Start record

Computational Photography

CSE 576, Spring 2020

Aleksander Holynski

References:

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https://ai.googleblog.com/2018/11/night-sight-seeing-in-dark-on-pixel.html
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https://www.timothybrooks.com/tech/hdr-plus/
https://ai.googleblog.com/2017/10/portrait-mode-on-pixel-2-and-pixel-2-xl.html
https://arxiv.org/abs/1812.08861
https://sites.google.com/view/handheld-super-res/

Slides + materials borrowed from:

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[Seitz] https://docs.google.com/presentation/d/13BZeGNF6MyNMWAnBETzf3hT41QR3ktL46UhZMshkkOw/edit
[Hedman et al] https://richardt.name/publications/capture4vr/
[Debevec et al] http://www.pauldebevec.com/Research/HDR/ & http://www.pauldebevec.com/Research/HDR/debevec-siggraph97.pdf
[Hedman et al] http://visual.cs.ucl.ac.uk/pubs/instant3d/
[Hoppe et al] http://hhoppe.com/proj/flash/
https://www.youtube.com/watch?v=VQgYPv8tb6A
[Efros] http://graphics.cs.cmu.edu/courses/15-463/2005_fall/www/463.html

[reference]

Aleksander Holynski

Aleksander Holynski

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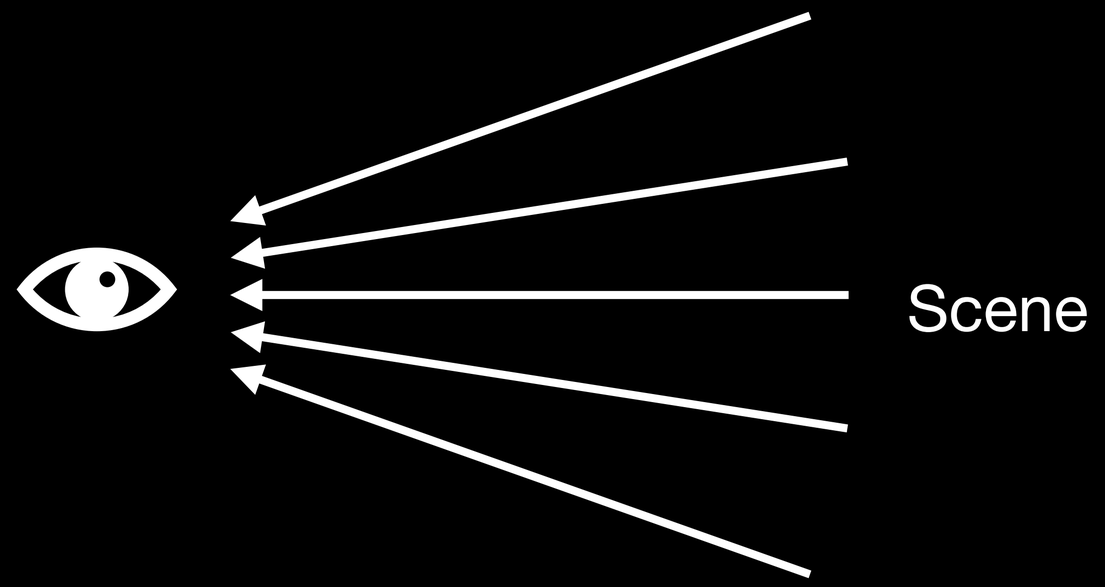
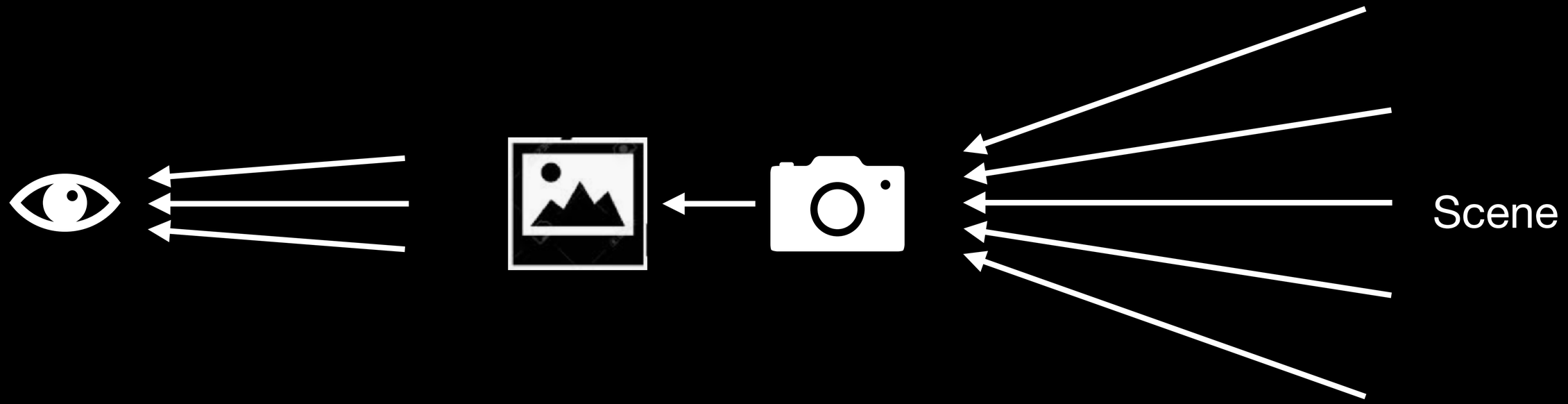
Aleksander Holynski

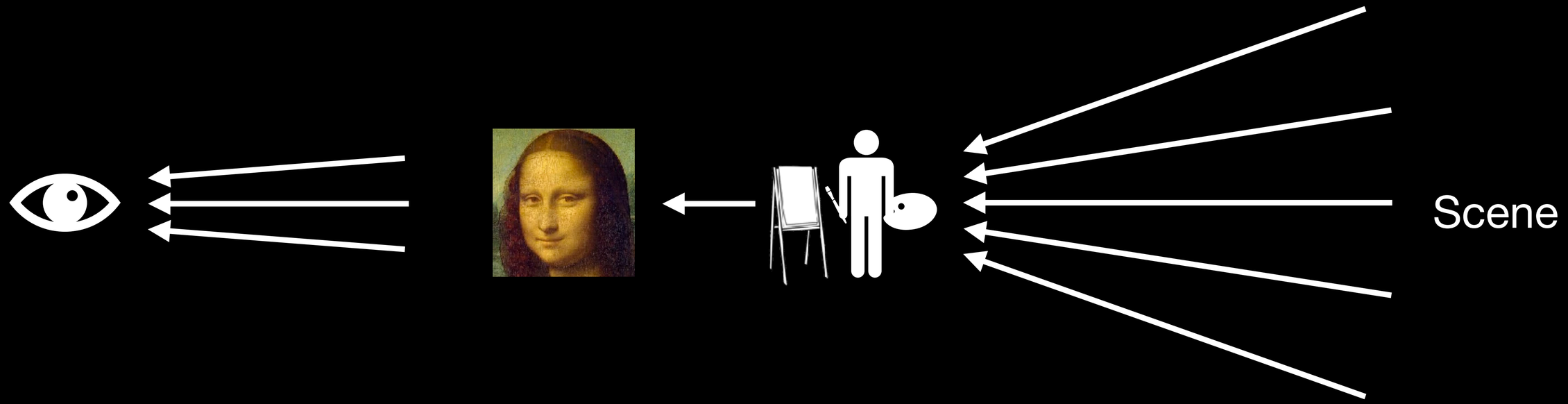
Aleksander Holynski

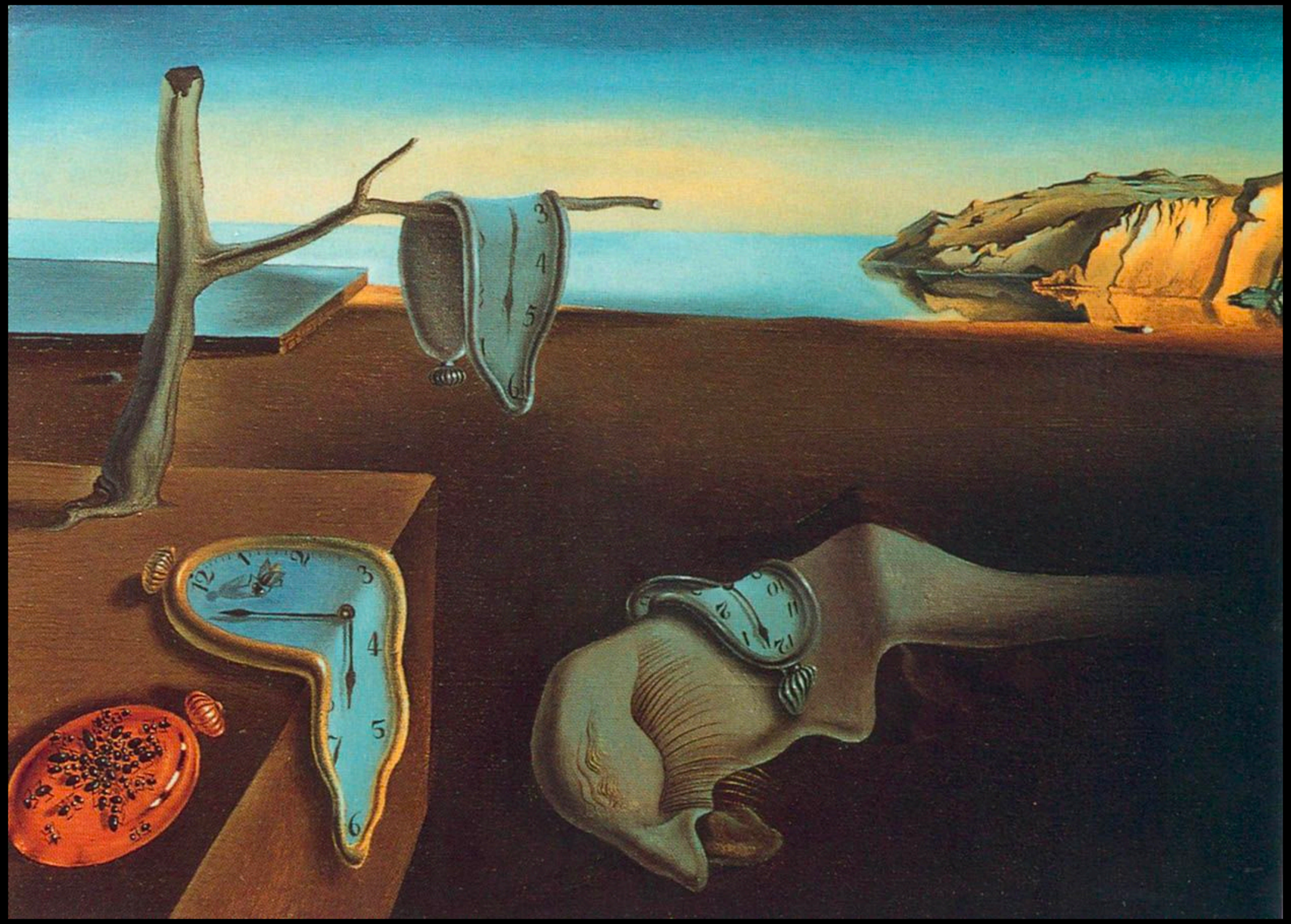
What is a camera?

