An Overview of Light Field Acquisition

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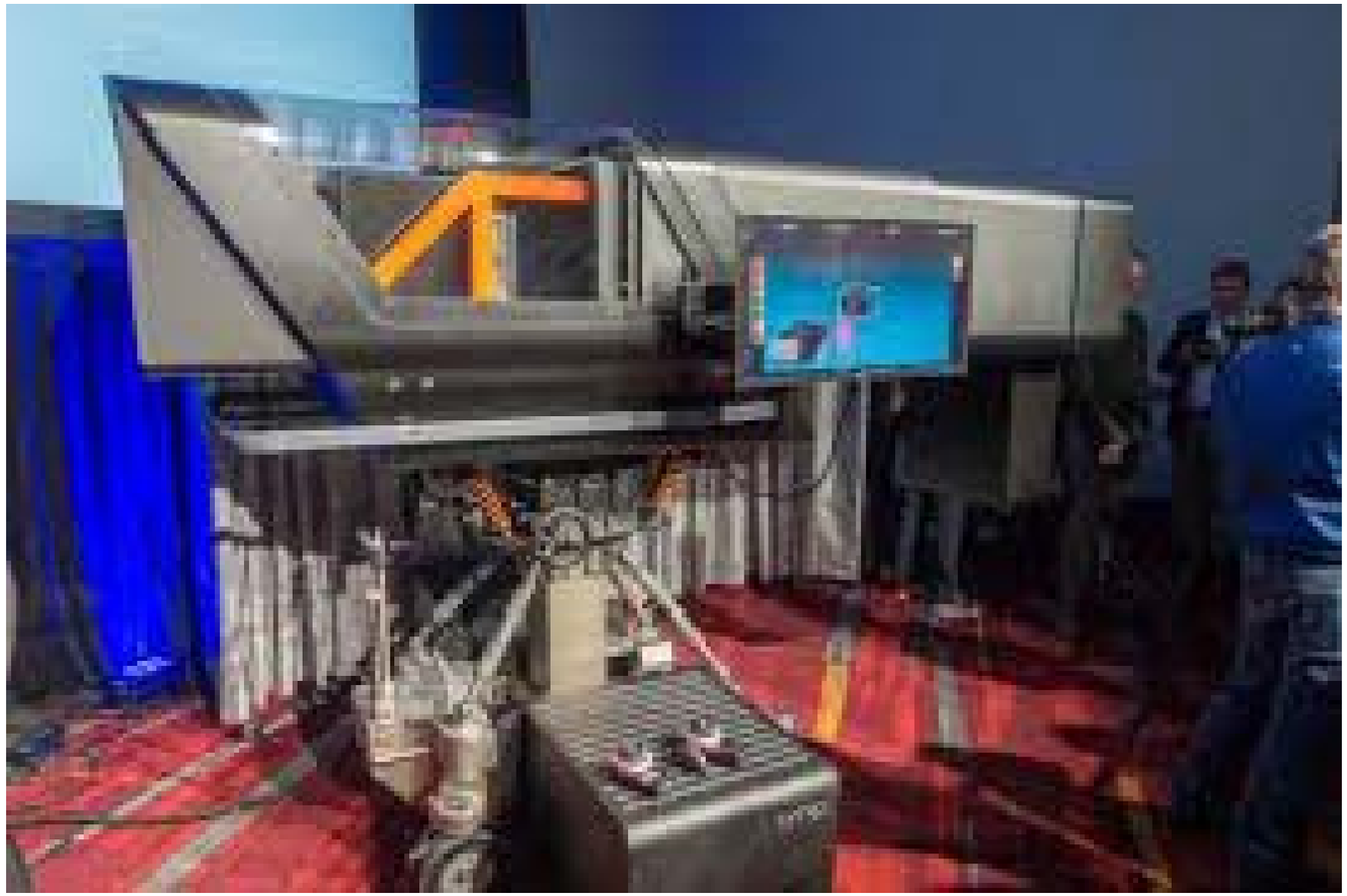
Topics

- Some History
- Reminder: What is Light Field Imaging again?
- How is this useful?
- Conclusions

NAB 2016

Lytro Light Field Cinema Camera

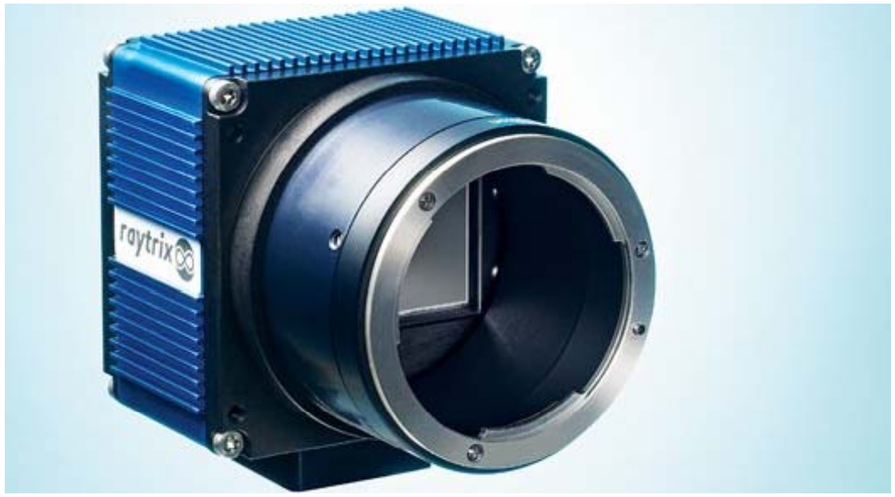


First Commercial Light Field Cameras

2010

First Commercial Light Field Cameras available

raytrix 3D light field camera



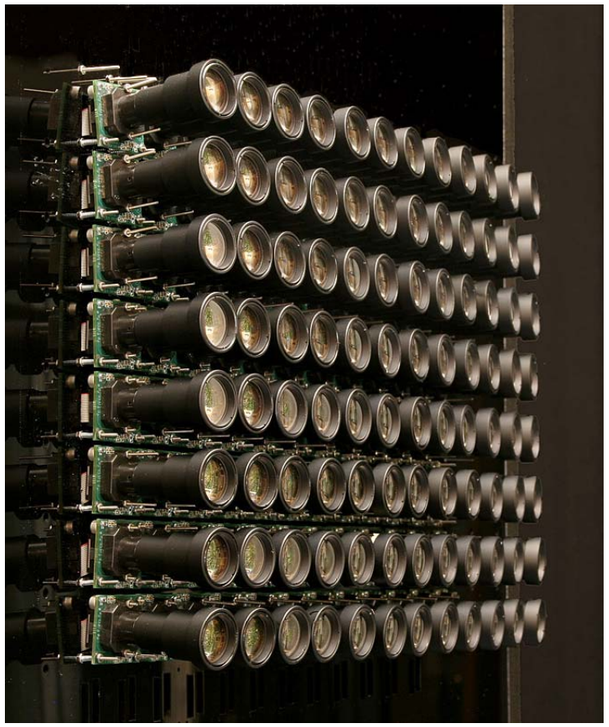
LYTRO™ Picture Revolution

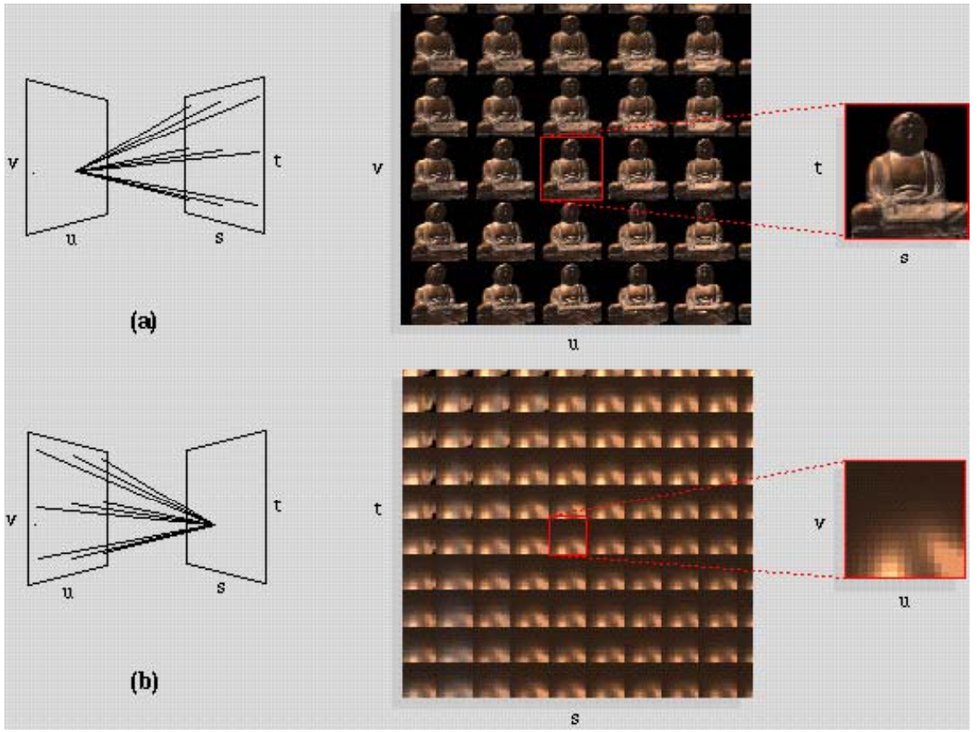
2012

Introduction of Light Field into CG

1996

Introduced into Computer Graphics by **Marc Levoy** and **Pat Hanrahan,** Stanford





