdot 2\pi$$



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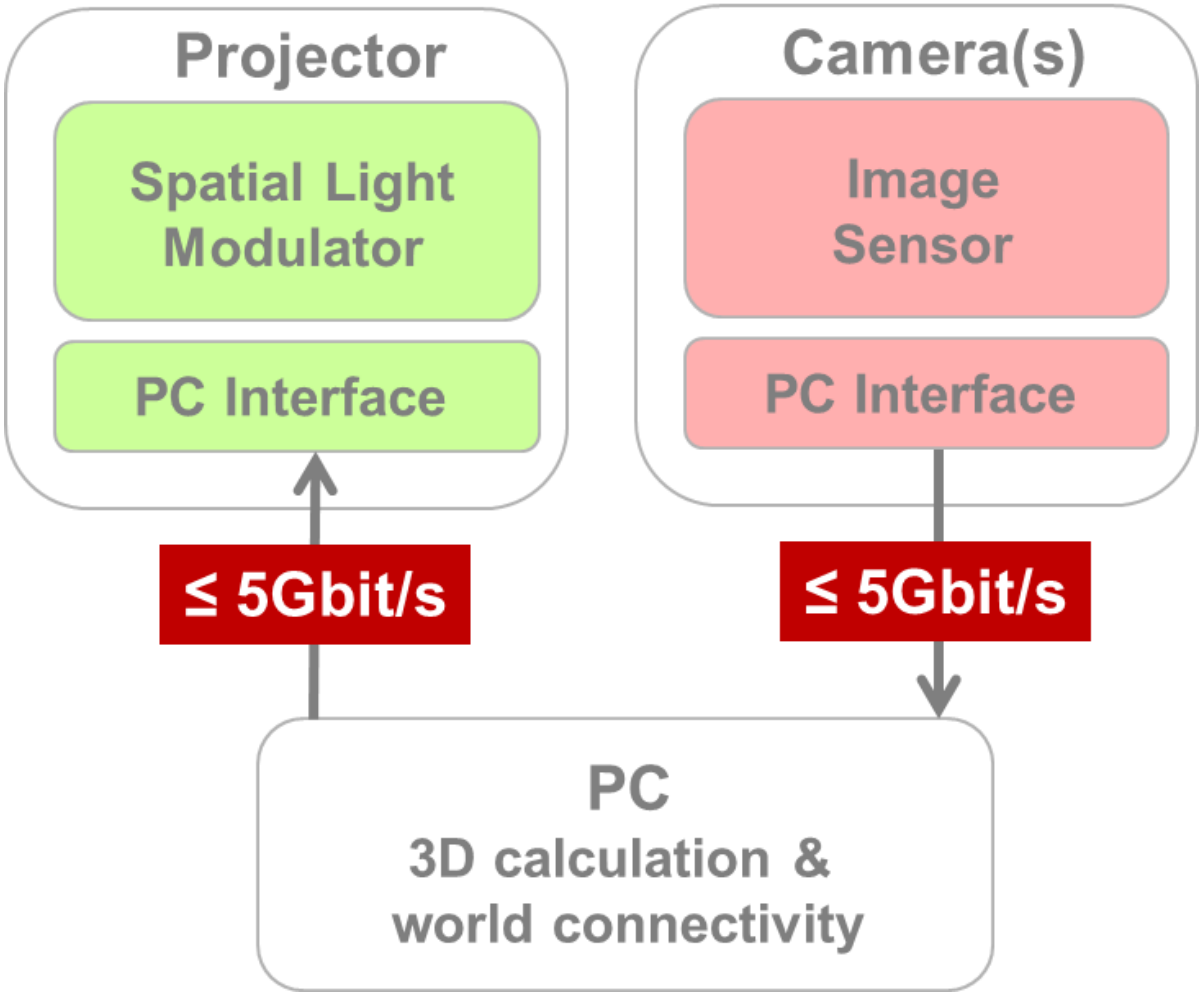
