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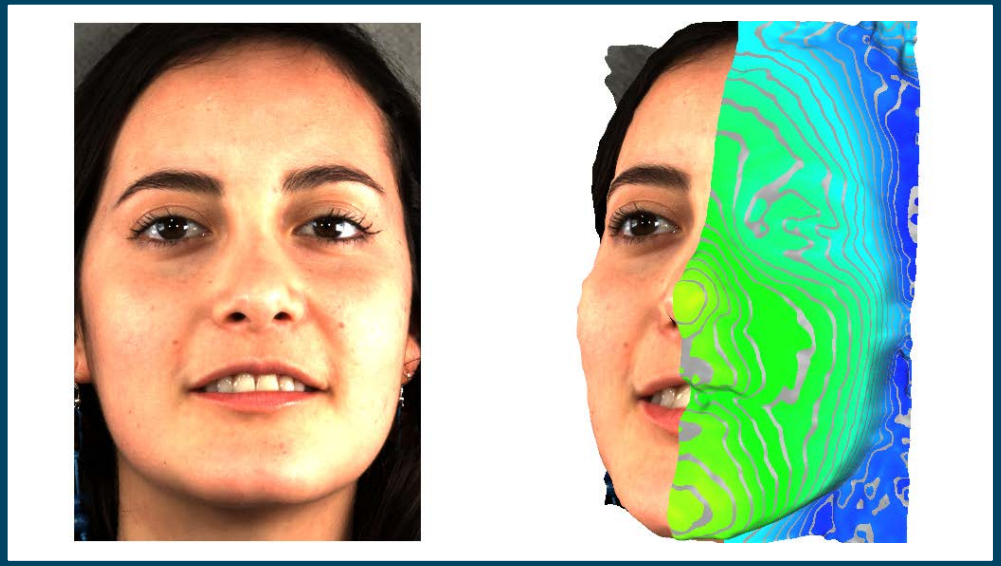
Light Field Cameras

for metric 3D measurements



Dr. Christian Perwass

www.raytrix.de

The Company

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- Founded 2009 – 15 employees in 2015
- Light field cameras for industry and research
- Patented MLA design for optimal depth-of-field and effective resolution combination

Image Engineering Innovation Award 2013

CHIP Awards 2012 „Innovation of the Year“

iF Design Award 2014

reddot design award

References

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Content

Basic Image Generation

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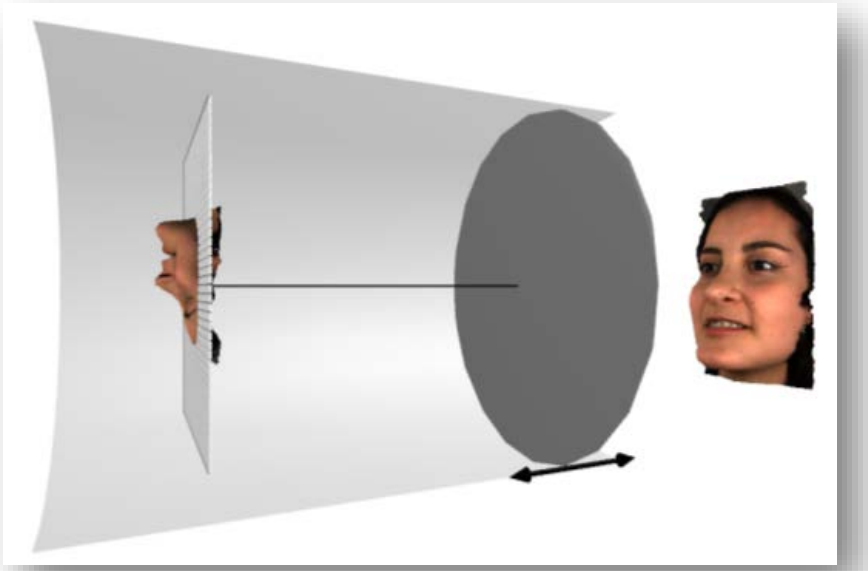
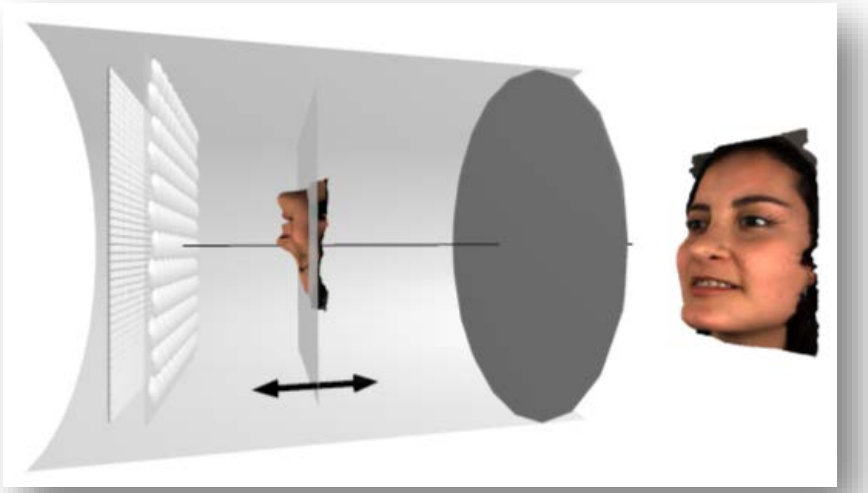
Standard Camera
Main lens focuses directly onto image plane.



Lightfield Camera
Main lens generates intermediate image. Microlens array acts as camera array that focuses intermediate image onto image plane.



