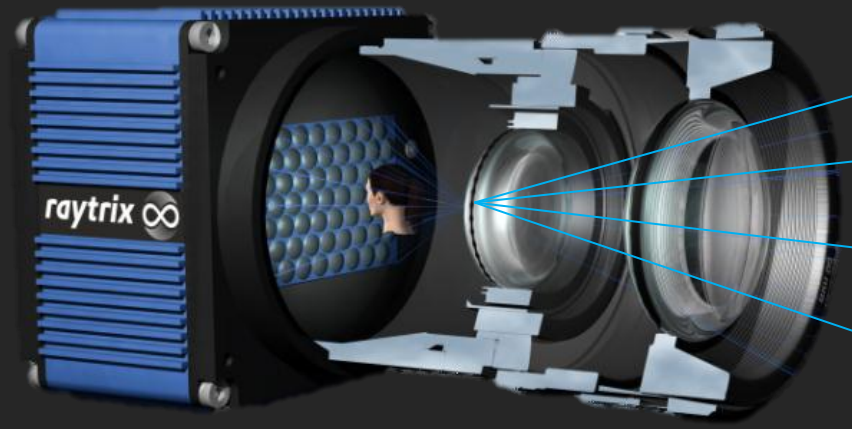
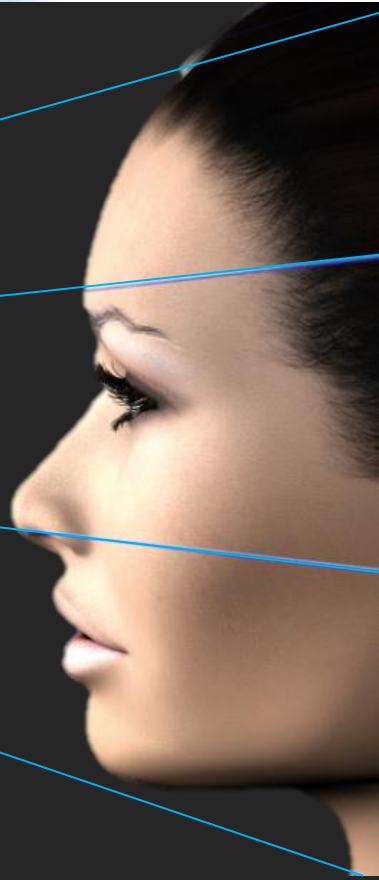
3D Light Field Camera Technology

raytrix

3D reconstruction and extended depth-of-field based on only one snapshot and a single-lens camera





3D Light Field Camera

Products & Reseller Prices

valid until March 1st, 2013

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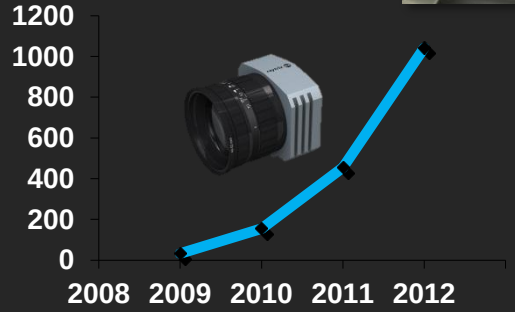
The Company

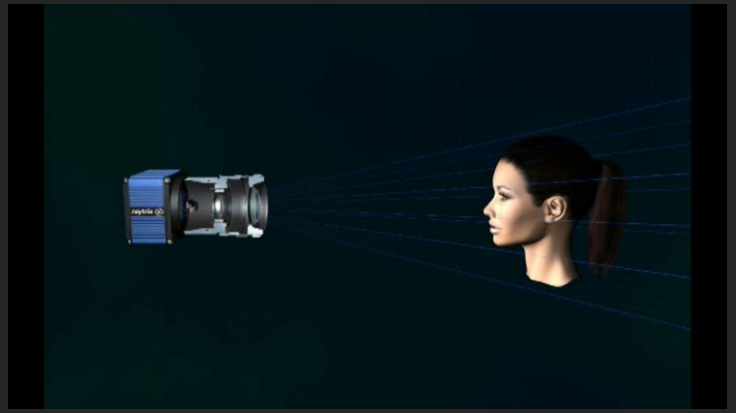
3D reconstruction and extended depth-of-field based on only one snapshot and a single-lens camera

- Founded 2008 by general managers & private chairholders: Dr. Lennart Wietzke, Dr. habil. Christian Perwass
- Staff: 20
- Main markets: R&D, Universities, machine vision, PIV, microscopy/endoscopy
- Patents: US-Pat.-No.: 2012/0050562 A1 , European patent No. 2244484
- Awards: CHIP-Award 2012: „Innovation of the year“, First winner of Image Engineering Innovation Award 2013
- Clients: Toshiba, Samsung, intel, Microsoft, BOSCH, Sony, LGe, John Hopkins, MIT, US-Army, US-Navy, German printing factory, Zeiss, EADS, NASA, ETH, Sumitomo/JP, Olympus, NOKIA, HTC, Max Planck, Fraunhofer, DLR, RICOH, CASIO, …

Volume



*CHIP Award 2012
„Innovation of the Year“
for Raytrix
Light Field Camera Technology



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3D Light Field Camera Technology*

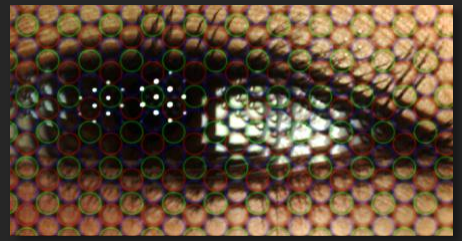
raytrix

3D reconstruction and extended depth-of-field based on only one snapshot and a single-lens camera

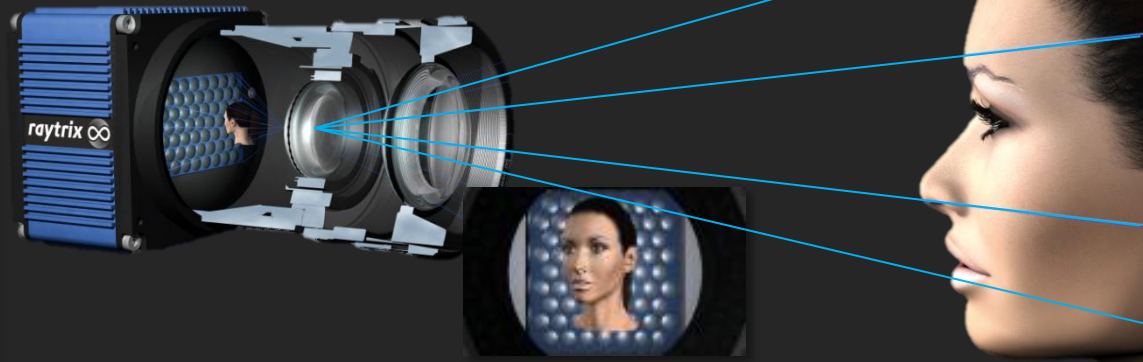
3D Light Field Camera

- calibration-free monocular camera
- robust & space-saving setup
- down to micron resolution
- extended depth-of-field by software re-focus
- captures fast moving objects by single shot

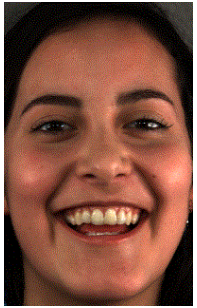
Light field engine



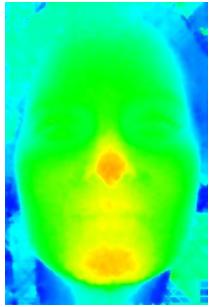
4D light field raw image data



Micro-lens array (MLA) optics



perspective shift

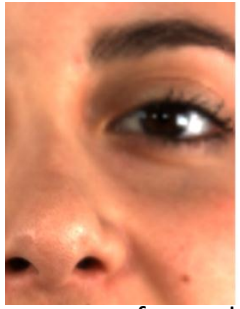


3D depth map

in total focus

3D view

re-focus plane on eye



re-focus plane on nose

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* US-Pat.-No.: 2012/0050562 A1 , CHIP-Award 2012: „Innovation of the year“

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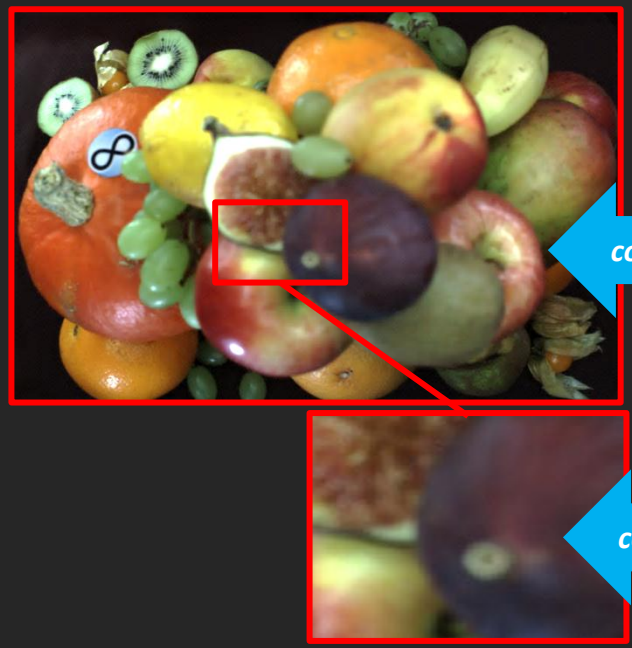
3D Light Field Camera Technology*

