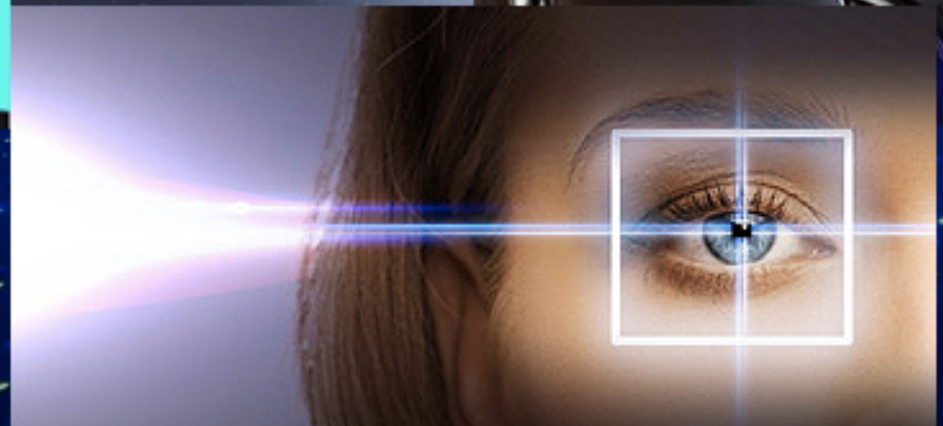
IESSF Emerging Technologies in Lighting

The Hottest, Smartest, & (Mostly) Non-IoT



Jan.19 2017

What do LEDs, Sensors & IoT Have To Do With Lighting?

Robert F. Karlicek, Jr.

Professor, Rensselaer Polytechnic Institute

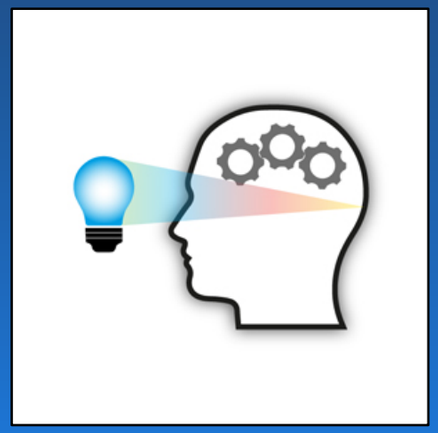
Director, Center for Lighting Enabled Systems & Applications (LESA)

Outline

- Lighting and IoT – inevitable, but….
- Novel Applications of Digitized Illumination
- Futuristic Concepts – beyond Illumination

Visible Light Communications

Cognitive Systems



Building Management

Horticulture and “Pharming”

Healthcare/Eldercare

Think of all those sensors and microprocessors……

Market Opportunity: 4B Streetlight + 500B light sockets

Sense the World, Process, Analyze and Act on the data

Environment	Weather	Pollution
• Ambient Light	• Temperature	• Smoke/Odor
• Power Monitoring	• Humidity	• NOx, HC, CO/CO_2
• Digital signs	• Rainfall	• Radiation/Radon
• Ultrasound	• Wind	• Chemical Spills
• Motion	• Seismic	• Meth
• RT Location System	• Pressure	• Particulate Matter
• Audio/Video	• UVA/UVB	• Garbage

Internet of Things intel

Using Intel Technology/Ambient Computing IOT Platform

*RTLS: Real time location system

Sandhiprakash Bhide, Intel Corporation, 2016 7

http://energy.gov/sites/prod/files/2016/02/f29/bhide_connected_raleigh2016.pdf

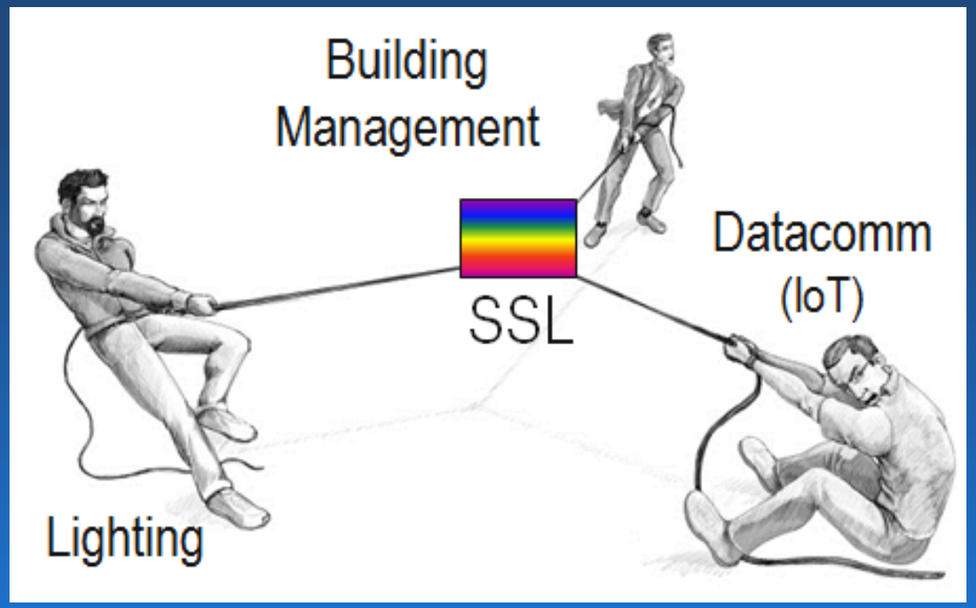
Lighting and IoT – an irresistible attraction?

Good reasons to integrate IoT and Lighting

–IoT uses Sensors

–Sensors need Power

–Lighting has Power



- What is the Value Proposition?
- What is the value of Lighting Quality?
- Can Lighting Companies be IoT experts?
- Will IoT energy use diminish SSL adoption?