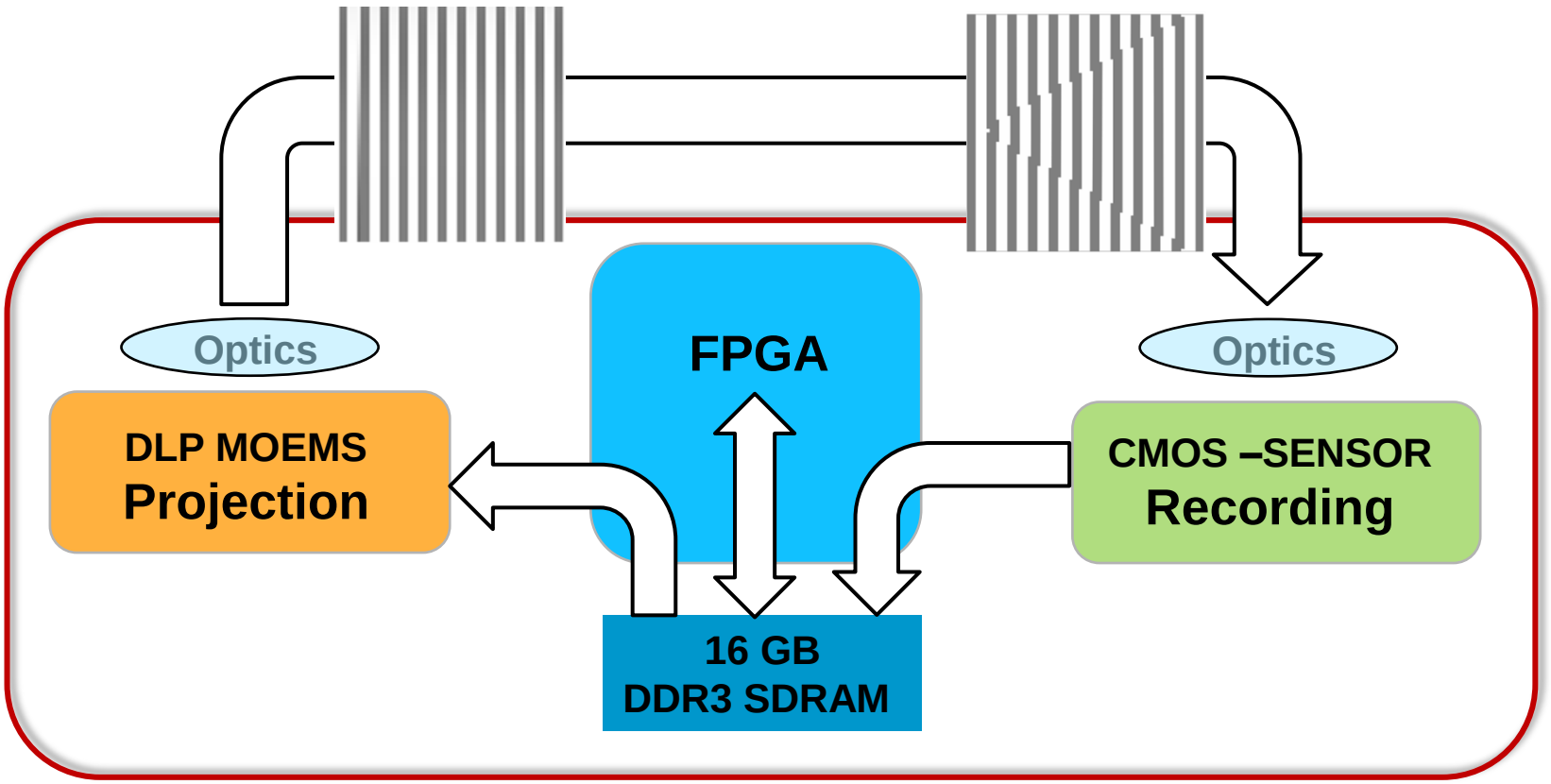
Standard sensor architecture