What is a photograph?


Scene

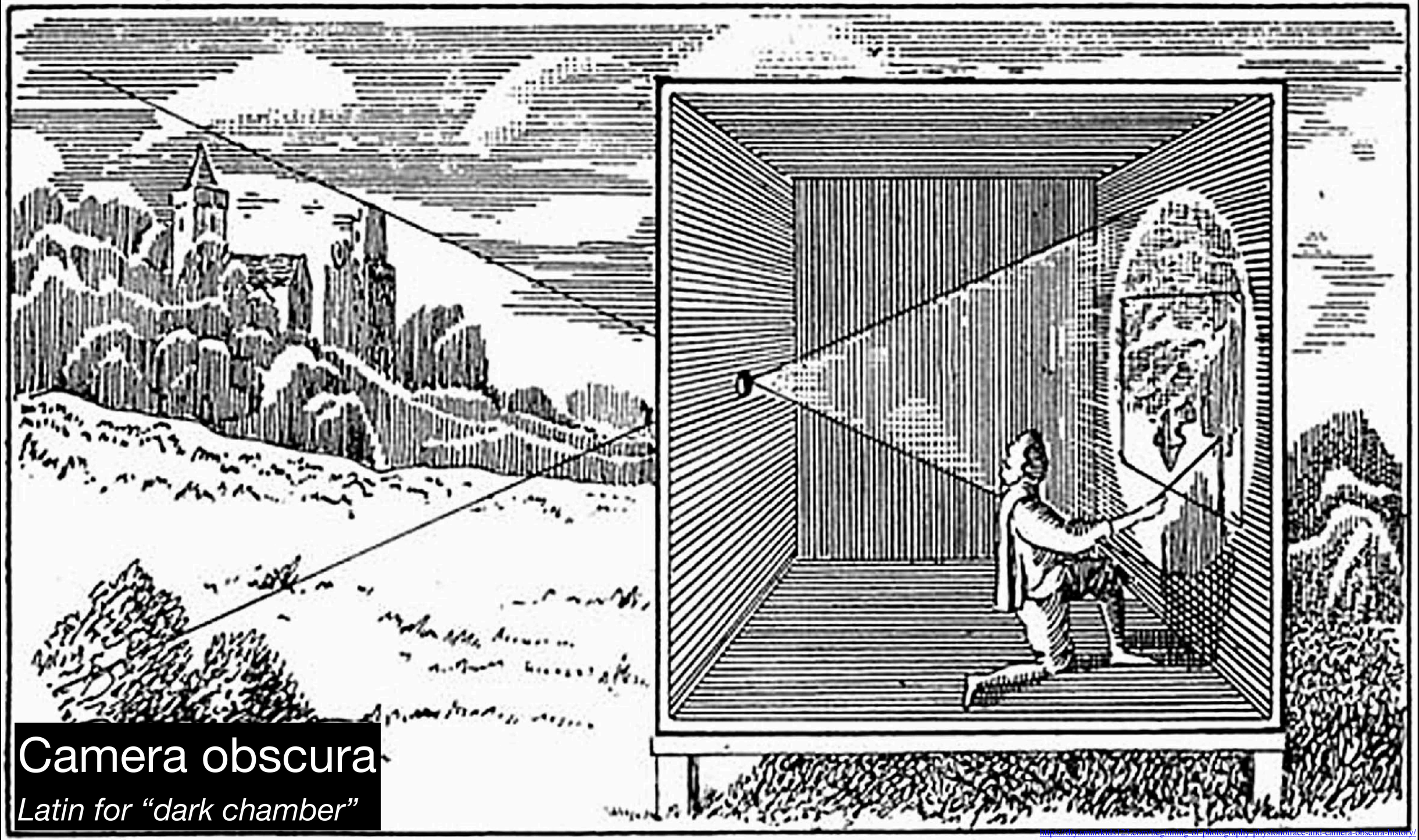

Scene


Scene



Art ≠ realism

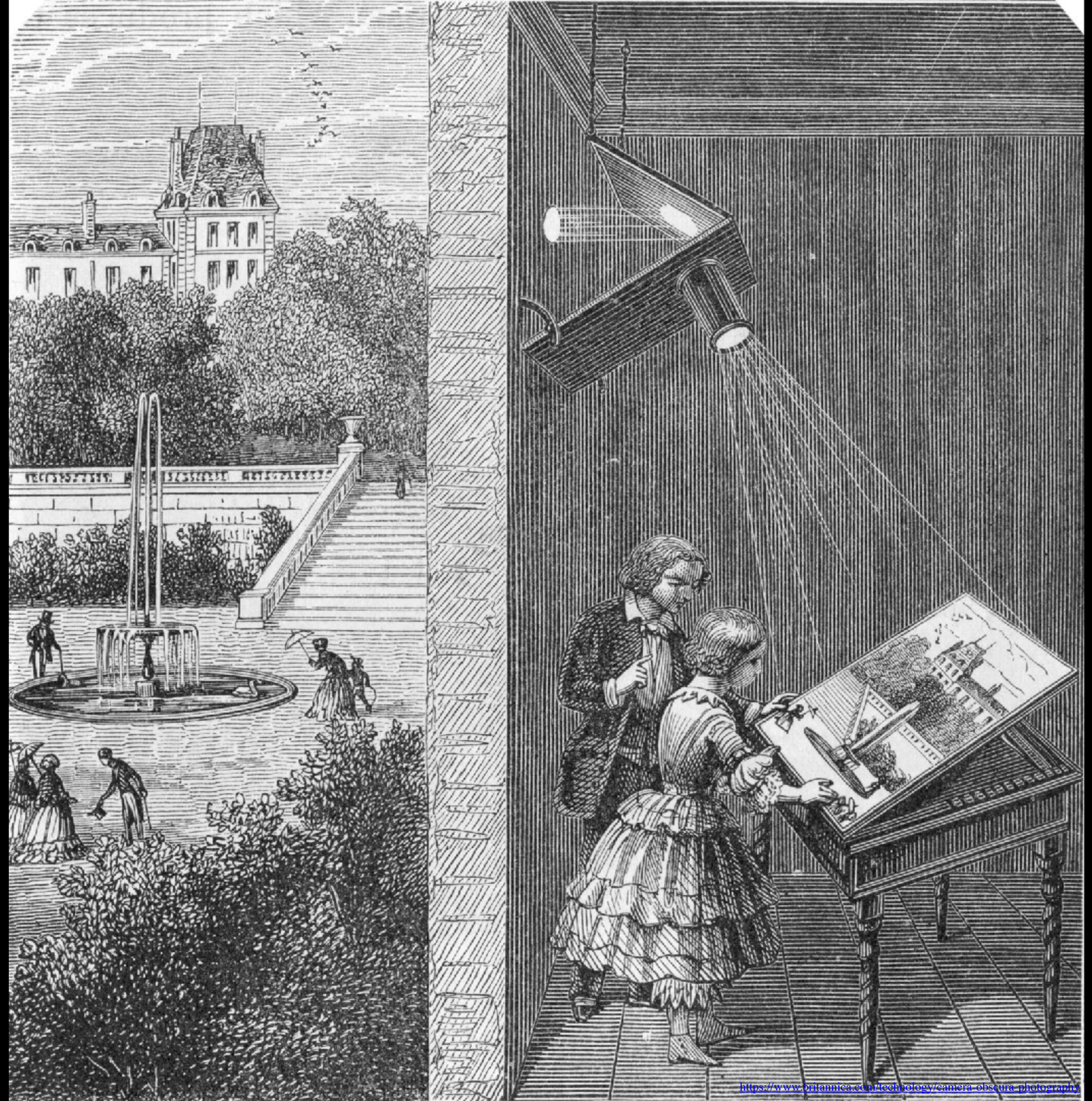
Realism is hard



Camera obscura

Latin for “dark chamber”

https://ryanmarkham123.com/beginning-of-photography-physionotrace-and-camera-obscura-history/