Source: Marc Levoy - http://graphics.stanford.edu/projects/lightfield/

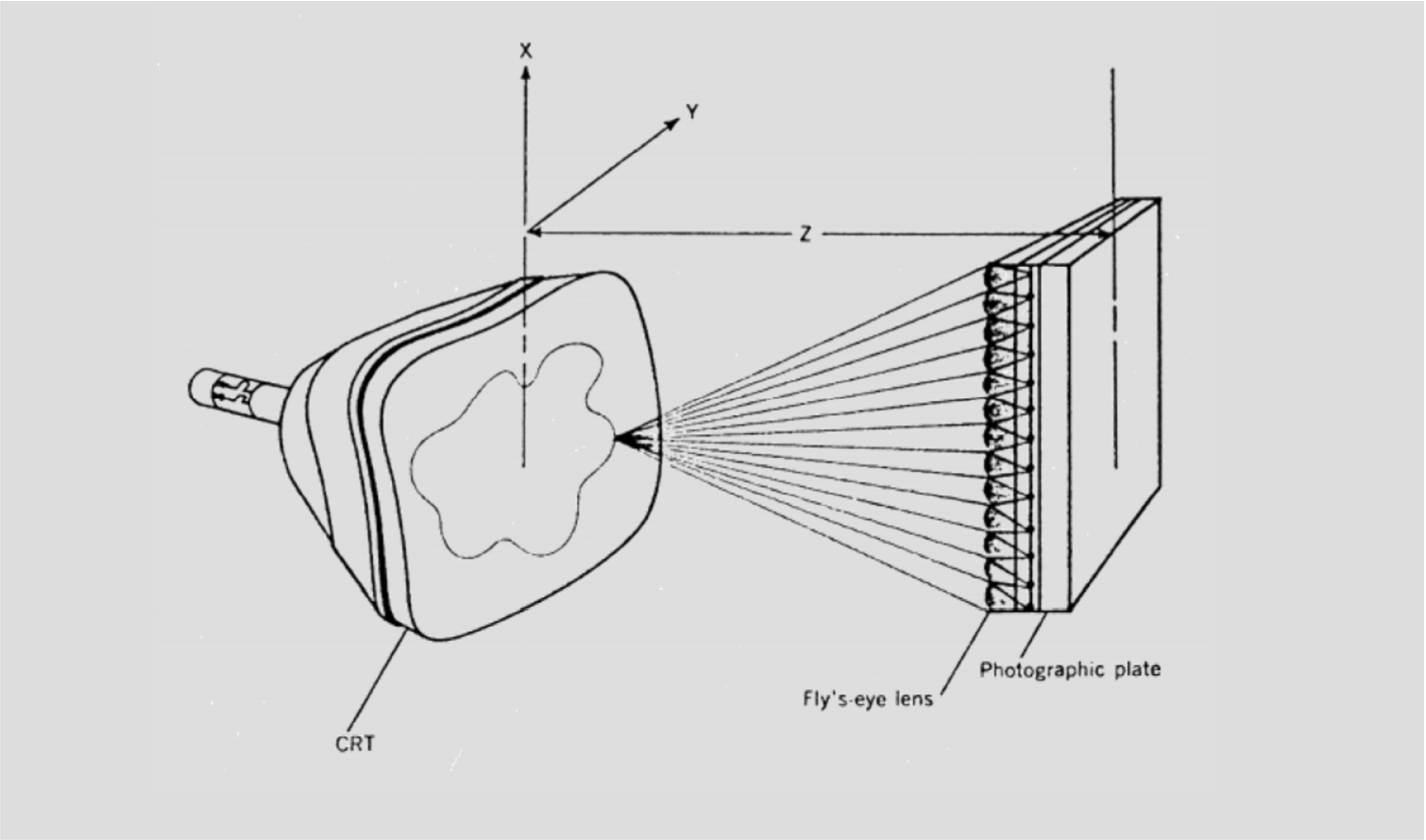
Pioneering Digital Light Field Implementation

1968

Ara Chutjian
First Digital Light Field

This pre-dates the first digital camera (Kodak 1975)!

Note: The first digital camera had 0.01 Megapixels; the first digital lightfield camera - 0.1 Megapixels



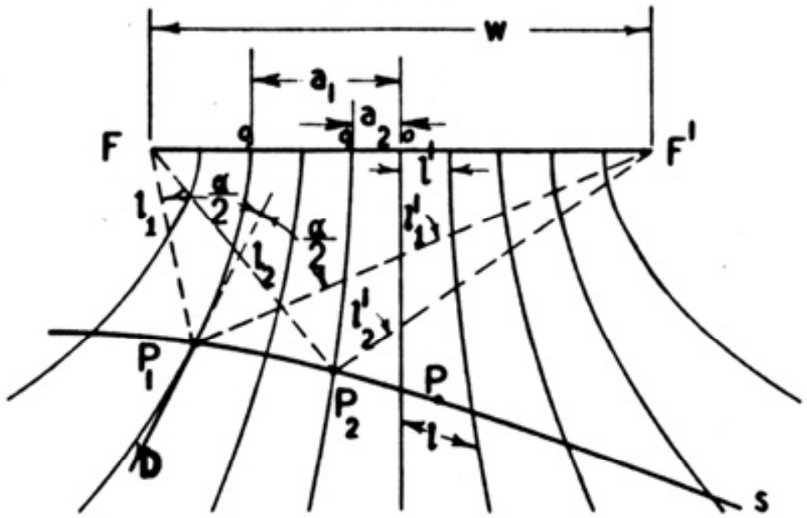
Source: Todor Georgiev, Adobe
http://www.tgeorgiev.net/Lippmann/100_Years_LightField.pdf

First use of the term “Light Field”

1936

Andrey Aleksandrovich Gershun

Defined the term “light field” as the amount of light traveling in every direction through every point in space.



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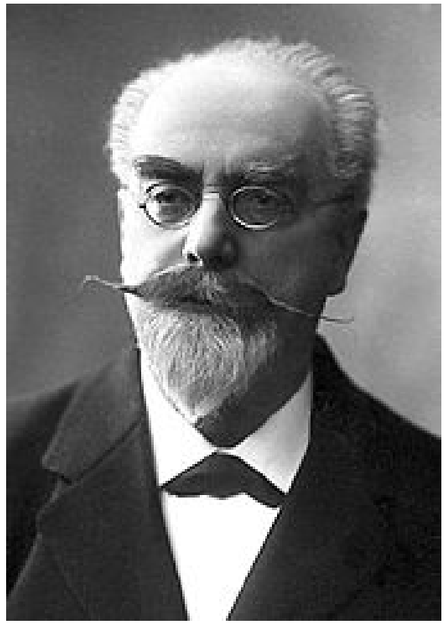
Discovery of Integral Photography

1908

Gabrial Lippmann

Integral Photographs are first described



Gabriel Lippmann

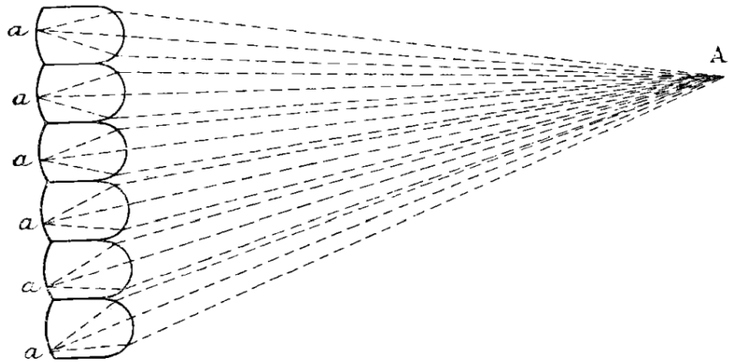


Fig. 1.

Communication at the French Society of Physics: Session of March 20th, 1908

Source: Todor Georgiev http://www.tgeorgiev.net/Lippmann/index.html/

Description of Wave Fields

1846

Michael Faraday

describes “Thoughts on Wave Vibrations”

“…light should be considered to manifest a field, similarly to magnetic fields”

Iron filings act as a spherical sensor which follows rays of magnetism from a central point. The vectors of the field are captured as well as the foot-candle-esque drop-off in intensity over distance from the central point.

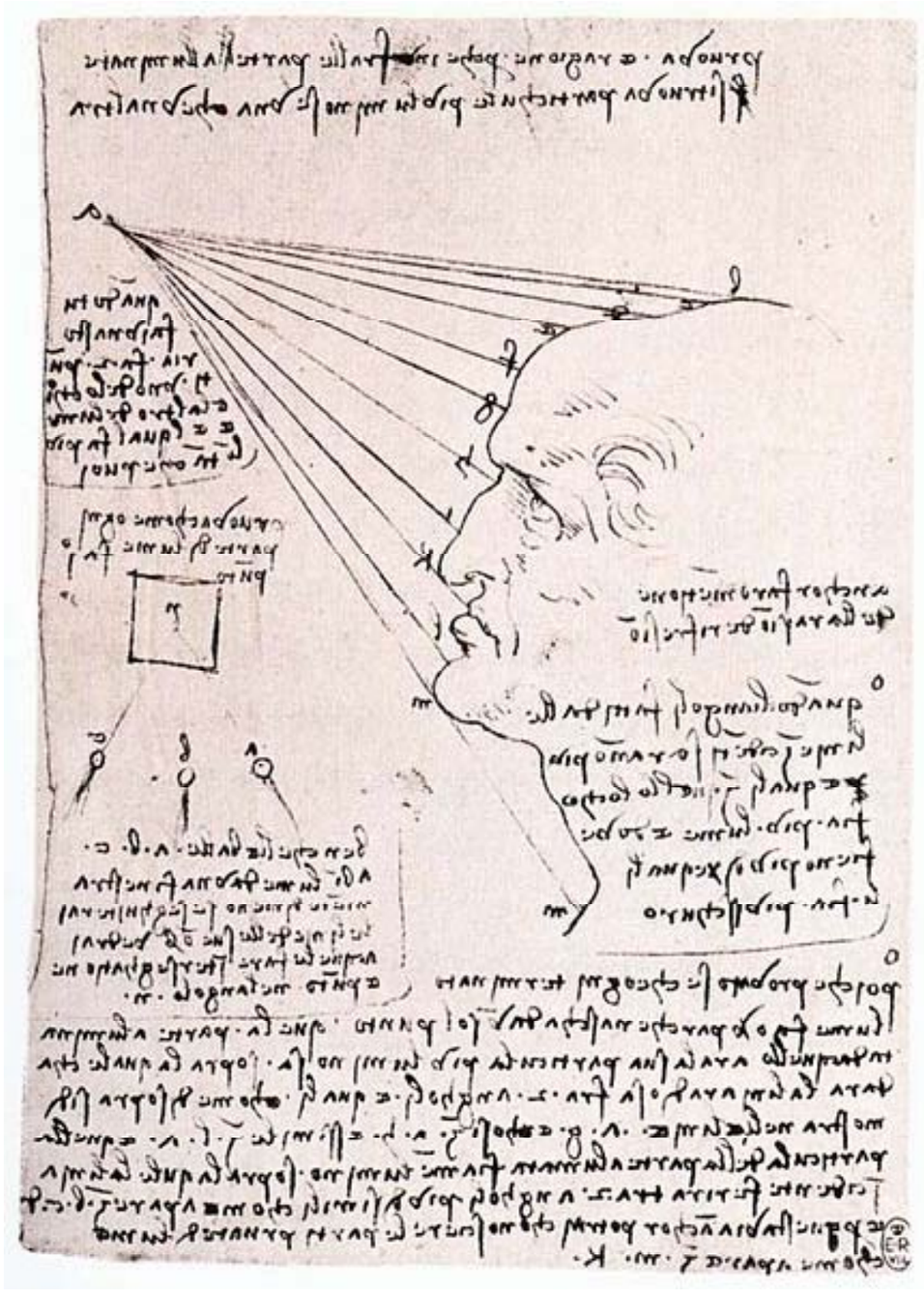
Describing light as “Radiant Pyramids”