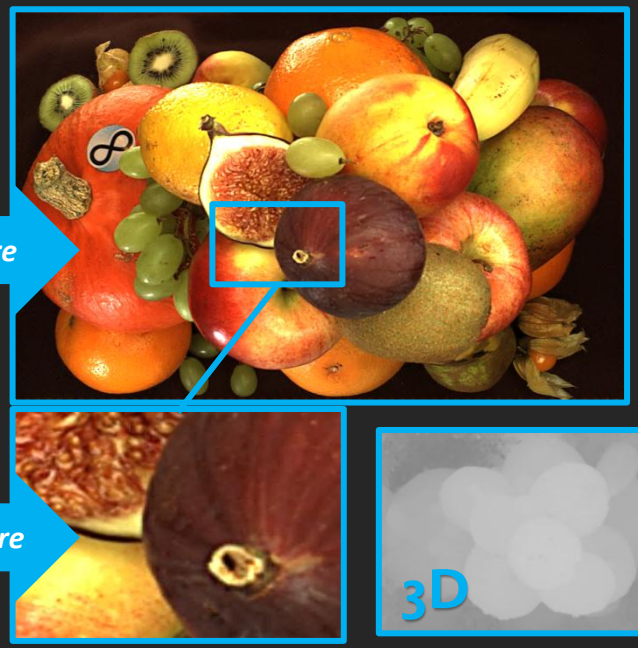
3D reconstruction and extended depth-of-field based on only one snapshot and a single-lens camera

Standard 2D camera

Raytrix light field camera



compare



3D
Light Field
Camera

compare

Extended depth-of-field

3D depth map

Note: Both images have been taken under same conditions

* US-Pat.-No.: 2012/0050562 A1 , CHIP-Award 2012: „Innovation of the year“

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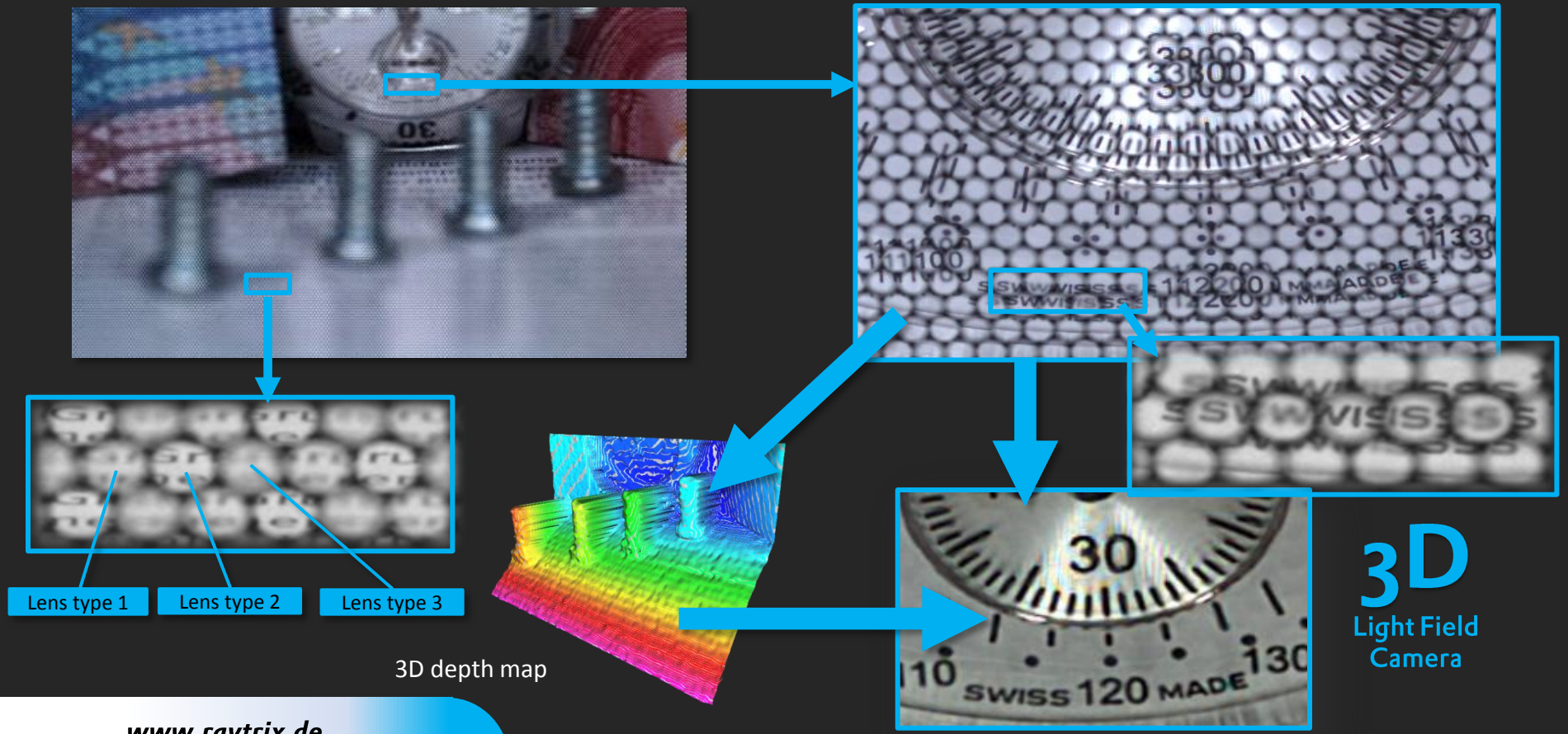
3D Light Field Camera Technology*

3D reconstruction and extended depth-of-field based on only one snapshot and a single-lens camera



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3D reconstruction and extended depth-of-field based on only one snapshot and a single monocular camera

Single-lens 3D Light Field Camera

R5 High Speed Video Camera System

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R5 Microscope 3D Light Field Camera

*Light Field Camera Technology** raytrix

3D reconstruction and extended depth-of-field based on only one snapshot and a single monocular camera

R5 microscope camera with 10x magnification of a two-cent coin

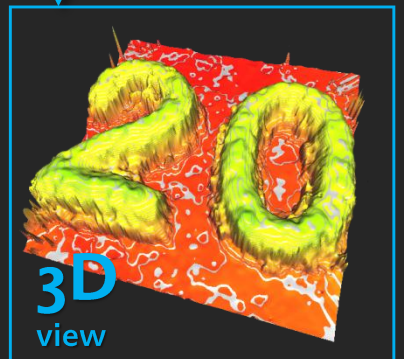
1.3mm field-of-view (FoV) of the imprint „***20***“ on a two-cent coin with 0.5mm depth of field (DoF)

Single-lens 3D Light Field Microscope Camera

- calibration-free monocular camera
- robust & space-saving setup
- down to micron resolution
- extended depth-of-field by software re-focus
- captures fast moving objects by a single shot
- no special structured illumination required
- mono, color and NIR cameras available

Re-focus

Total focus with 6x extended depth-of-field and 1 Megapixel



3D view

Color coded depth map with approx. 200 discrete Z-layers

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* US-Pat.-No.: 2012/0050562 A1 , European patent No. 2244484, CHIP-Award 2012: „Innovation of the year“

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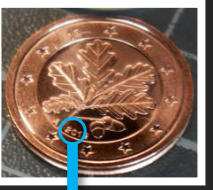


R5 Microscope Example: Two-Cent Coin

3D Light Field Camera Technology* raytrix

3D reconstruction and extended depth-of-field based on only one snapshot and a single-lens camera

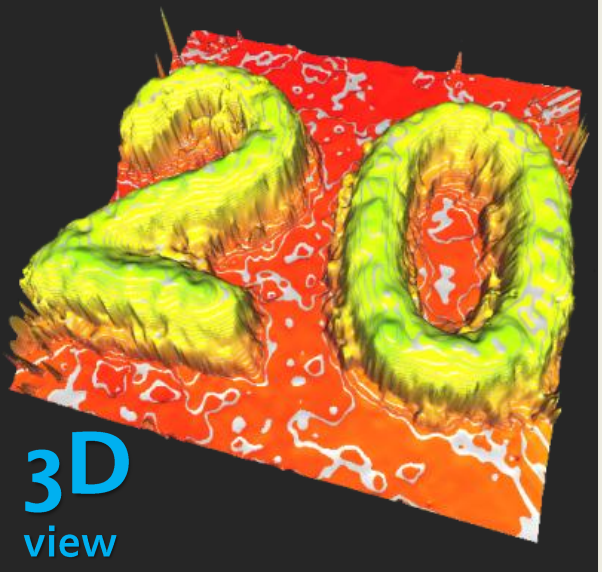
Standard 2D Camera

compare

Standard 2D camera with 4.2 Megapixel resolution and blured image region in the foreground

Raytrix 3D Light Field Camera

Total focus with 6x extended depth-of-field and 1 Megapixel



Color coded depth map with approx. 200 discrete Z-layers

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* US-Pat.-No.: 2012/0050562 A1 , CHIP-Award 2012: „Innovation of the year“

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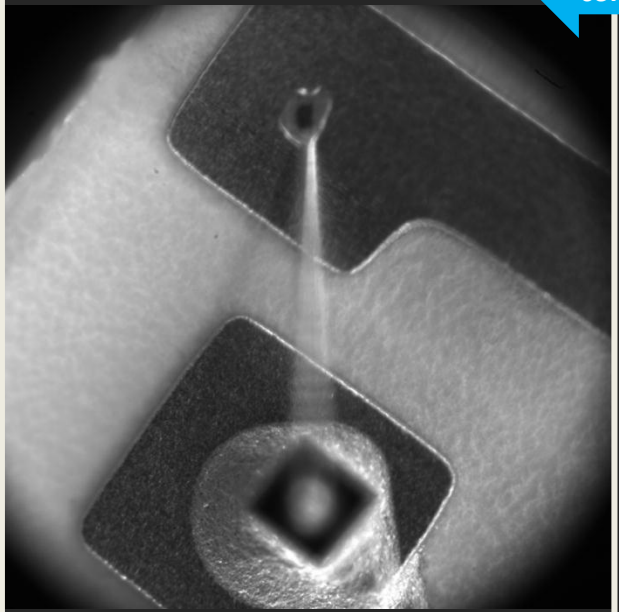
R5 Microscope Example: LED Bonding Wire