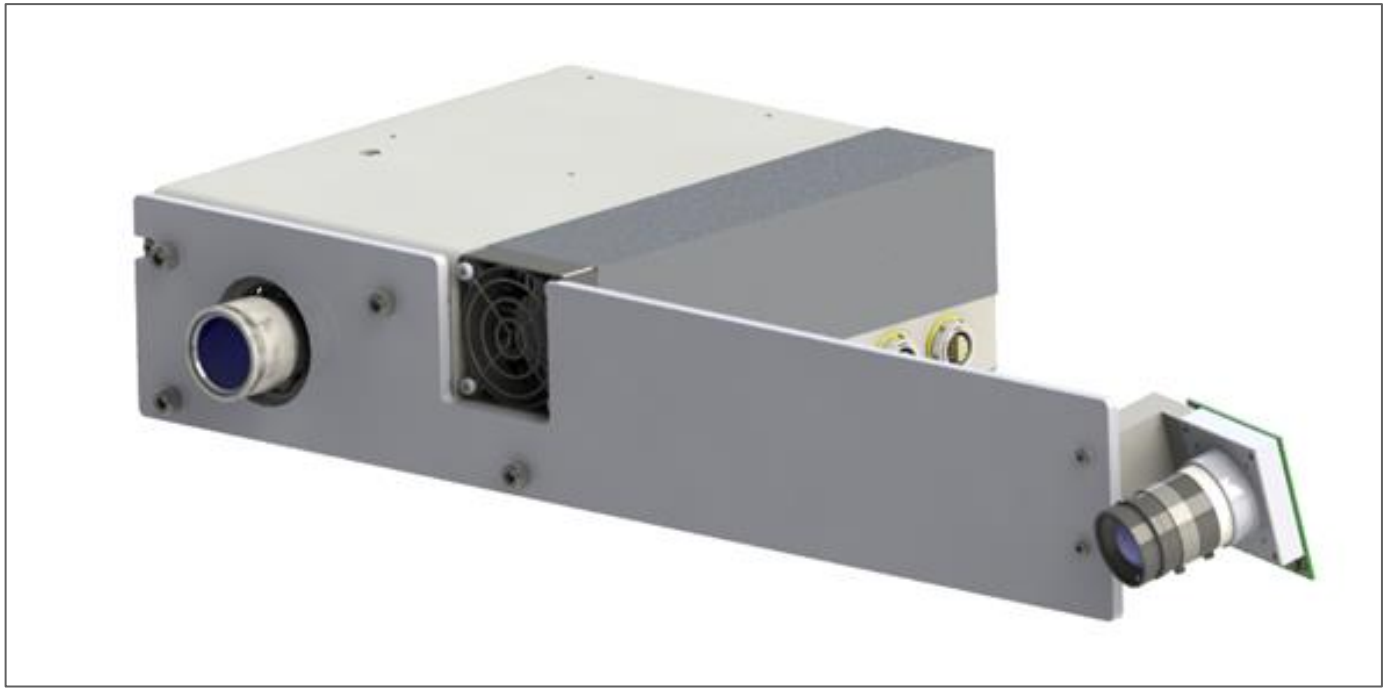
DLS

Direct Link Sensor

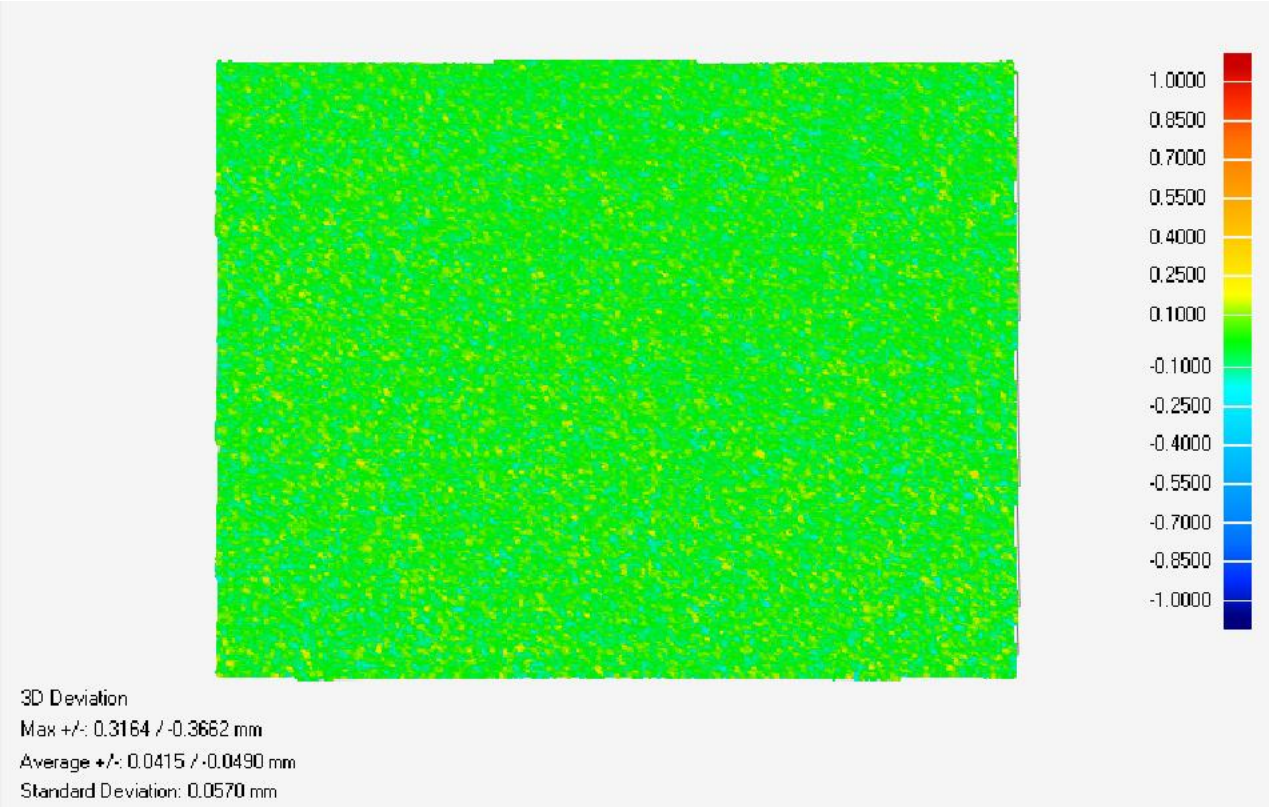


Direct Link Sensor - DLS