Example

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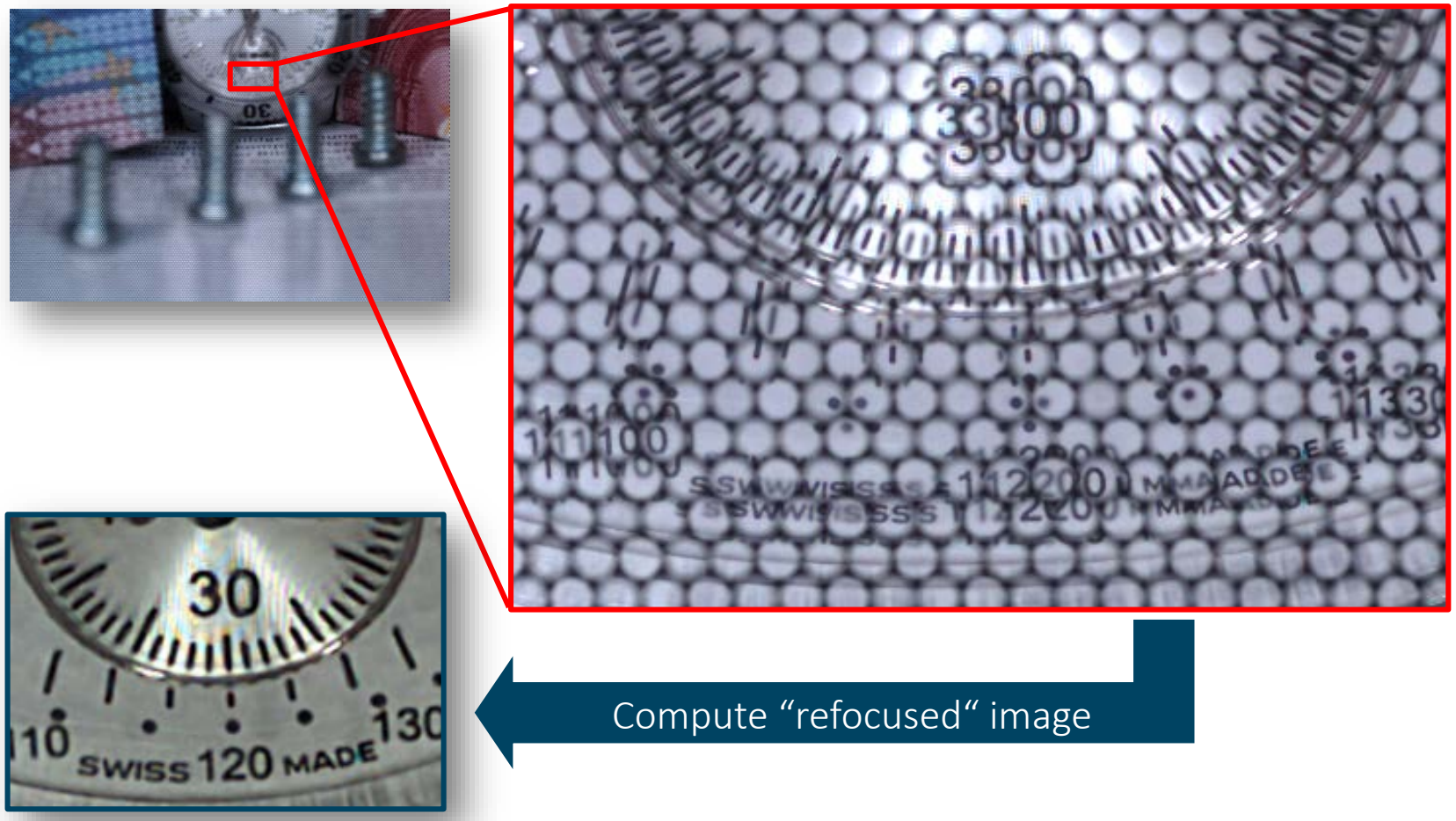
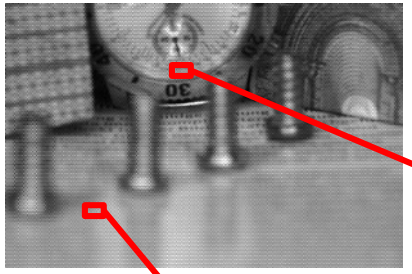
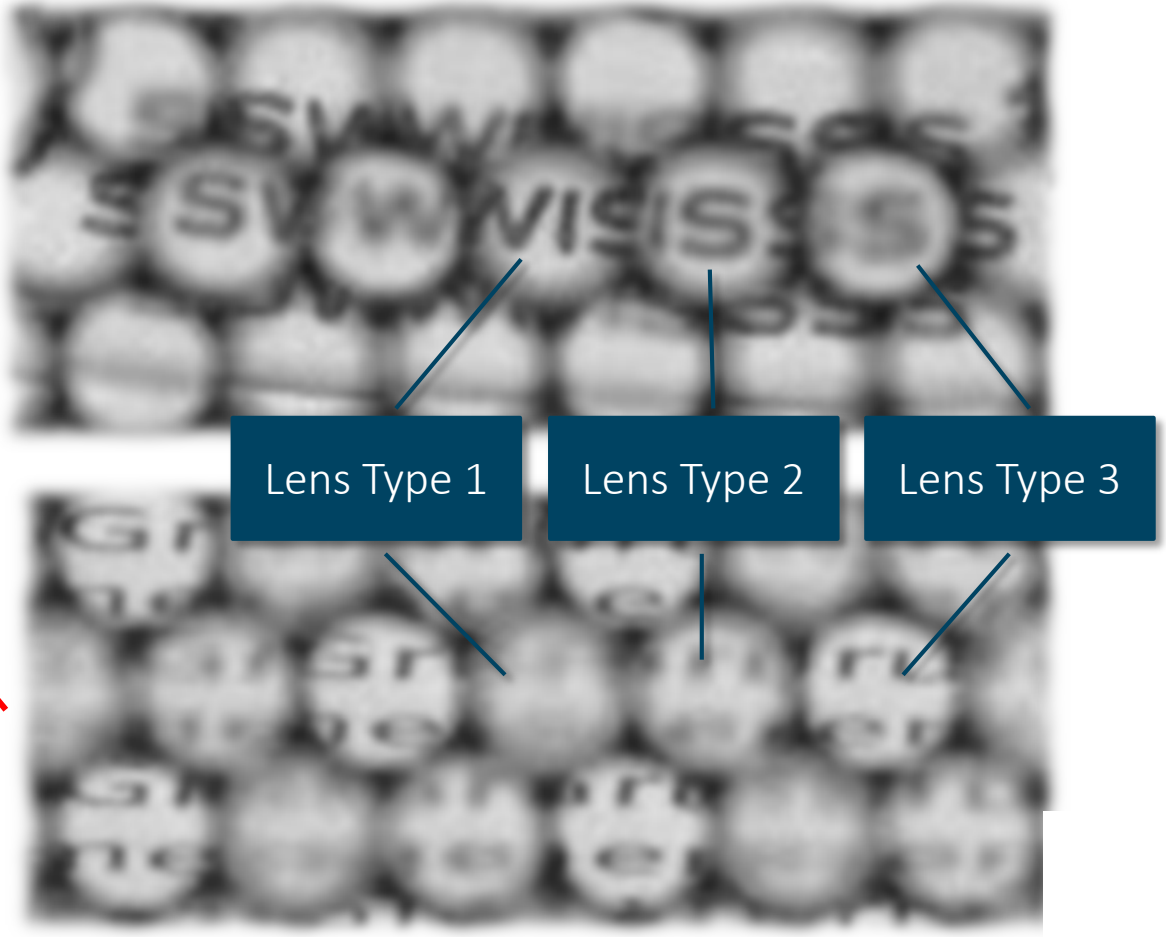
Plenoptic Camera Raw Image



Extended Depth-of-Field





Raytrix cameras use micro lens arrays with different micro lens types which differ in their focal length. This extends the depth-of-field of the camera.