1492

Leonardo DaVinci

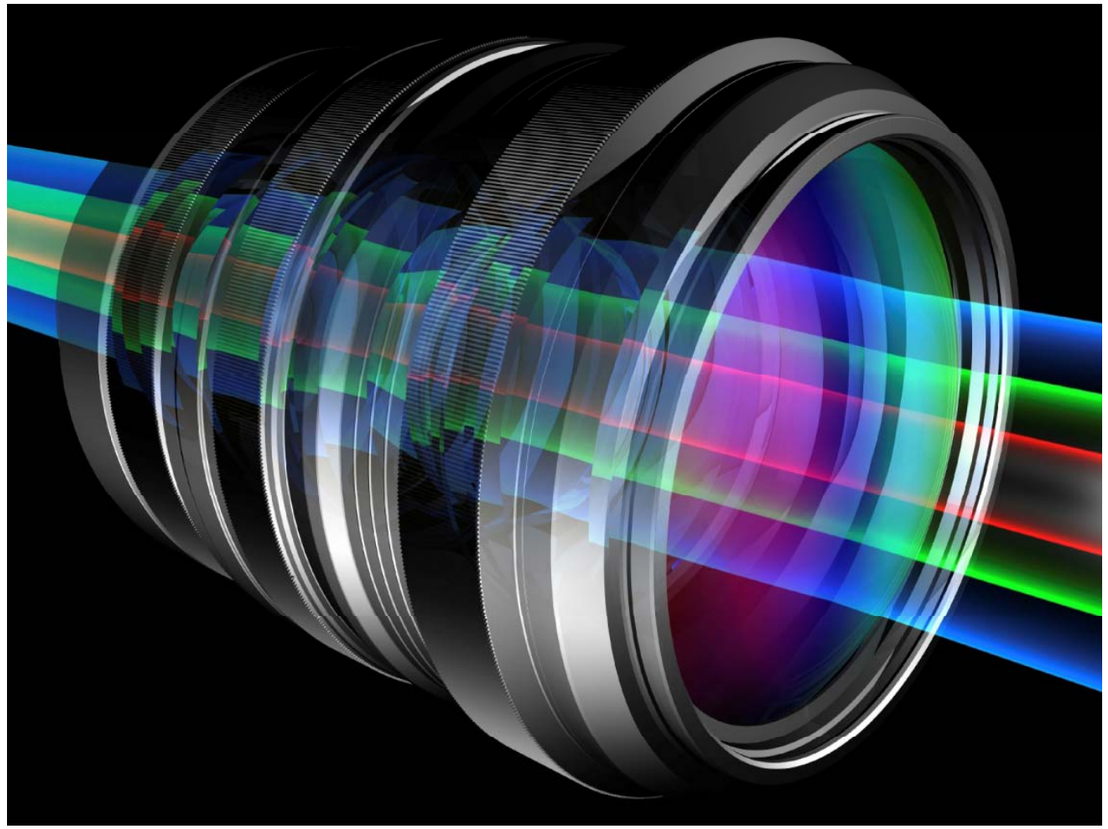
describes light rays in radiant pyramids

an *“imaging device capturing every optical aspect a scene”*



Traditional photography

- Light rays are captured at (virtually) one point: Aperture
- Light rays from all directions combine on each photo-site
- Vector information lost



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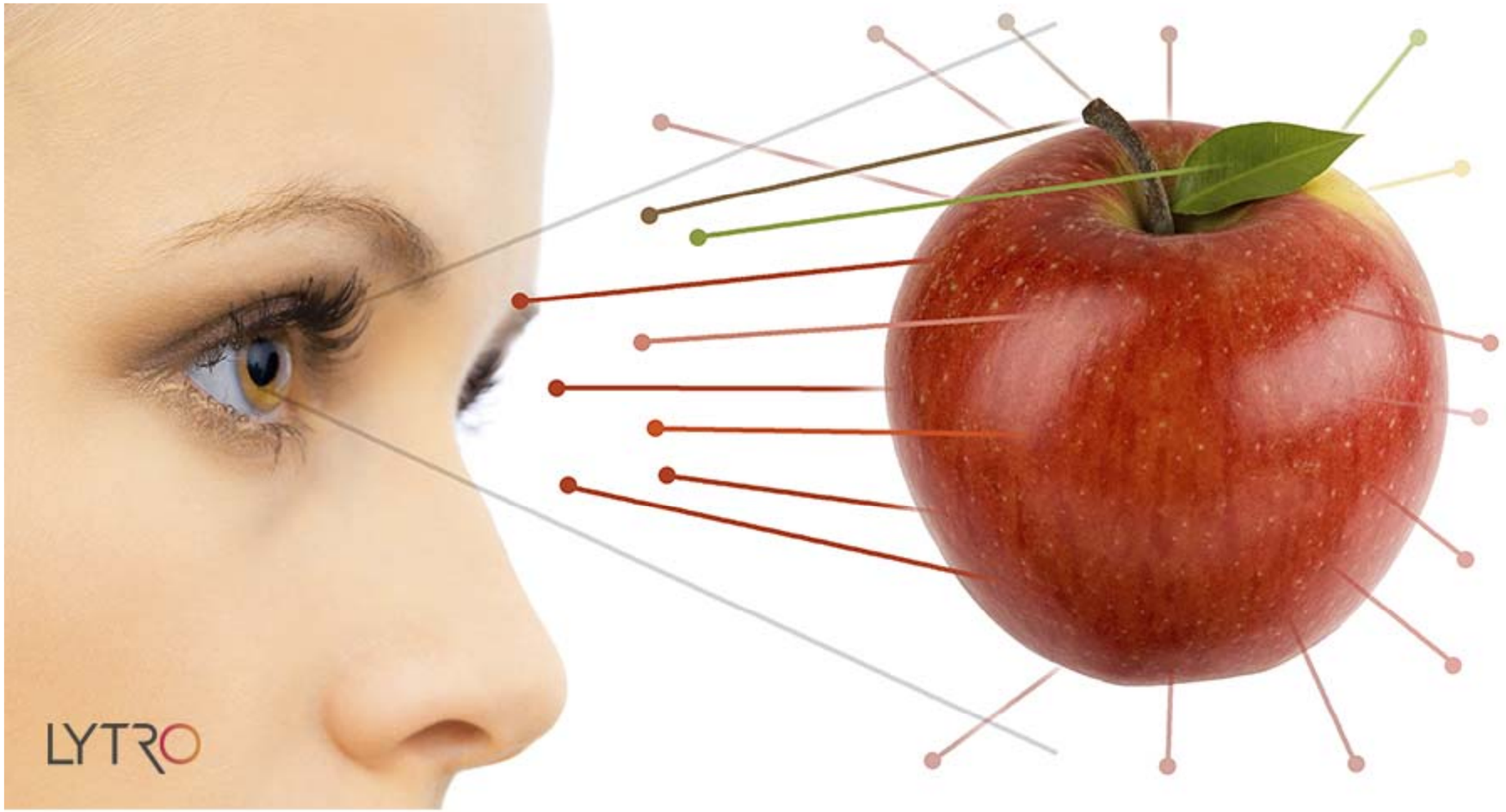
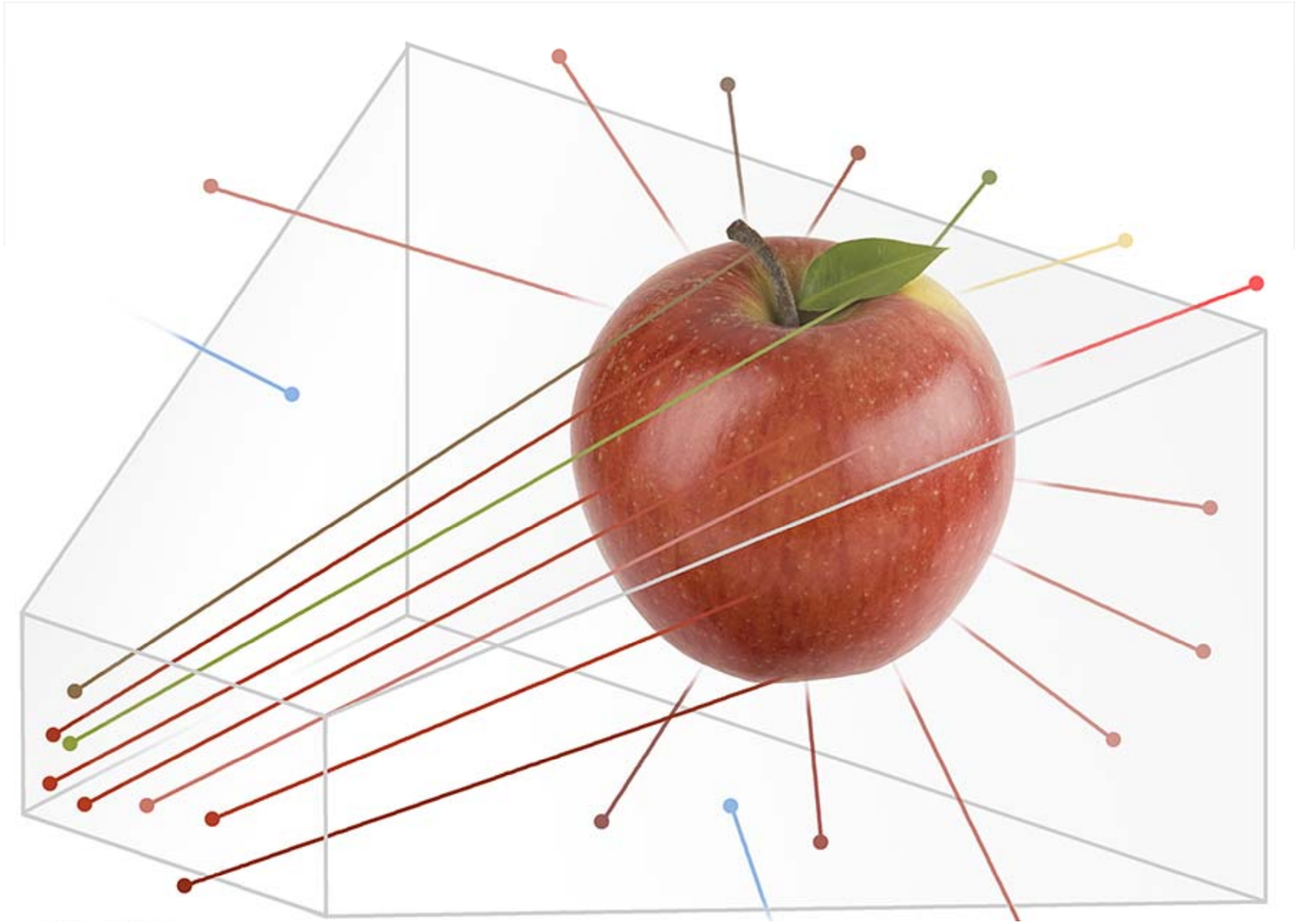
Light Fields surround us…