System development 2015 - 2018



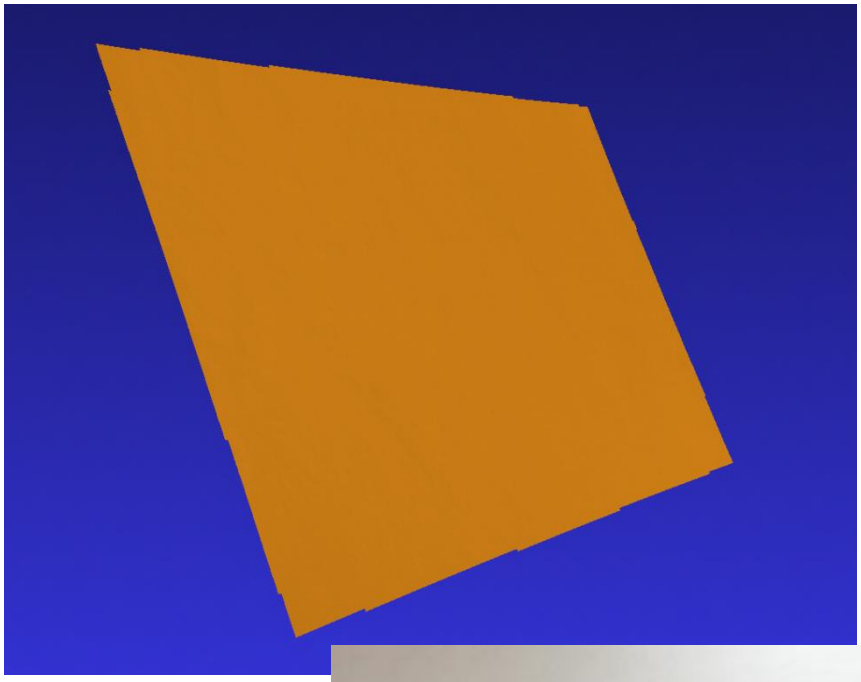
Precision



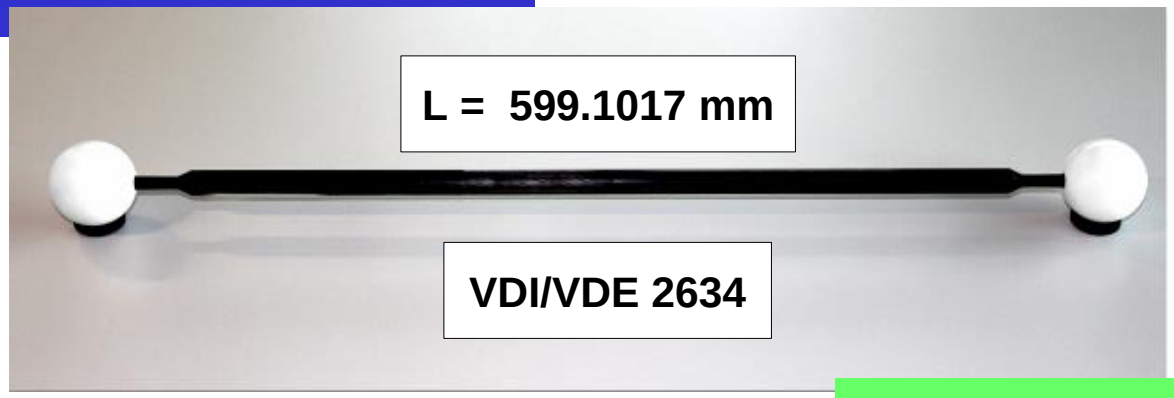
Repeatability

σ = 0.06 mm

