

New Trends in Optics

Focus Tunable Lenses

Light-Field Imaging

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Swiss Photonics Workshop – Machine Learning

CSEM SA – Neuchâtel – 04. Feb. 2016

EDMUND OPTICS – KEY FACTS

EO Catalog

27000 Products
OEM Quantities

Service

Design
Founded 1942
Headquarter US

Worlds Largest Inventory

Manufacturing in Japan China Singapore US Design Centers in US and Asia
Europe: UK and Germany

Imaging Catalog

Optical Prototyping Service
Preferred Supplier
Rapid Prototyping

We love Optics



New Trends in Optics

Part I

Focus Tunable Lenses

LIQUID LENS APPLICATIONS

- **Barcode Scanning** Handheld and Stationary Devices
- **Medical Imaging** Intraoral cameras
- **Consumer Market** Cell phones, Tablets, Camcorders, ...
- **LED-Lighting** Adjusting Illuminated Area
- **Laser Processing** Field Flattening / Larger Volumes and True 3D
- **Microscopy** Overcome Depth-of-Field Limitations



Images Courtesy of Cognex / Optotune / Varioptic

LIQUID LENS APPLICATIONS

Every Application with Varying Distance between Object and Sensor Benefits from...

- Wide Focusing Range
- Fast Tuning
- Reliable Operation
- Fast Acquisition Times
- Less Cost
- More Compact Footprint

TWO MANUFACTURERS IN EUROPE

Varioptic France (2002)



OEM

Electrowetting



OEM



M12

Optotune Switzerland (2006)



Manual

Electro-Mechanics



C-Mount



OEM

ELECROWETTING – WHAT IS IT?

- **Capacitor-Like Structure**

→ **L:** Conductive Liquid // **I:** Isolator // **S:** Substrate

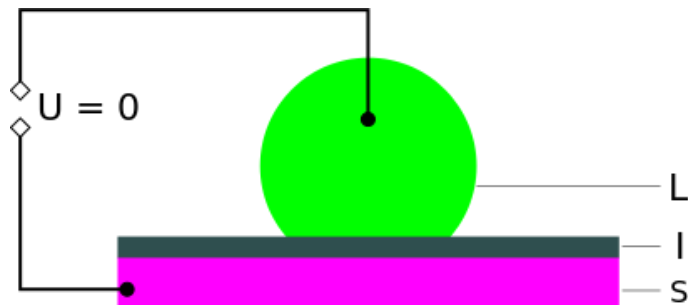
- **No Voltage:**

→ Contact Angle / Wetted Area Depends on Surface Tension Ratios

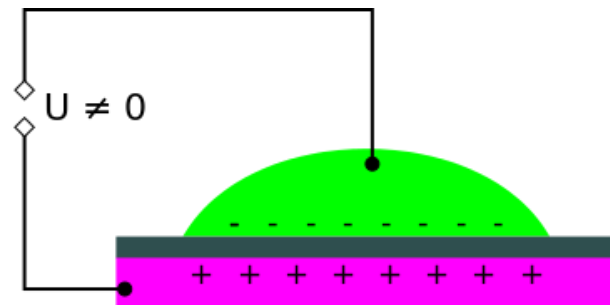
- **Applying an Electric Field**

→ Results in Electrostatic Force

→ Maximize Contact Area (Liquid vs. Substrate)