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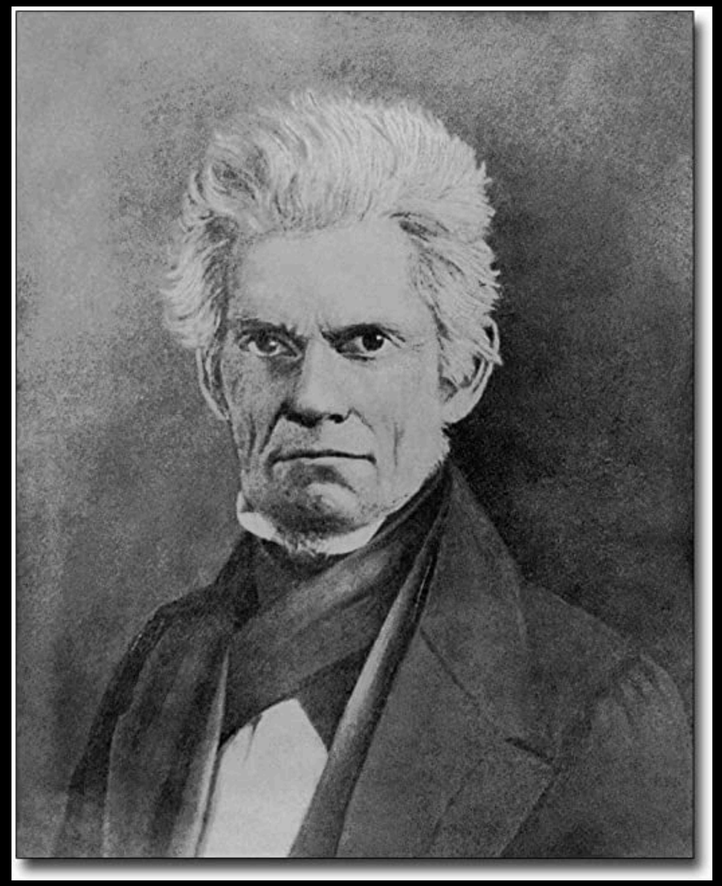
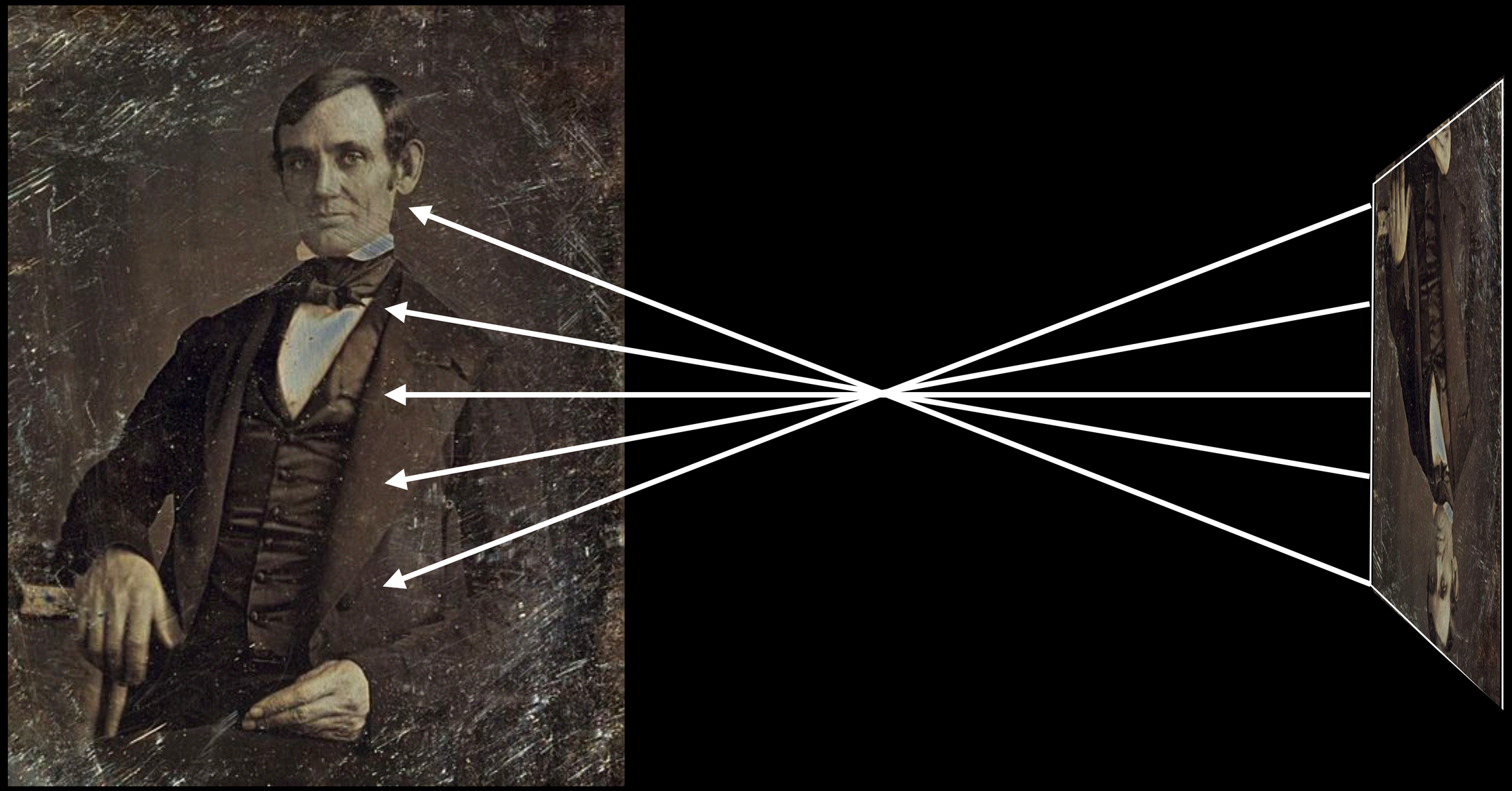
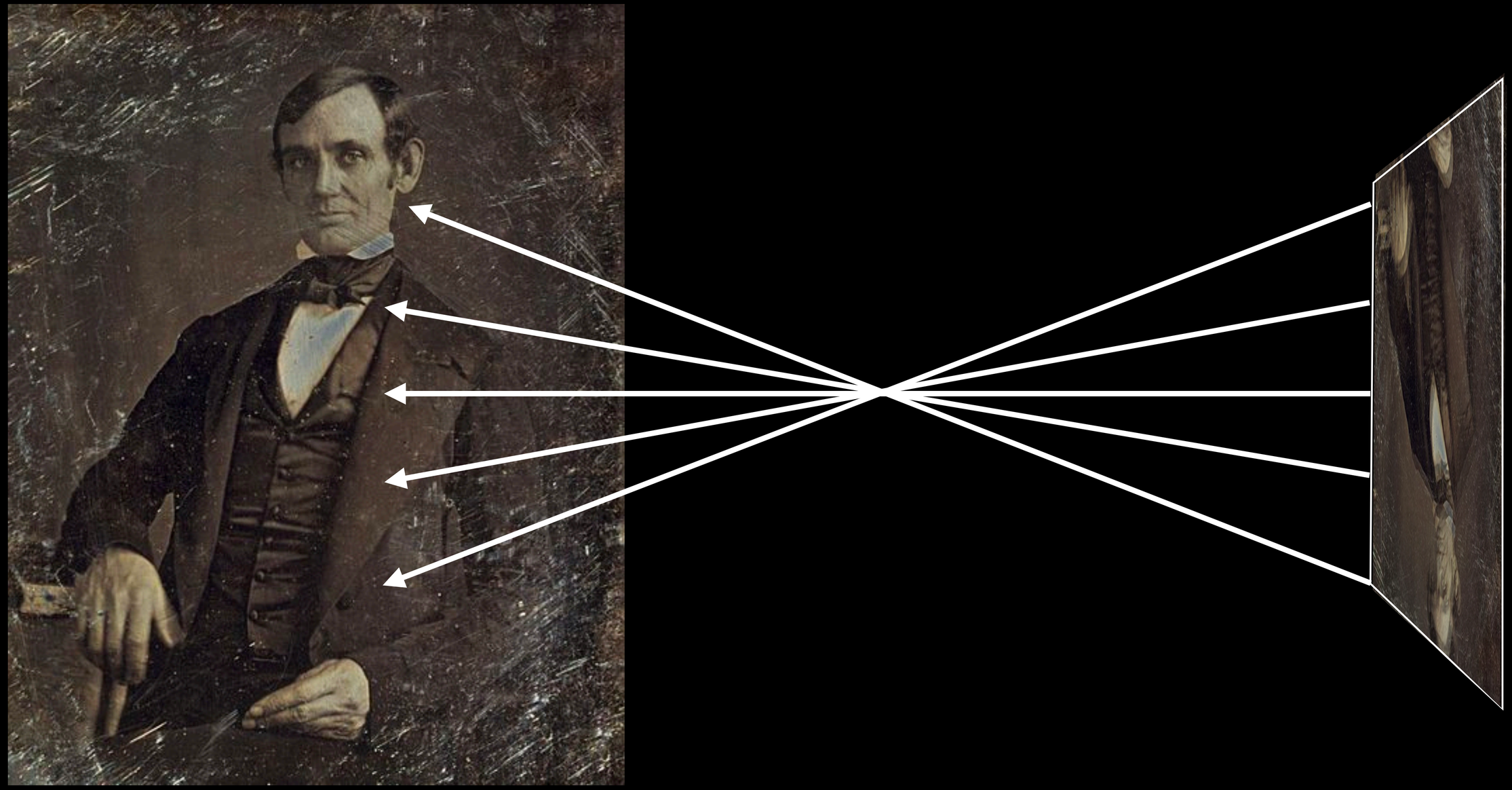
https://www.nrw.net/artwork/radenko-milak-drawing-a-landscape-using-a-portable-camera-obscura



