Slides adapted from Adrian Jarabo

✓ Computational displays (Lecture #6)

✓ Computational illumination (Lecture #7)

- Color values: Tristimuli? More accurate? Intensity range?

Inspired by a slide by Fredo Durand

- *A quantized electromagnetic wave* (***Quantum hypothesis***)


And assuming a time harmonic
monochromatic planar field
James Clerk Maxwell (1831-1979)

$$E_{\mathbf{xy}}(r) = \langle I_s \sin(\omega r + \phi_s), I_p \sin(\omega r + \phi_p) \rangle$$

$$E = \int_0 \quad |I_p(\lambda)|^2 + |I_s(\lambda)|^2 d\lambda$$

- The components of each phasor: **Amplitude and phase**

✓ Computational displays (Lecture #6)

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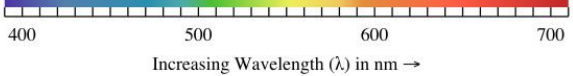
✓ Computational illumination (Lecture #7)

- How can we capture them back with our camera.

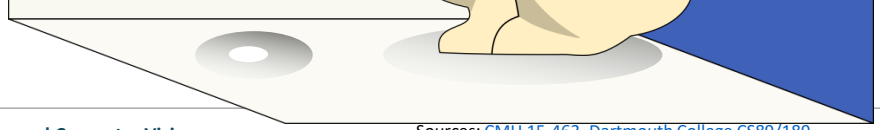
James Clerk Maxwell (1831-1979)

Source: Fredo Durand

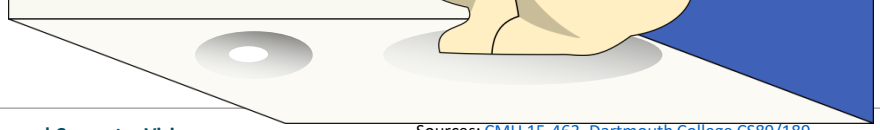
color is complicated



range of these wavelengths.



Sources: CMU 15-463, Dartmouth College CS89/189.



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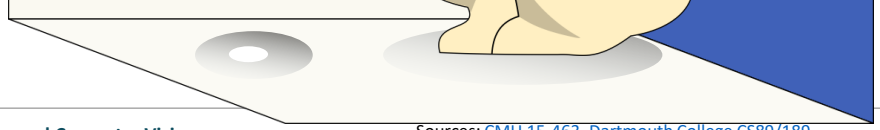
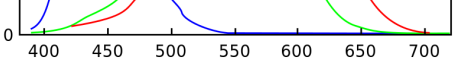


Sources: CMU 15-463, Dartmouth College CS89/189.

$$E = \int_0 \left(\Phi_p(\lambda) \left(\Phi_p(\lambda) \Phi_s(\lambda) \right) d_s(\lambda) \right) d\lambda$$

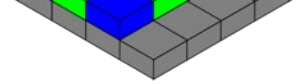
cone distribution for normal vision
(64% L, 32% M)

long $L = \int_{\lambda} \Phi(\lambda) L(\lambda) d\lambda$

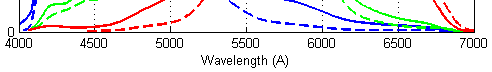


Colours, and the Relations of the Colours of the Spectrum.” Philosophical Transactions of the Royal Society of London

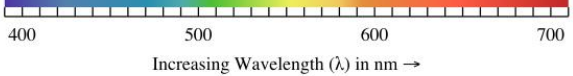
Why more green pixels?



Generally do not match human LMS.



