

Computational Photography

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Experimental Visualization Lab

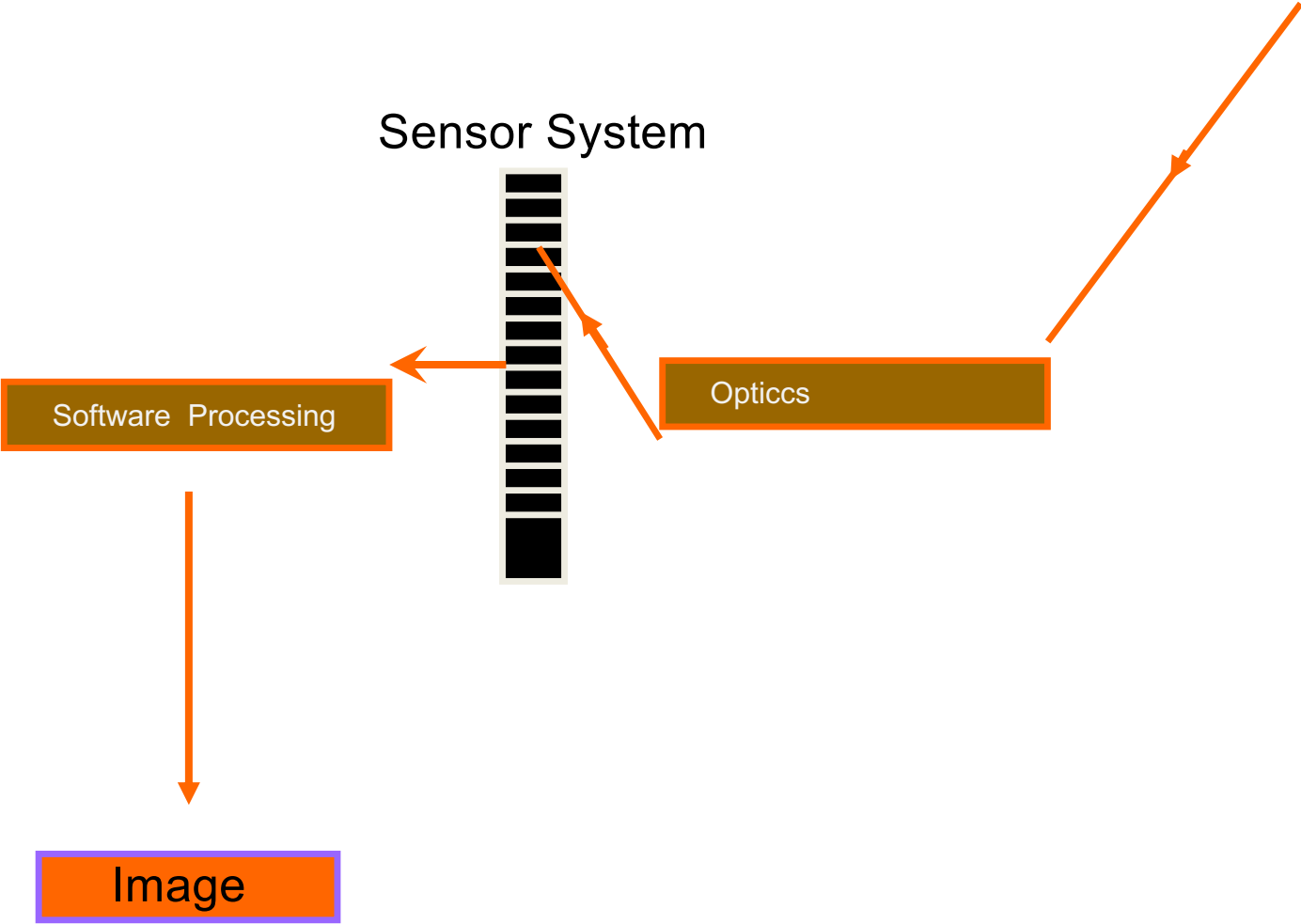
Media Arts & Technology

University of California, Santa Barbara

Definition of Computational Photography

- **An R & D development in the mid 2000s**
- **Computational photography** refers to digital image-capture cameras where computers are integrated into the image-capture process within the camera
- Examples of computational photography results include in-camera computation of digital panoramas,^[6] high-dynamic-range images, light-field cameras, and other unconventional optics
- Correlating one's image with others through the internet (Photosynth)
- Sensing in other electromagnetic spectrum
- **3 Leading labs:** *Marc Levoy*, Stanford (LightField, FrankenCamera, etc.)
Ramesh Raskar, Camera Culture, MIT Media Lab
Shree Nayar, CV Lab, Columbia University