Light Field Camera Technology* raytrix

3D reconstruction and extended depth-of-field based on only one snapshot and a single-lens camera

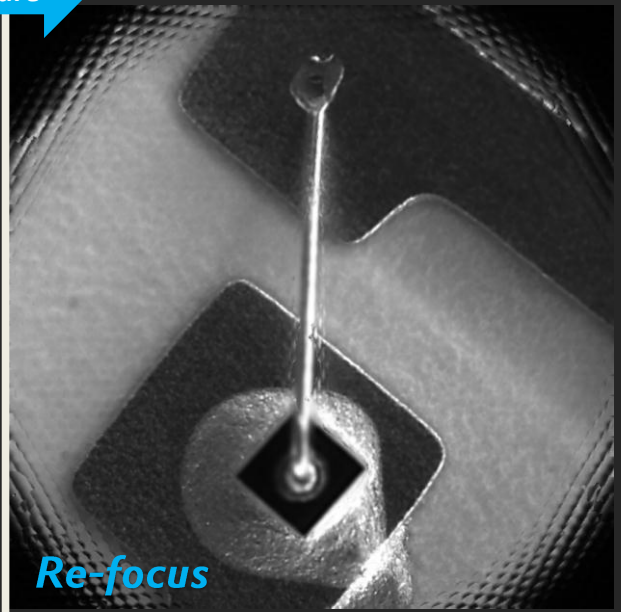
Standard 2D Camera

compare

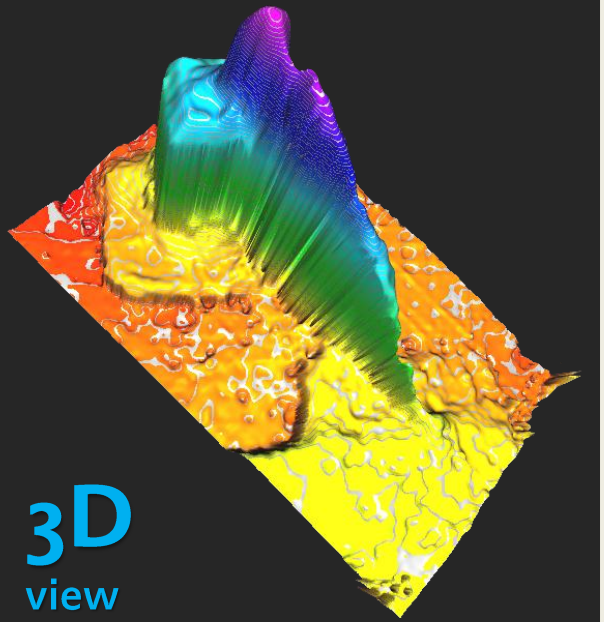


Standard 2D camera with 4.2 Megapixel resolution and blured image region in the foreground

Raytrix 3D Light Field Camera



Total focus with 6x extended depth-of-field and 1 Megapixel



Color coded depth map with approx. 200 discrete Z-layers

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* US-Pat.-No.: 2012/0050562 A1 , CHIP-Award 2012: „Innovation of the year“

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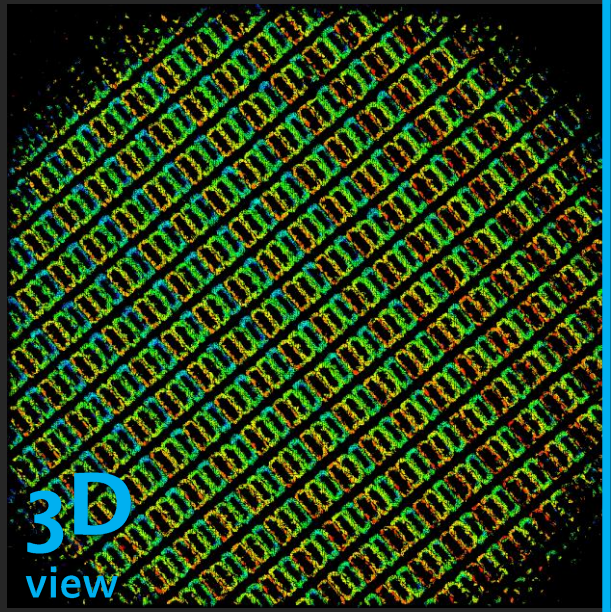
R5 Microscope Example: „Retina“ Display

3D reconstruction and extended depth-of-field based on only one snapshot and a single-lens camera

High resolution „Retina“ display

Raytrix 3D Light Field Camera

Total focus with 6x extended depth-of-field and 1 Megapixel



Color coded depth map with approx. 200 discrete Z-layers. Note, that RGB pixels are on different depths.

* US-Pat.-No.: 2012/0050562 A1 , CHIP-Award 2012: „Innovation of the year“

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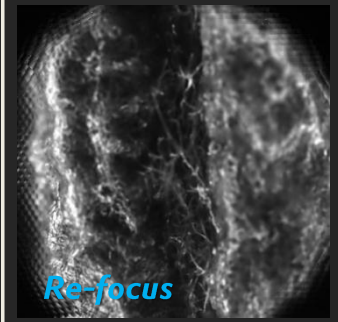
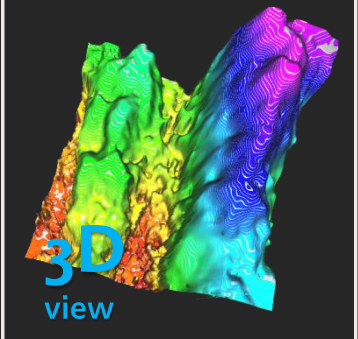
R5 Microscope Examples

3D Light Field Camera Technology* raytrix

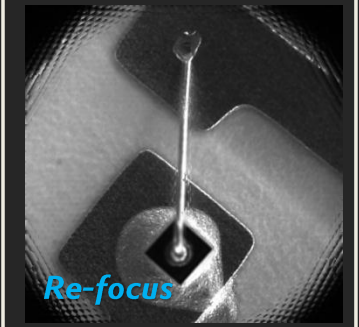
3D reconstruction and extended depth-of-field based on only one snapshot and a single-lens camera

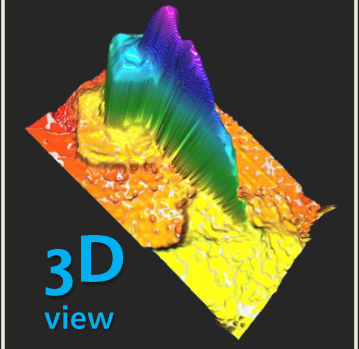
Rosemary



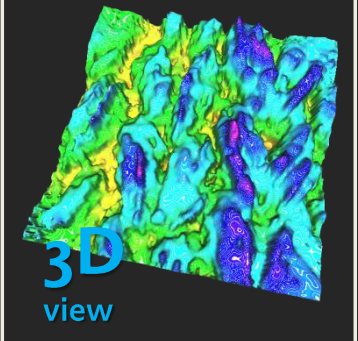


LED Bonding Wire

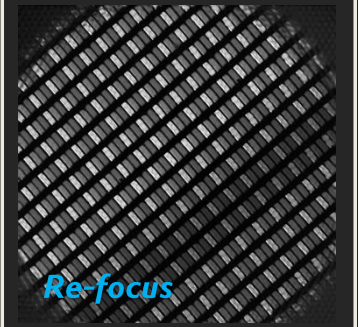


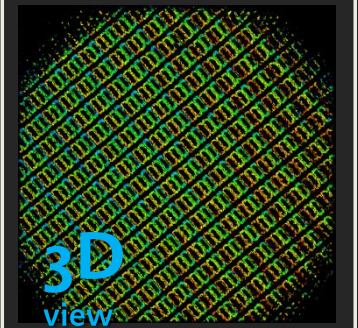


Microfibre Cloth

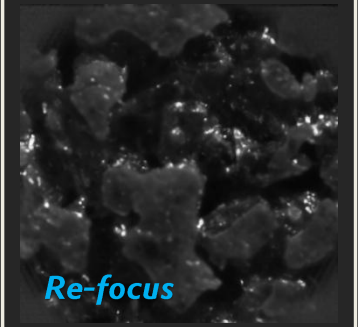


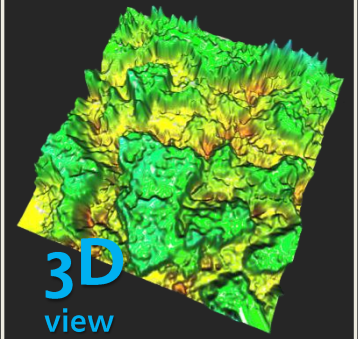
„Retina" Display





Sandpaper





* US-Pat.-No.: 2012/0050562 A1 , CHIP-Award 2012: „Innovation of the year"

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R5 3D Bonding Wire & Spot Weld Inspection

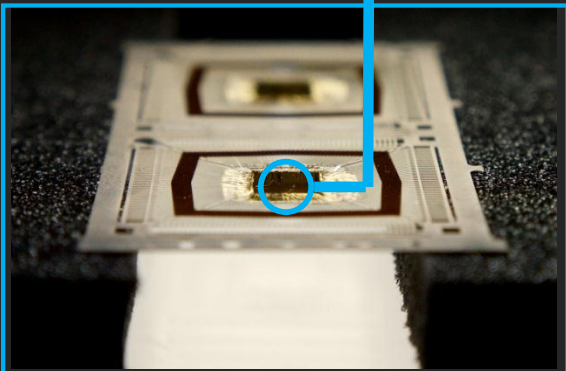
Light Field Camera Technology* raytrix

3D reconstruction and extended depth-of-field based on only one snapshot and a single monocular camera

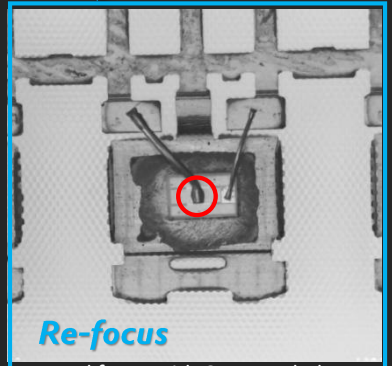
Telecentric lens by R5 camera with f/5.66