Worldwide Patent

Extended Depth of Field

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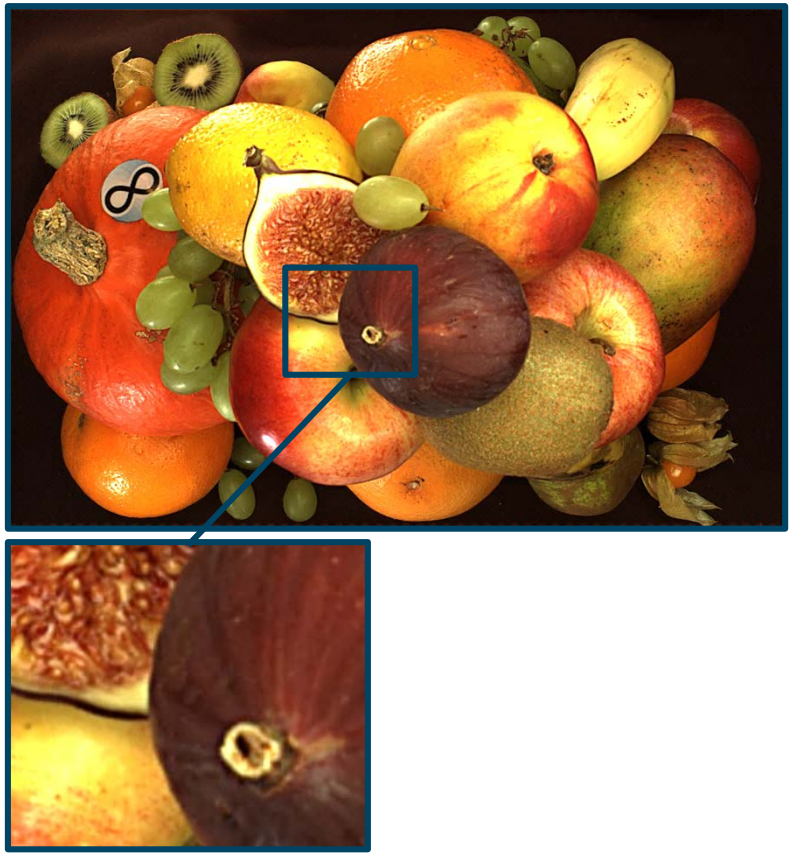
Comparison for standard photography

Standard Camera

Raytrix Lightfield Camera

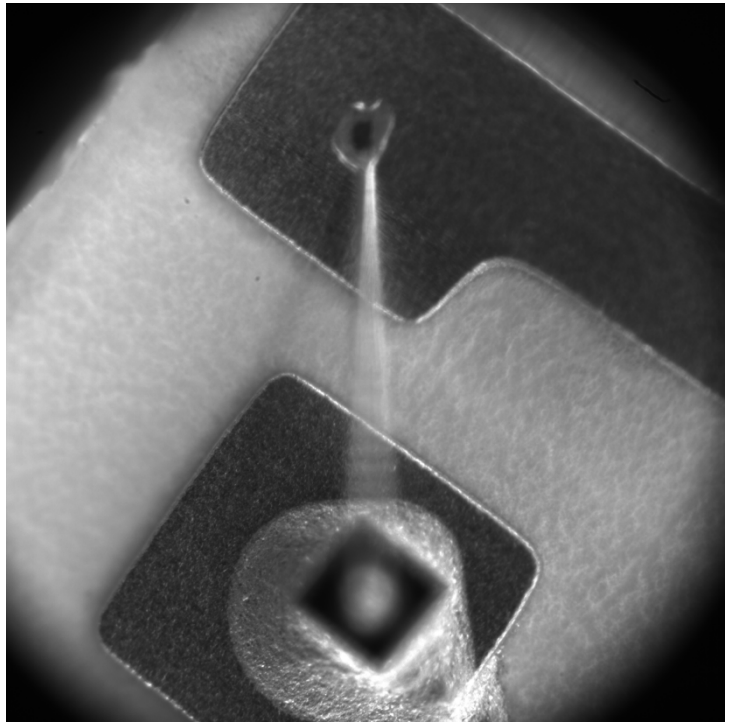


Both images were taken with same 11 megapixel sensor, same lens and same aperture.