IoT and Lighting are connected at the socket

IoT consumes extra power, can reduce LED advantage in energy efficiency

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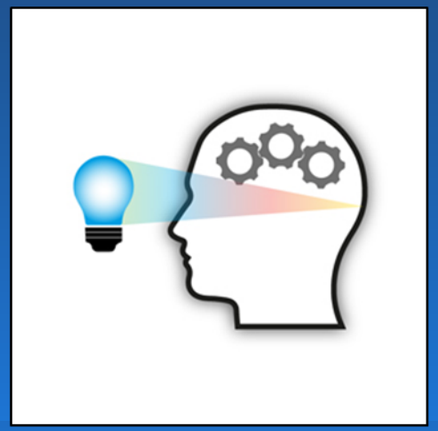

Building Management

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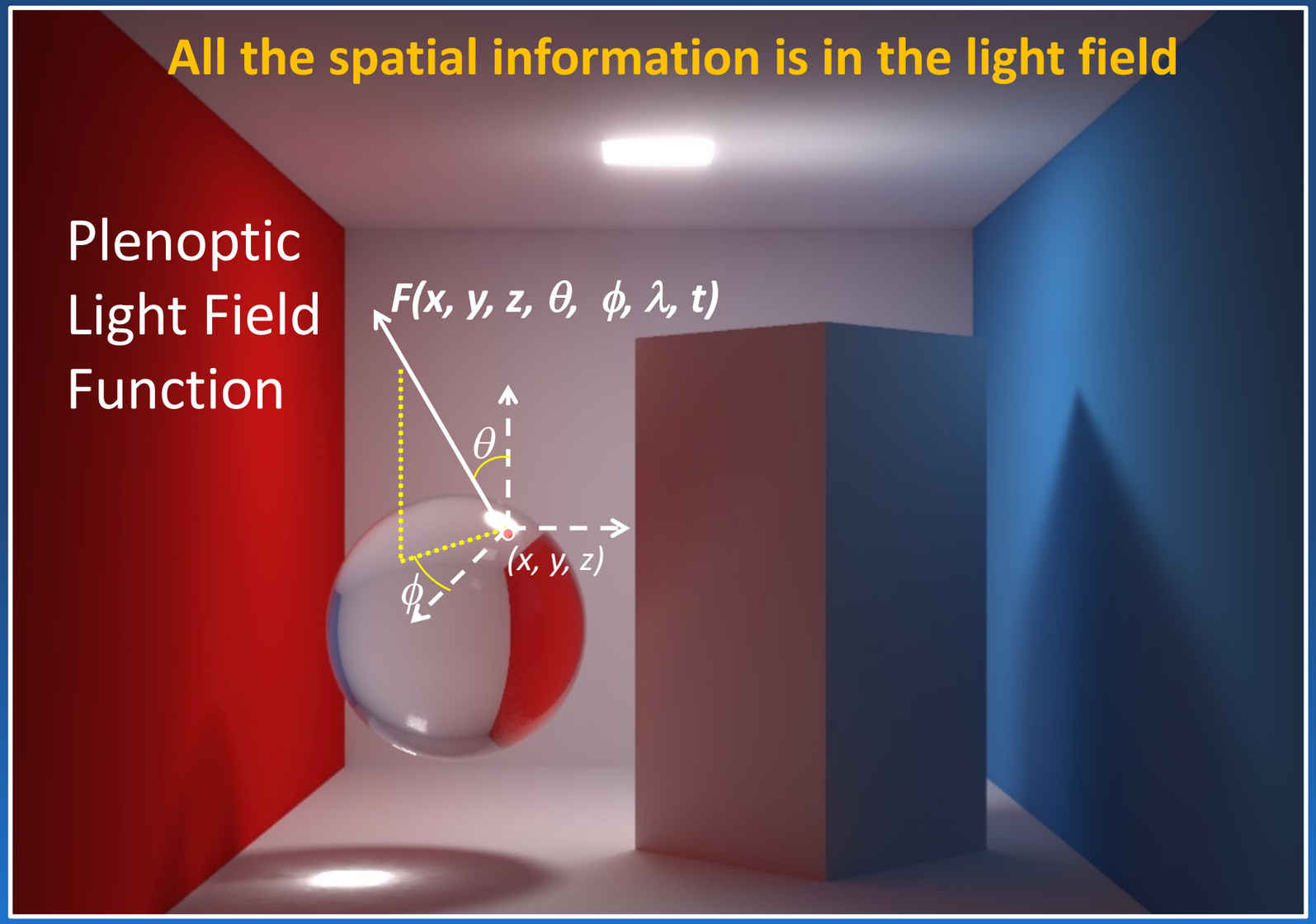
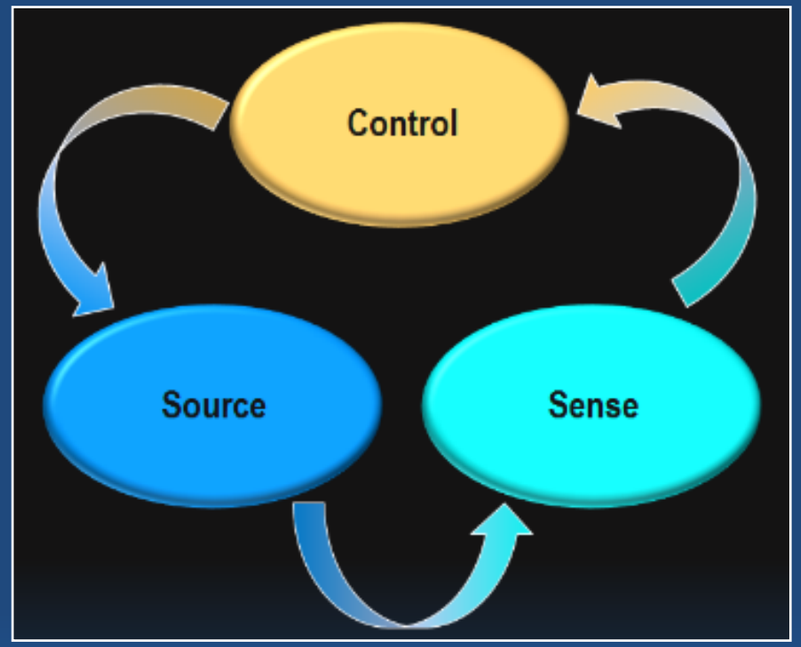
Putting lighting systems to work to create value added services