Definition of Computational Photography

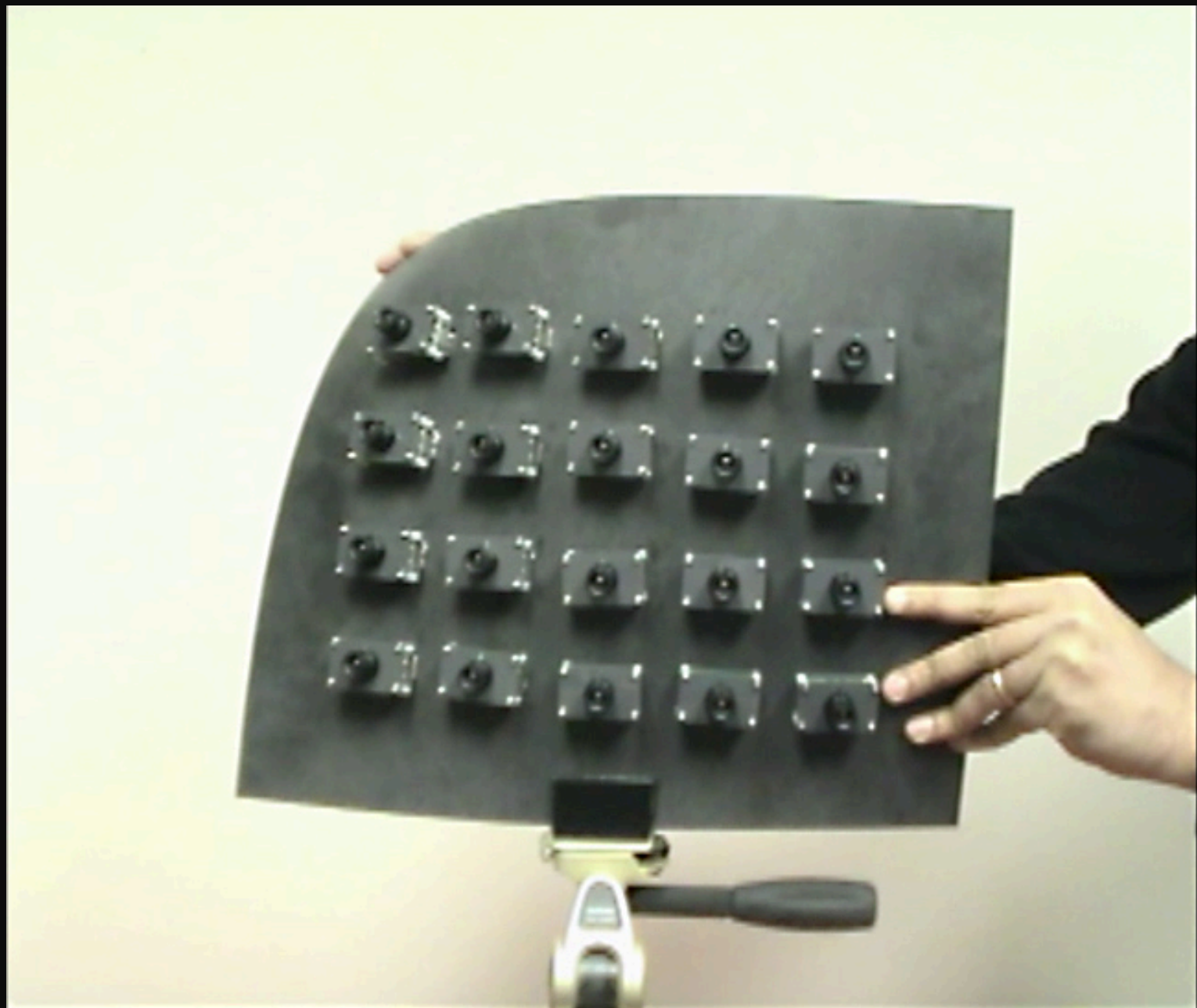


Digital Photography	Computational Photography	Computational Imaging / Camera	Computational Image Sensor
<p>Image processing applied to captured images to produce "better" images.</p> <p>Examples: Interpolation, Filtering, Enhancement, Dynamic Range Compression, Color Management, Morphing, Hole Filling, Artistic Image Effects, Image Compression, Watermarking.</p>	<p>Processing of a set of captured images to create "new" images.</p> <p>Examples: Mosaicing, Matting, Super-Resolution, Multi-Exposure HDR, Flash and No-Flash, Light Field from Multiple View, Structure from Motion, Shape from X.</p>	<p>Capture of optically coded images and computational decoding to produce "new" images.