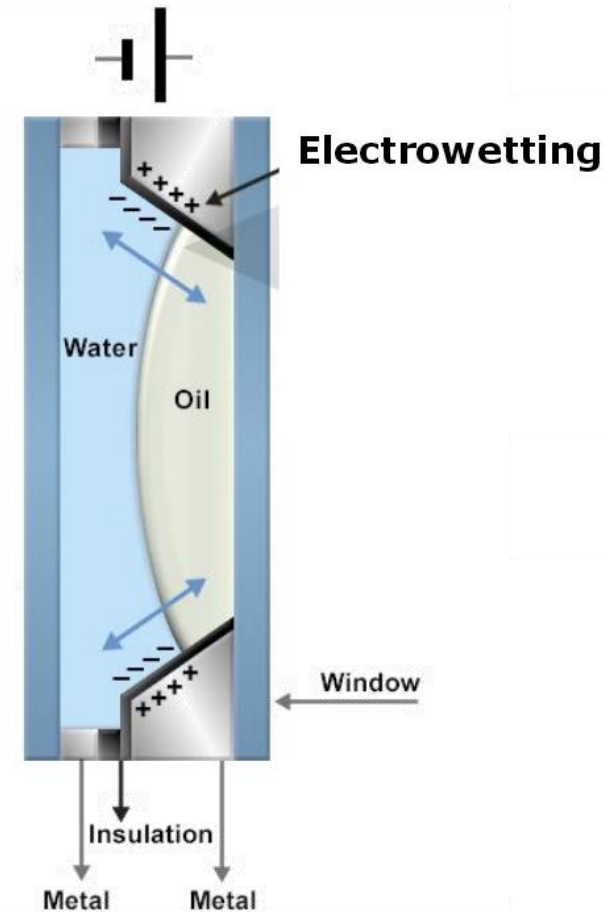


www.wikipedia.com



VARIOPTIC – HOW DOES IT WORK?

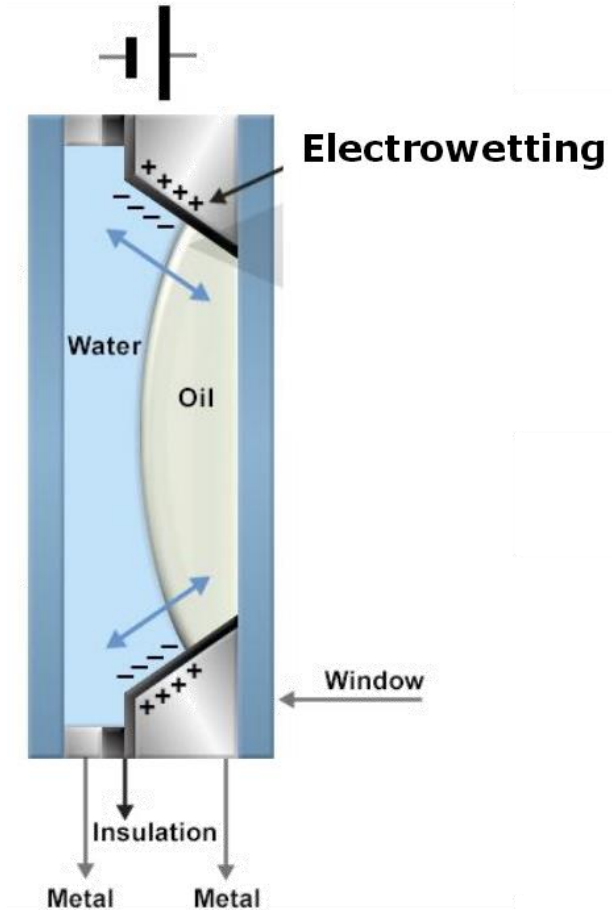
- **Oil + Water of Identical Mass Density**
 - Minimize Gravity-Induced Deformations
 - More Robust (Vibration + Shock)
- **Capacitive Nature:**
 - No Power Consumption (Mobile Devices)
 - No Self-Inflicted Heat (Thermally Induced Aberrations)
- **Electrostatic Force: Rather Weak by Nature**
 - High Voltages Required (~60 V)
 - Limits Clear Aperture
 - Determines Speed



www.varioptic.com

VARIOPTIC – ARCTIC SERIES

- Clear Apertures: 2.5 mm // 3.9 mm
- Focus Range: 5 cm to Infinity
- Life Time >500,000,000 Cycles
- VIS and NIR AR Coatings
- Transmission >97% (VIS)
- Operating Temperatures: -20°C – 60°C



www.varioptic.com

EO Edmund
optics | worldwide

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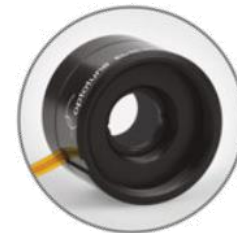