Henrik Wann Jensen graphics.ucsd.edu



Digitized Tunable Illumination

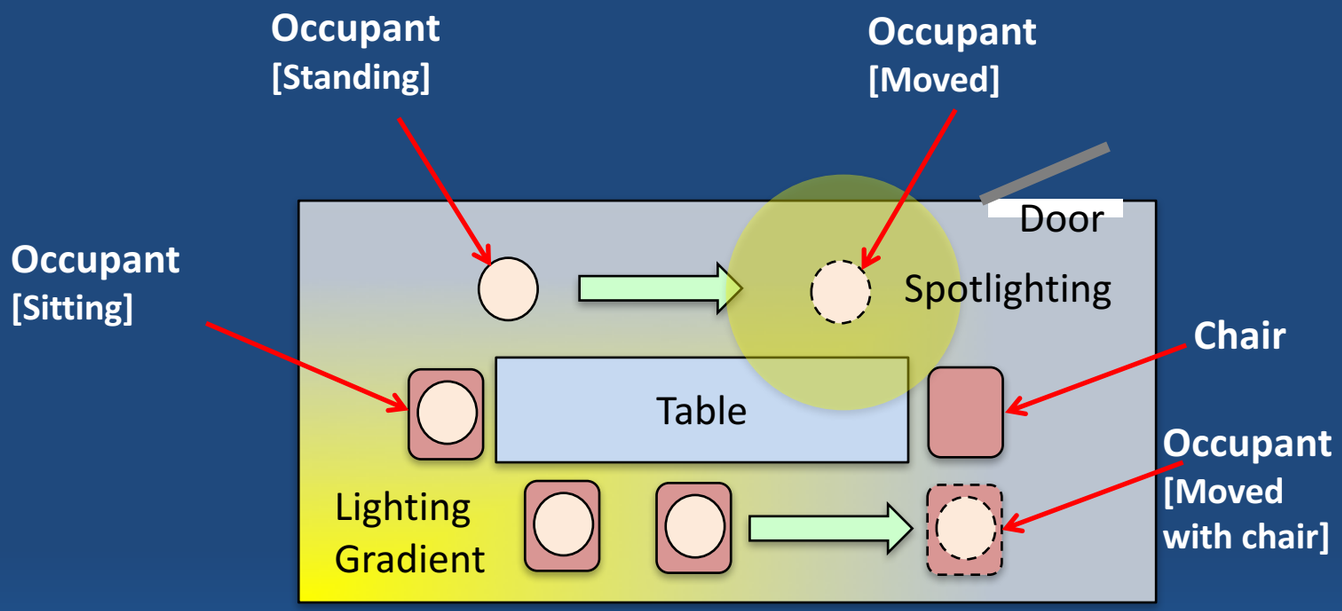
Control & Communications

Light Field Sensing

Digitized Adaptive Lighting Systems

- Color Tunable Lighting
  - Human Centric Lighting
  - Reflectivity Mapping
  - Dynamic Metameric Variation
- Time of Flight Sensing
  - ToF integrated with communications
  - Localizes people, poses, objects
- Light Transport Mapping
  - Illumination contour control
  - Complements TOF methods
  - Human – System Interface

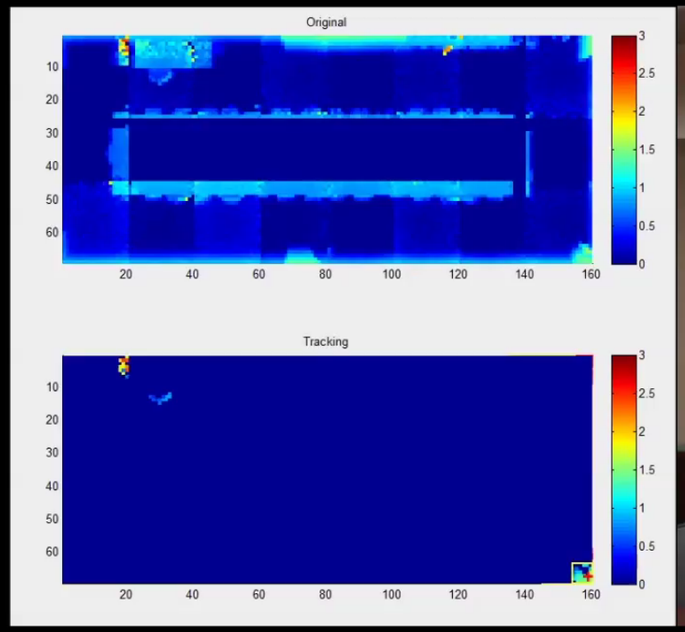
Using digitized light to compute…..



- How many occupants?
- Where are they?
- What are they doing?
- What is the “right light”?