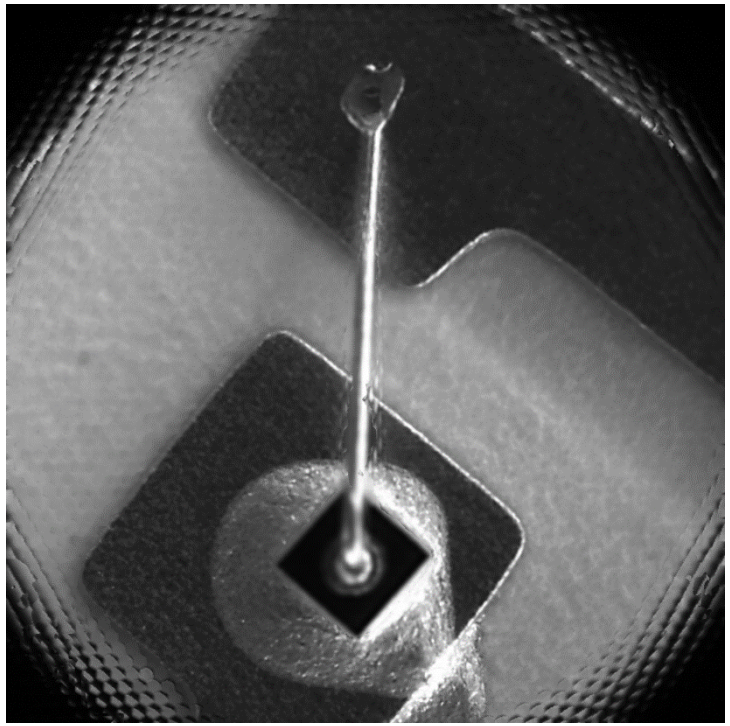
Extended Depth of Field

Comparison for microscopy

Standard 4MP Camera



Raytrix Lightfield Camera R5µ



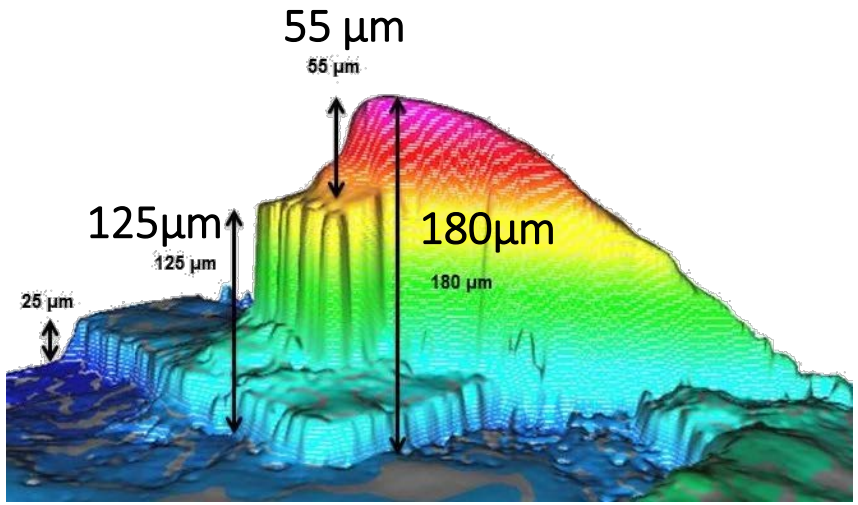


Image Computation

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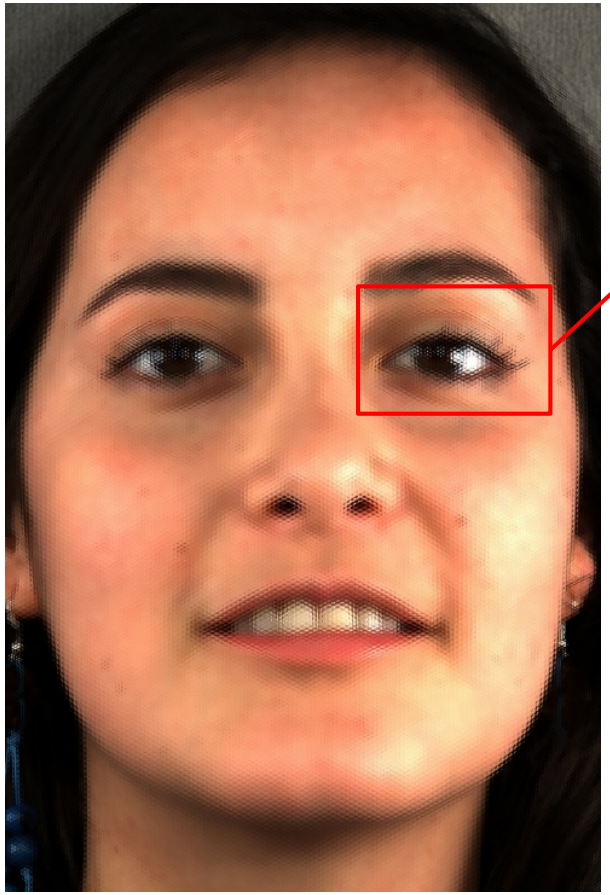
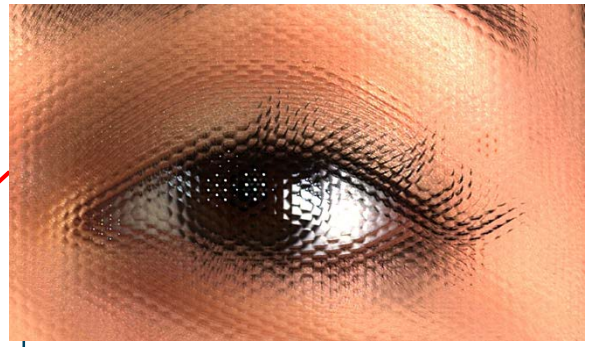
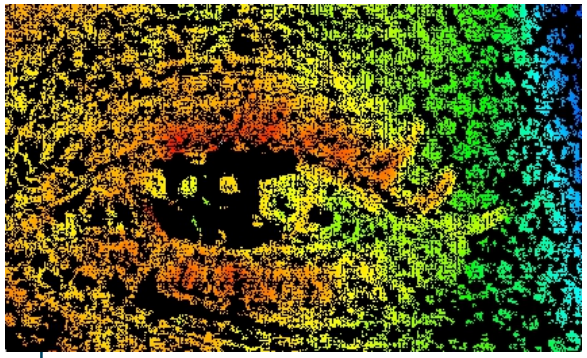
From raw image to total focus



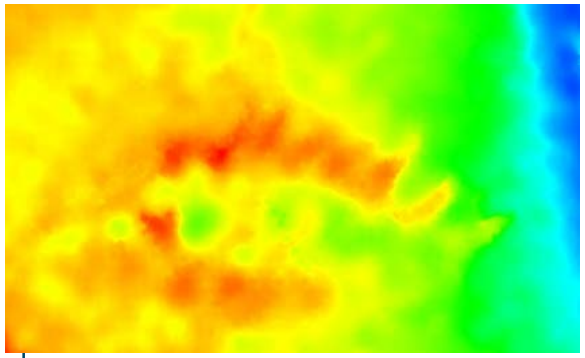


Micro-images show multiple imaging of object parts

Computationally reconstructed image from raw image and depth map



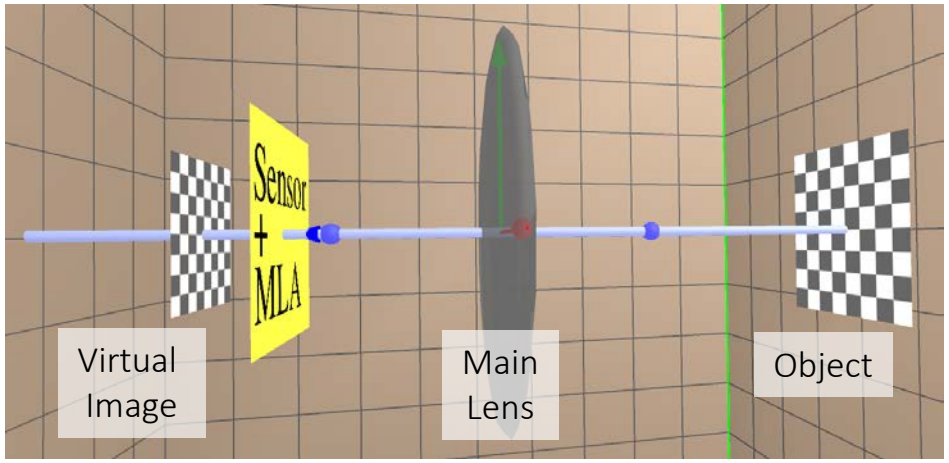
Color-coded depth map for high-contrast areas