Manual

Electro-Mechanics



C-Mount

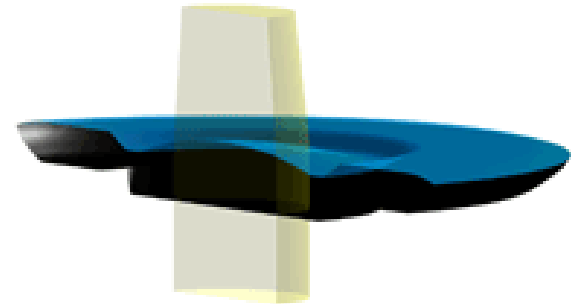


OEM

FOCUS TUNABLE LENSES

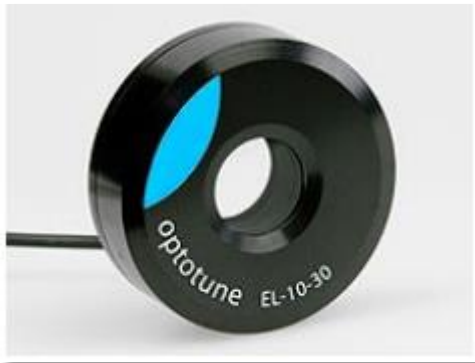
Electromechanical Approach

- **Voice-Coil Actuator**
 - Ring Pushing Down on the Membrane
 - Changes the Shape of the Lens
- **Changing Current**
 - More or Less Liquid in the Center of the Lens
- **Current-Driven**
 - ~100s of mA // 5V
- **Power Dissipation**
 - **Heat** // Active Focal Length Correction



www.optotune.com

OPTOTUNE PRODUCTS



- **Aperture** **6 mm // 10 mm // 16mm**
- **Tuning Range** **80 - 200mm Focal Length**
- **Offset Lenses**
- **Various Liquids Available – Application-Specific**
- **VIS and NIR AR Cover Glasses**
- **1,000,000,000 Cycles**
- **-40°C – 70°C Operating Temperature**
- **Higher Damage Threshold → Laser Applications**
- **Large Apertures → Gravity-Induced Coma Aberrations Visible in Vertical Operation**

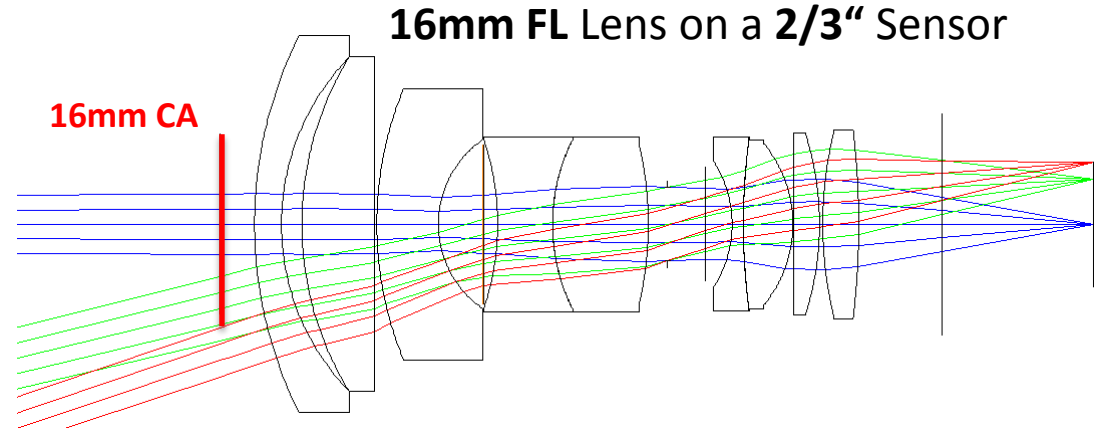
www.optotune.com



USING TUNABLE LENSES UP FRONT



- Easy to Implement
- Might Require Filter Mount – C-Mount Adapter
- Versatile Setup (min WD ~100mm)