- Lighting Control
- Building Services
- Data Services
- Healthcare Services

Giving Sight to Light (Digitized Reflected Light)



IR TOF Camera
(today)

Single Pixel
Visible Light
VL TOF

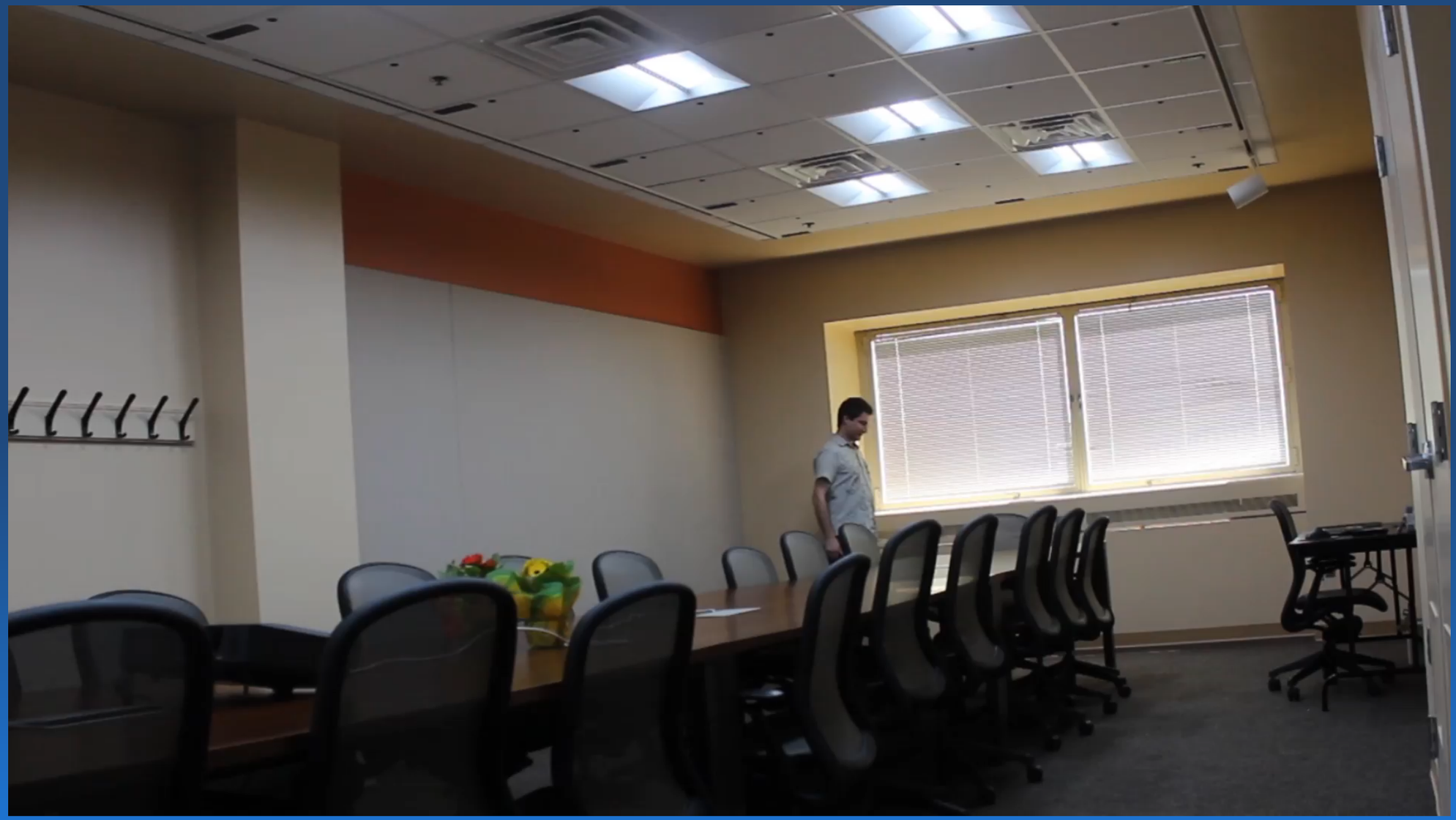
Number of people: 1

	ID	Position	Height
1	1	[158, 67]	1.52

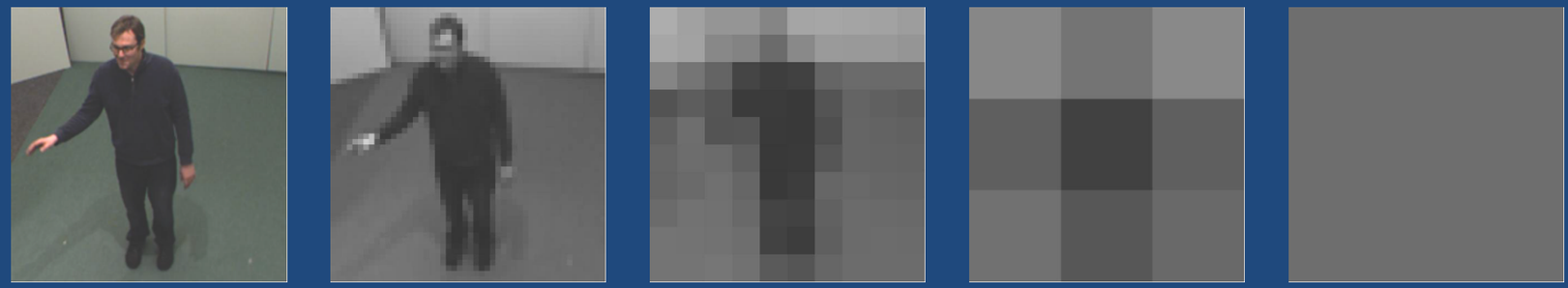
DATA

- Lighting Control
- Building Services
- Data Services
- Healthcare Services

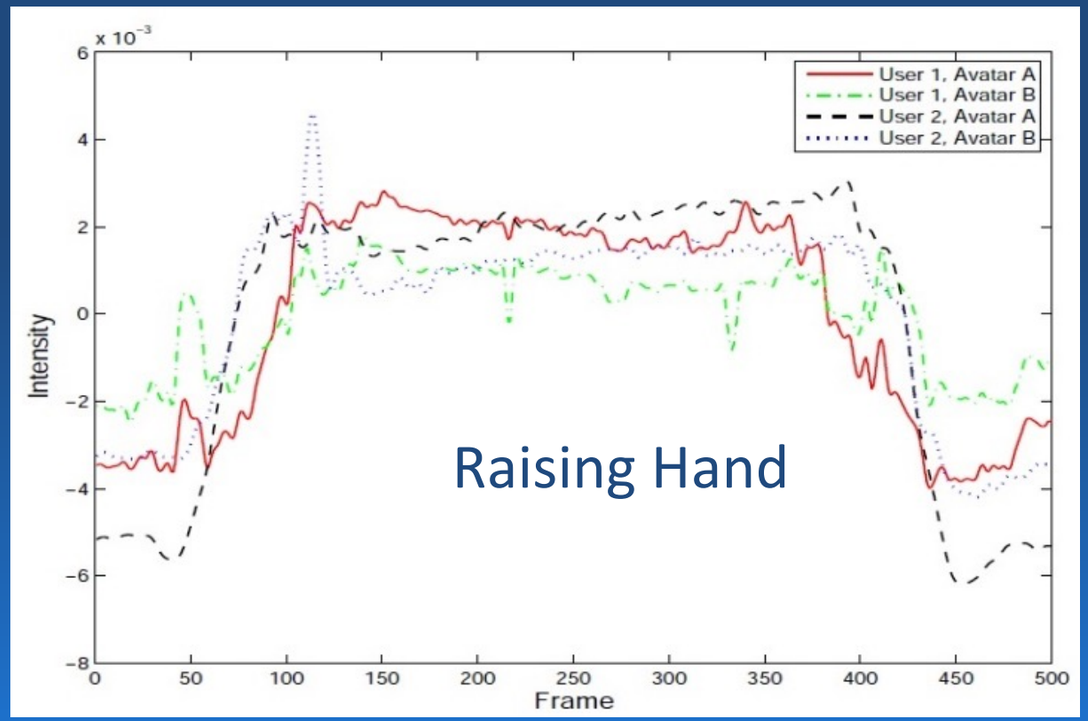
Activity Logging, Smart Buildings, Security