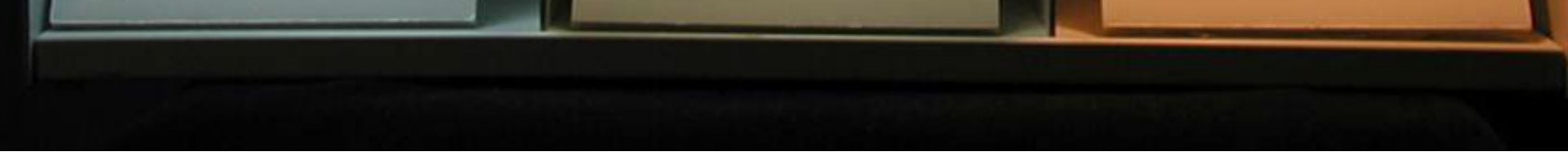
$f(\lambda)$


400
500
600
700
Increasing Wavelength (λ) in nm →


UV
IR


UV
IR
λ


S
M
L
S
M
L



[1] NASA
[3] rshephorse, Flickr
[2] Cheng et al., Vibrational spectroscopic imaging of living systems: An emerging platform for biology and medicine, Science 2015

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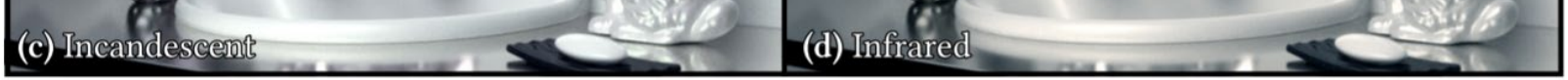
Source: Baek et al. 2017

Source: Liu et al. 2017



Source: [Dupuy and Jakob, 2018]

Source: [Alvarez-Cortes et al. 2015]

Dawn of the Planet of the Apes © 20th Century Fox


UV
IR
λ

- Static Scenes only
- Low spatial resolution

Source: Choi et al. 2017

Brainstorming:

Can we do this with a conventional (i.e. no filters) camera?

(2D) (3D to 2D)

Source: Choi et al. 2017

Reconstruction is an inverse problem of optical imaging

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aperture?

Source: Baek et al. 2017

Source: Choi et al. 2017

(2D) (3D to 2D)

Source: Choi et al. 2017

Source: Choi et al. 2017

Source: Choi et al. 2017

Choi et al. 2017

Choi et al. 2017

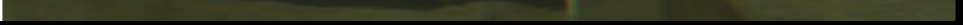
N/2 samples = N pixels

[Lin et al. 2014]

Source: Choi et al. 2017

sparse coding (PSNR: 28.36dB)

Choi et al. 2017



Source: Baek et al. 2017

Source: Baek et al. 2017

- *Exploiting sparsity on the gradient domain.*
- *See [Baek et al. 2017]*

James Clerk Maxwell (1831-1979)

- How can we capture them back with our camera.

Source: Fredo Durand

$$E_{\mathbf{xy}}(r) = \langle I_s \sin(\omega r + \phi_s), I_p \sin(\omega r + \phi_p) \rangle$$

Linear polarization

Linear polarization

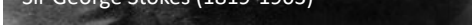
Elliptical polarization

Elliptical polarization – Off-phase

If $I_s = I_p$ and $\phi_s - \phi_p = 90º$ then circular polarization

$$E_{\mathbf{xy}}(r) = \langle I_s \sin(\omega r + \phi_s), I_p \sin(\omega r + \phi_p) \rangle$$

We need another form of representing pol/unpolarized light!



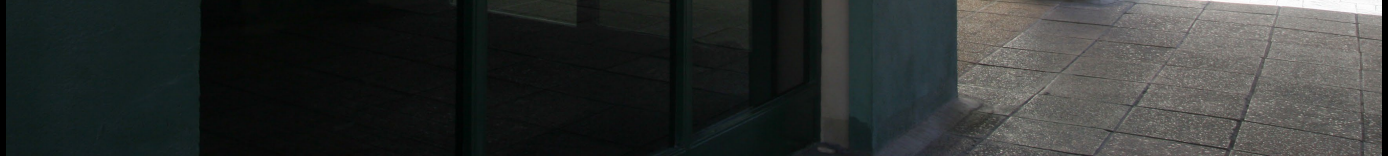
Sir George Stokes (1819-1903)