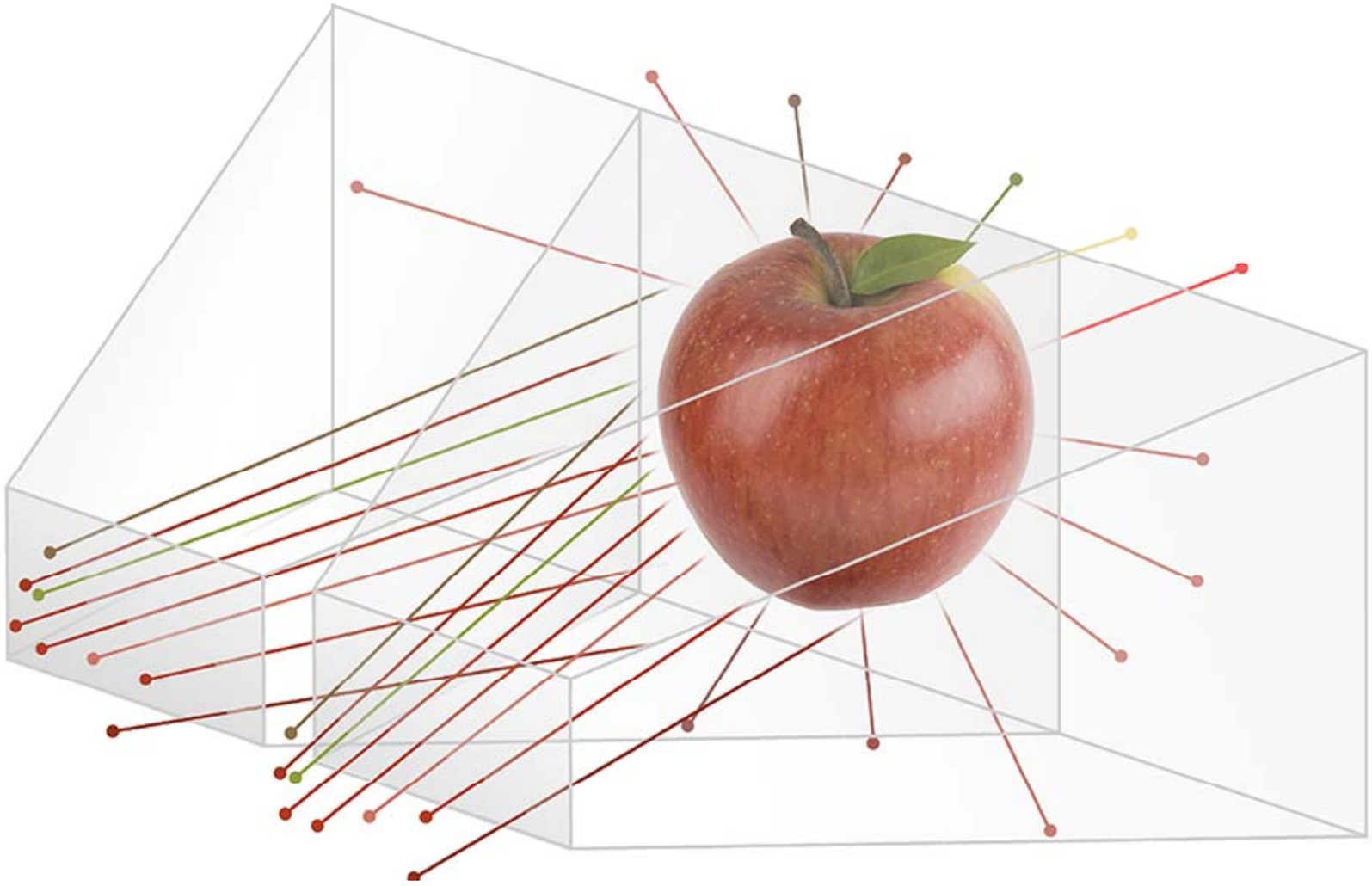
Source: Lytro

Traditional Photography



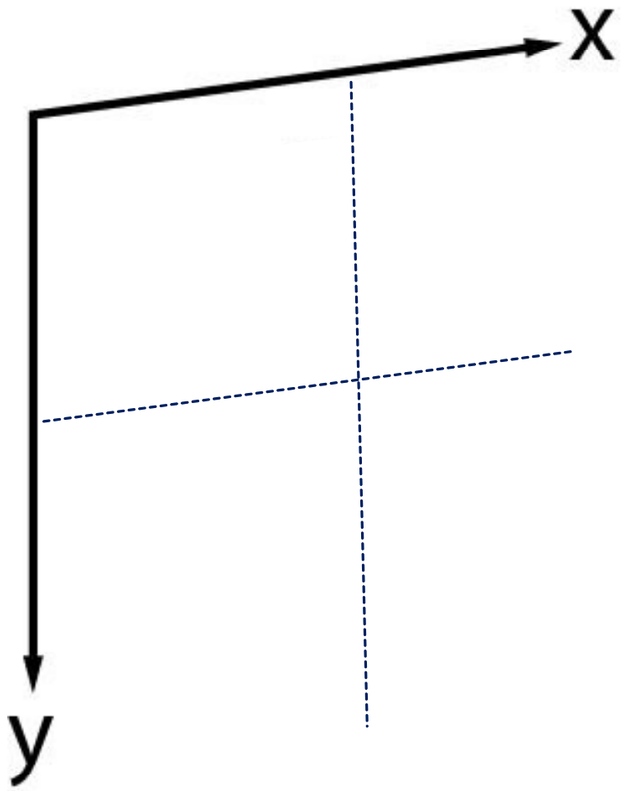
Source: Lytro

Stereoscopic Photography



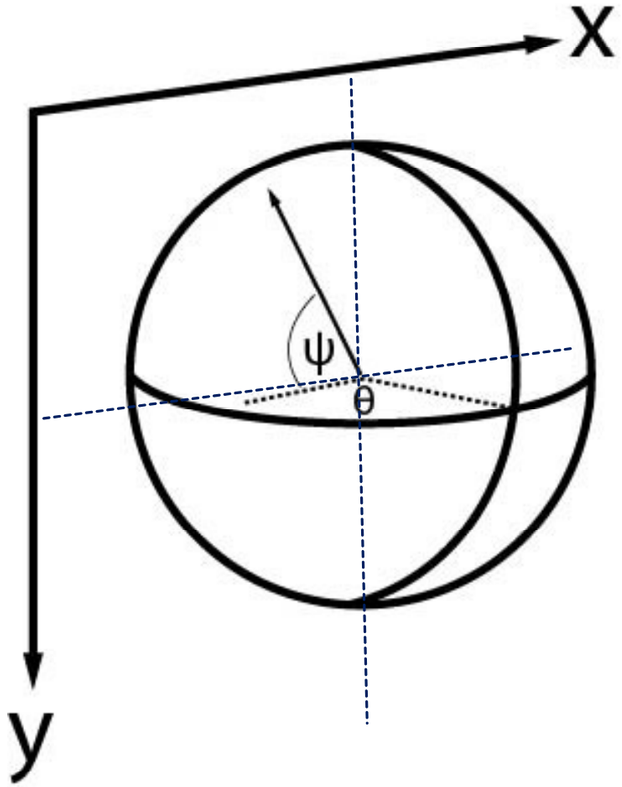
Source: Lytro

Light Field Photography



- X and Y encode the position in the window of the sample

Light Field Photography

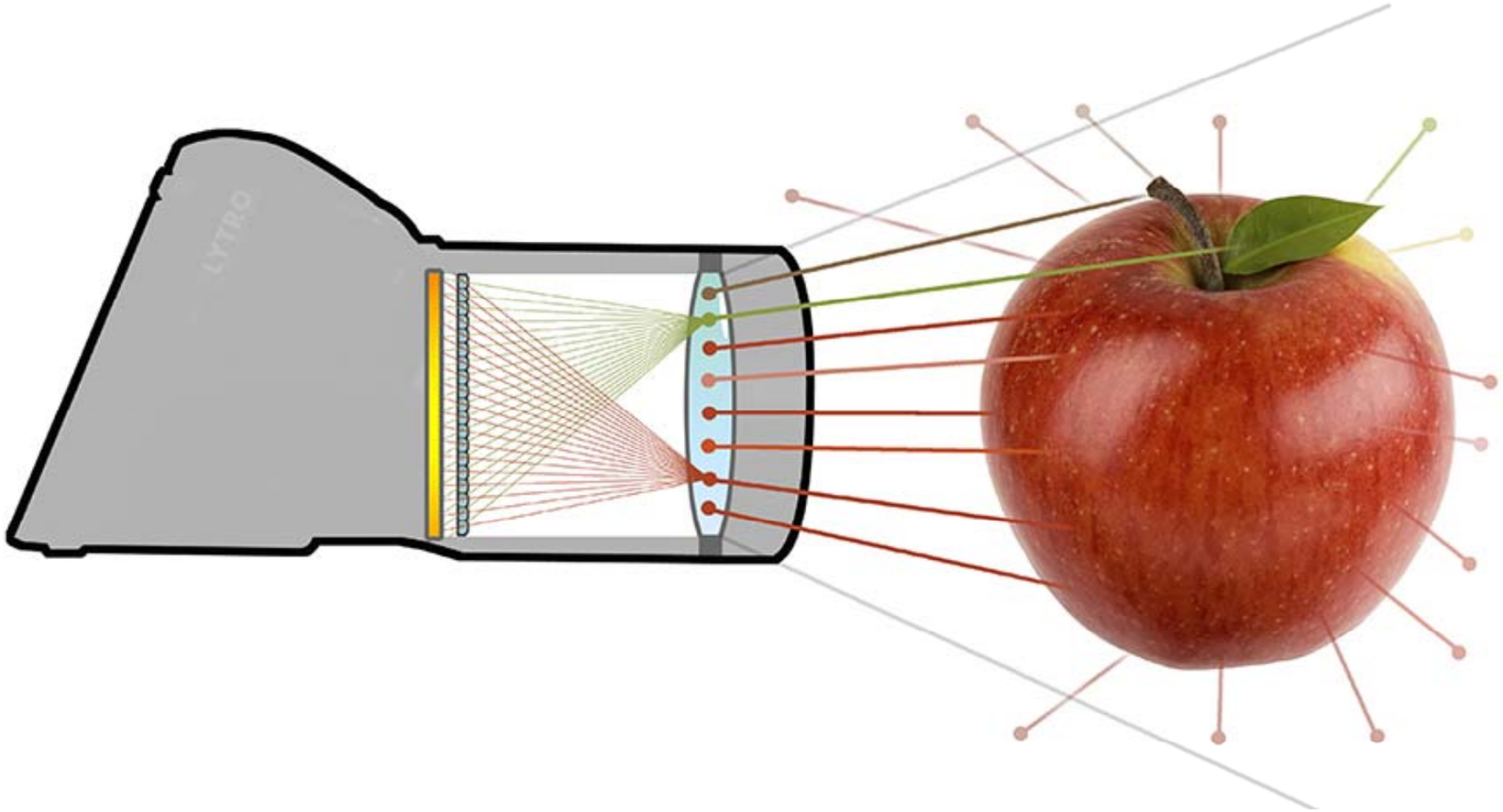


- X and Y encode the position in the window of the sample
- Theta and Psi encode the direction the light is coming from.