</p> <p>Examples: Coded Aperture, Optical Tomography, Diaphanography, SA Microscopy, Integral Imaging, Assorted Pixels, Catadioptric Imaging, Holographic Imaging.</p>	<p>Detectors that combine sensing and processing to create "smart" pixels.</p> <p>Examples: Artificial Retina, Retinex Sensors, Adaptive Dynamic Range Sensors, Edge Detection Chips, Focus of Expansion Chips, Motion Sensors, Neural Network Chips.</p>

Shree K. Nayar, Director (lab description [video](#))

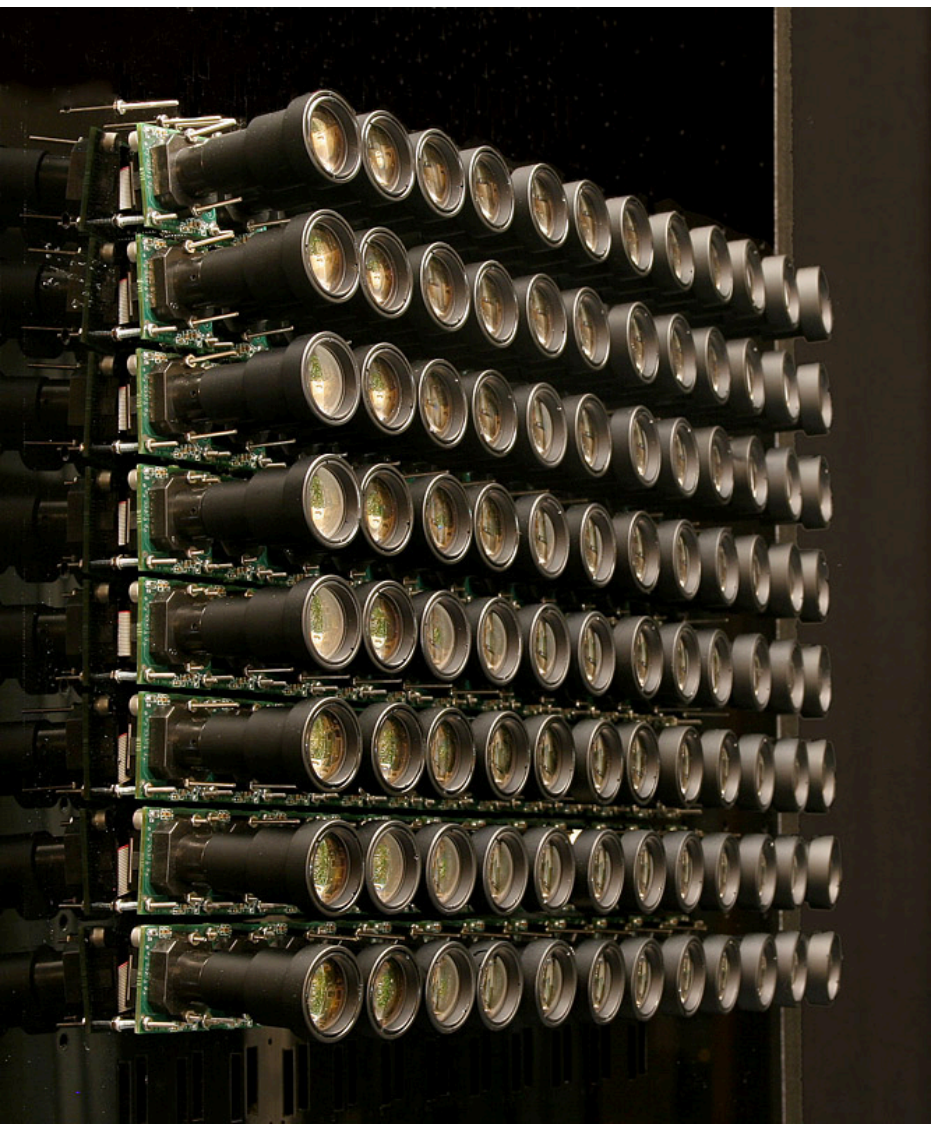
- Computer Vision Laboratory
- Lab focuses on vision sensors; physics based models for vision; algorithms for scene interpretation
- Digital imaging, machine vision, robotics, human-machine interfaces, computer graphics and displays [[URL](#)]