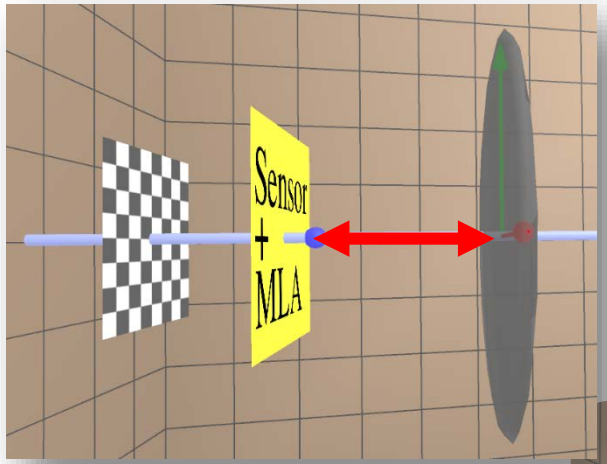
Filled depth map

Metric Calibration Model

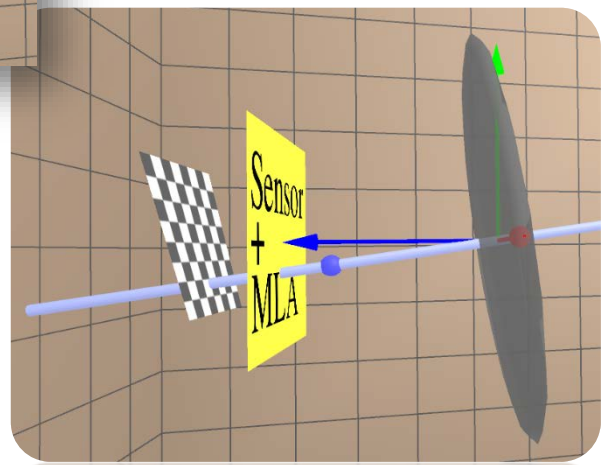
Free Parameters



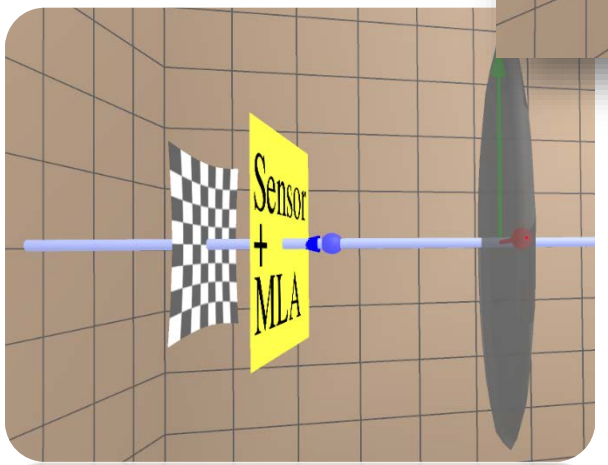
Simplified projection model



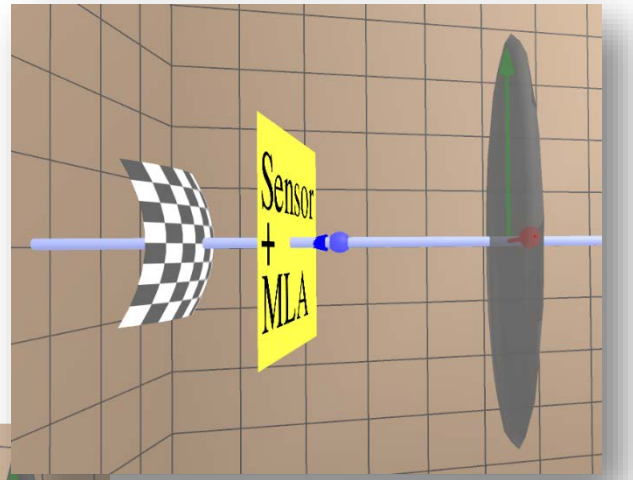
Focal Length



Optical Axis



Radial Distortion



Depth Distortion

Metric Calibration

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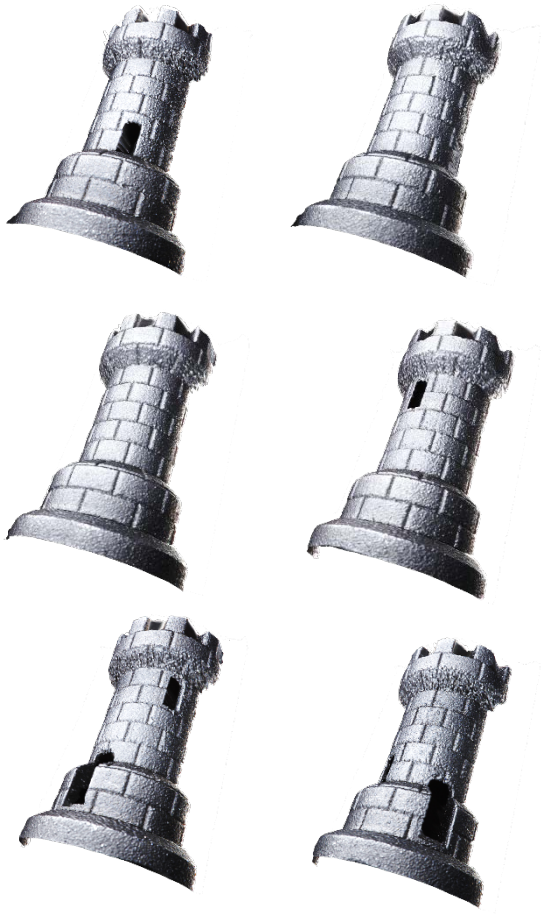
Stitching of 6 Views of Tower