- R,G,B values (luminance intensity)

Light Field Photography

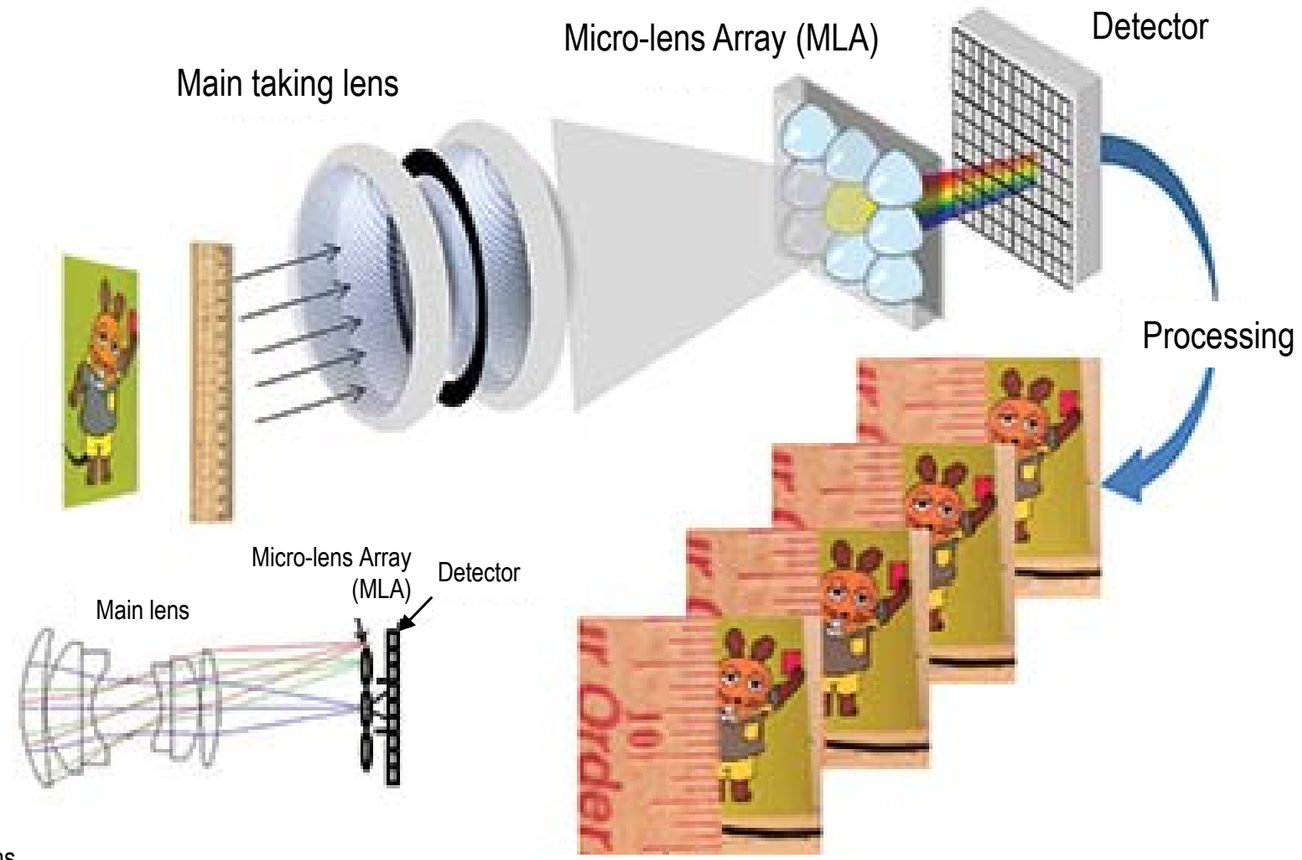
Camera array

Light Field Photography



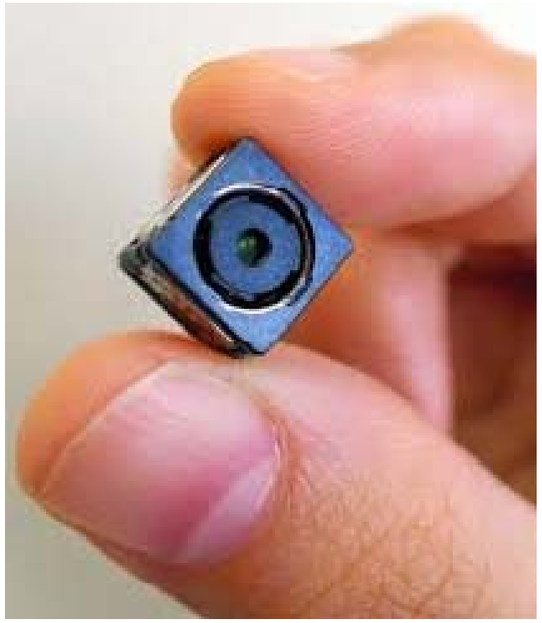
Source: Lytro

Micro-lens array camera architecture



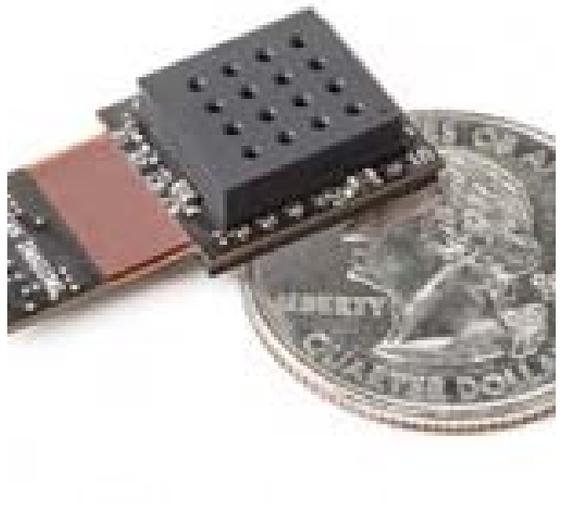
Light-Field Imaging and Display Systems
SID Information Display, August 2016
Nikhil Balram and Ivana Tošić

Light field imaging explorations….



Toshiba LF
500,000 microlenses

Linx Imaging
Multiple aperture
(Acquired by Apple)