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Focal Length	Compact Fixed Focal Length Lenses Applicable Stock Numbers	Camera Sensor Size											
		1/4"		1/3"		1/2.5"		1/2"		1/1.8"		2/3"	
		10mm CA*	16mm CA*	10mm CA*	16mm CA*	10mm CA*	16mm CA*	10mm CA*	16mm CA*	10mm CA*	16mm CA*	10mm CA*	16mm CA*
8.5mm	#58-000	Grey	Green	Grey	Red	Grey	Red	Grey	Grey	Grey	Grey	Grey	Grey
12mm	#58-001, #86-607 - #86-613	Yellow	Green	Grey	Green	Grey	Green	Grey	Yellow	Grey	Red	Grey	Grey
16mm	#59-870, #85-348 - #85-354, #85-336	Green	Green	Red	Green	Grey	Green	Grey	Yellow	Grey	Red	Red	Red
25mm	#85-355 - #85-361, #85-337	Green	Green	Green	Green	Yellow	Green	Yellow	Green	Red	Green	Red	Green
35mm	#85-362 - #85-368, #85-338	Green	Green	Green	Green	Green	Green	Green	Green	Yellow	Green	Yellow	Green
50mm	#86-614 - #86-620	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green

*Clear Aperture

Vignetting: ■ Minimal/None ■ Moderate ■ Significant ■ Not Recommended

SUMMARY

Software? Matlab, Labview
Temperature Drifts?
Vibrations Lifetime? 10000000 Cycles
How fast? 10 - 50 ms
Gravity

Future Developments:

Larger Apertures Temperature Handling Multi-Electrode Designs

- Control Gravity (Image Quality)
- Improve Response Times
- 2015: Optotune **16mm** Aperture
- 2016: Varioptic **8mm** Aperture, Multi-Electrode

New Trends in Optics

Part II

Light-Field Imaging

WHAT IS LIGHT-FIELD IMAGING?

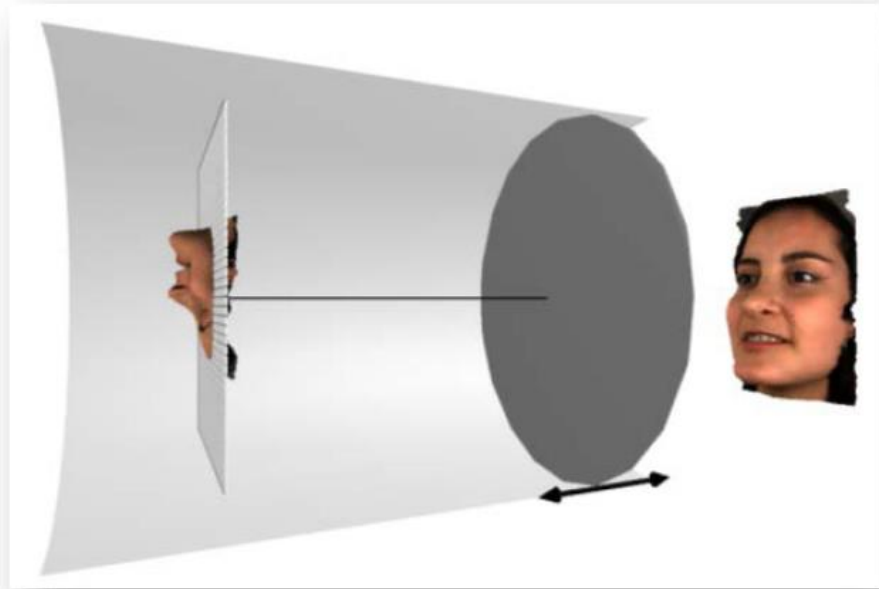
A Simple Way of Getting 3D Images:

- One Shot
- One Lens
- **One Camera – a Plenoptic Camera**
- Ambient Lighting

IMAGE-GENERATION

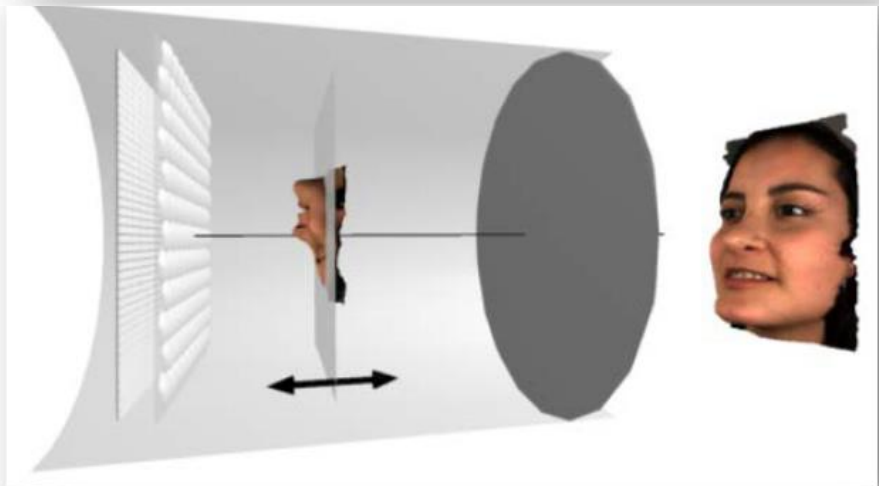
Standard Camera

- Main Lens Focusing on Sensor
- 3D Object – 3D Image – 2D Sensor
- Refocusing = Reposition Lens