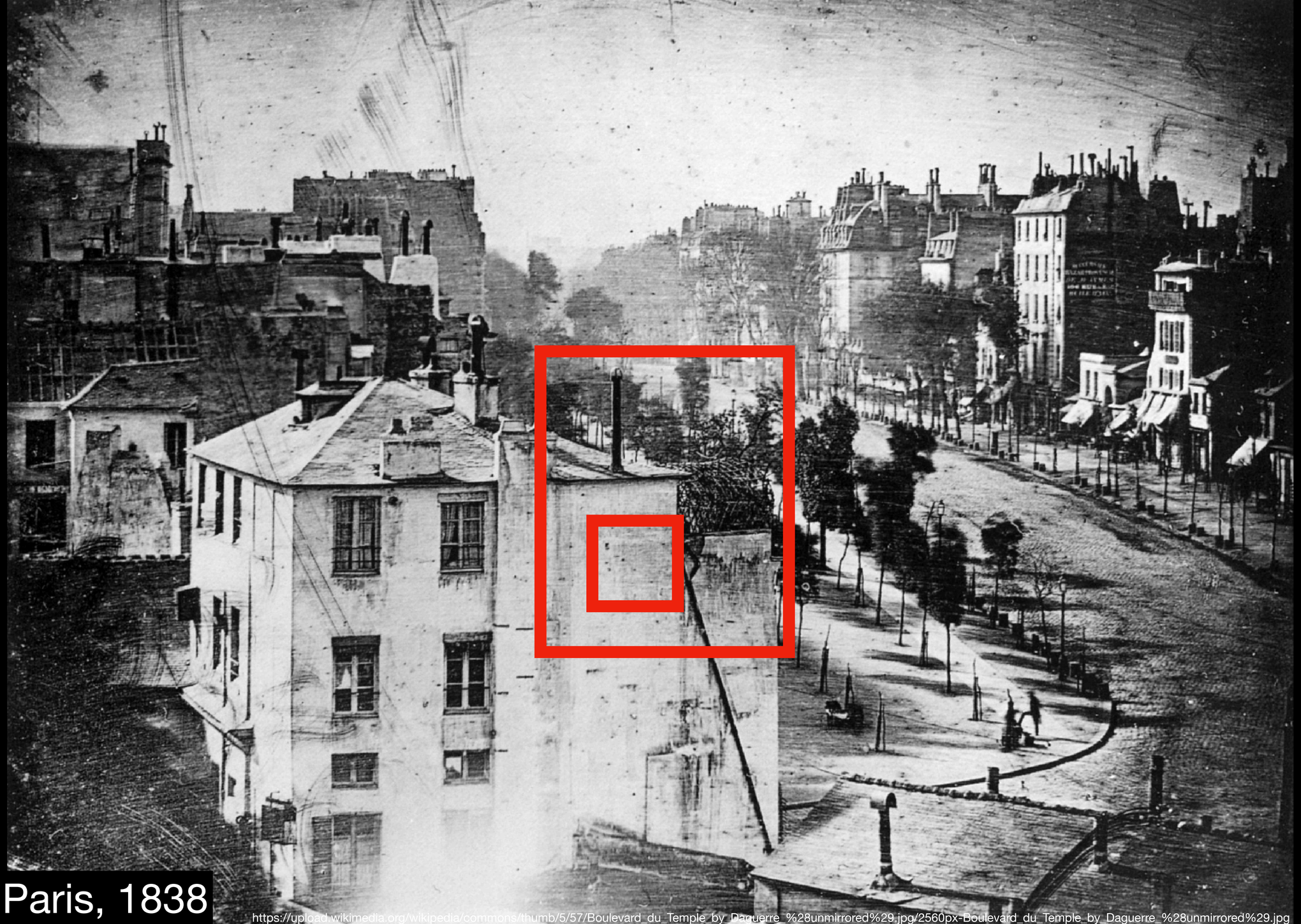
Dageurrotypes

Louis Daguerre & Nicéphore Niépce



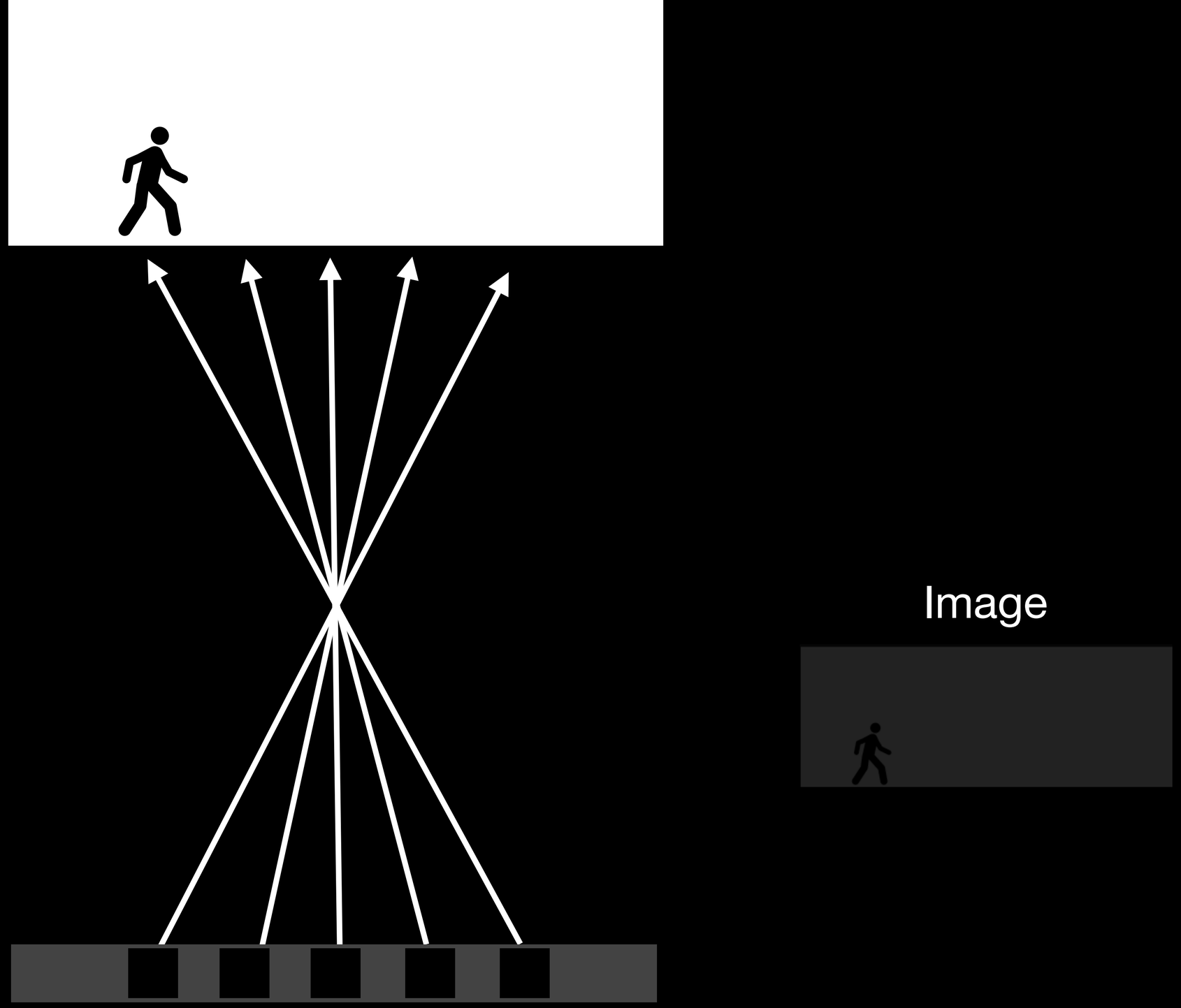


Motion blur

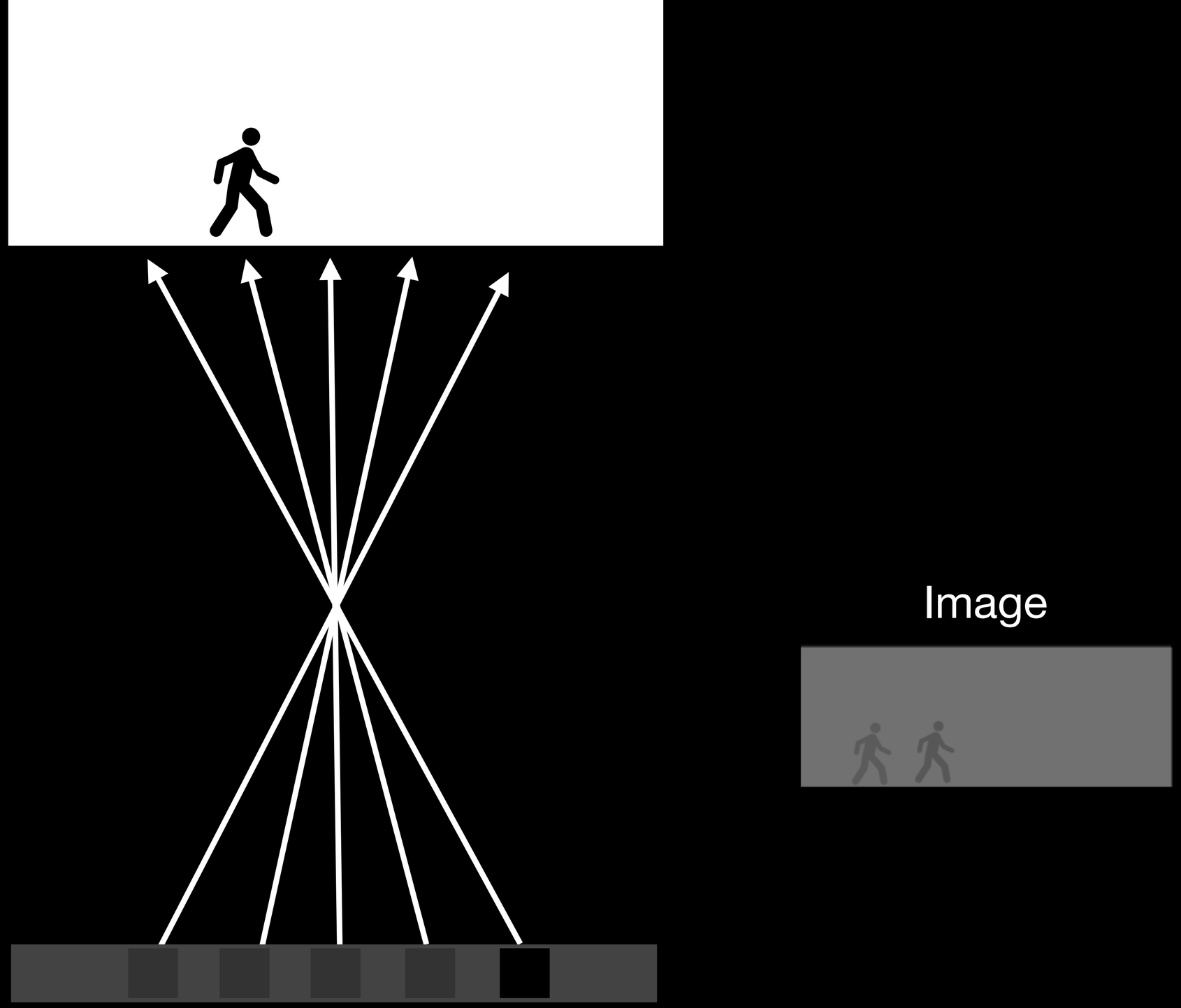


Paris, 1838

https://upload.wikimedia.org/wikipedia/commons/thumb/5/57/Boulevard_du_Temple_by_Daguerre_%28unmirrored%29.jpg/2560px-Boulevard_du_Temple_by_Daguerre_%28unmirrored%29.jpg