- **Refraction** (lens / dioptrics) and **reflection** (mirror / catoptrics) are combined in an optical system, (Used in search lights, headlamps, optical telescopes, microscopes, and telephoto lenses.)
- Catadioptric Camera for 360 degree Imaging
- Reflector | Recorded Image | Unwrapped [dance video]
- 360 degree cameras [Various projects]



- Light fields were introduced into computer graphics in 1996 by Marc Levoy and Pat Hanrahan. Their proposed application was *image-based-rendering* - computing new views of a scene from pre-existing views without the need for scene geometry.
- Light field: Returns the amount of light traveling in 3D space. Add time or multiple lenses – extends to 4D (Gershun, 1936)
- Different point of views allows multifocus depth

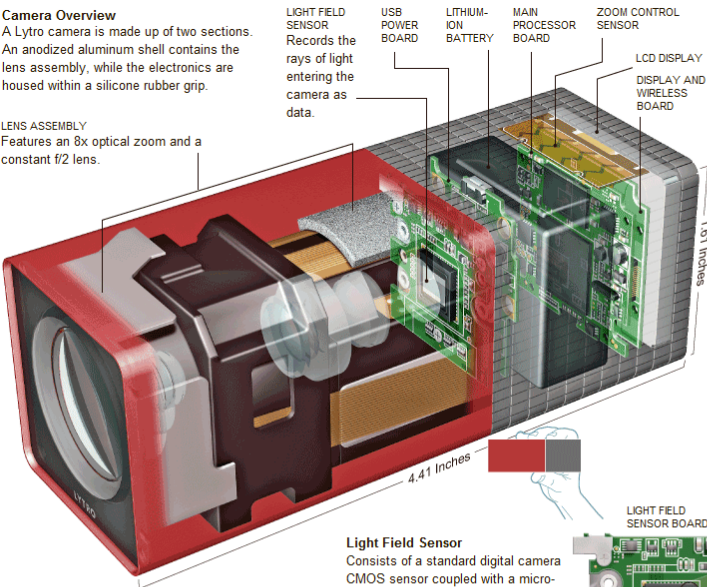
Marc Levoy, Computer Science Lab, Stanford



Camera Overview

A Lytro camera is made up of two sections. An anodized aluminum shell contains the lens assembly, while the electronics are housed within a silicone rubber grip.

LENS ASSEMBLY
Features an 8x optical zoom and a constant f/2 lens.

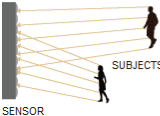


Light Field Sensor

Consists of a standard digital camera CMOS sensor coupled with a micro-lens array. The array contains thousands of miniature lenses.

Capturing Light

Lytro's light field sensor captures not only the color, intensity and position of the light, but also its direction, which is lost in traditional cameras.

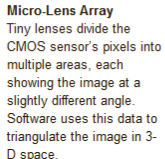
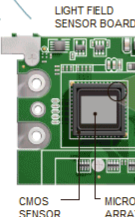


Changing Focus

Because all the directional information of the entering light is captured, software can change the focal plane. Clicking any point on the image brings that area into focus, whether raindrops on the surface of a window or buildings beyond.

Controlling the Camera

Lytro uses a 1.46-inch touch screen. Swiping back and forth allows you to view previous or later photos, while swiping up brings up a menu bar. The shutter button and a slider for the zoom are molded into the top of the unit, while the power button and a USB connector are on the bottom.



Micro-Lens Array

Tiny lenses divide the CMOS sensor's pixels into multiple areas, each showing the image at a slightly different angle. Software uses this data to triangulate the image in 3-D space.