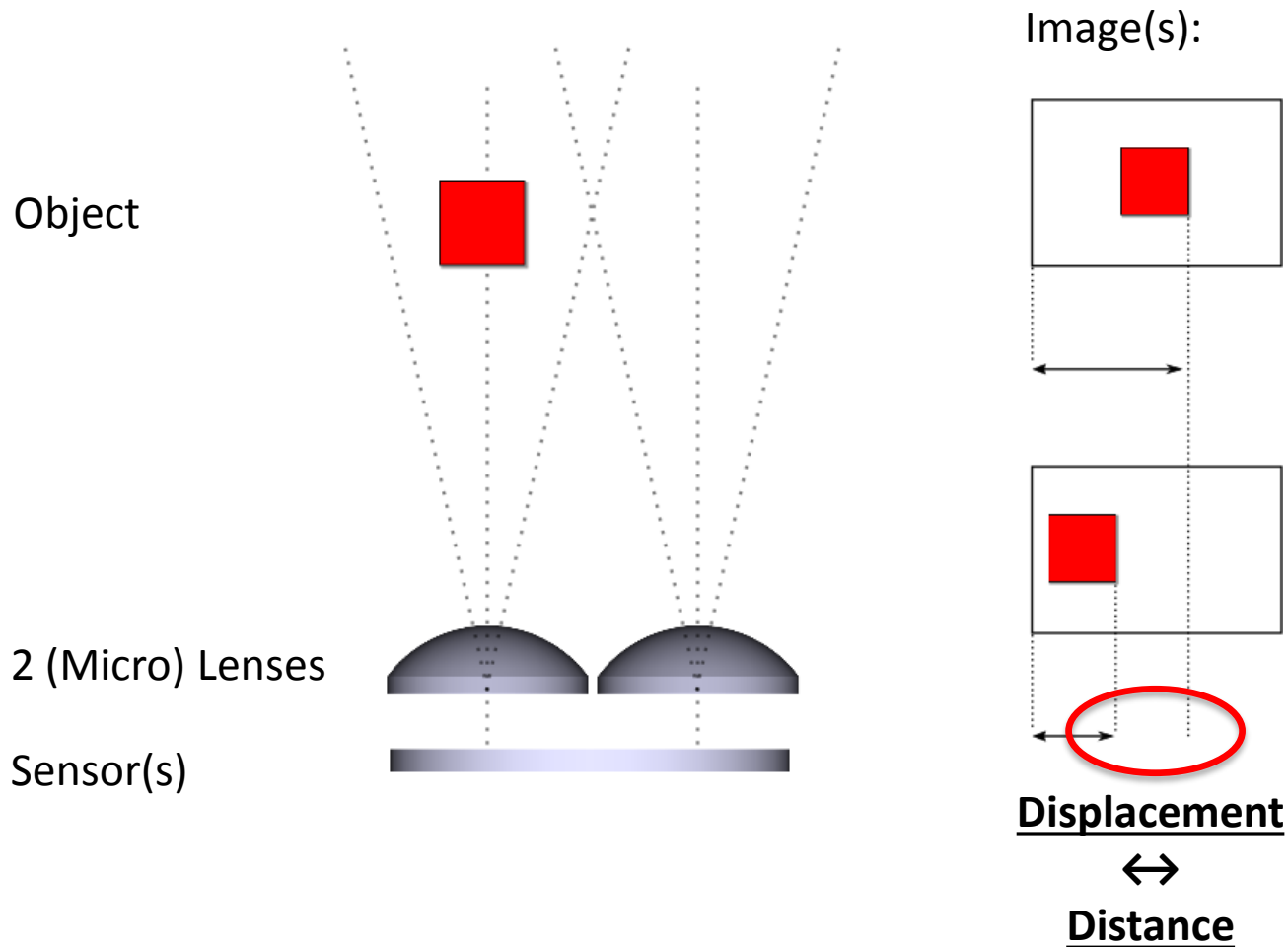


Plenoptic Camera

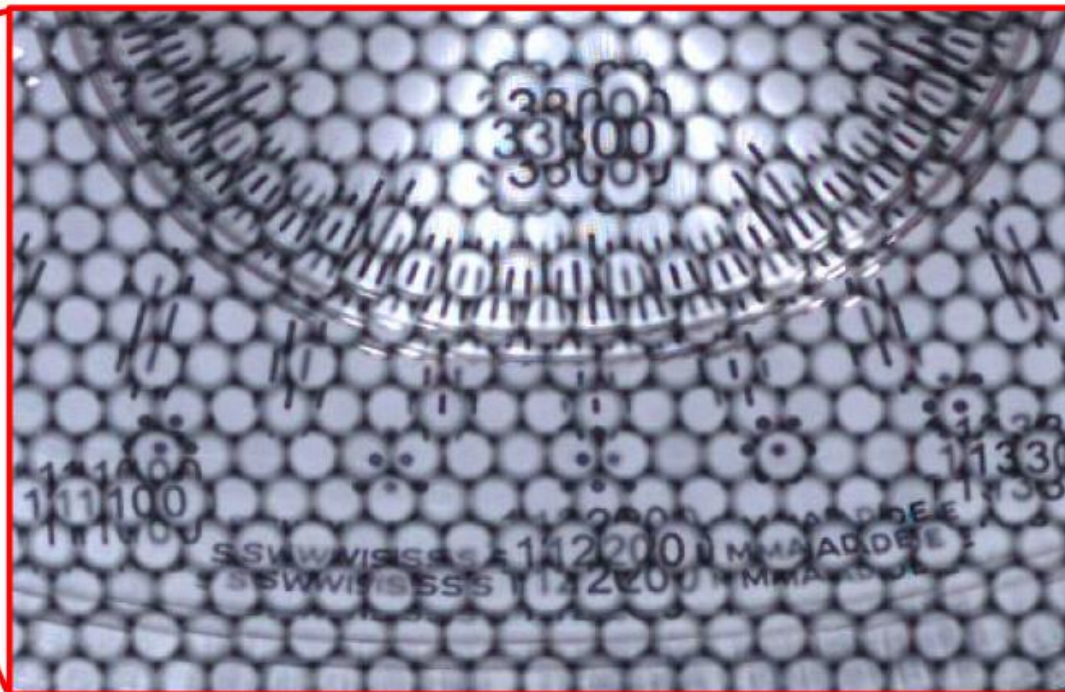
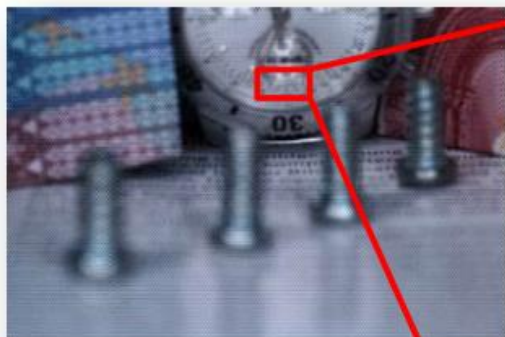
- Main Lens Generates Intermediate Image.
- **MicroLens Array** Focusing this Image on the Sensor.