t = 1



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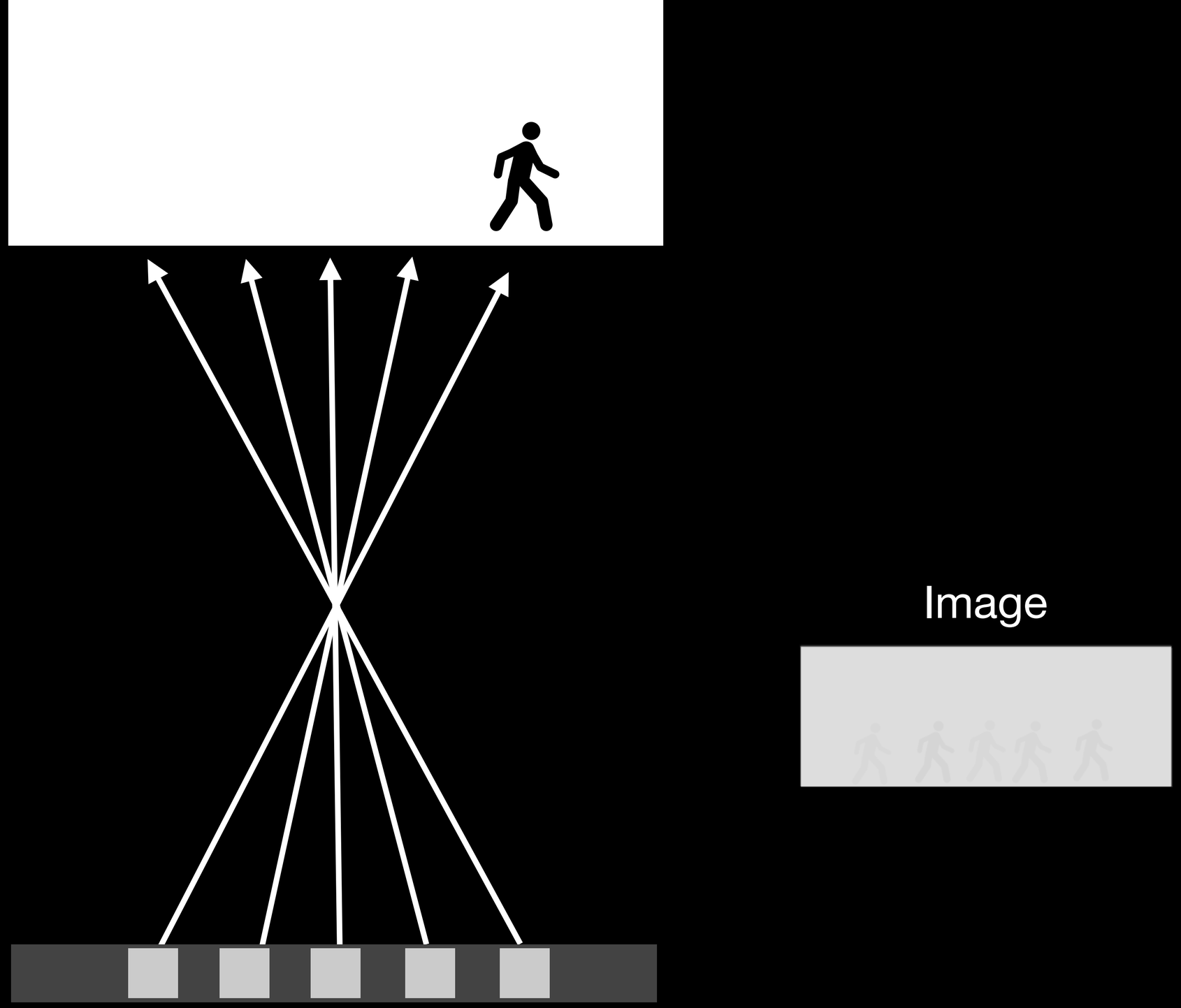


t = 5

happy
thinkmakeshareblog.com

larue.photo

1830s

1925

Instant cameras

$13,000

0.01MP

1975, Kodak’s first digital camera

$2000

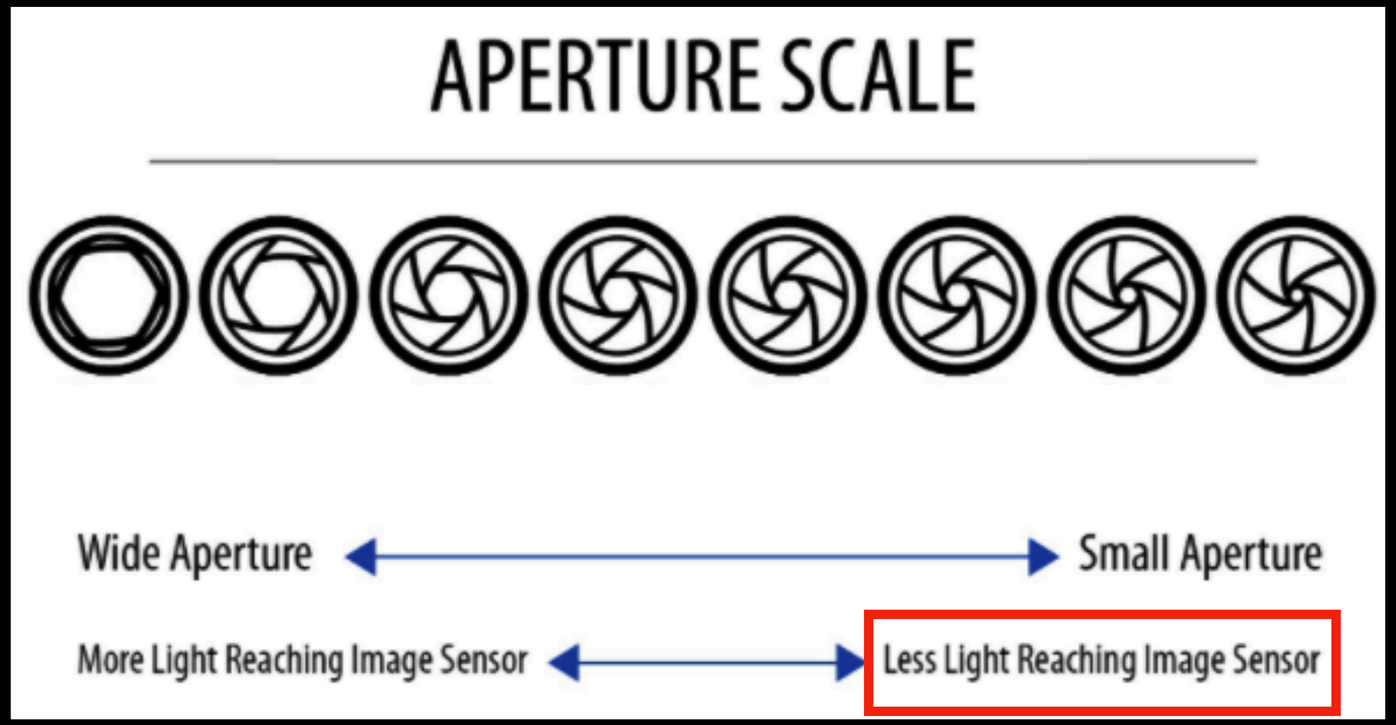
46MP

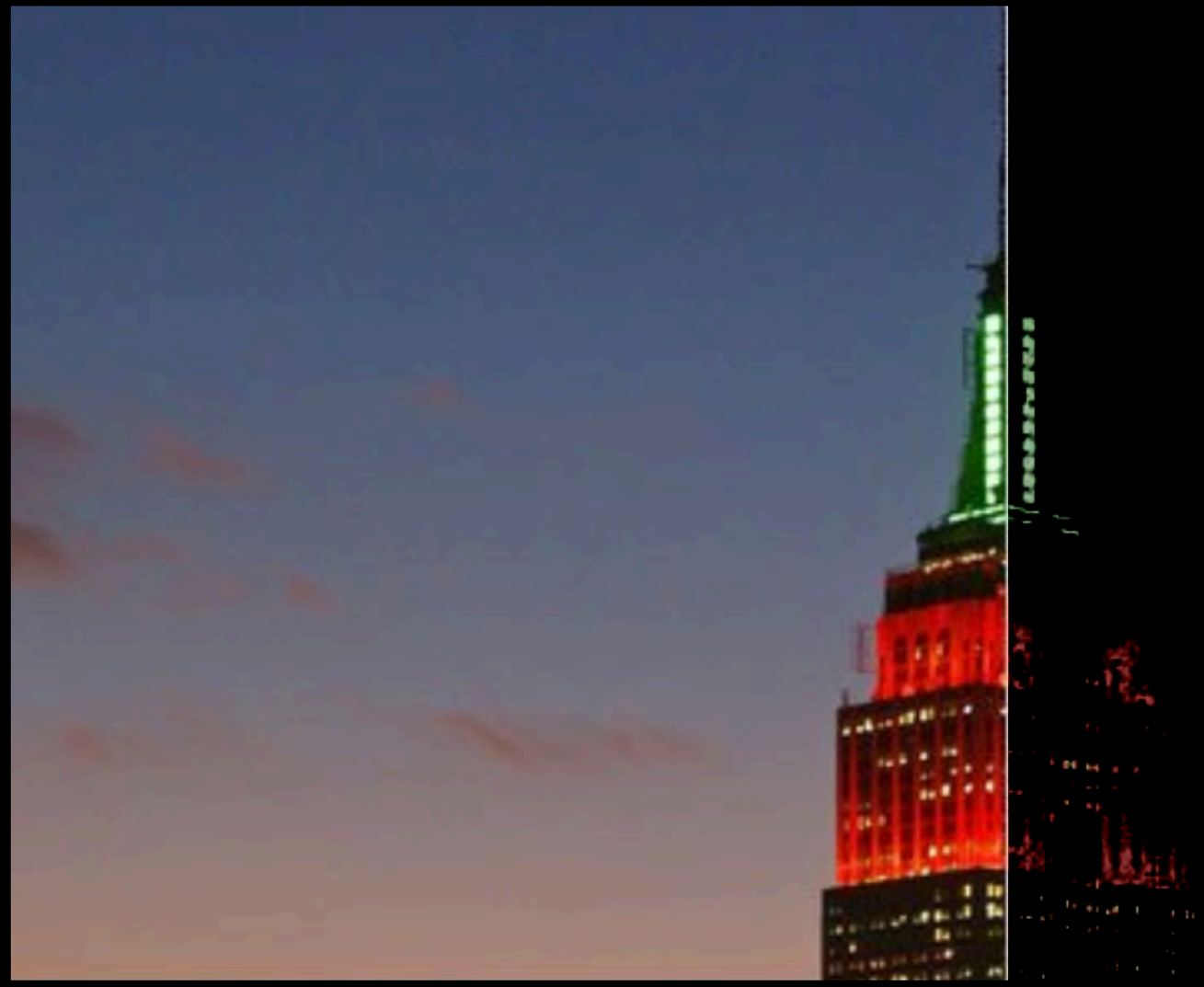
Today

Sensor size: ~1400 mm^2 ~30 mm^2

Chapter 1

Merging bursts


APERTURE SCALE
Wide Aperture
Small Aperture
More Light Reaching Image Sensor
Less Light Reaching Image Sensor