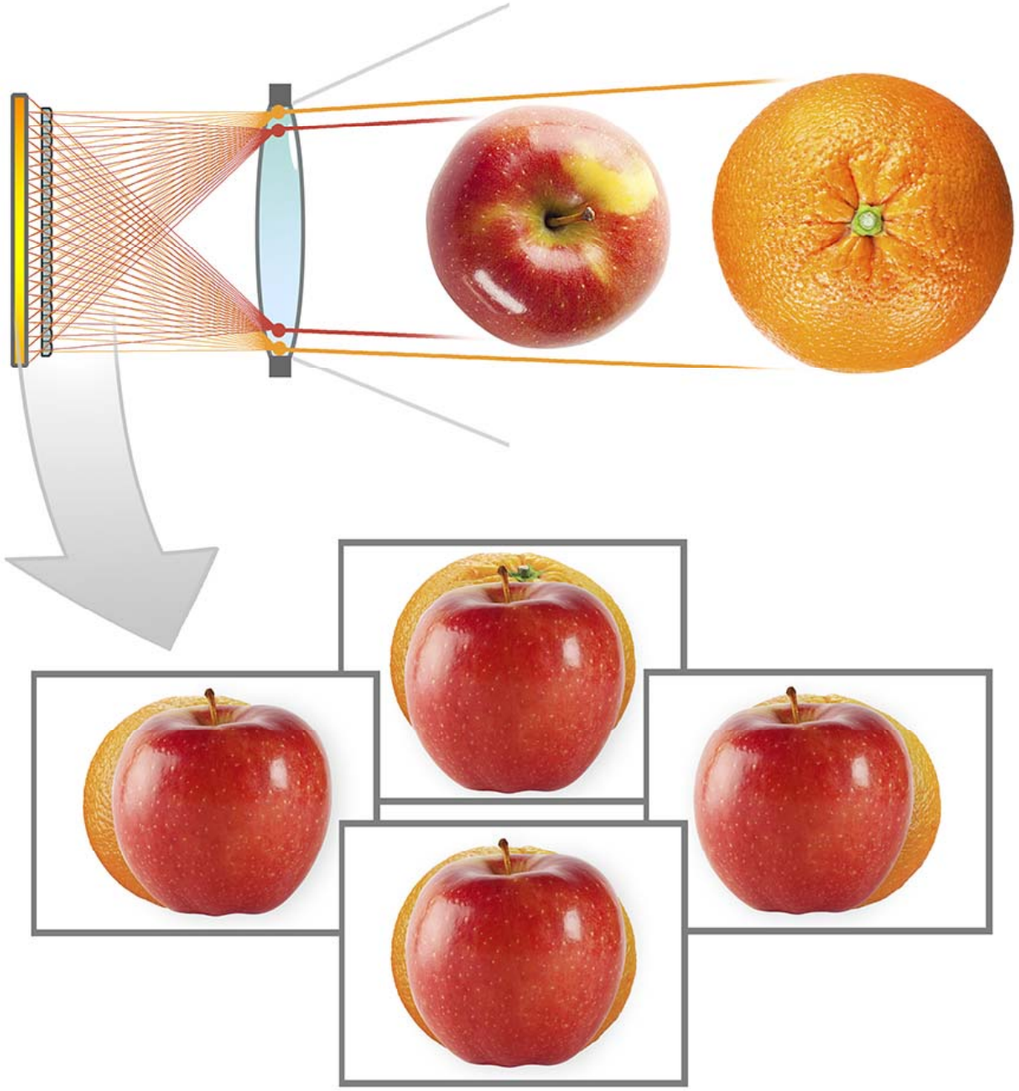
Pelican Imaging
Pi-Cam

TESSERA

Huge storage requirements!

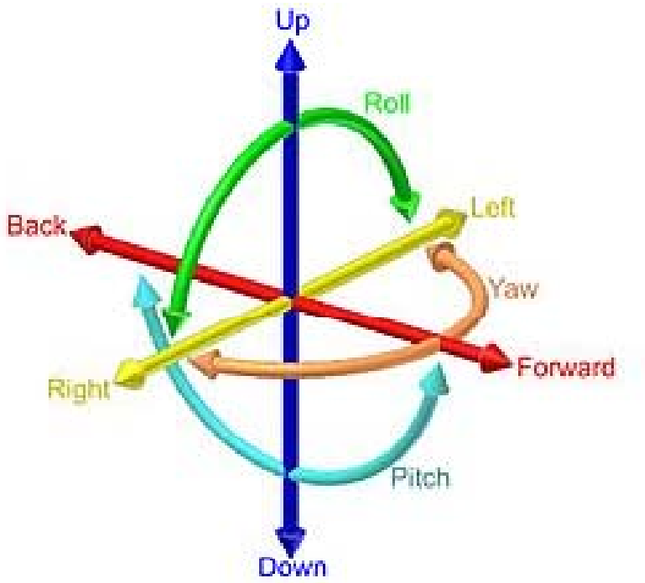
Projecting onto a $2m^2$ surface

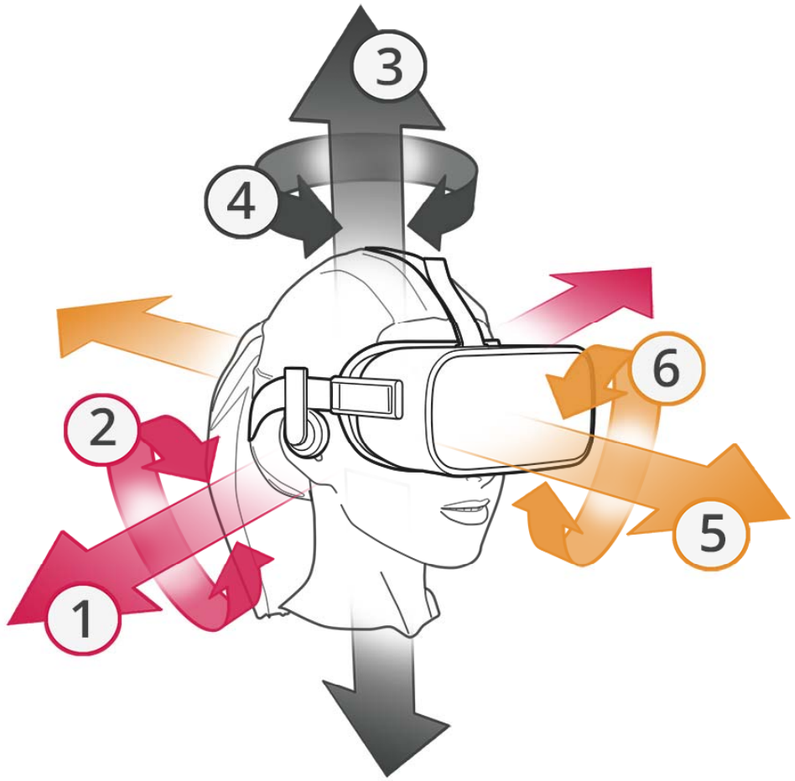
- 500 gigapixels (“gigarays”?) per image
- 60 fps = 400 petabytes/hour
  - 500 billion rays * 3 bytes/ray for 8-bit color * 60 fps



Source: Lytro

6DoF (Degrees of Freedom)



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SERIES
2003
A
D 38
FRANKLIN

BBOC
Big Ball of Cameras*

*BBOC- Credit to Ryan Damm, Visby

Image Source: The Fulldome Blog
https://thefulldomeblog.com/2015/11/17/collection-of-360-video-rigs/

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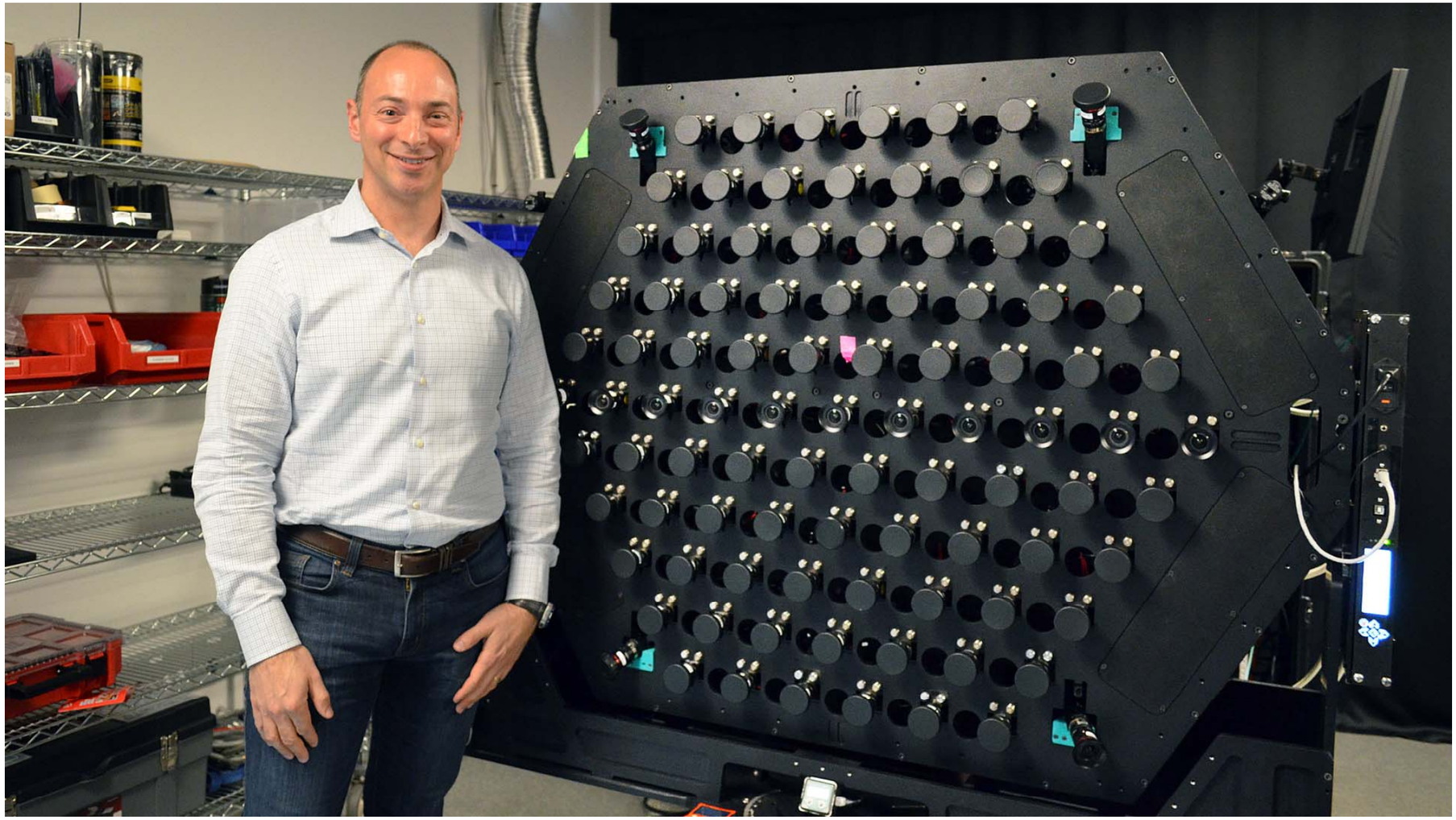

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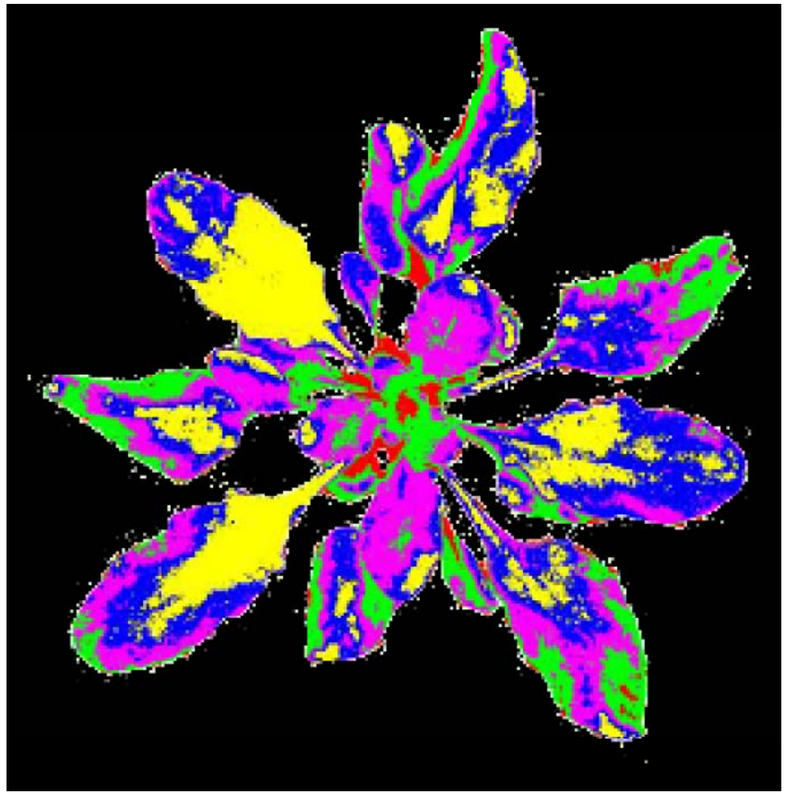
Light Field Applications