Original

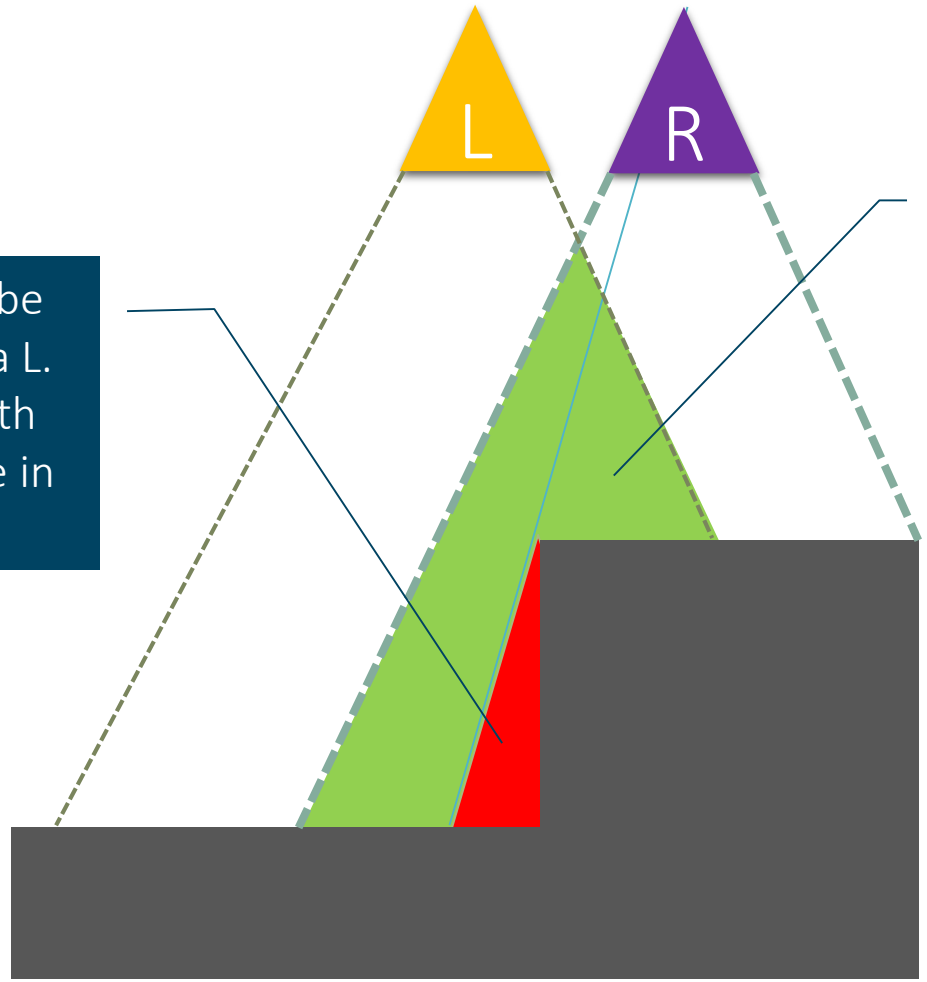
6 reconstructed views



Stitching Result

Occlusion

with Stereo Camera System

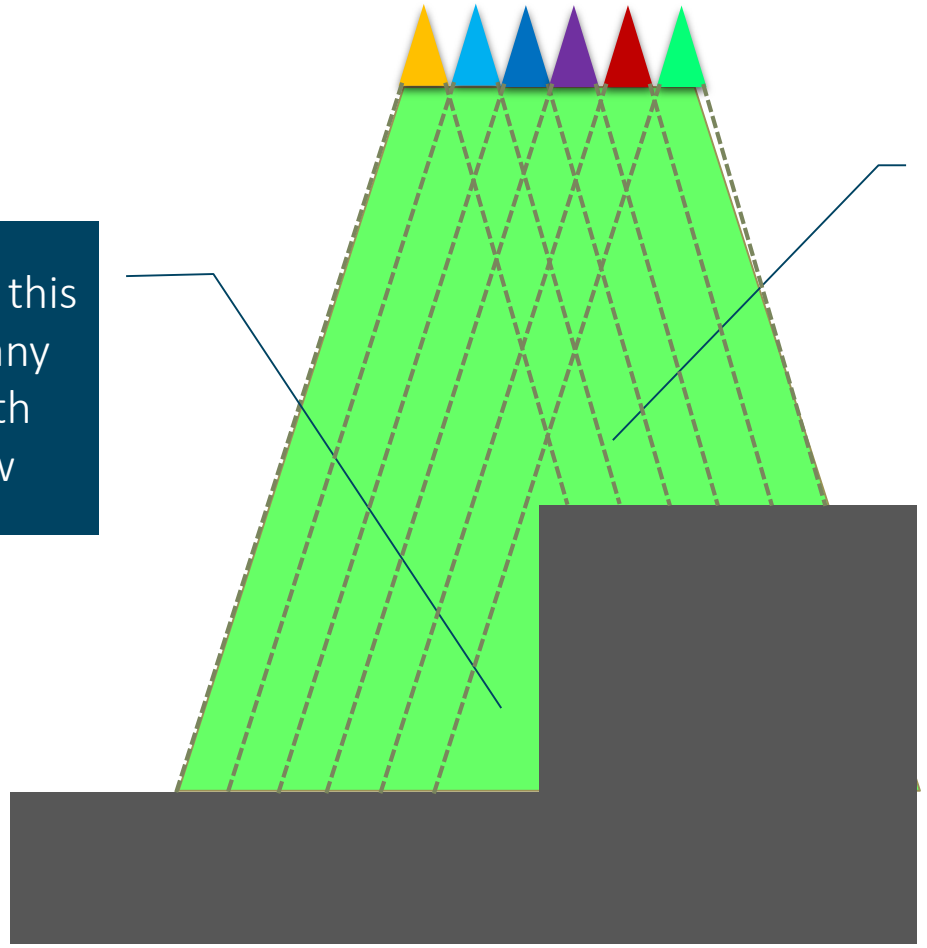


Red area can only be seen by left camera L. Therefore, no depth calculation possible in this area.

Depth estimation possible only in green area.