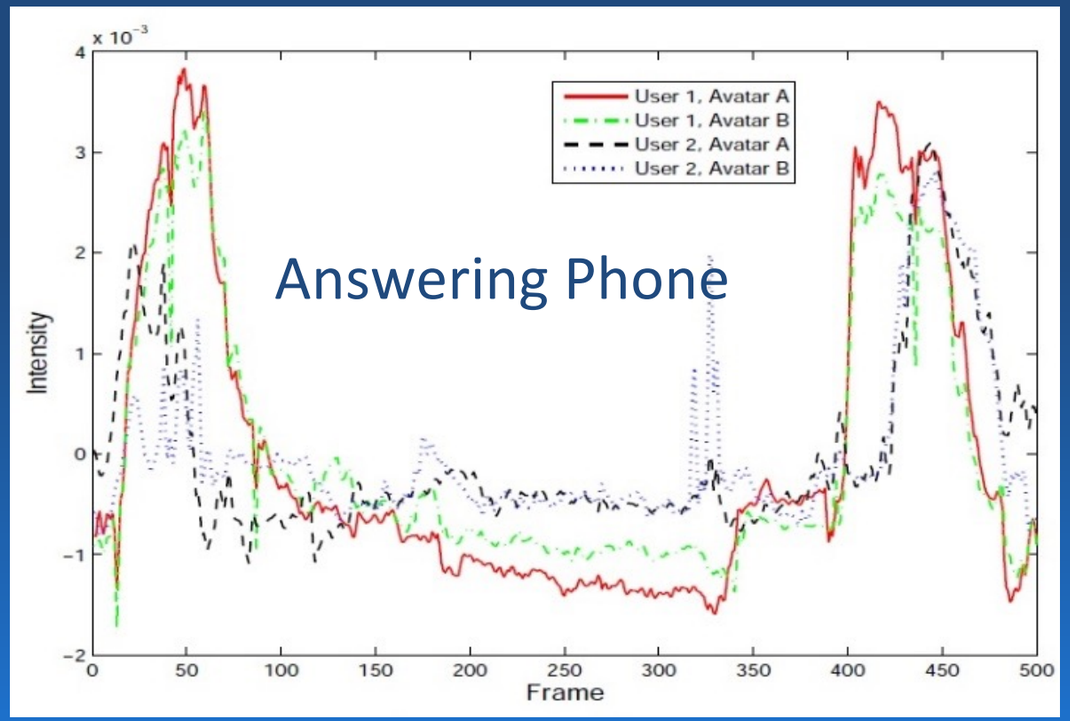


Gesture Recognition from networked color sensors



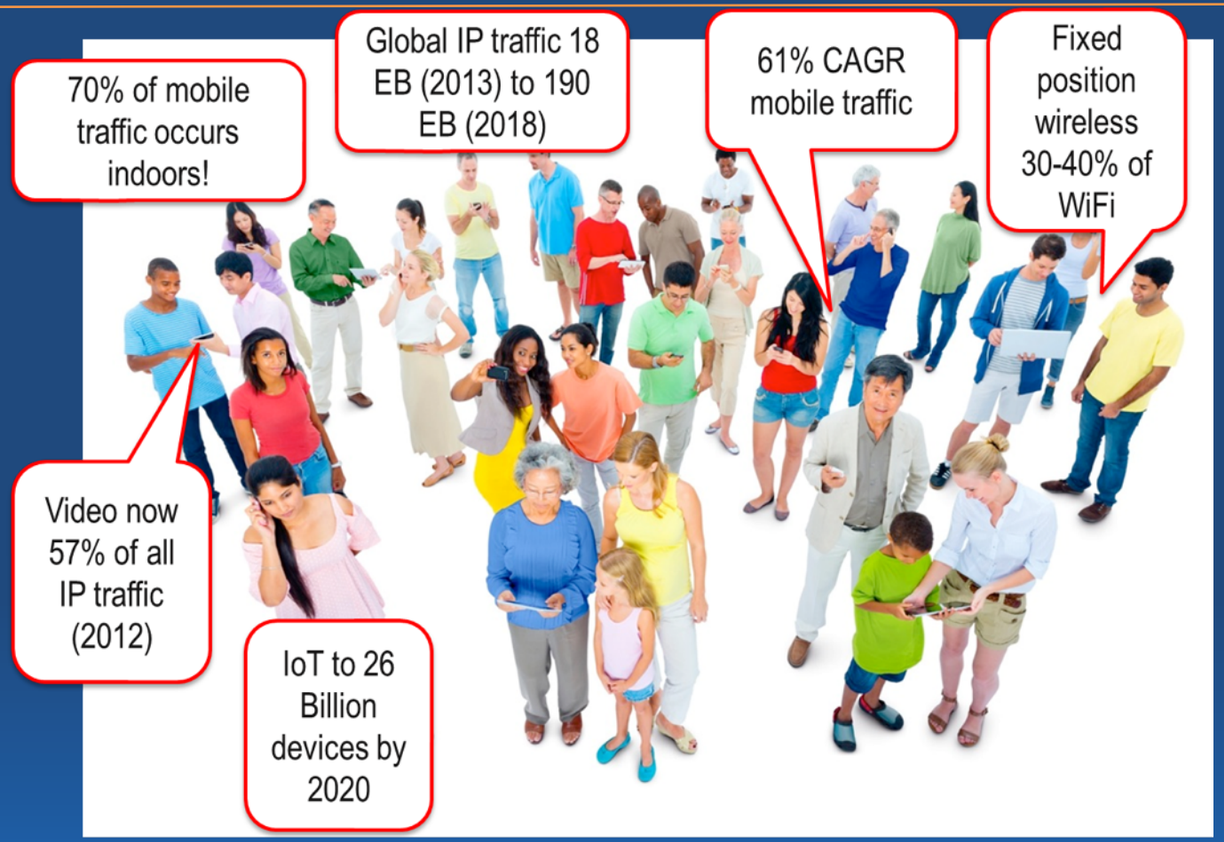
Dai, Saghafi, Wu, Konrad, Ishwar, *IEEE Int'l. Conf. on Image Processing,* 2015





LiFi and WiFi Integration

- Indoor Light Based GPS + Data services emerging
- Wireless VLC is focus of a several startup companies
- Increasing attention from LED systems companies