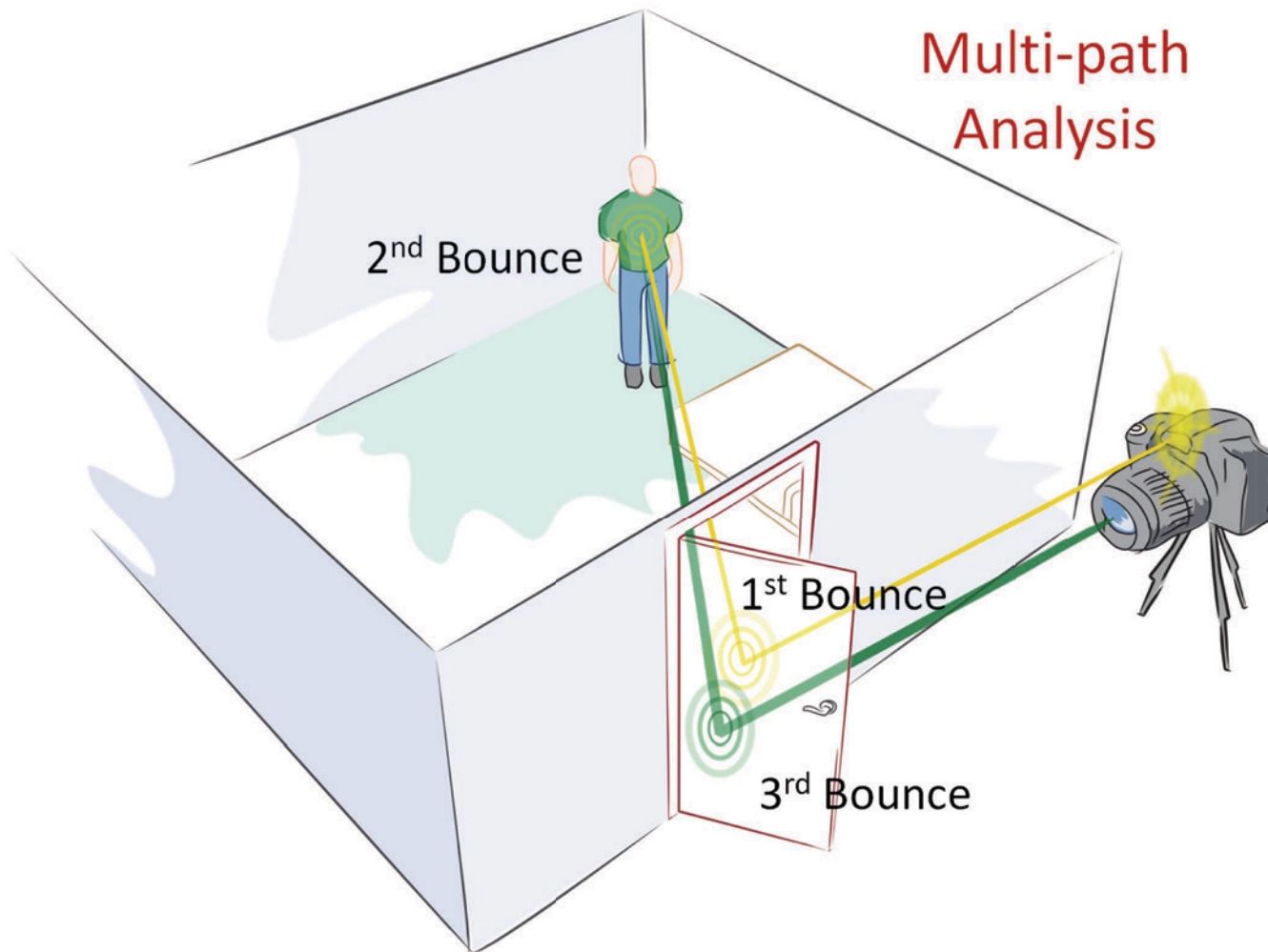
Ramesh Raskar, Director [[lablink](#)]

More than a billion people now using networked, mobile cameras: Rapid evolution in activities based on visual exchange

Our goal is to go beyond post-capture software methods and exploit unusual optics, modern sensors, programmable illumination, and bio-inspired processing

Keynote: 2:00/5:07 Biology to Wishlist - [[video](#)]

“Femto Camera”, Ramesh Raskar, Camera Culture, MIT Media Lab



- To compute the geometry of the object inside the room the user directs an ultra short laser beam onto the door and after the first bounce the beam scatters into the room
- The light reflects from objects inside the room and again from the door back toward the transient imaging camera
- An ultra-fast array of detectors measures the time profile of the returned signal from multiple positions on the door