Accuracy

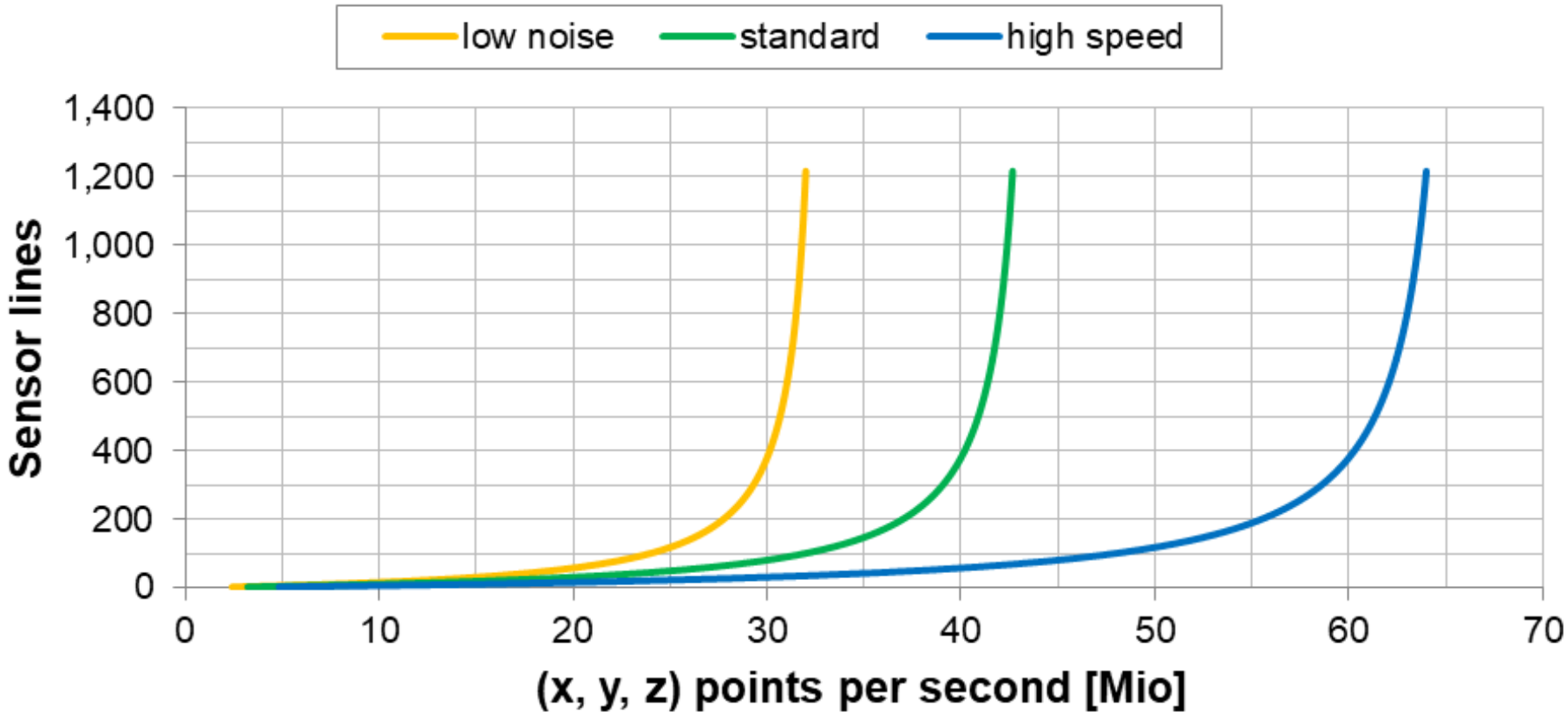


1x1x1 m³



Δ (x,y,z) < 0.3 mm

Speed



> 20 Mio (x,y,z) points/s

Completeness