LiFi

IEEE 802.15 WPAN™
Task Group 7 (TG7)
Visible Light Communication

Jugnu

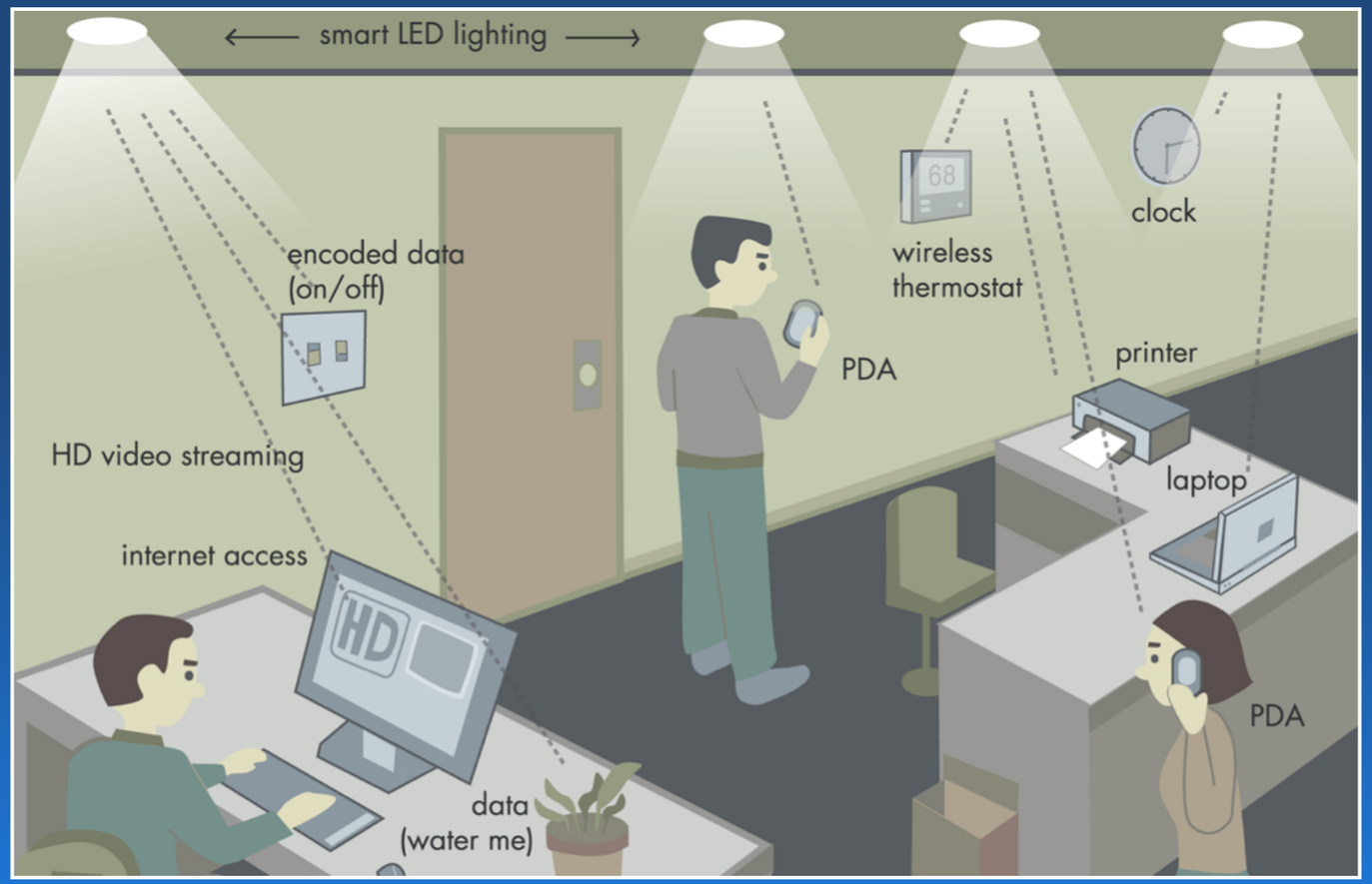
LEDCOM

Light becomes data
pureLiFi

Illumination: Communication *AND* Sensing

VLC Receivers in Devices: Visible Light Communications

Modulated lighting for both light sensing and communications



Receivers in Ceiling:

- 3D spatial maps
- Track location, motion
- Estimate activity
- Preserve Privacy

Light Field Sensing superior to other localization methods

Existing Sensor Technology	Location Accuracy	Pose Estimation	Privacy Preserving	Localize Objects	Comments
PIR Motion Detectors	⊗	⊗	✓	⊗	False negatives and positives
IR Imaging Arrays	✓	⊗	✓	**Limited**	Not CMOS compatible, costly
Ultrasonic Sensing	⊗	⊗	✓	⊗	False positives
RF Tagging	**Limited**	⊗	⊗	**If tagged**	RFID tags needed, RF penetrates walls complicating location
RF Attenuation	**Limited**	⊗	✓	**Limited**	RF wall penetration issues complicates precision localization
Camera Systems	✓	✓	⊗	✓	Cannot be used everywhere due to privacy concerns