COMPARISON: MICRO-STEREO SYSTEM



RAW AND REFOCUSED IMAGE



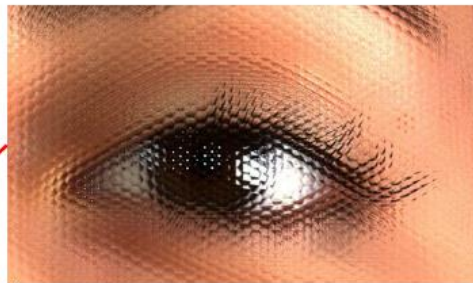
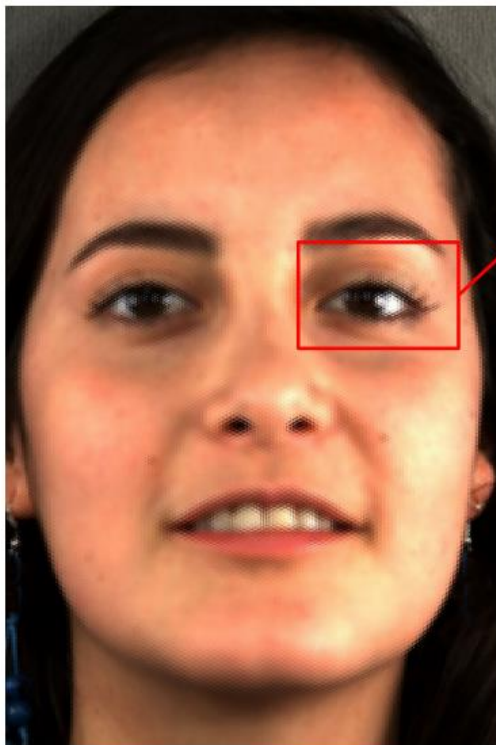
Compute "refocused" image

Loss in Resolution: Factor of 4

Image Courtesy of Raytrix

MORE THAN REFOCUS: 3D IMAGING

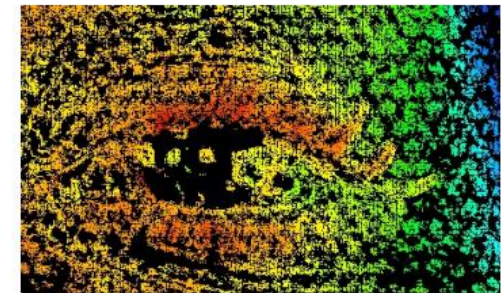
From Raw Image to Total Focus



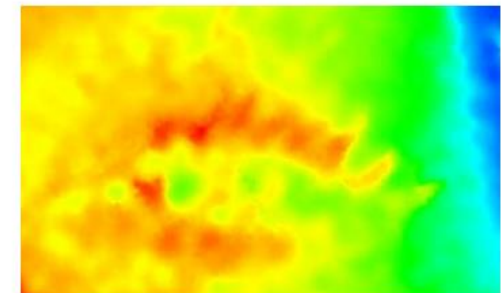
Micro-images show multiple imaging of object parts



Computationally reconstructed image from raw image and depth map



Color-coded depth map for high-contrast areas



Filled depth map

12MP raw images // ~5 fps 2D and 3D

Image Courtesy of Raytrix





EO – WE DESIGN & MANUFACTURE

THANK YOU FOR YOUR ATTENTION!

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