Occlusion

with Light Field Camera

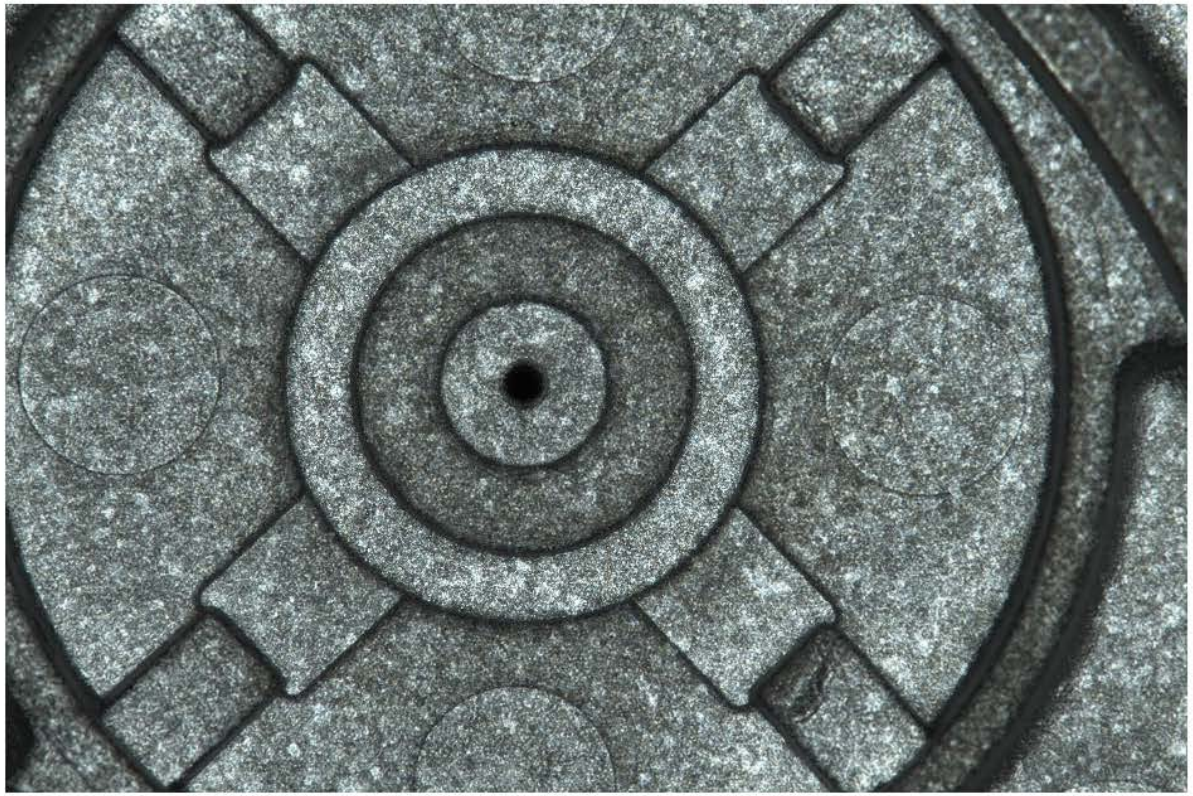


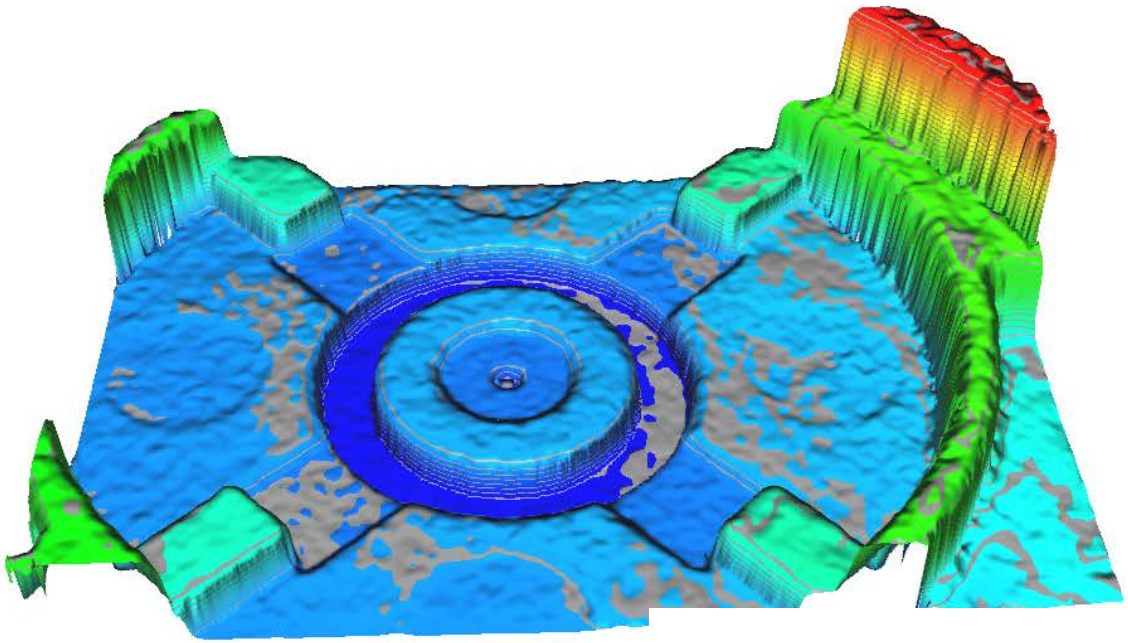
No occlusion area in this example due to many micro cameras with small field of view

Depth estimation possible in green area

Sharp 3D-Edges

Good reconstruction of sharp 3D-edges





Picture taken with Raytrix R29M camera

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Content

Application Areas

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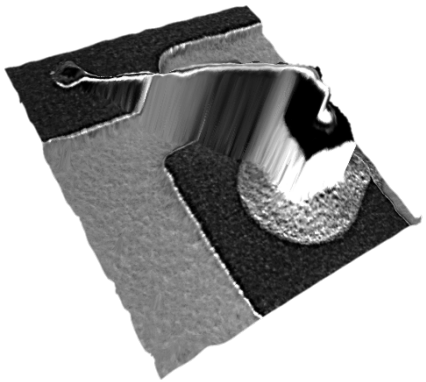

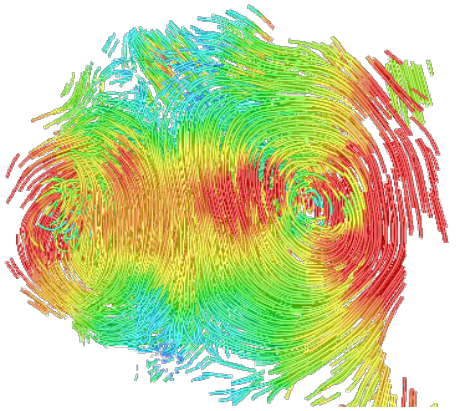

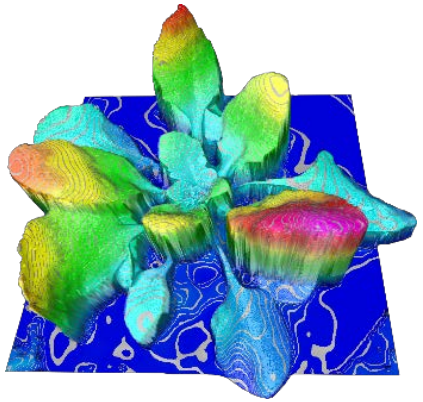

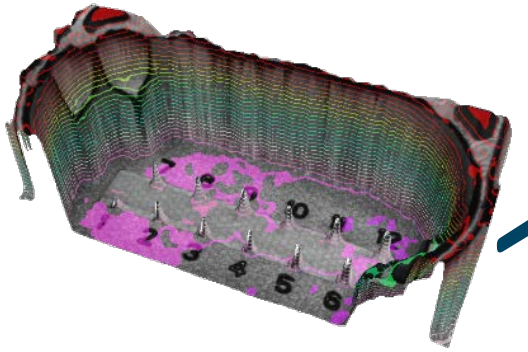

3D Machine Vision

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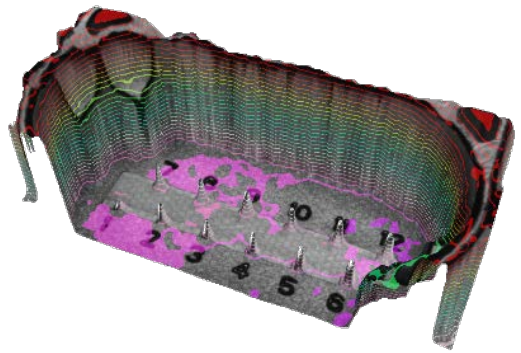
3D Machine Vision

Examples	Connector pin inspection	Inspect pin height and connector body at the same time
	Surface inspection	Find defects, measure shape
	Contaminations in Glass	Find defects in transparent material and determine depth
Advantages	Only 1 Camera	*Robust against vibrations; Low space requirements*
	Large depth-of-field	*See more depth*
	Fast capture (flash)	*High throughput in production lines*
	No special lighting	*Save setup & hardware costs*
	Small objects	*Works for production of micro parts*
	Difficult objects, e.g. deep seated	*Capture 3D where other systems do not work*



3D Fluid Mechanics

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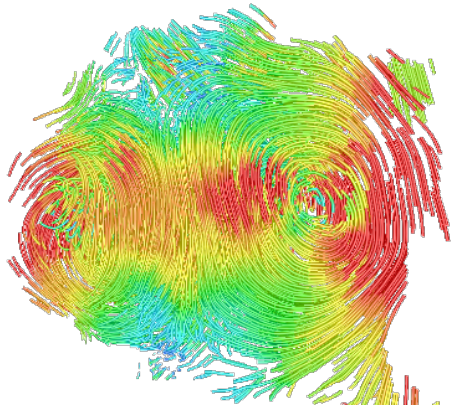
3D Fluid Mechanics