Light Field Sensing	✓	✓	✓	✓	**Precise Dynamic Localization of People and Things**

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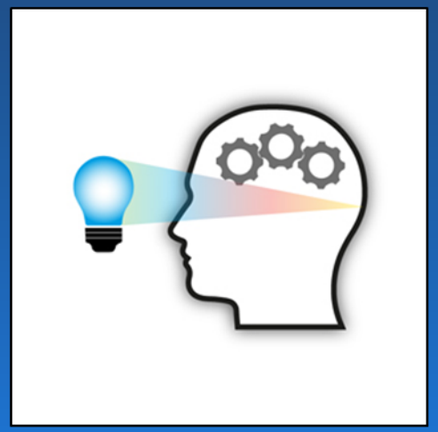

Building Management

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Healthcare/Eldercare

Forward Looking Applications

Virtual Hospital Window

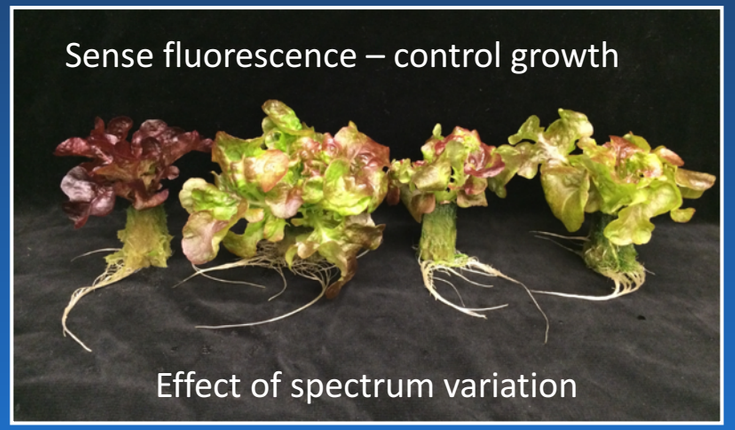
2134 patient days
2111 virtual window days
87 survey respondents

Collaborators:
Partha Dutta
St. Peter's Hospital

32.7% rated virtual window equal to normal window
21.2% rated virtual window superior to normal window

Optimized Plant Growth

- Digitized Light/Fluorescence tracks plant stress
- Dynamic wavelength control impacts plant physiology
- Future impact in plant based chemical synthesis
  (Vaccines, Pharmaceuticals, Specialty Chemicals)



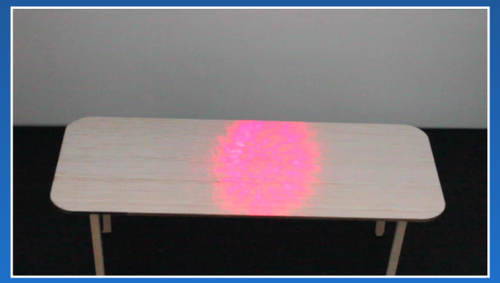
Collaborator: Tessa Pocock

Futuristic Concepts

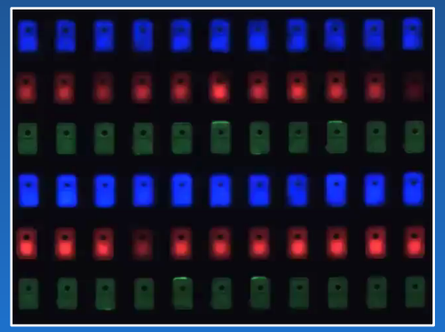
Projection and Illumination

- Active Beam Shaping
- Illumination Video Fusion
- Lasers for Illumination
- Immersive, Augmented Reality