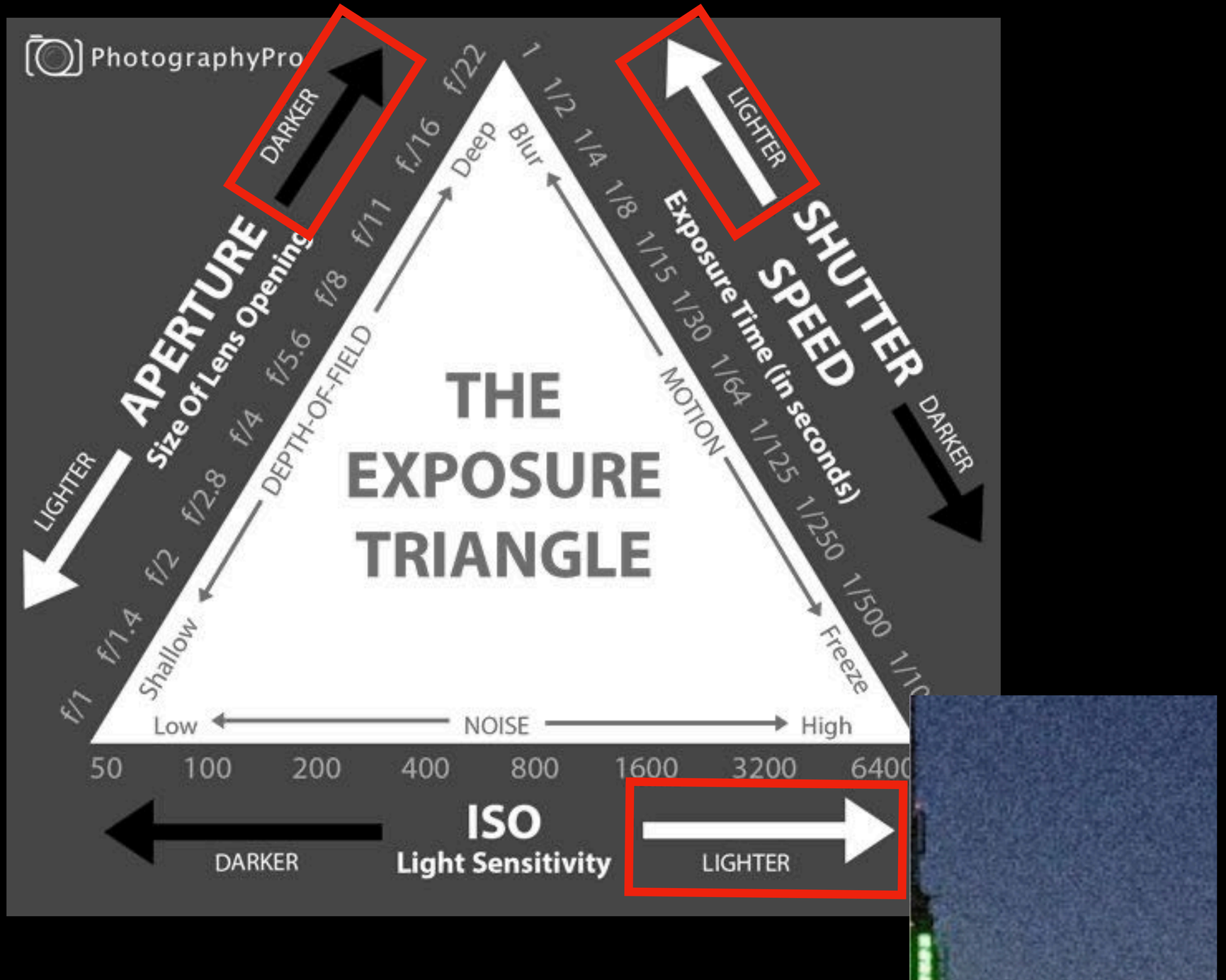


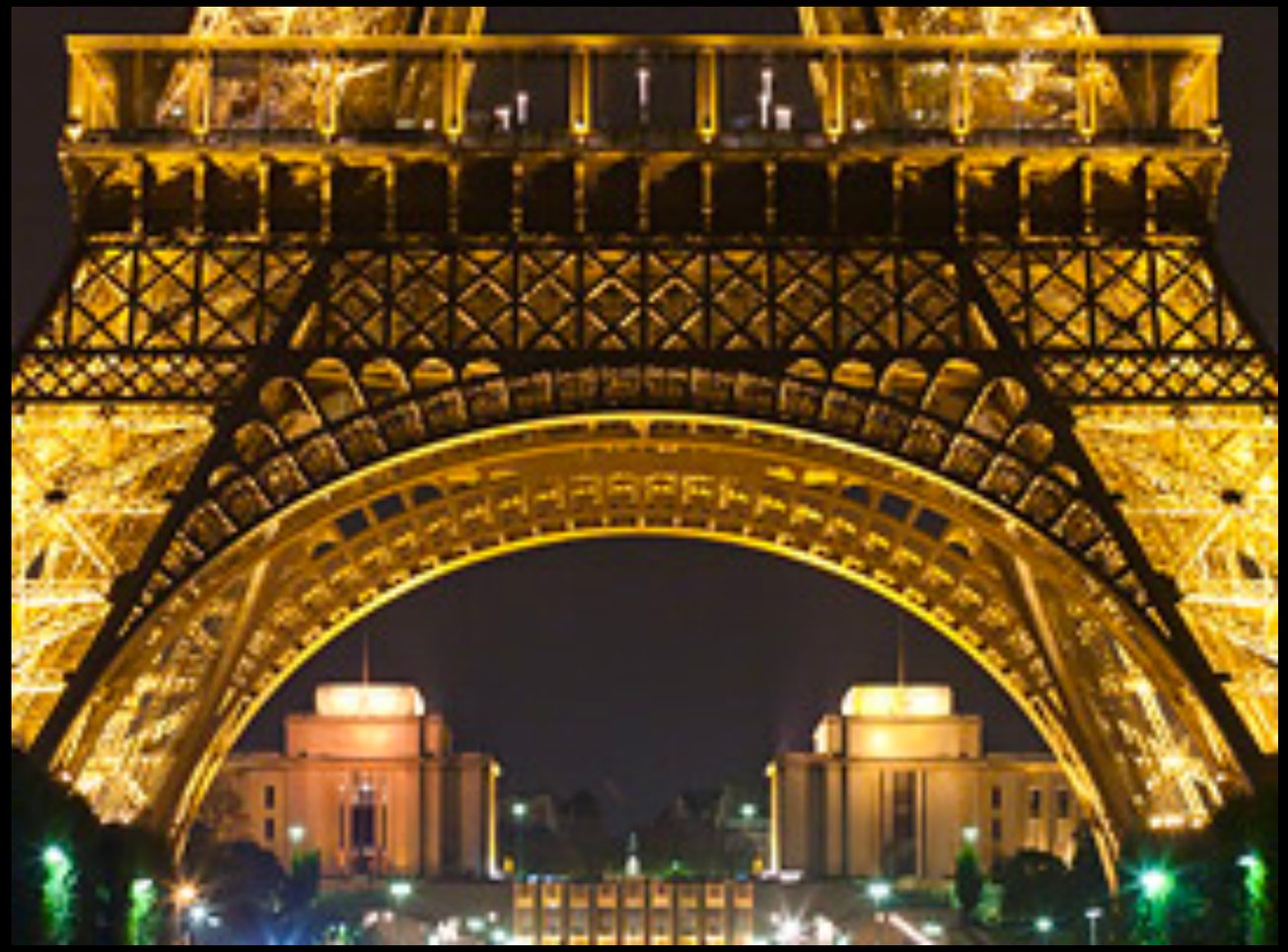
Larger opening

Smaller opening

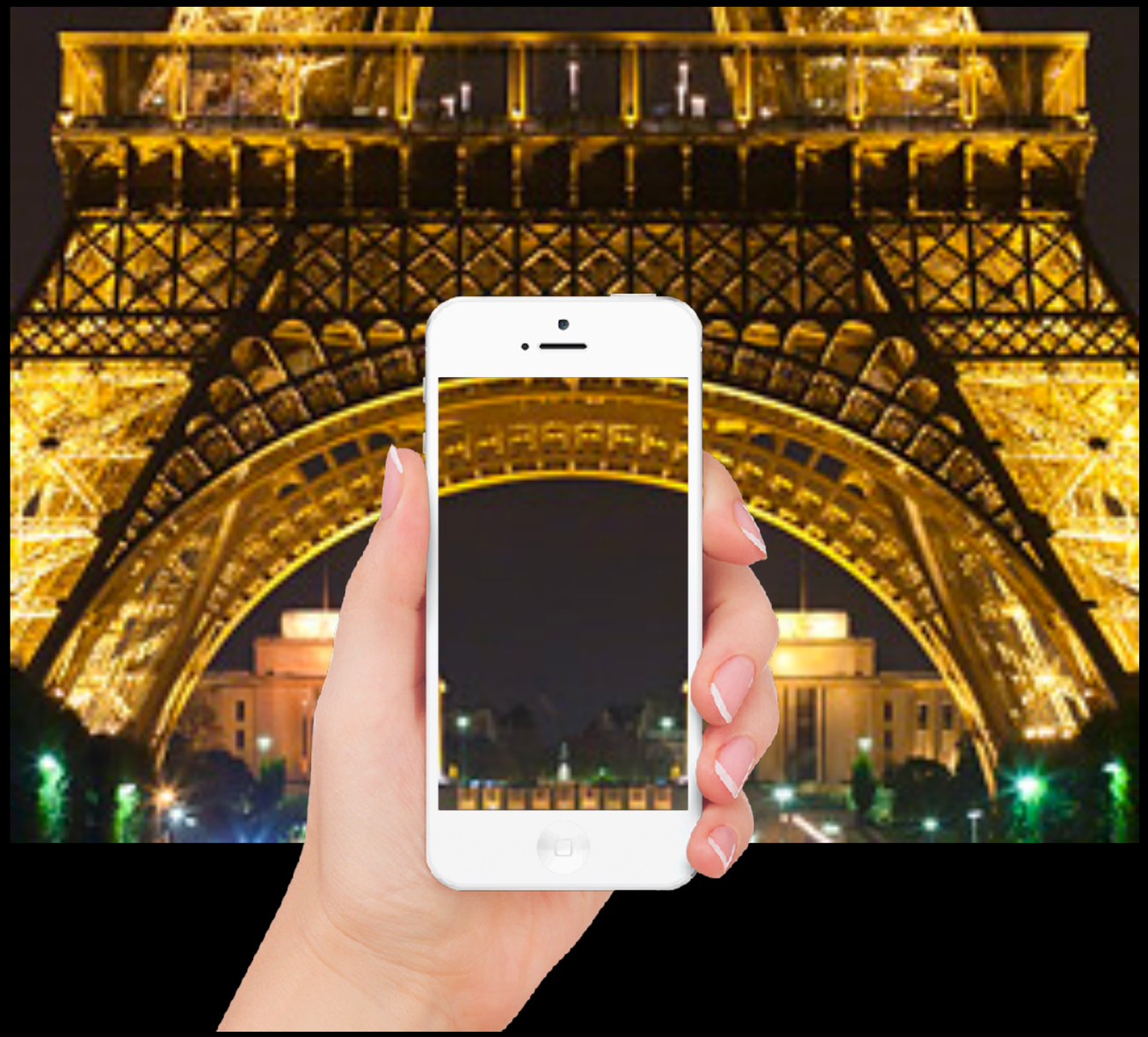
Larger opening

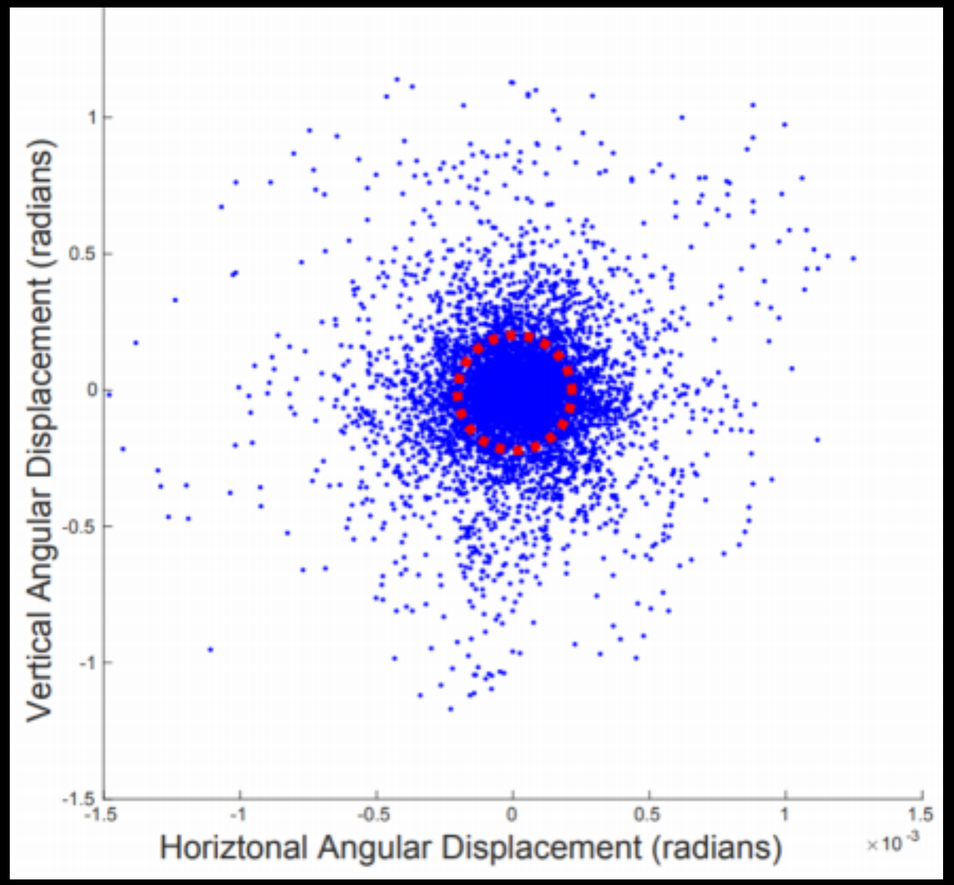
Smaller opening


PhotographyPro
THE EXPOSURE TRIANGLE
APERTURE
Size of Lens Opening
DARKER
LIGHTER
f/1 f/1.4 f/2 f/2.8 f/4 f/5.6 f/8 f/11 f/16 f/22
Shallow
DEPTH-OF-FIELD