Single-lens 3D Light Field Camera

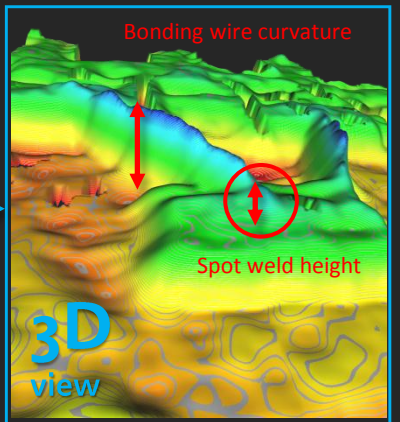
- calibration-free monocular camera
- robust & space-saving setup
- down to micron resolution
- extended depth-of-field by software re-focus
- captures fast moving objects by a single shot
- no special structured illumination required
- mono, color and NIR cameras available

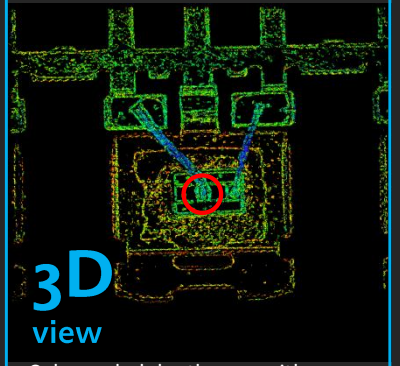


11mm field-of-view (FoV) of bonding wires with 0.5cm depth of field (DoF)



Total focus with 6x extended depth-of-field and 1 Megapixel





Color coded depth map with approx. 200 discrete Z-layers

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* US-Pat.-No.: 2012/0050562 A1 , European patent No. 2244484, CHIP-Award 2012: „Innovation of the year“

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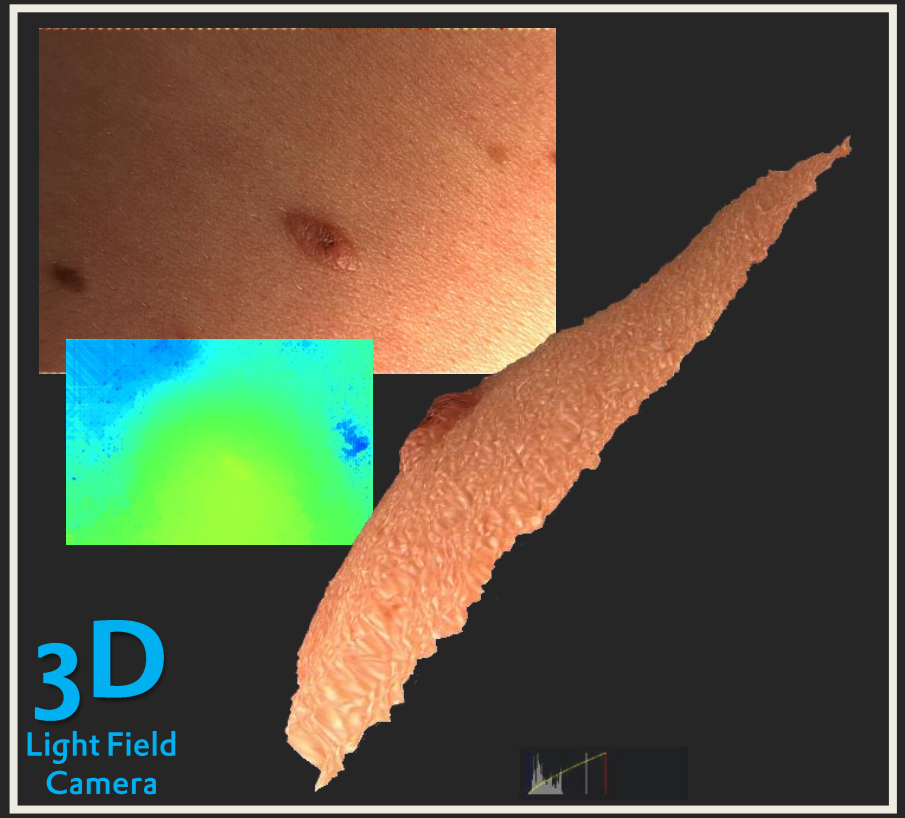
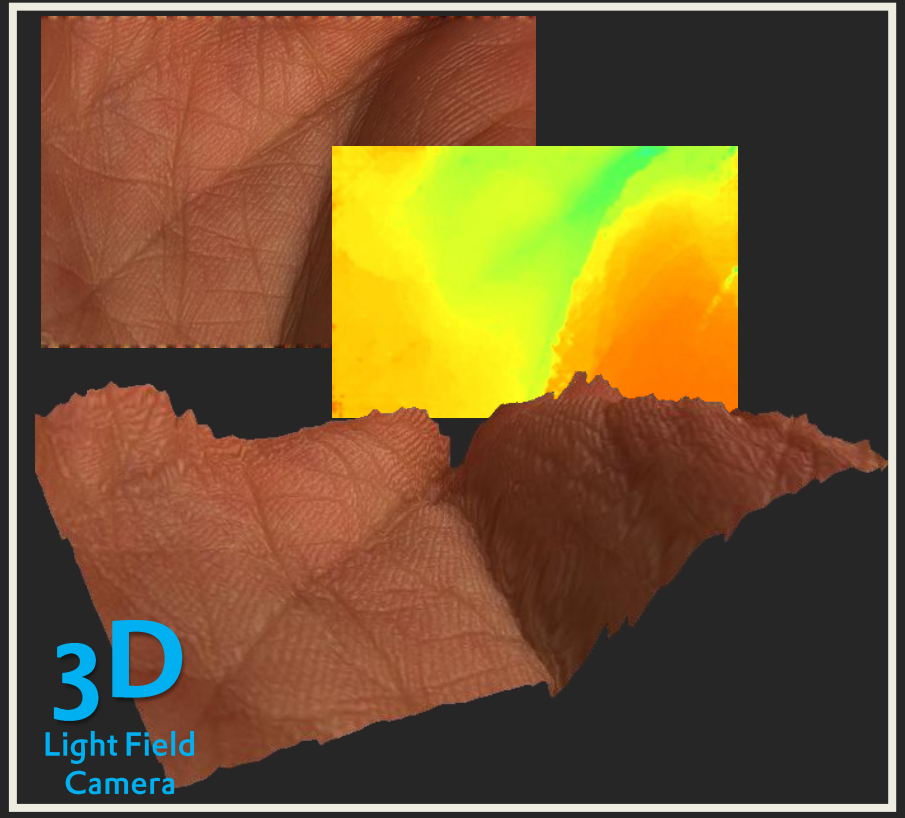
R5 Medical Application: 3D Skincare

Light Field Camera Technology* raytrix

3D reconstruction and extended depth-of-field based on only one snapshot and a single-lens camera





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R5 High-Speed 3D Light Field Video Camera

*Light Field Camera Technology**

raytrix

3D reconstruction and extended depth-of-field based on only one snapshot and a single-lens camera

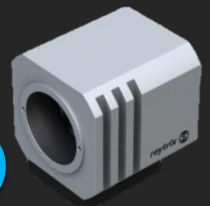
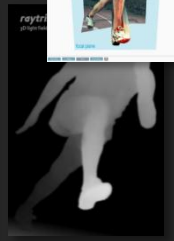


illustration may differ

3D
Light Field Camera



- calibration-free monocular camera
- robust & space-saving setup
- down to micron resolution
- extended depth-of-field by software re-focus
- captures fast moving objects by a single shot
- no special structured illumination required
- mono, color and NIR cameras available

R5 Specifications	
Lateral resolution	max 1 MP (25% of original image sensor resolution)
Extended depth-of-field	max 6x of standard cameras
Frame rate	25 FPS (GigE), 57 FPS (Dual-GigE), 90 FPS (USB 3.0), 180 FPS (Camera-Link)
Light field image sensor	4.2 Megarays, 2048 x 2048 pixel, 5.5µm pixel pitch, CMOSIS CMOS
3D depth resolution	max 200 discrete depth layers
Fixed aperture	f/2.4, f/5.66, f/26 (microscopy), … (***we offer full customized micro lens array optics meeting your needs)***
Interface	Single/Dual Gigabit Ethernet, Camera-Link, USB 3.0 superspeed
Lens mount	C-mount
Software support	MVTec Halcon plugin interface, SDK/API programming interface for Microsoft Windows
Hardware requirements	NVIDIA GeForce GTX-680 with 2 GB GPU memory (or higher)
Software requirements	Microsoft Windows 7 (32bit), CUDA with OpenGL 4.0 and Compute Capability 2.0
Applications	Fluid flow (3D Particle tracking, PIV), Light Field R&D, machine vision, endoscopy, microscopy, visual quality inspection, life science, …

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* US-Pat.-No.: 2012/0050562 A1 , CHIP-Award 2012: „Innovation of the year“

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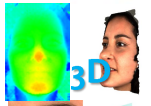
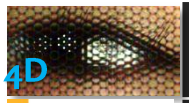
R5 High-Speed 3D Light Field Video Camera

*Light Field Camera Technology** raytrix

Camera	Illustration	Description	Price
R5 M GigE		Mono, Gigabit Ethernet, 25 FPS	5990 €
R5 C GigE		Color, Gigabit Ethernet, 25 FPS	6990 €
R5 NIR GigE		Near IR, Gigabit Ethernet, 25 FPS	9990 €
R5 M CL		Mono, Camera-Link, 180 FPS	9990 €
R5 C CL		Color, Camera-Link, 180 FPS	10990 €
R5 NIR CL		Near IR, Camera-Link, 180 FPS	14990 €