Display and Illumination



Active Light Pattern Management



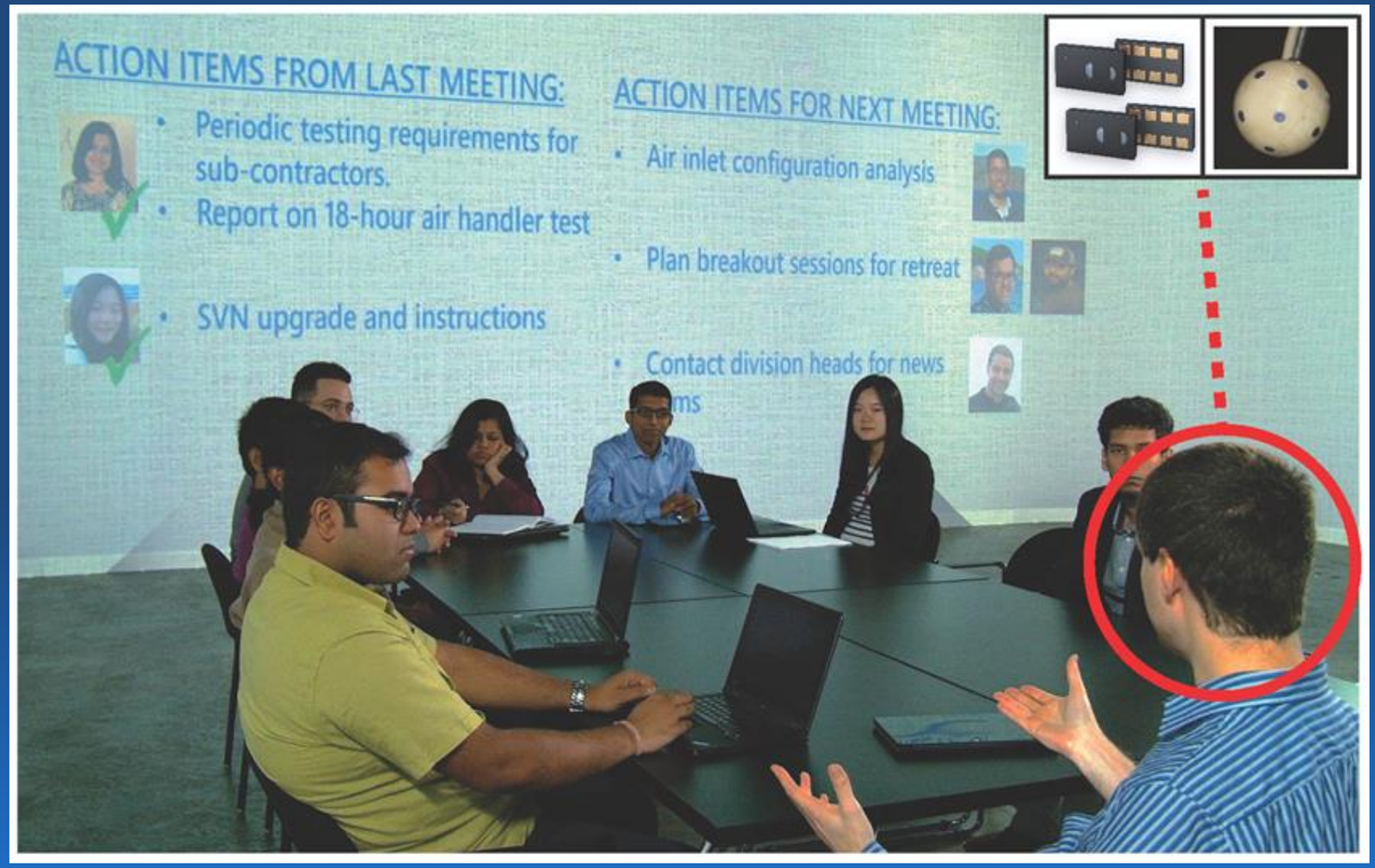
µPixel Direct View Displays

Lasers in Future Lighting Systems?

- First step in the integration of projection with illumination
- Beam steering, pan/tilt
- Novel low cost MEMS platform
- Eliminate speckle using diffusers and/or superluminescent LEDs

From LESA collaborators David Bishop and Jessica Morrison (BU)

Illumination with Information and Voice Processing



Courtesy of Professors Rich Radke and Jonas Braasch (LESA @ Rensselaer)

The Room is a fully cognitive meeting participant

- Responsive Lighting
- Illumination Video Fusion
- Natural Language Processing
- Immersive, Augmented Reality

This concludes The American Institute of Architects Continuing Education Systems Course

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Lighting Enabled Systems & Applications

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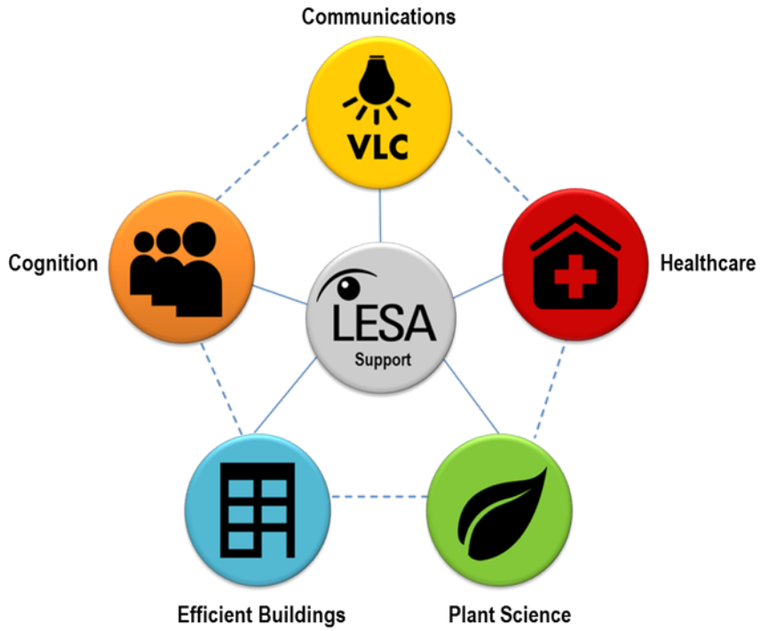

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