Examples

Petrol injection	Determine 3D distribution of droplets in injection process
Flow over sediment	Measure flow of water and the effect on the ground sediments at the same time
Micro flow in blood vessels	Optimize design of stands by investigating flow

Advantages

Only 1 Camera	Robust & simple setup saves time and is more versatile
Large depth-of-field	Calculate 3D-flow in a volume and not just a slice
Double-Shot & High speed capture	Can be used for any type of experiment
Microscopic Flow	Microscopic scenarios like Stands
Difficult setups	Setups with only a single access point



3D Microscopy

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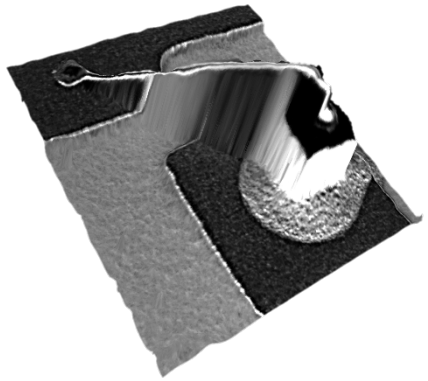
3D Microscopy

Examples	Bonding Wires	Inspect 3D shape of bonding wires with high throughput
	Solar Cells	Inspect surface of solar cells for defects
	IC Connector Pins	Check for bend IC pins before placing on PCB

Advantages	3D with standard Microscope	Reduce cost by using available microscopes
	Large depth-of-field	Can see much more than with a standard camera
	Fast, single image capture	No scanning necessary, high frame rates possible
	Metric 3D	Use the camera as 3D measurement device
	Robust setup	No de-calibration due to vibration, etc.



3D Plant Analysis

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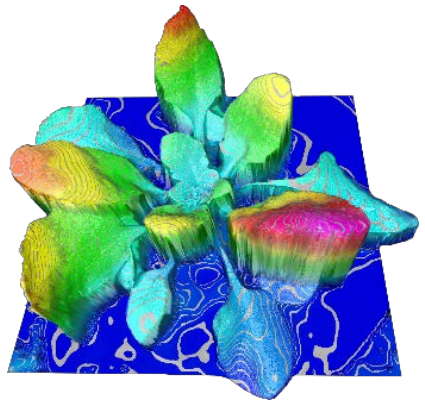
3D Plant Analysis

Examples	Plant breeding	Automatically inspect and analyze plant growth in 3D
	Picking	Color image plus 3D helps in picking fruit and vegetables
	Weeding	Robust weed recognition and extraction by combination of color image and 3D
Advantages	Single Camera 3D	*Robust against vibrations and wind*
	Large depth-of-field	*see the whole plant*
	Use available light	*non-invasive, does not influence plant growth*
	Metric 3D	Camera is a 3D measurement device



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Content

One Shot – Many Outputs

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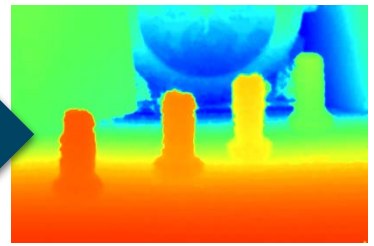
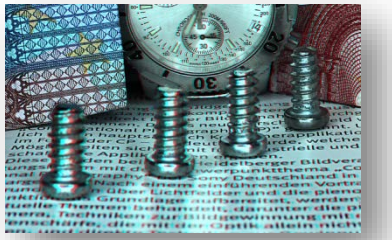
Single shot
- One raw image
- Video possible
- Makro and Tele lenses
- Arbitrary object sizes and distances
- High effective resolution

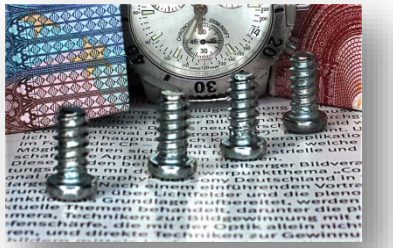


Depth Map
- No metric 3D-calibration needed but possible
- Depth can only be calculated at structured areas

3D-Data

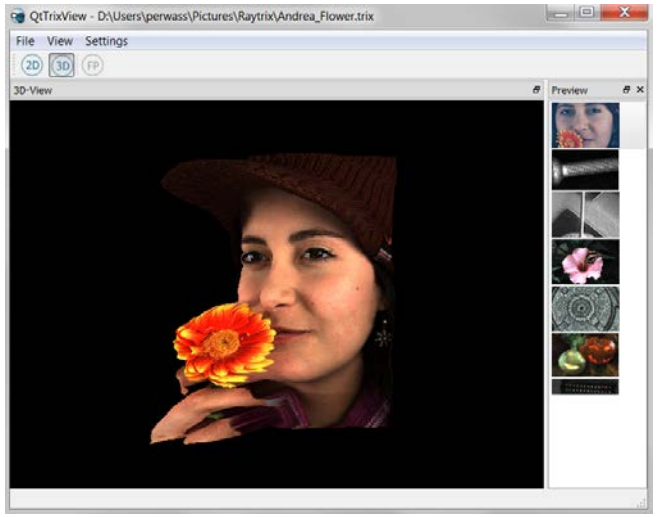


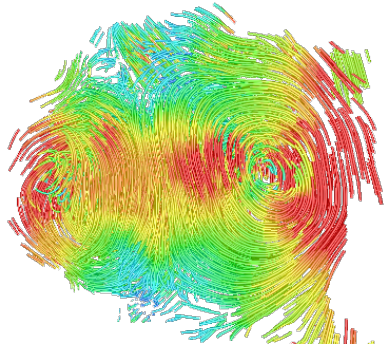
3D-View
- Variable base line
- Variable image orientation
- Multi-View for auto-stereoscopic displays



All-In-Focus

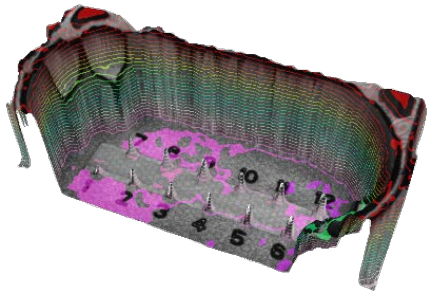
Image Processing
- selective per-pixel focus
- Variable view point horizontally and vertically
- Variable 3D-zoom effect

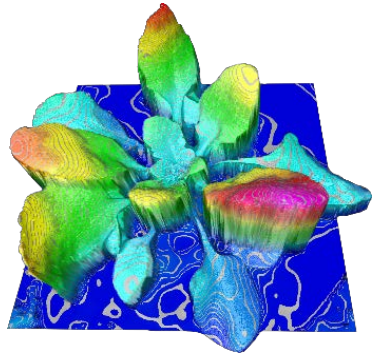




Download the free *TrixViewer* for Windows® and MacOS® and *raw light field data* from

www.raytrix.de





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Contact

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