Deep
SHUTTER SPEED
Exposure Time (in seconds)
LIGHTER
DARKER
1 1/2 1/4 1/8 1/15 1/30 1/64 1/125 1/250 1/500
Blur
MOTION
Freeze
Low
NOISE
High
50 100 200 400 800 1600 3200 6400
ISO
Light Sensitivity
DARKER
LIGHTER



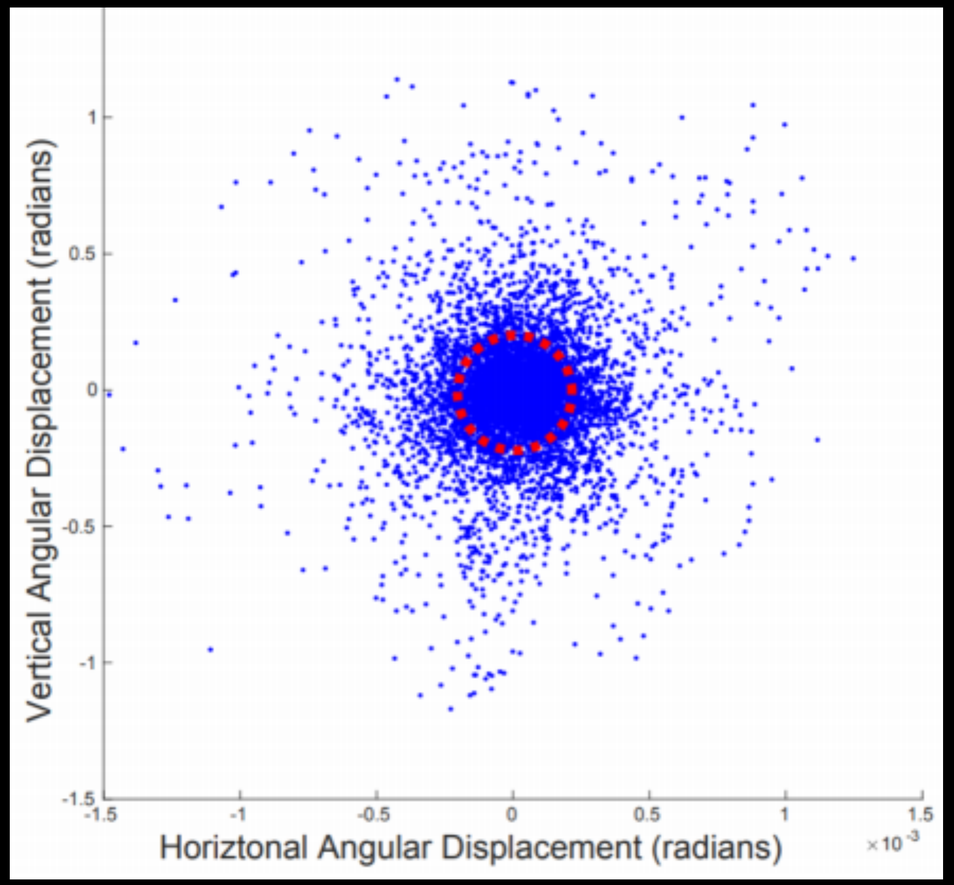
Canon
EOS 600D





[Wronski et al]

https://arxiv.org/pdf/1905.03277.pdf

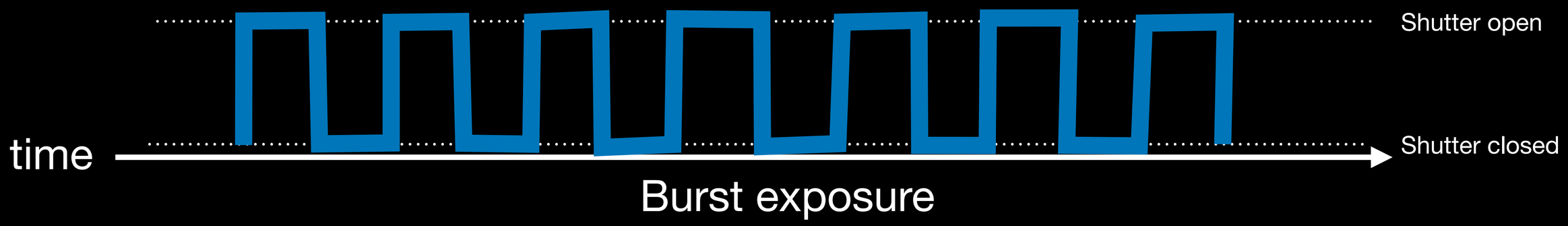


[Wronski et al]