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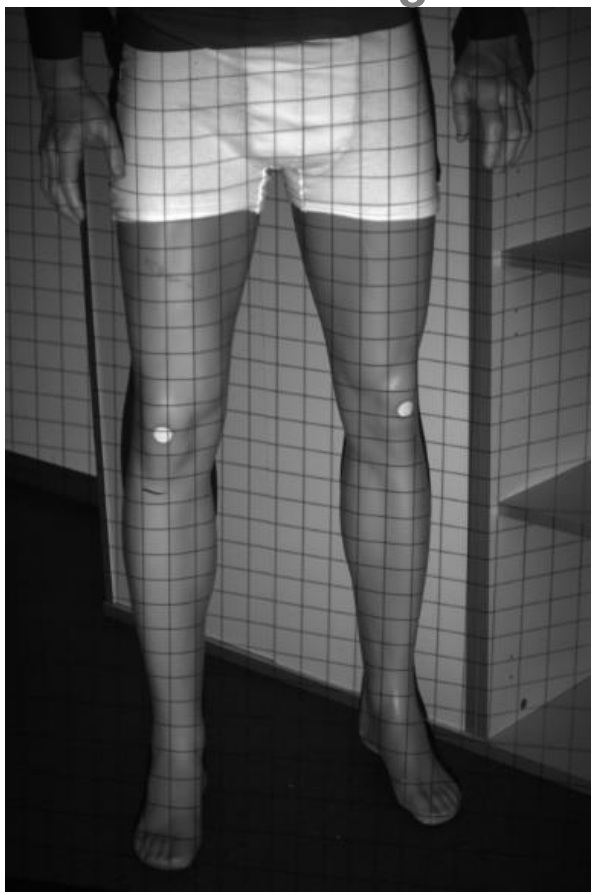
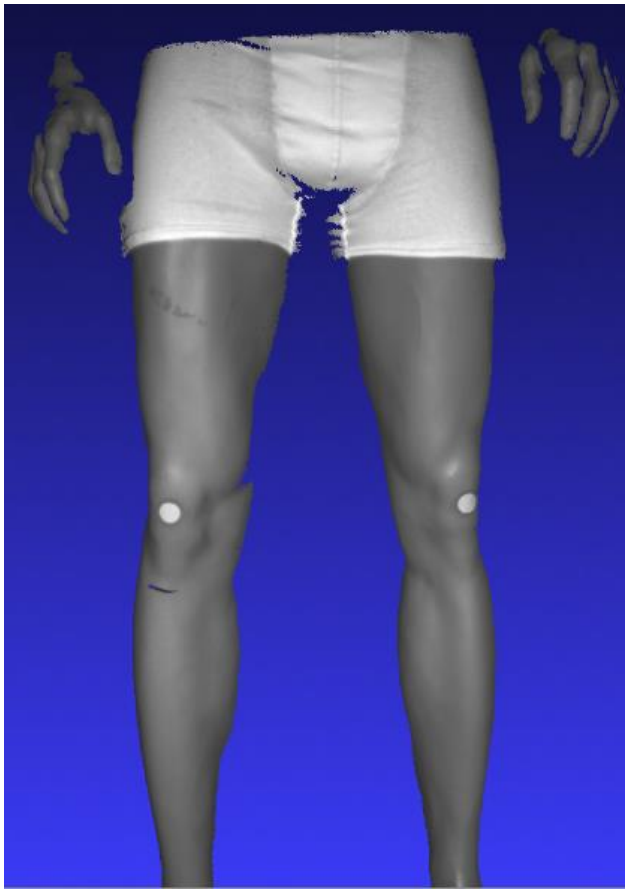
Camera image