Wifi Camera



Visualizing Wifi using the Wifi Camera

Somlai-Fischer, A.¹⁾, Sjöln, B.²⁾ and Haque, U.³⁾

1) Aether Architecture, Budapest, Hungary. E-mail: adam@aether.hu

2) Automata AB, Stockholm, Sweden. Email: bengt@automata.se

3) Haque Design+Research. Email: info@haque.co.uk

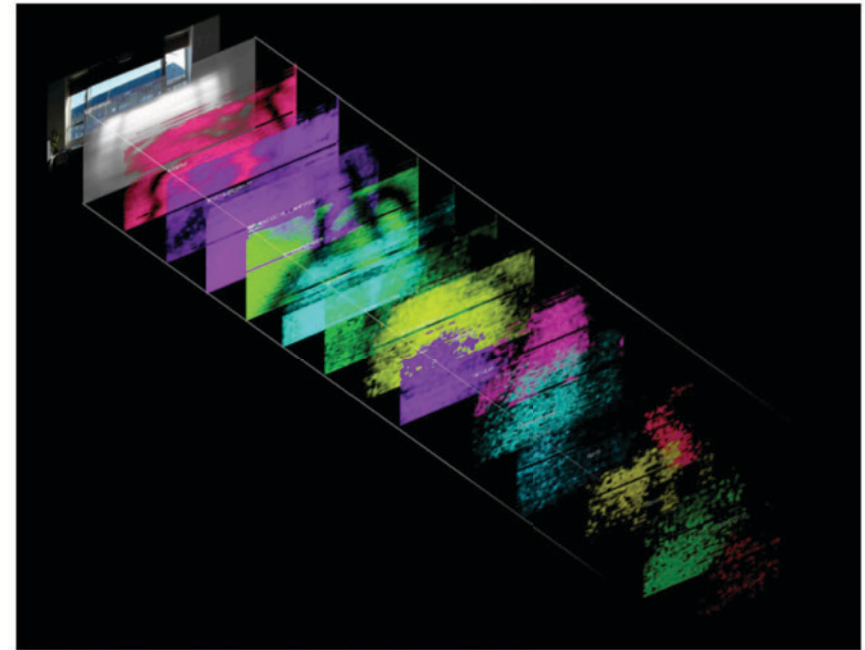


Fig.1. Amalgamated image of fifteen Wifi networks permeating a domestic living room.