Optics	Illustration	Description	Price
Filter		White image filter	190 €
50mm		C-mount high resolution optics	990 €
Telecentric		C-mount high resolution optics	From 3990 €
12mm		C-mount high resolution optics	990 €

Software	Illustration	Description	Price
Multiview		Multiview perspective shift	490 €
3D+		3D depth map estimation	990 €
Focus+		Software re-focus after the fact	490 €
4D SDK		Light field raw image data access, Windows DLL programing interface	2990 €
HALCON plugin	HALCON the Power of Machine Vision	Machine vision interface for MVTec Halcon	490 €

Hardware	Illustration	Description	Price
Light Field Engine		GUI computer with high speed light field processing GPU	3990 €
GPU		High speed GPU	990 €
Frame Grabber		PCIe Frame Grabber for Camera-Link cameras	1990 €

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raytrix

3D reconstruction and extended depth-of-field based on only one snapshot and a single monocular camera

Single-lens 3D Light Field

R11 | R25 | R29 High End Cameras

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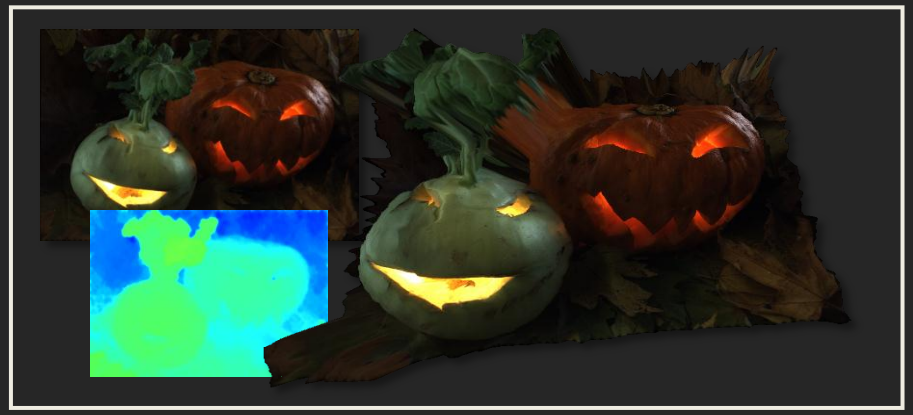
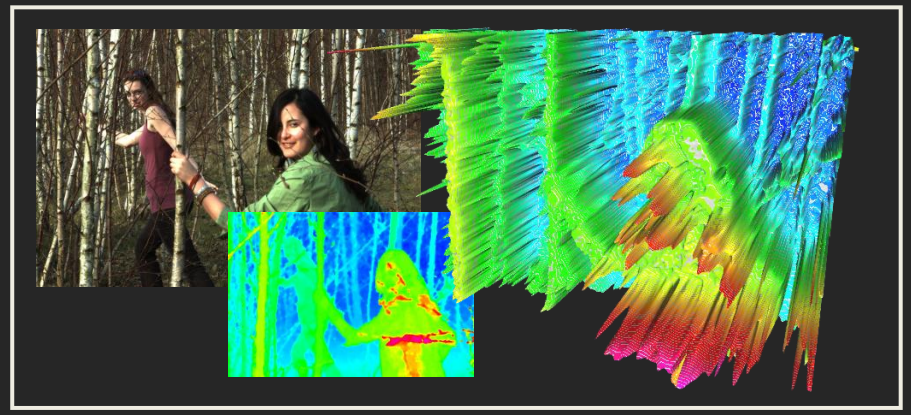
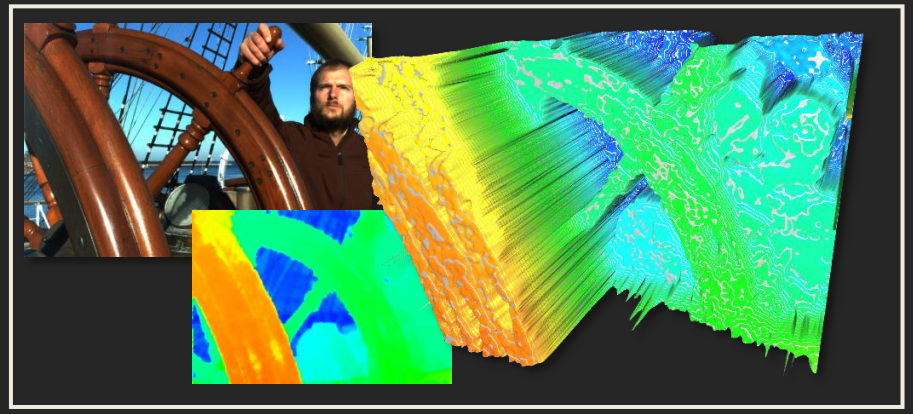
R11 | R29 3D Photography

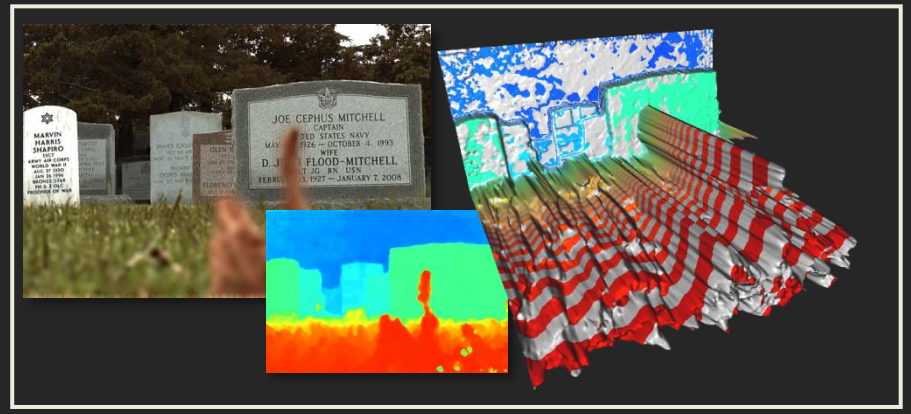
Light Field Camera Technology* raytrix

3D reconstruction and extended depth-of-field based on only one snapshot and a single-lens camera









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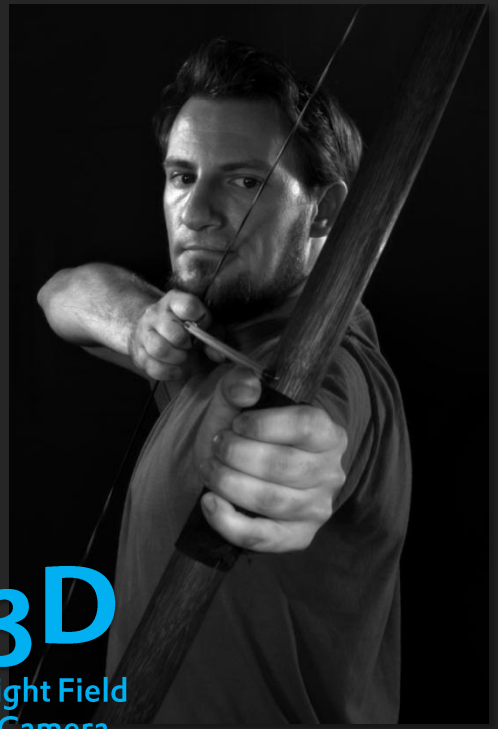
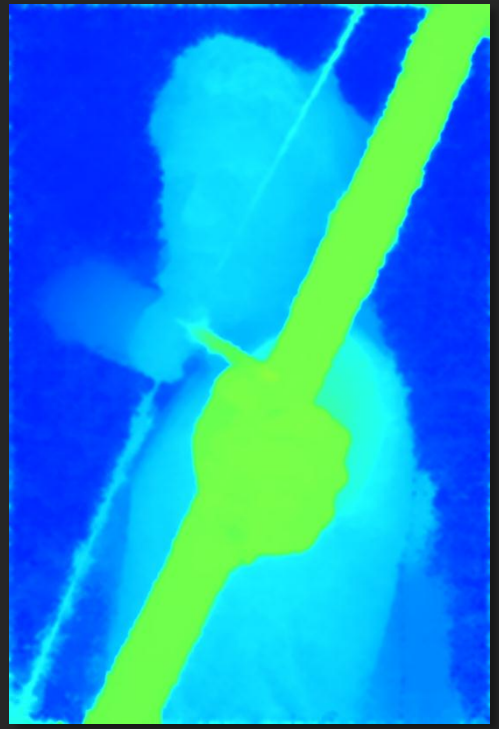
R11 | R29 3D Sports Photography

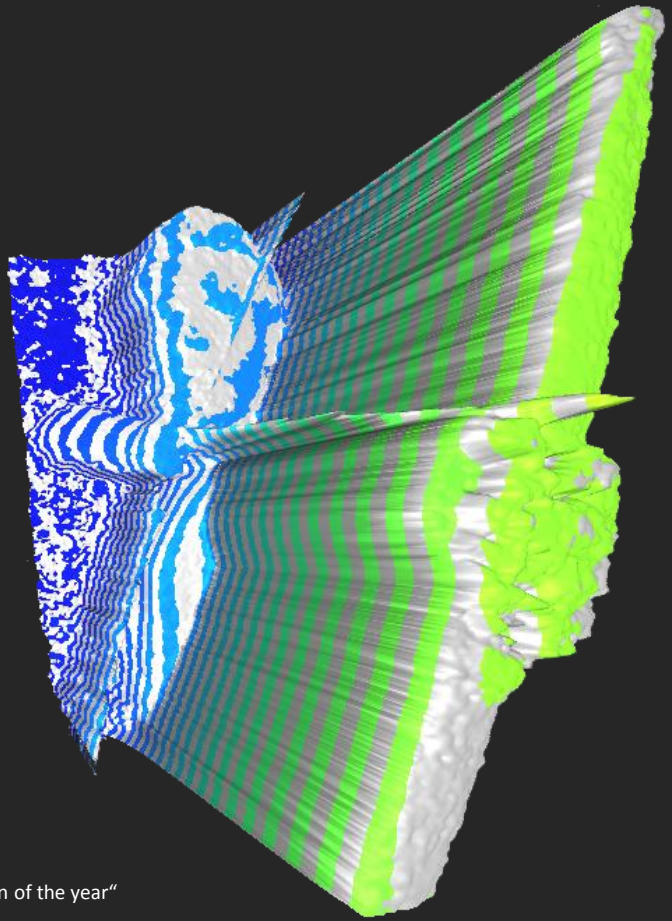
3D reconstruction and extended depth-of-field based on only one snapshot and a single-lens camera