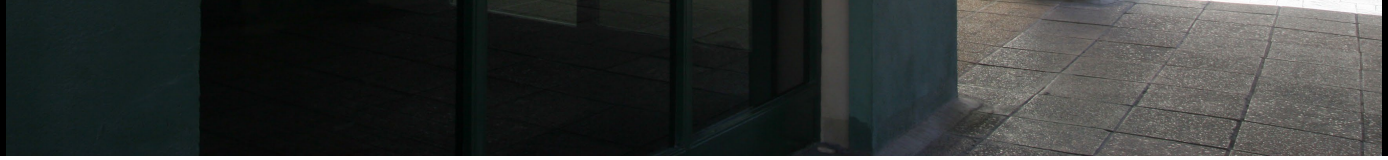
Philosophical Society

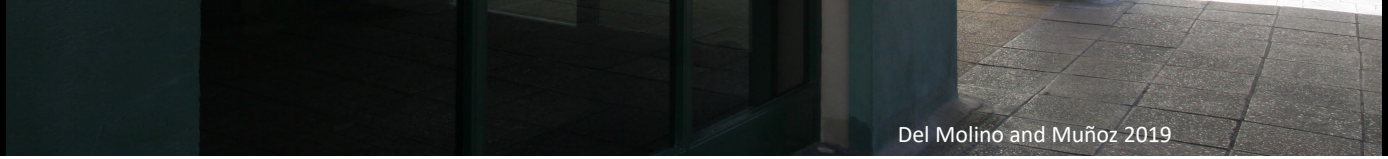
Sir George Stokes (1819-1903)

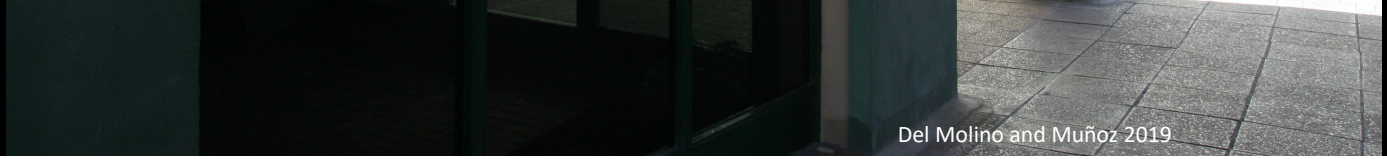
$$S_3 = \mathrm{Im}(E_p E_s^*)$$

Sir George Stokes (1819-1903)






Del Molino and Muñoz 2019


Del Molino and Muñoz 2019

Sources: CMU 15-463, Dartmouth College CS89/189.


(b)
(d)
(f)

Sources: CMU 15-463, Dartmouth College CS89/189.

- ...

A conventional Camera

Polarizing Filters

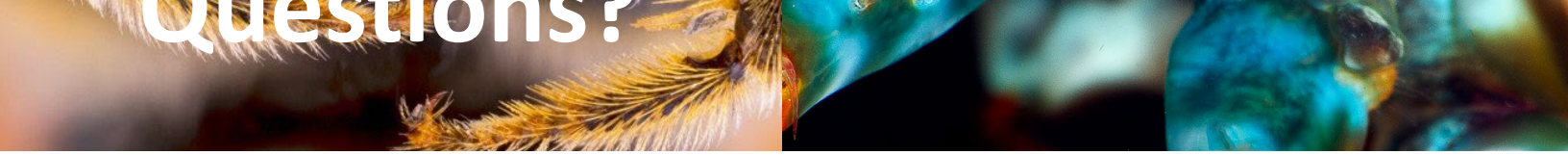
Del Molino and Muñoz 2019

Del Molino and Muñoz 2019

Del Molino and Muñoz 2019

Del Molino and Muñoz 2019

- In the end, some of the most sophisticated eyes in nature exploit them heavily.


Questions?

for depth estimation in scattering media. *Optics letters*, *43*(6), 1299-1302.