3D model

3D model + texture



Coverage ≥ 75°

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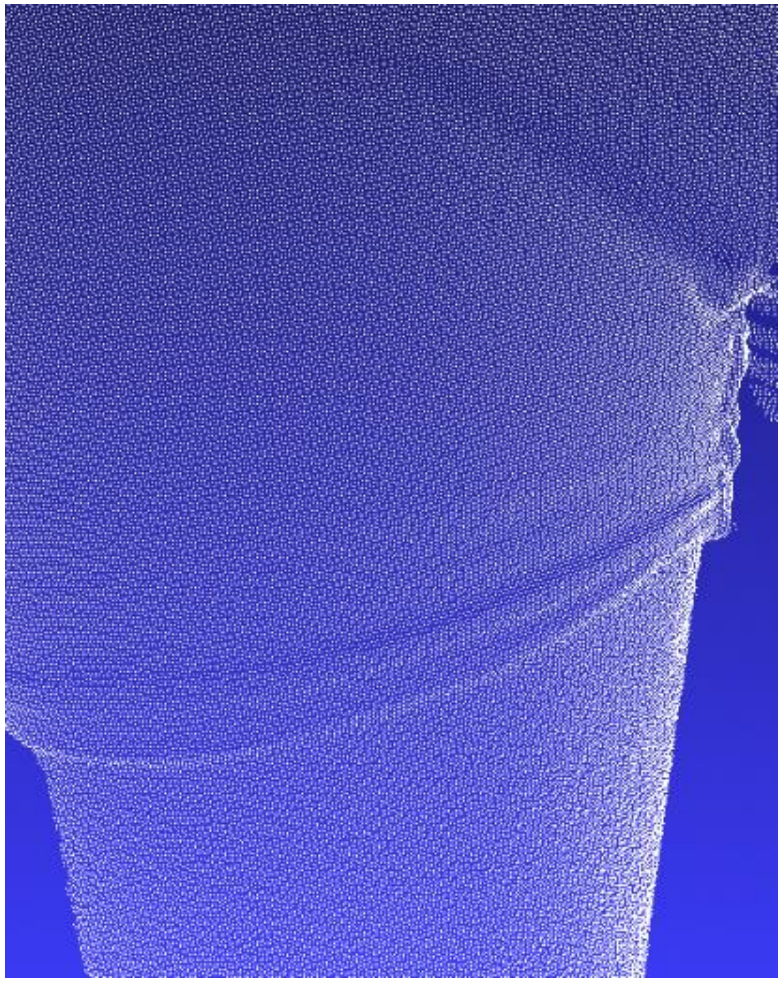
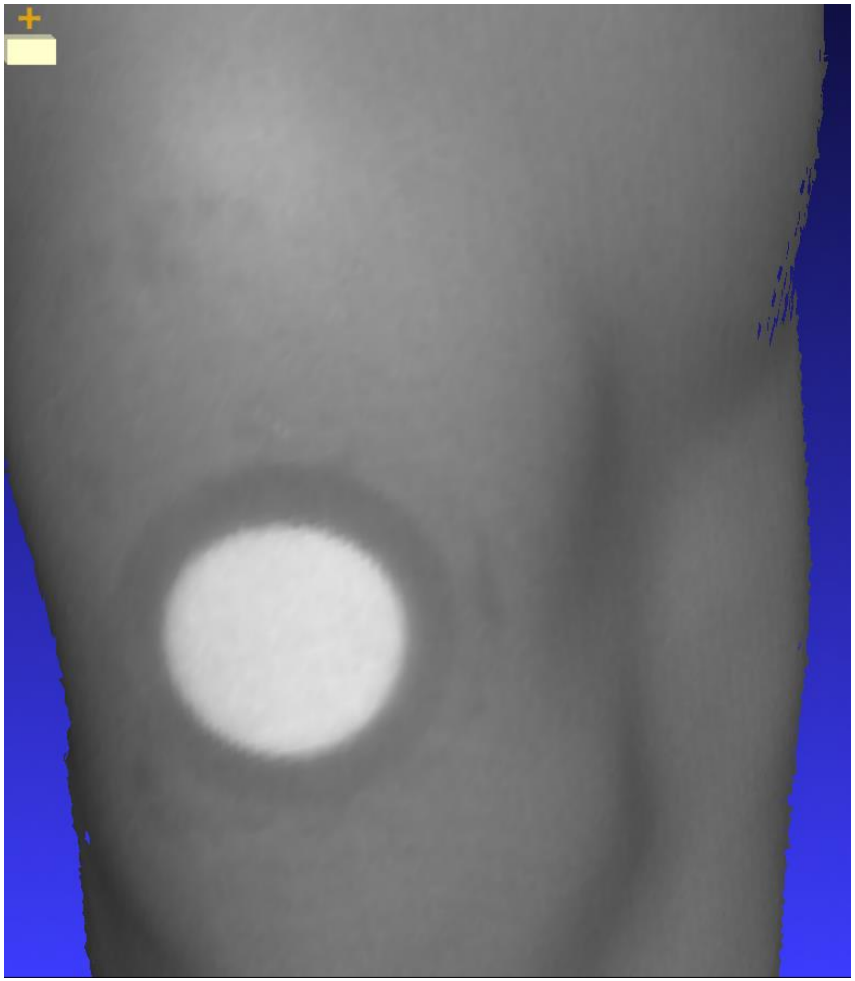
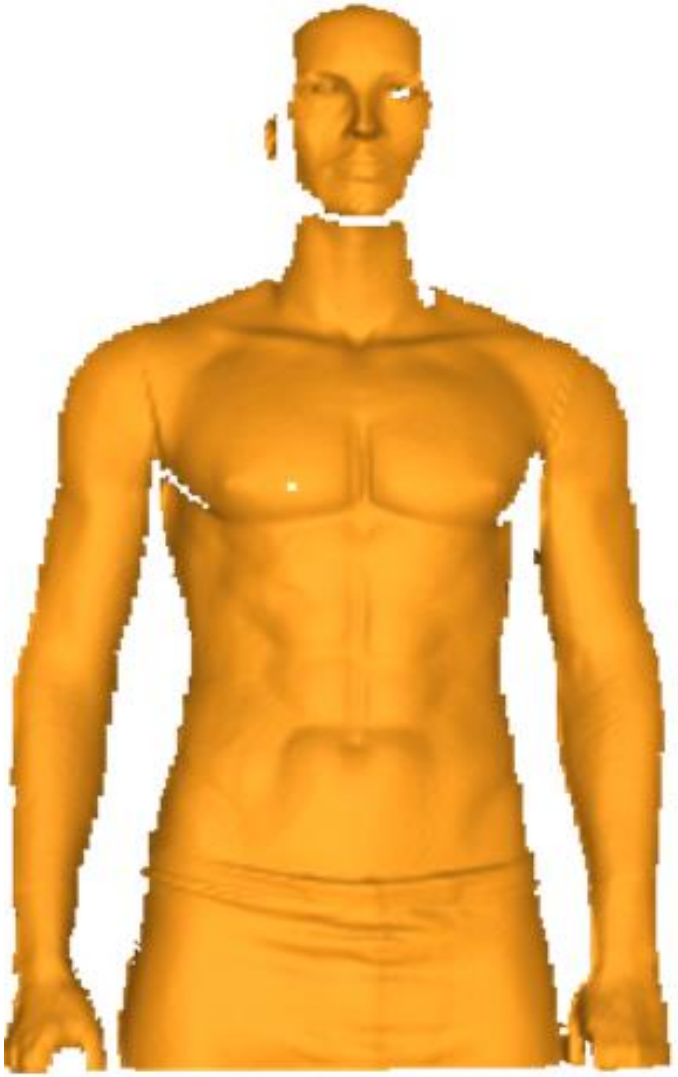
Point density