- Automated Optical Inspection

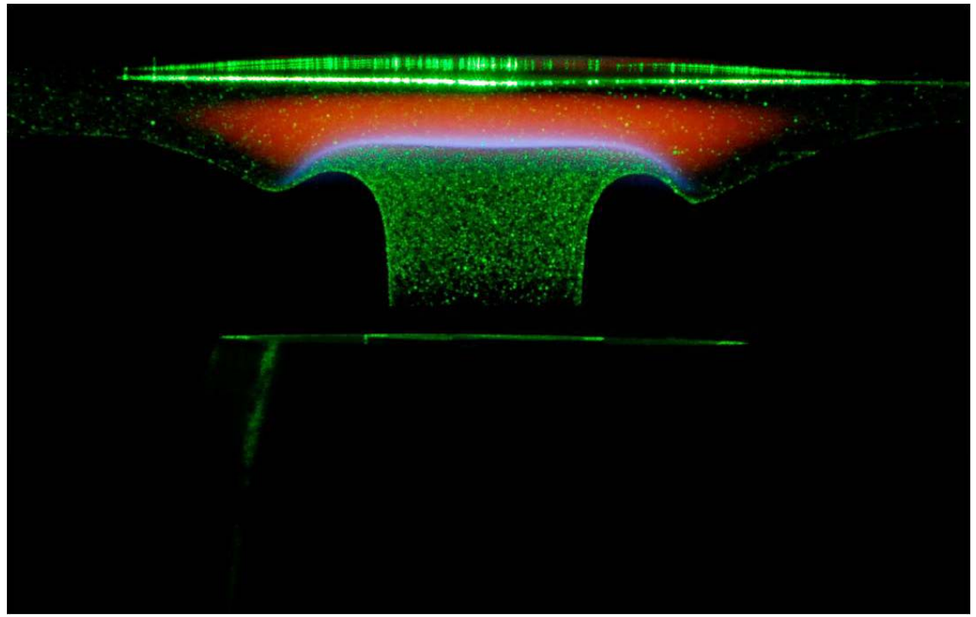
Light Field Applications

- Automated Optical Inspection
- Plant Phenotyping



Light Field Applications

- Automated Optical Inspection
- Plant Phenotyping
- Particle Image Velocimetry



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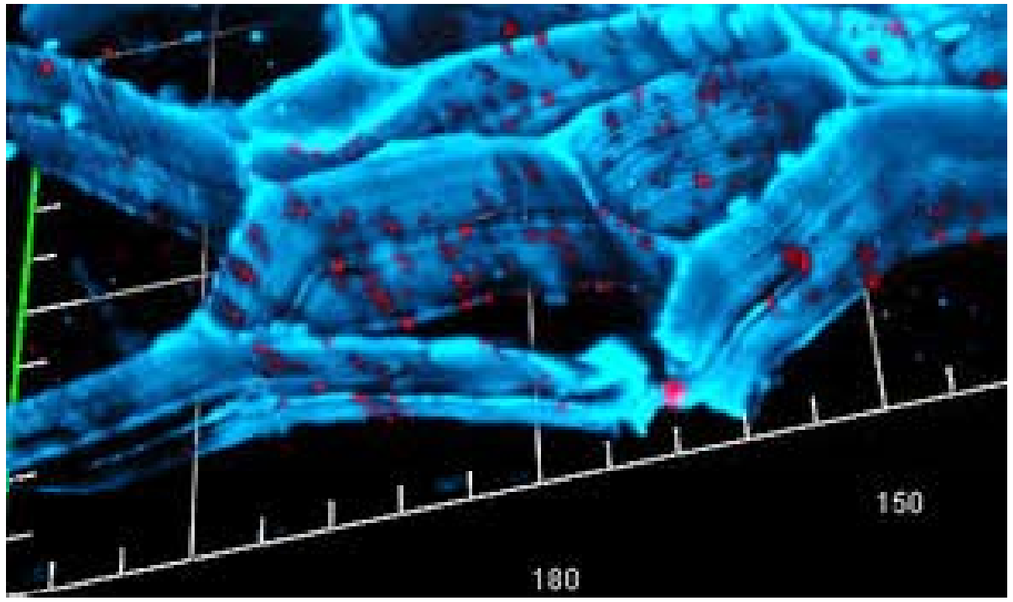
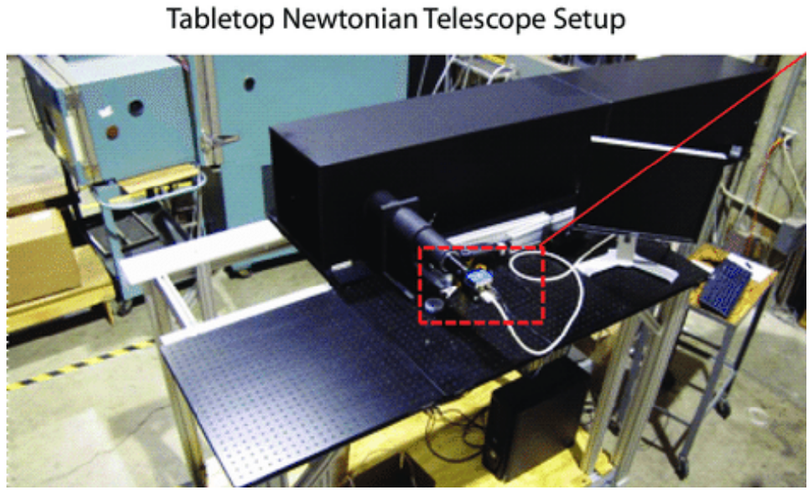
Light Field Applications

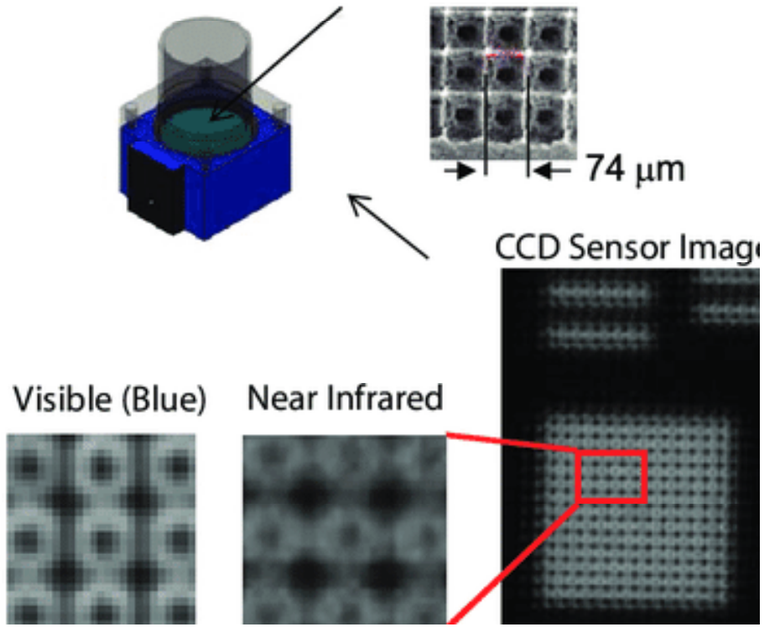
- Automated Optical Inspection
- Plant Phenotyping
- Particle Image Velocimetry
- 3D Microscopy



Light Field Applications

- Automated Optical Inspection
- Plant Phenotyping
- Particle Image Velocimetry
- 3D Microscopy (& Telescope)





A High Magnification Light-Field Telescope for Extended Depth-of-Field Biometric Imaging, David Stoker and Jonathan Wedd

Light Field Applications

- Automated Optical Inspection
- Plant Phenotyping
- Particle Image Velocimetry
- 3D Microscopy (& Telescope)
- Virtual reality / Augmented reality

Light Field Applications

- Automated Optical Inspection
- Plant Phenotyping
- Particle Image Velocimetry
- 3D Microscopy (& Telescope)
- Virtual reality / Augmented reality
- Traditional cinema CG

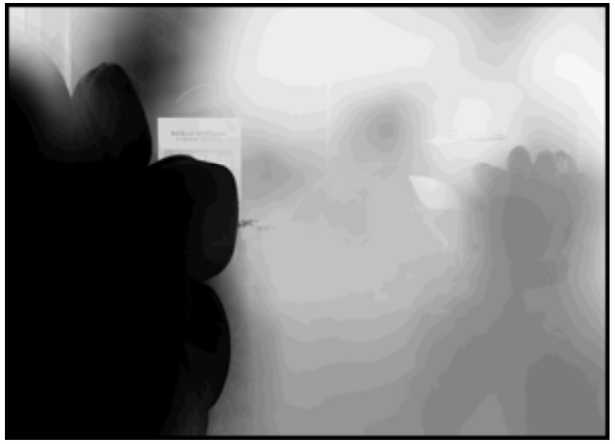
David E. Jacobs, Jongmin Baek, Marc Levoy.
Focal Stack Compositing for Depth of Field Control. Stanford Computer Graphics Laboratory Technical Report 2012-1. October, 2012.