3D
Light Field
Camera



Color coded depth map



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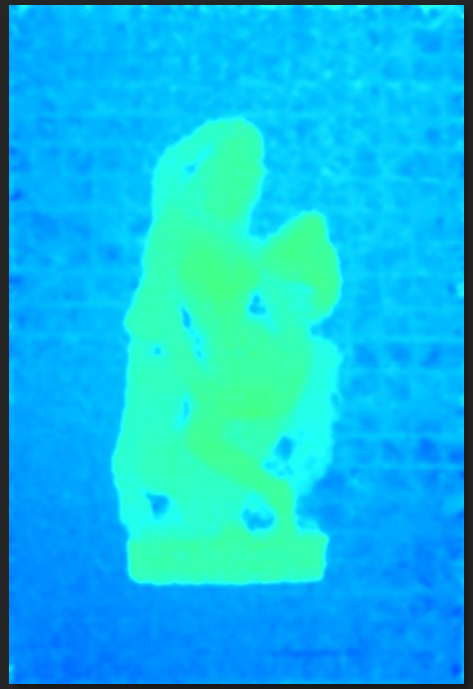
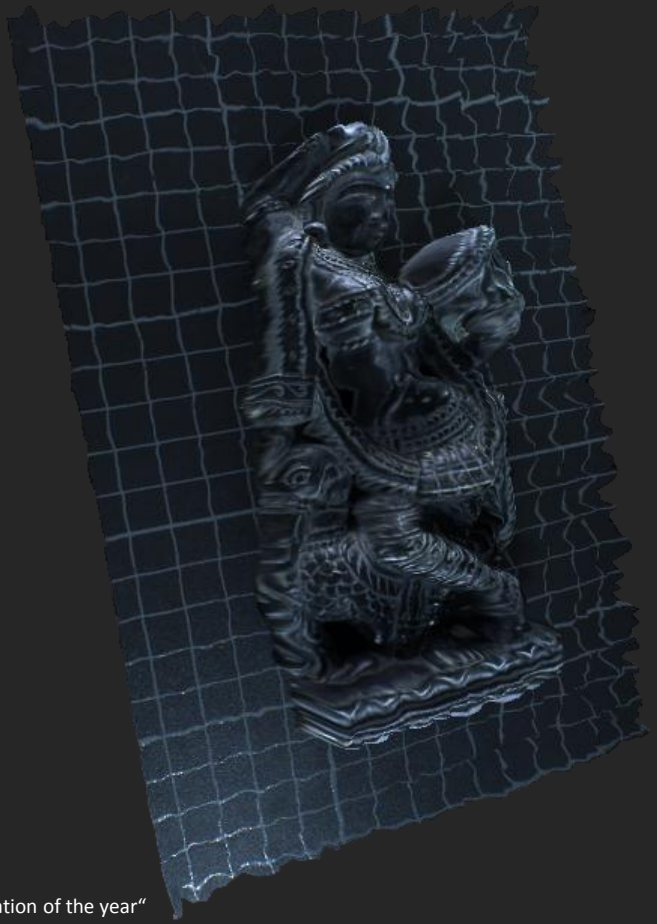
R11 | R29 Art Scanning

3D reconstruction and extended depth-of-field based on only one snapshot and a single-lens camera

3D
Light Field
Camera



Color coded depth map



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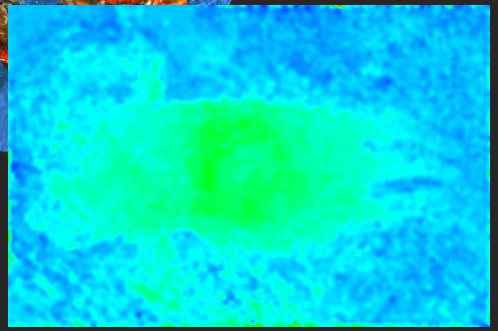
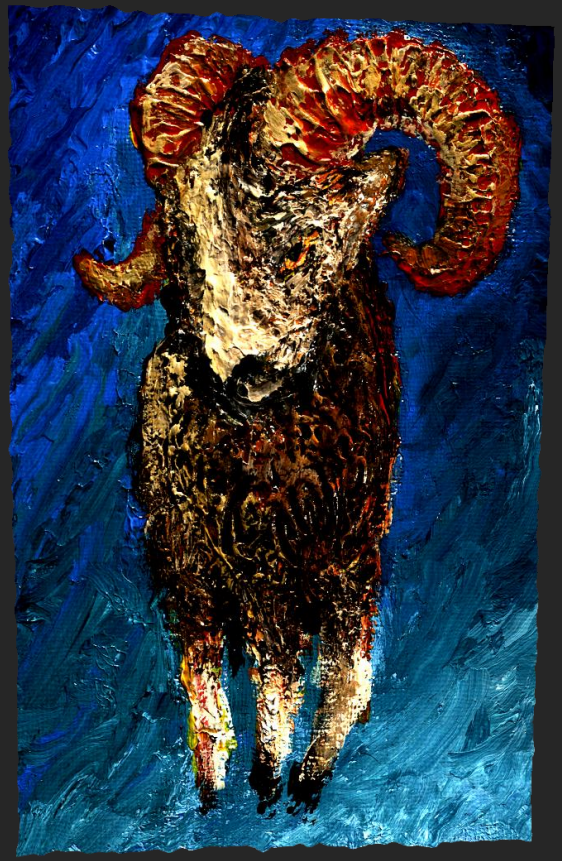
R29 Art Scanning

3D reconstruction and extended depth-of-field based on only one snapshot and a single-lens camera



Color coded depth map



3D
Light Field
Camera

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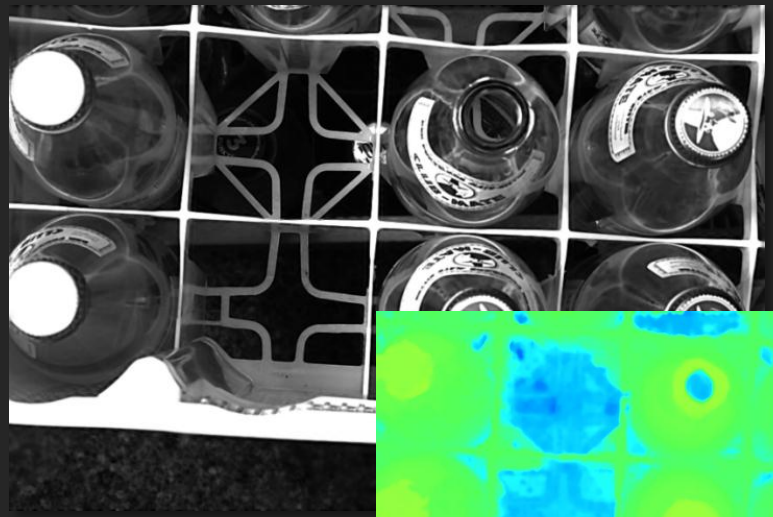
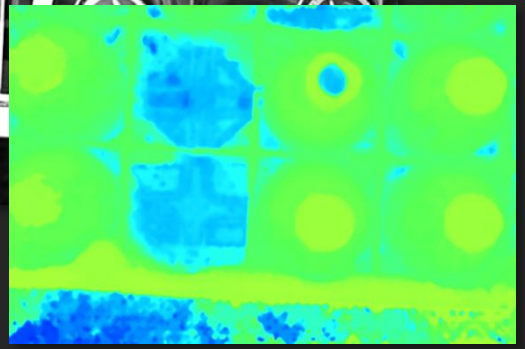
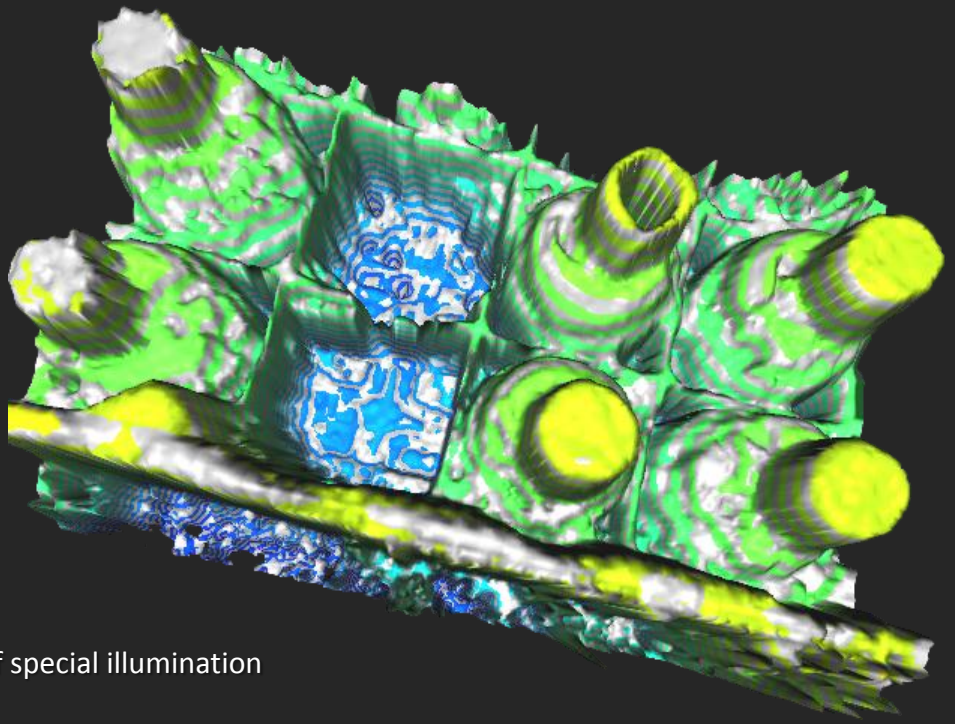
R11 3D Bottle Detection