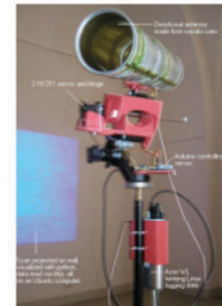


Fig.2. Equipment

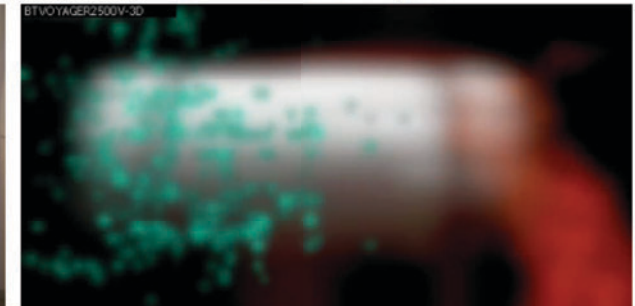
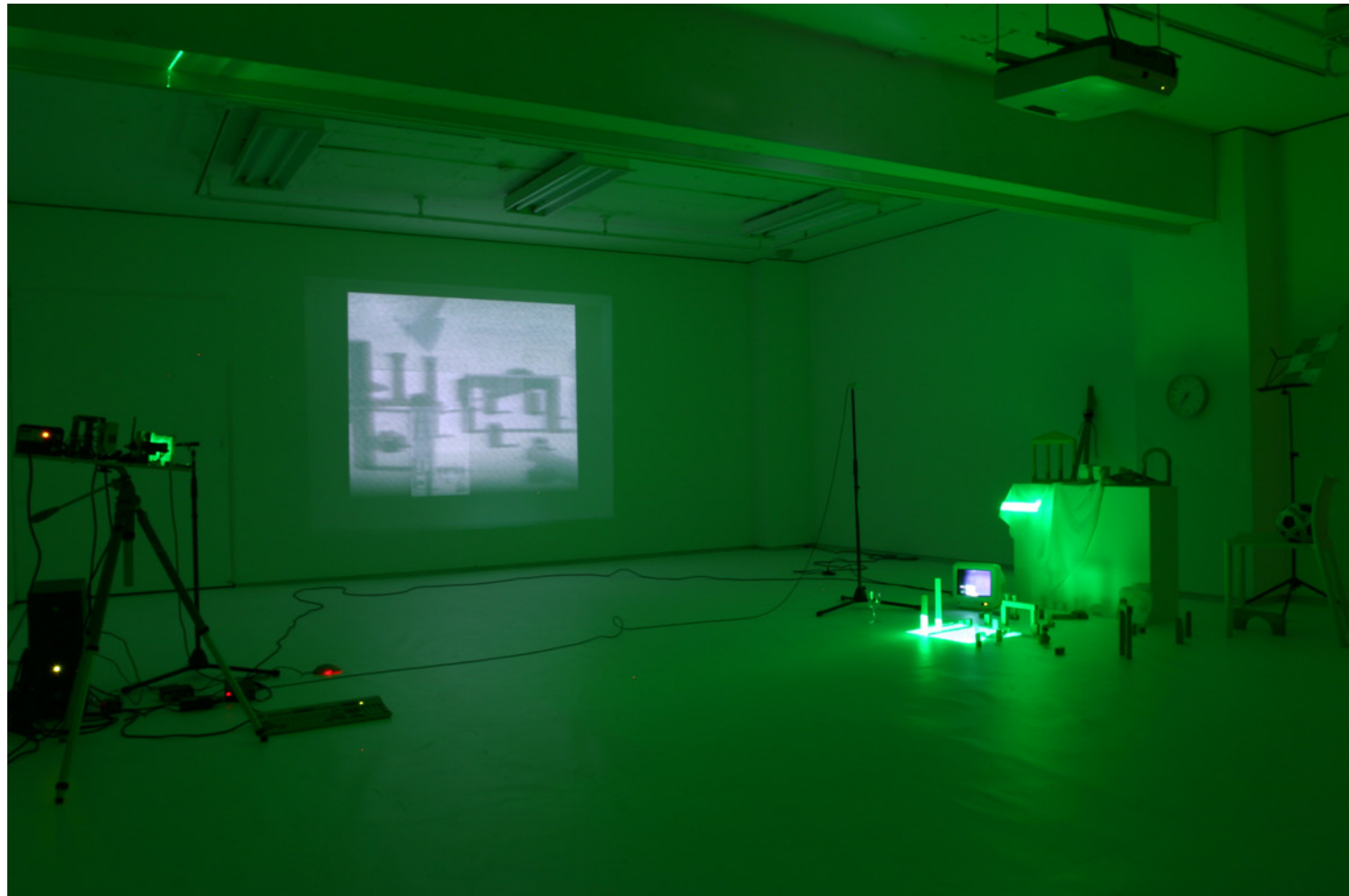


Fig.3. View of window showing two networks coming through

These images were created using a "Wifi Camera" custom designed by Somlai-Fischer, Sjöln and Haque (information available at <http://wificamera.propositions.org.uk/>). It makes a use of a directional 2.4Ghz wifi antenna mounted on servos scanning an environment at varying resolutions, measuring signal strength of all present networks to generate an image of the wifi "view" of the space. A light sensor is mounted on the antenna in order to generate a visible-light image that confirms precise orientation.

Ruska's Room, Masaki Fujihata

- Creating an image without optical lens –
Ruska's Room [[video](#)]



Arts & Engineering Conundrum

- **Technological Push:** Engineering research prioritizes advancing the technology for the sake of research – Needs seem secondary
- **Aesthetic Pull:** Artists want technologies developed driven by project needs
- The engineers will participate only if research is advanced, otherwise they see it as “service” or distraction
- The challenge for the artists is to identify and articulate how an artistic context can advance research

- Frankencamera (into a Leica camera)
- Lytro , LightField (Levoy Lab at Stanford)
- LightField Video (Debevec Lab Campanile/Matrix)
- View Synthesis, (Snavely Lab, Cornell)
- Femto (Ramesh Raskar Camera Culture, MIT)
- Computer Vision Lab, Columbia University
- PhotoSynth (Obama inauguration)
- GigaPixel (Photo enlargement Software)

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<http://vislab.ucsb.edu>

<http://georgelegrady.com>