Enabling Focal Stacks

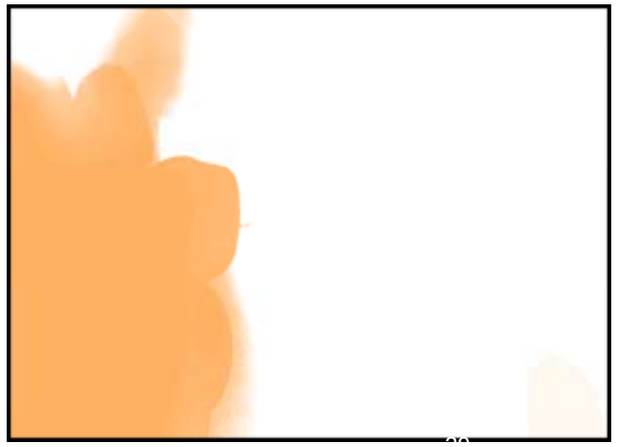
a) Single focal stack slice

b) Reduced depth of field composite

c) Extended depth of field composite



Scene depth map
(darker means closer)



Defocus maps used to generate the images in (b) and (c), respectively
(orange means blurry)

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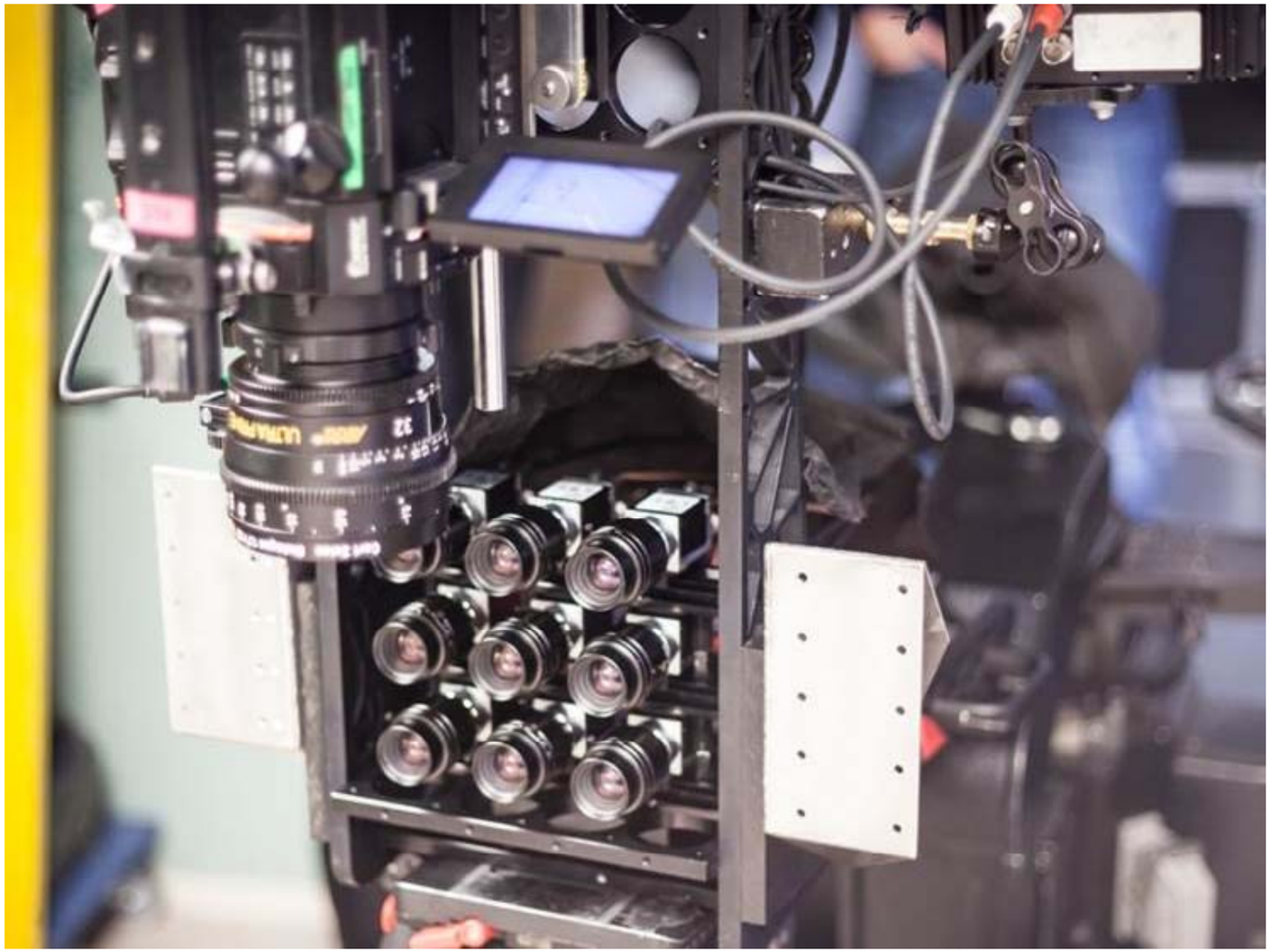
Cinematic Example: “Coming Home”

“Coming Home” Camera rig



Initial investigations by Fraunhofer IIS

- High definition 4D video capture (RGBD) from an array of 16 high-definition cameras set up in a planar arrangement
- 4D Non-Linear editing and compositing
- 4D Depth based color grading
- 4D Object extraction from background and repositioning without keying
- 4D Multi-perspective removal of foreground objects (Disney Research)
- 4D Perspective shift from a 9 camera point cloud
- 4D Interactive scene and character relighting after capture
- 4D Digital focus pull after capture
- 4D Focal tracking after capture
- 4D Freeze Frame view render (Timefreeze View Rendering with perspective shift
- 4D Combined relighting (CG augmented and natural)
- 4D Depth based interactive relighting

Content Creation Tools

Fraunhofer IIS

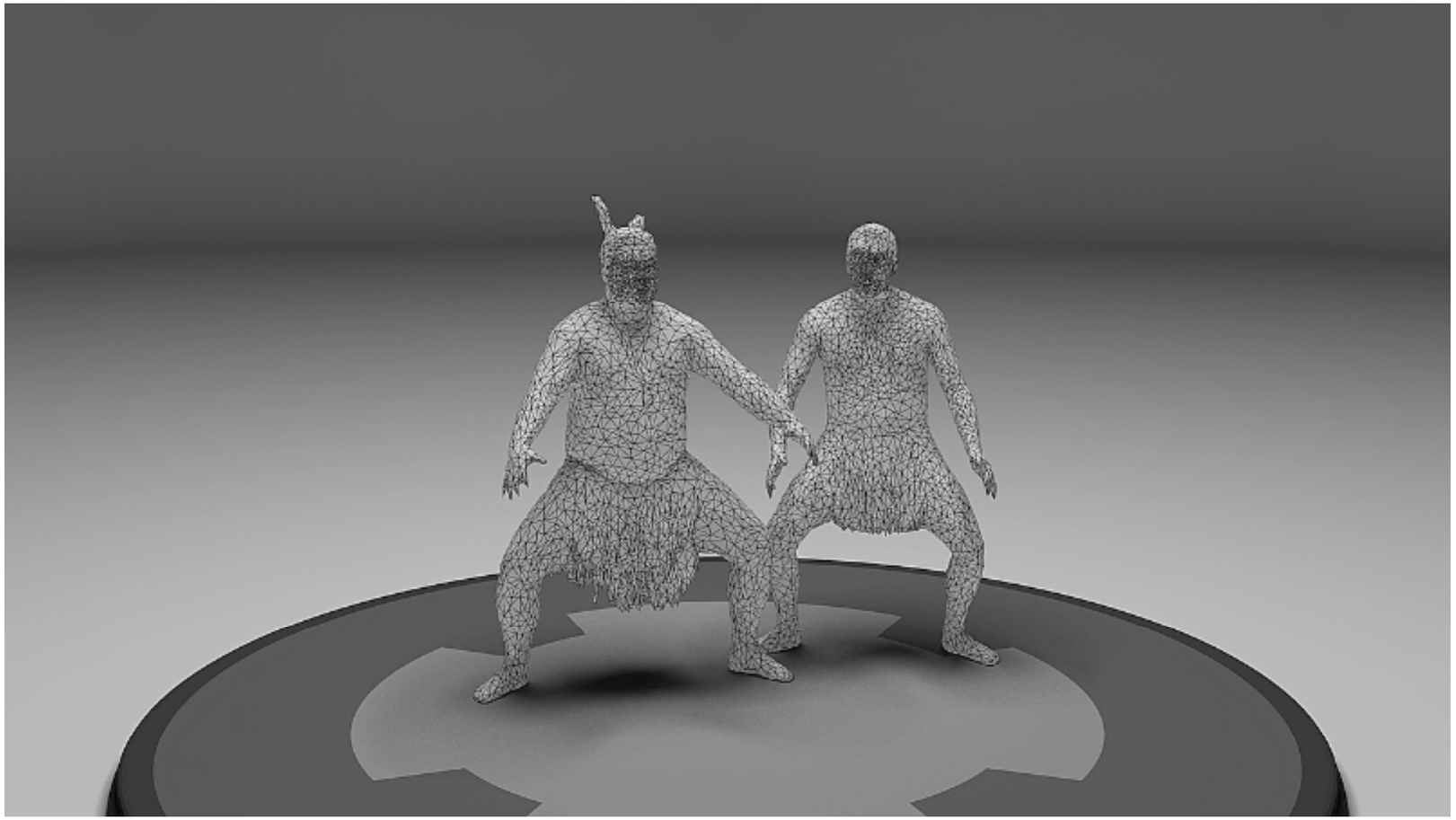
Realception®

Post-processing tools to work with light-field data input

Free Viewpoint Video

High-Quality Streamable Free-Viewpoint Video
A Collet, M Chuang, P Sweeney, D Gillett, D Evseev, D Calabrese, H Hoppe, A Kirk, S Sullivan
Microsoft Corporation, SIGGRAPH 2015

Free Viewpoint Video



Microsoft

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A Collet, M Chuang, P Sweeney, D Gillett, D Evseev, D Calabrese, H Hoppe, A Kirk, S Sullivan
Microsoft Corporation, SIGGRAPH 2015

ORBX Holographic Video

otoy

An artistic Enabler?

- Cinematographer control of:
  - Framing & Composition
  - Depth of field
  - Focal point / rack-focus
  - Lighting / reflections

- Workflow Benefits?
  - Light Field enables more flexibility in post
  - Potential for cost savings

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In Summary…

- Light Field Imaging is not new
  - But practical implementations are now becoming possible
- …but it enables revolutionary imaging attributes
- Data size is VERY large
- New standards for compressive light field are needed

An Overview of Light Field Acquisition

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