3D reconstruction and extended depth-of-field based on only one snapshot and a single-lens camera



2D view of bottles





3D depth map without the need of special illumination

3D
Light Field Camera

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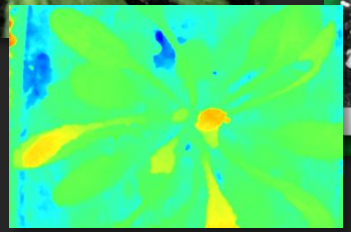
R11 | R29 Image Segmentation / Plant Analysis

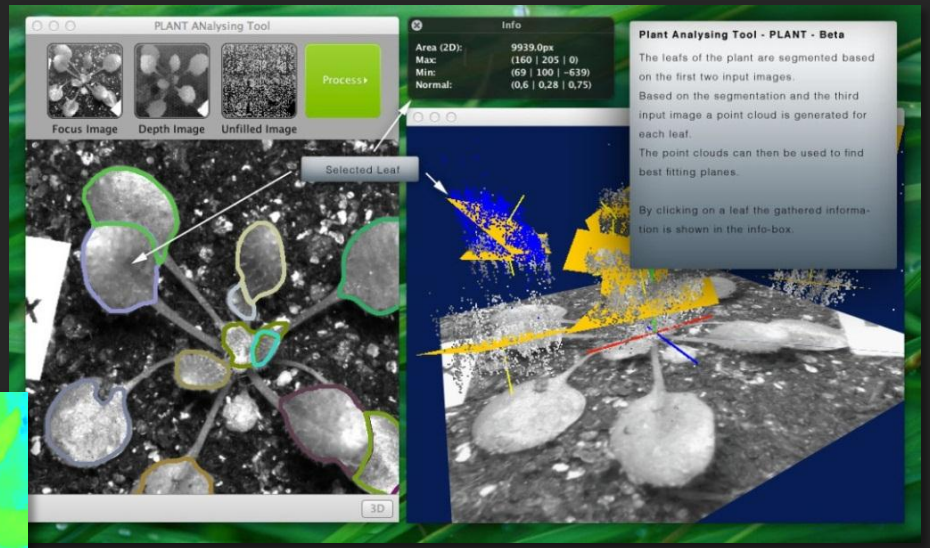
Light Field Camera Technology* raytrix

3D reconstruction and extended depth-of-field based on only one snapshot and a single-lens camera

2D view of a small plant



3D depth map without the need of special illumination



Automated 3D image segmentation of leafs based on 3D depth map and texture information

3D Light Field Camera

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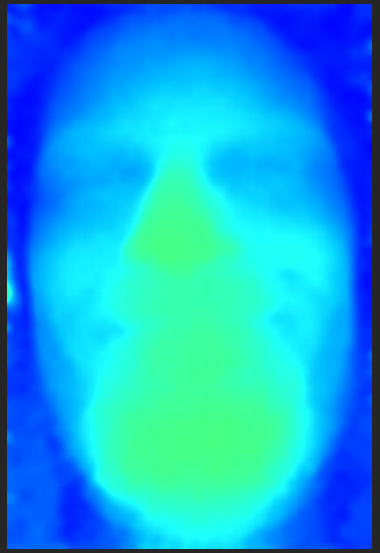
R&D App: Skype Telephone Conferences

3D reconstruction and extended depth-of-field based on only one snapshot and a single-lens camera

3D
Light Field
Camera

2D front view of a face



Color coded depth map

Automated 3D rotated face based on 2D front view and 3D depth map

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R11 long distance 3D with 500mm Tele Optics

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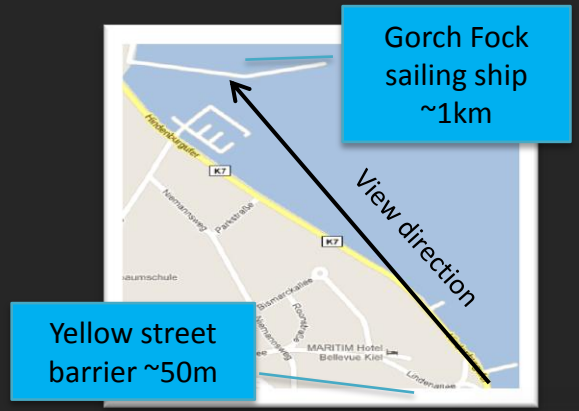
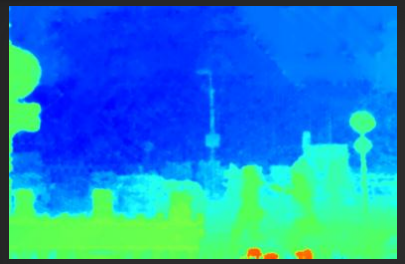
3D reconstruction and extended depth-of-field based on only one snapshot and a single-lens camera

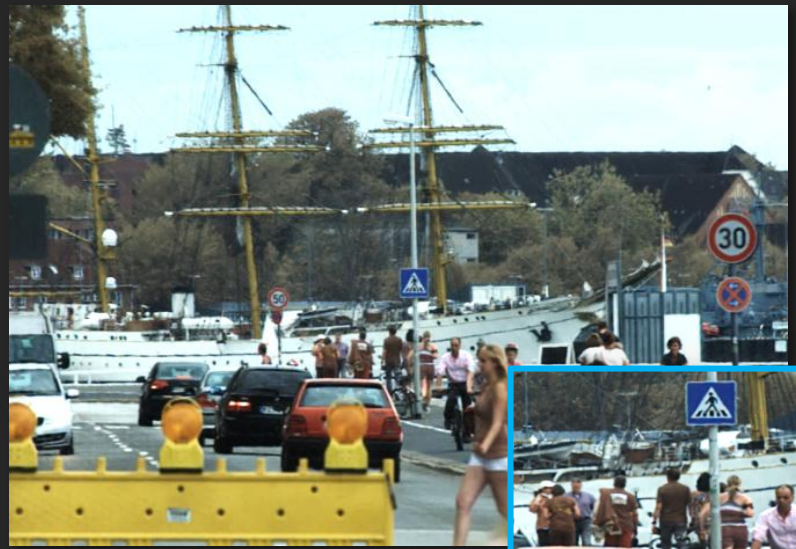


Location (Google Maps)

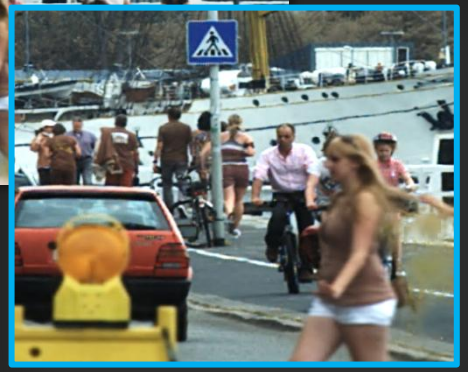
3D
Light Field Camera



Color coded depth map



Total focus



Full-HD resolution

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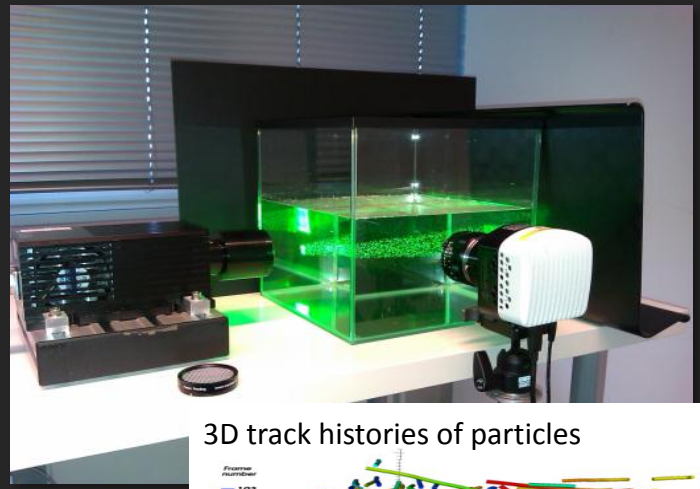
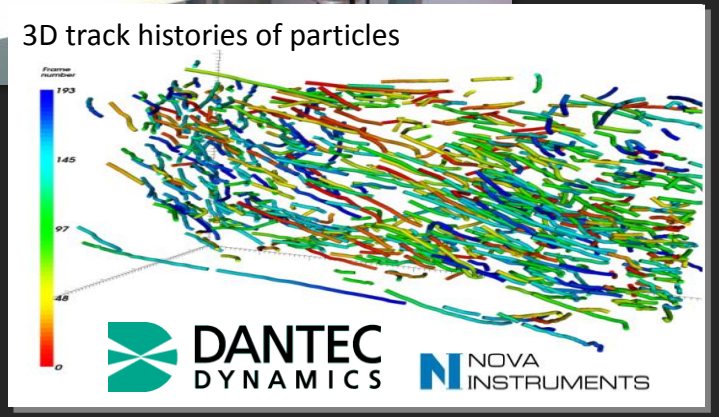
R11 | R29 Volumetric Fluid Dynamics (PIV)

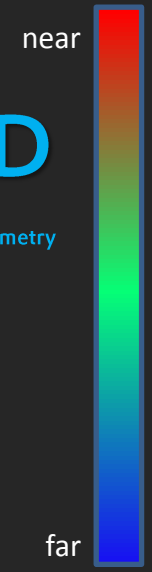
3D reconstruction and extended depth-of-field based on only one snapshot and a single-lens camera