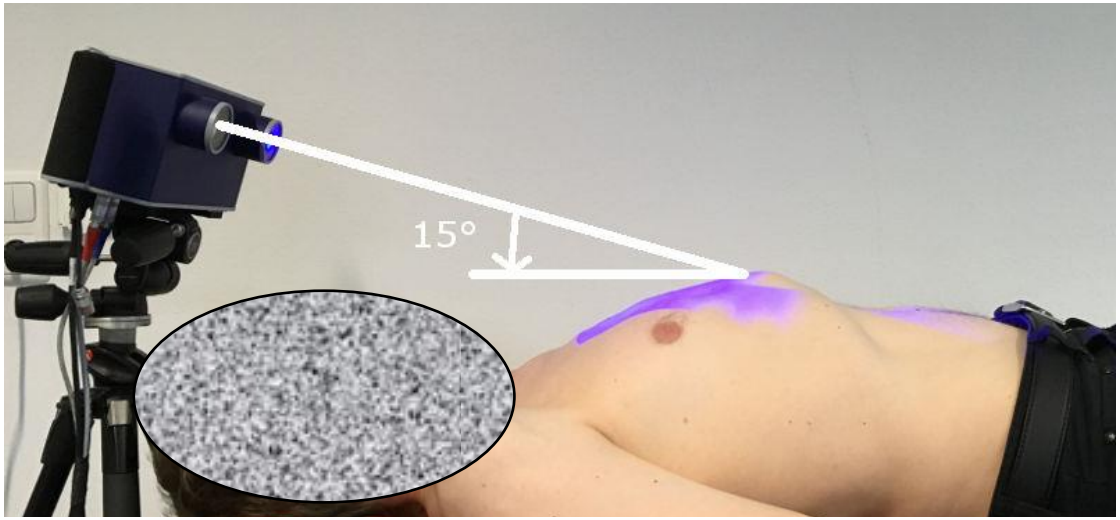
0.5 mm point spacing

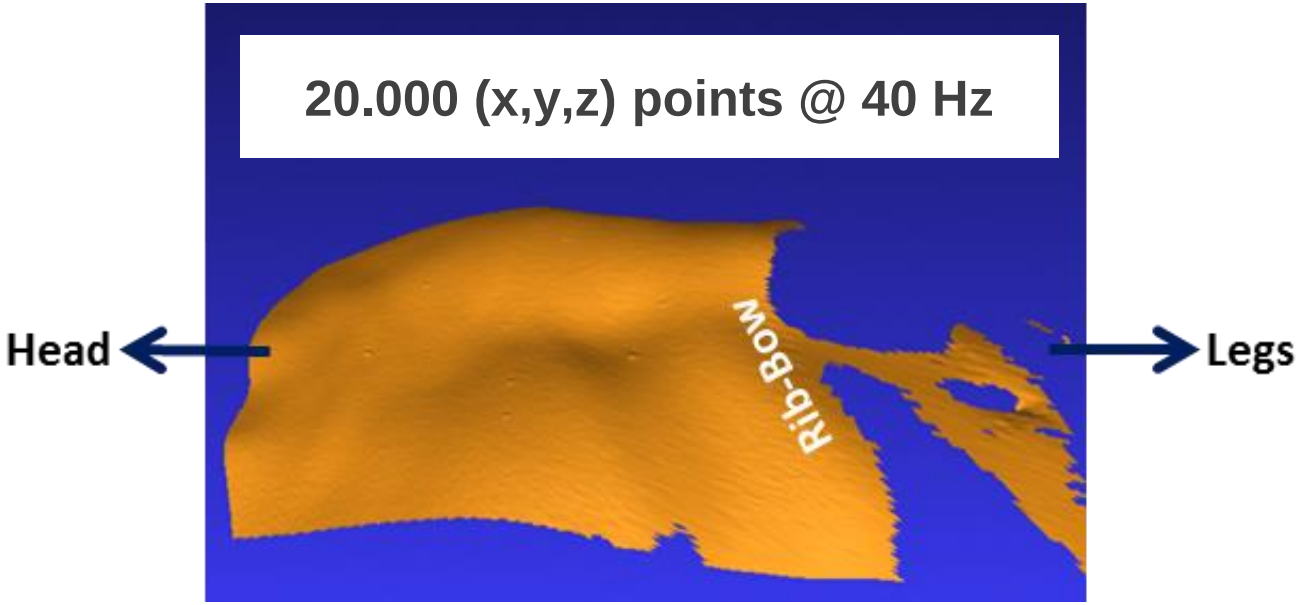
Surface tolerance



Surface reflectivity range 1/1000

Low surface angle





β ≤ 15°)

Large depth of meauring volume

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Summary

Requirements	Passive Stereo-Vision (COR)	Random Pattern Projection (COR)	sin Fringe Projection (PHASE)
Non-contacting			
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Added value			
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Direct Link Sensor DLS – new platform for optical tracking

- 0.5 mm (x,y,z) point spacing
- 20 Mio (x,y,z) coordinates per s
- 10 valid bits per primary pixel for contrasted scenes
- FPGA assists for 20 ms latency