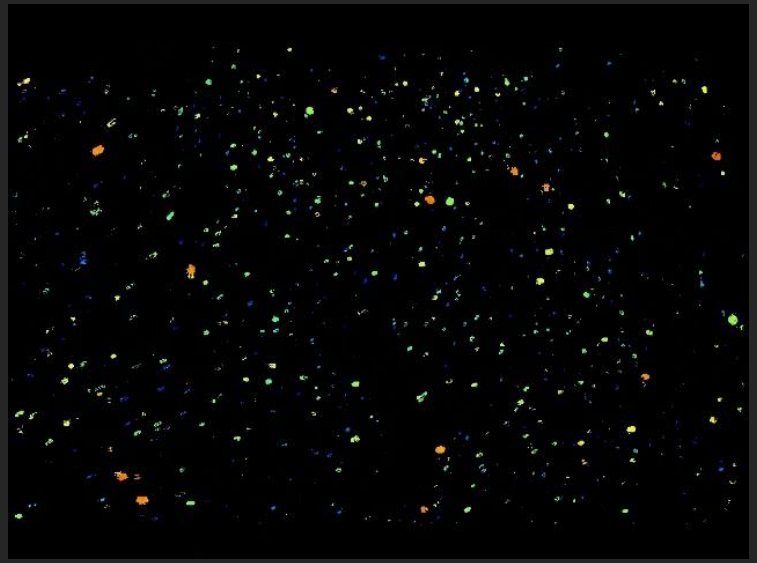


Single lens 3D

Light Field
Particle Image Velocimetry







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R11 3D Light Field Camera

Light Field Camera Technology* raytrix

3D reconstruction and extended depth-of-field based on only one snapshot and a single-lens camera

illustration may differ

3D
Light Field Camera

- Single-lens 3D
- Calibration-free
- Software refocus
- Multiview perspectives
- Extended depth-of-field
- High end image quality
- Excellent SNR ratio

R11 Specifications	
Lateral resolution	max 3 MP (25% of original image sensor resolution)
Extended depth-of-field	max 6x of standard cameras
Frame rate	6 FPS, max 10 FPS (Camera-Link)
Light field image sensor	10.7 Megarays, 9µm pixel pitch, 4008x2672 pixel, 23 pixel / microlens, global shutter, CDS
3D depth resolution	max 200 discrete depth layers
Fixed aperture	f/8, (***we offer full customized micro lens array optics meeting your needs)***
Interface	GigE, Camera-Link
Lens mount	Nikon/F-mount, M58, Canon
Software support	MVTec Halcon plugin interface, SDK/API programming interface for Microsoft Windows
Hardware requirements	NVIDIA GeForce GTX-680 with 2 GB GPU memory (or higher)
Software requirements	Microsoft Windows 7 (32bit), CUDA with OpenGL 4.0 and Compute Capability 2.0
Applications	Fluid flow (3D Particle tracking, PIV), Light Field R&D, machine vision, endoscopy, microscopy, plant research, visual quality inspection, surface inspection, life science, …

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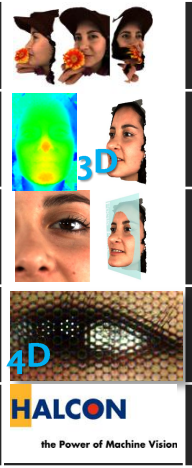
R11 High-End 3D Light Field Camera

*Light Field Camera Technology** raytrix

Camera	Illustration	Description	Price
R11 M GigE		Mono, Gigabit Ethernet, 6 FPS	24990 €
R11 C GigE		Color, Gigabit Ethernet, 6 FPS	29990 €
R11 M CL PIV		Mono, Camera-Link, 10 FPS, PIV	29990 €
R11 C CL PIV		Color, Camera-Link, 10 FPS, PIV	34990 €

Optics	Illustration	Description	Price
Filter		White image filter	290 €
50mm		F-mount high resolution optics	1990 €
100mm		F-mount high resolution optics	2990 €
200mm		F-mount high resolution optics	3990 €

Software	Illustration	Description	Price
Multiview		Multiview perspective shift	490 €
3D+		3D depth map estimation	990 €
Focus+		Software re-focus after the fact	490 €
4D SDK		Light field raw image data access, Windows DLL programing interface	2990 €
HALCON plugin		Machine vision interface for MVTec Halcon	490 €

Hardware	Illustration	Description	Price
Light Field Engine		GUI computer with high speed light field processing GPU	3990 €
GPU		High speed GPU	990 €
Frame Grabber		PCIe Frame Grabber for Camera-Link cameras	1990 €

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R25 3D Light Field Camera

Light Field Camera Technology* raytrix

3D reconstruction and extended depth-of-field based on only one snapshot and a single-lens camera

illustration may differ

- calibration-free monocular camera
- robust & space-saving setup
- down to micron resolution
- extended depth-of-field by software re-focus
- captures fast moving objects by a single shot
- no special structured illumination required
- mono, color and NIR cameras available

R25 Specifications	
Lateral resolution	max 6 MP (25% of original image sensor resolution)
Extended depth-of-field	max 6x of standard cameras
Frame rate	30, max 53 FPS (Camera-Link)
Light field image sensor	25 Megarays
3D depth resolution	max 200 discrete depth layers
Fixed aperture	(***we offer full customized micro lens array optics meeting your needs)***
Interface	Camera-Link, USB 3.0 superspeed
Lens mount	Nikon/F-mount, M58, Canon
Software support	MVTec Halcon plugin interface, SDK/API programming interface for Microsoft Windows
Hardware requirements	NVIDIA GeForce GTX-680 with 2 GB GPU memory (or higher)
Software requirements	Microsoft Windows 7 (32bit), CUDA with OpenGL 4.0 and Compute Capability 2.0
Applications	Fluid flow (3D Particle tracking, PIV), Light Field R&D, machine vision, endoscopy, microscopy, plant research, visual quality inspection, surface inspection, life science, …

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R29 3D Light Field Camera

Light Field Camera Technology* raytrix

3D reconstruction and extended depth-of-field based on only one snapshot and a single-lens camera

- Single-lens 3D
- Calibration-free
- Software refocus
- Multiview perspectives
- Extended depth-of-field
- High end image quality
- Excellent SNR ratio

R29 Specifications	
Lateral resolution	max 7 MP (25% of original image sensor resolution)
Extended depth-of-field	max 6x of standard cameras
Frame rate	max 6.2 FPS
Light field image sensor	28.8 Megarays, 5.5µm pixel pitch, 6576x4384 pixel, 23 pixel / microlens, global shutter, CDS, 8bit (14bit internal)
3D depth resolution	max 200 discrete depth layers
Fixed aperture	f/8, f/9.5, (***we offer full customized micro lens array optics meeting your needs)***
SNR	60 dB (10 bit)
Interface	Dual-GigE, Camera-Link
Dimensions	70mm x 71mm x 50mm, 300g
Integral time	17µm to 60s (PIV double frame mode: 200ns)
Lens mount	Nikon/F-mount, M58, Canon
Software support	MVTec Halcon plugin interface, SDK/API programming interface for Microsoft Windows
Hardware requirements	NVIDIA GeForce GTX-680 with 2 GB GPU memory (or higher)
Software requirements	Microsoft Windows 7 (32bit), CUDA with OpenGL 4.0 and Compute Capability 2.0
Applications	Fluid flow (3D Particle tracking, PIV), Light Field R&D, machine vision, endoscopy, microscopy, plant research, visual quality inspection, surface inspection, life science, …

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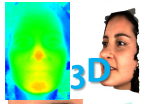
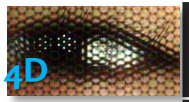
R29 High-End 3D Light Field Camera

*Light Field Camera Technology** raytrix

Camera	Illustration	Description	Price
R29 M GigE		Mono, Gigabit Ethernet, 6 FPS	34990 €
R29 C GigE		Color, Gigabit Ethernet, 6 FPS	39990 €
R29 M CL PIV		Mono, Camera-Link, 6 FPS, PIV	49990 €
R29 C CL PIV		Color, Camera-Link, 6 FPS, PIV	54990 €

Optics	Illustration	Description	Price
Filter		White image filter	290 €
50mm		F-mount high resolution optics	1990 €
100mm		F-mount high resolution optics	2990 €
200mm		F-mount high resolution optics	3990 €

Software	Illustration	Description	Price
Multiview		Multiview perspective shift	490 €
3D+		3D depth map estimation	990 €
Focus+		Software re-focus after the fact	490 €
4D SDK		Light field raw image data access, Windows DLL programing interface	2990 €
HALCON plugin	HALCON the Power of Machine Vision	Machine vision interface for MVTec Halcon	490 €

Hardware	Illustration	Description	Price
Light Field Engine		GUI computer with high speed light field processing GPU	3990 €
GPU		High speed GPU	990 €
Frame Grabber		PCIe Frame Grabber for Camera-Link cameras	1990 €

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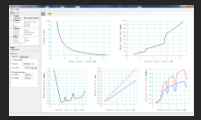

R29 3D Light Field Camera

Light Field Camera Technology* raytrix

3D reconstruction and extended depth-of-field based on only one snapshot and a single-lens camera

3D light field camera	R29 (f/8, 6 FPS)	R29	R29	R29	R29
Application example	Surface inspection	Life science	Life science	Portraits	Photography
X field of view	67mm	35mm	135mm	210mm	2,5m
Y field of view	45mm	23mm	90mm	140mm	1,667m
Z field of view (depth of field)	30mm	10mm	90mm	120mm	7,05m
Working distance	0,44m	0,8m	0,6m	0,8m	10m
Z depth resolution	140µm	40µm	400µm	1,4mm	0,167m
Illumination example	Low angle	Low angle	Ring light	Ring light	Daylight
Main lens optics	100mm macro	200mm macro	100mm macro	100mm macro	140,6mm
Sample object examples	Carbon, leather, glas bubbles, contact lenses, …	Insects, plants, screws, …	Plants, …	Face recognition, …	Security, traffic monitoring, …

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* US-Pat.-No.: 2012/0050562 A1 , CHIP-Award 2012: „Innovation of the year“

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