https://arxiv.org/pdf/1905.03277.pdf

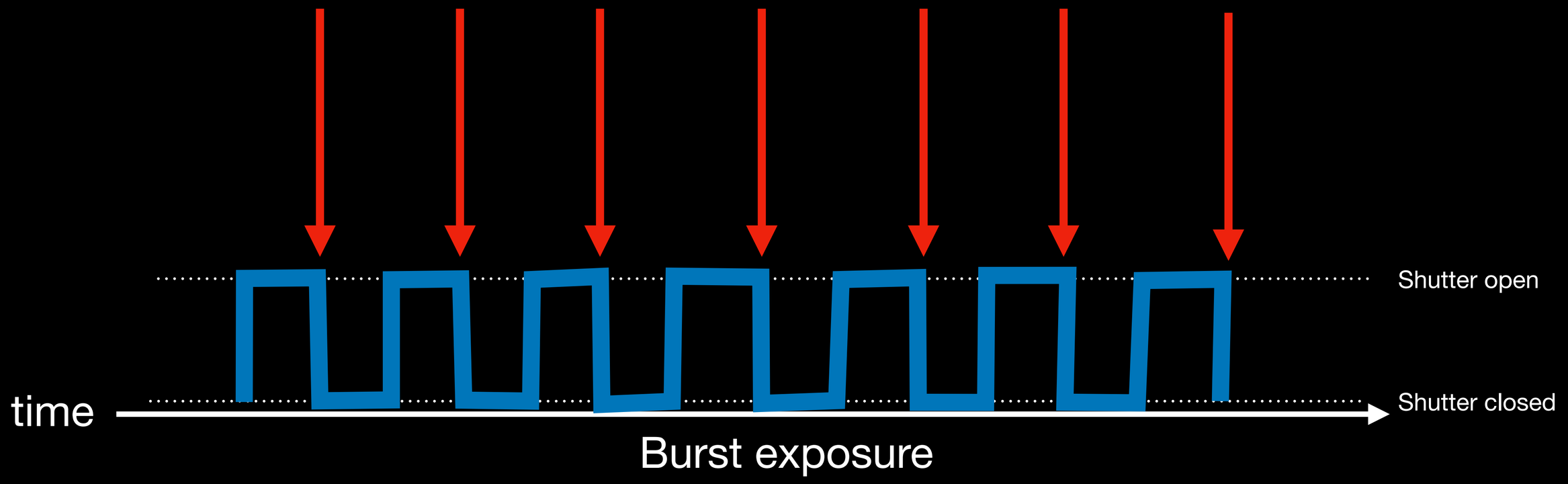
Burst photography

Burst photography



NO PARKING
518
518
Indochine

Burst photography



[Wronski et al]

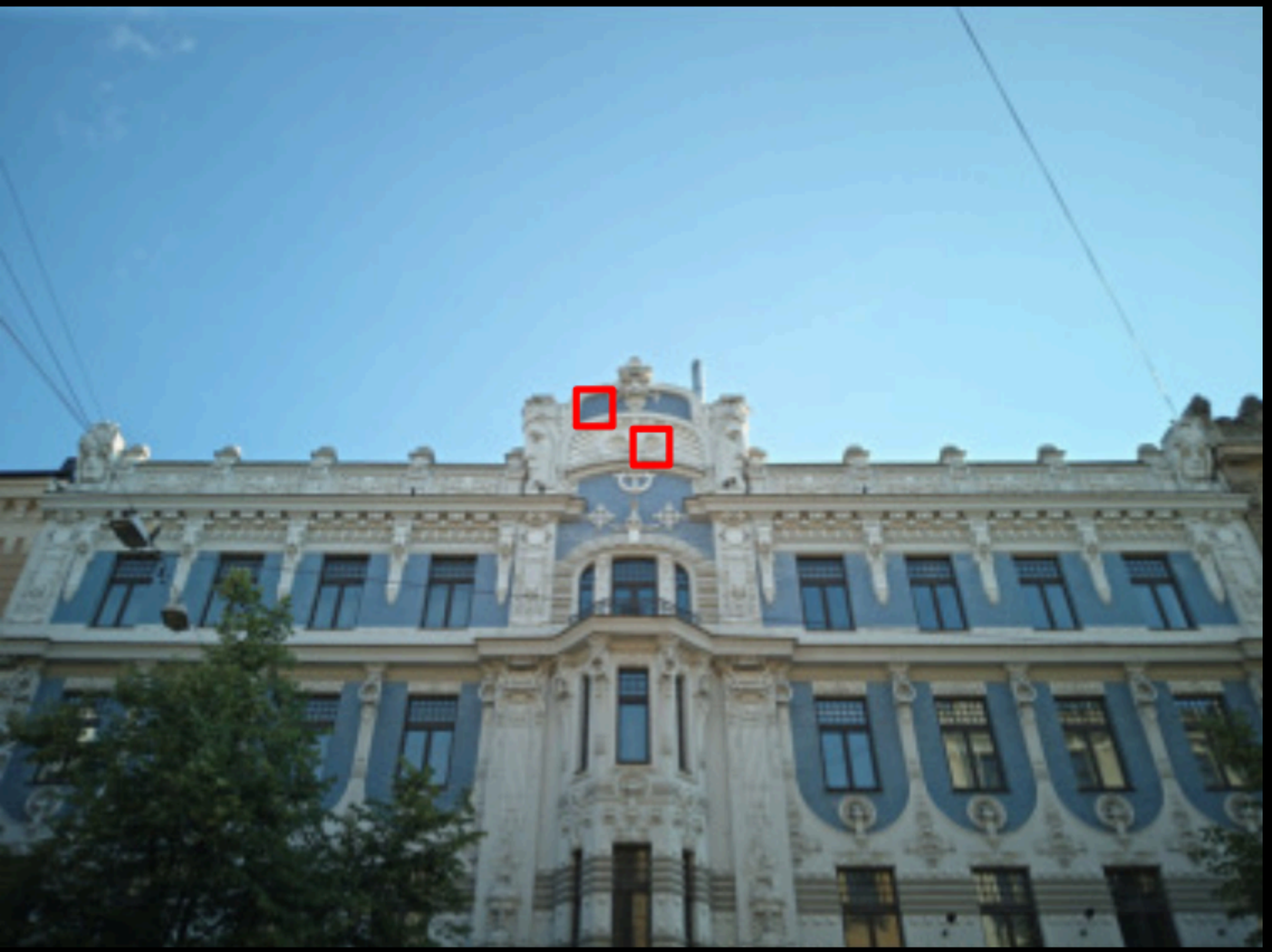
https://arxiv.org/pdf/1905.03277.pdf

[Wronski et al]

https://arxiv.org/pdf/1905.03277.pdf

[Wronski et al]

https://arxiv.org/pdf/1905.03275.pdf



[Wronski et al]

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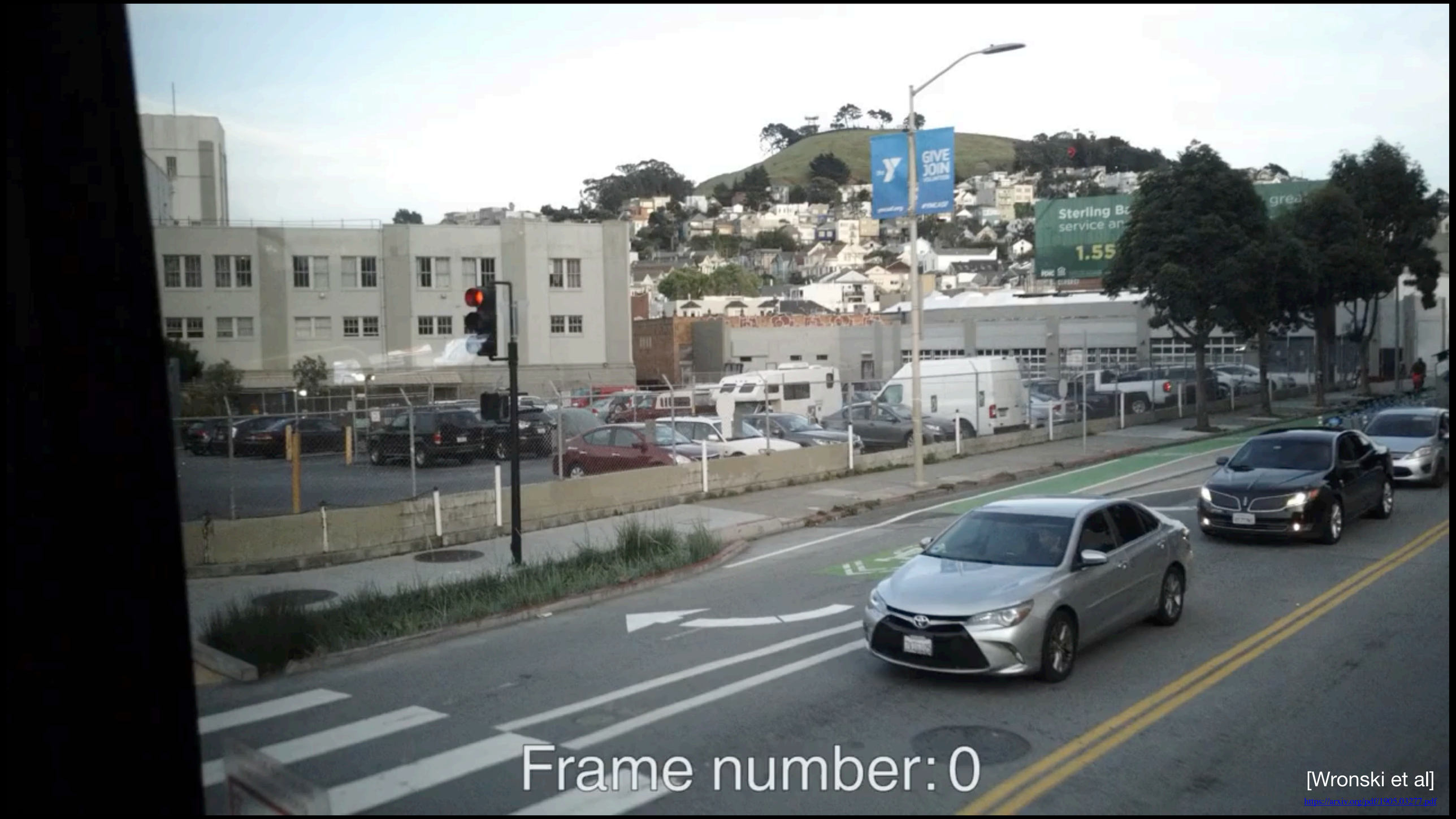


[Wronski et al]

https://arxiv.org/pdf/1905.03277.pdf

[Wronski et al]

https://arxiv.org/pdf/1905.03277.pdf

[Wronski et al]

https://arxiv.org/pdf/1905.03277.pdf

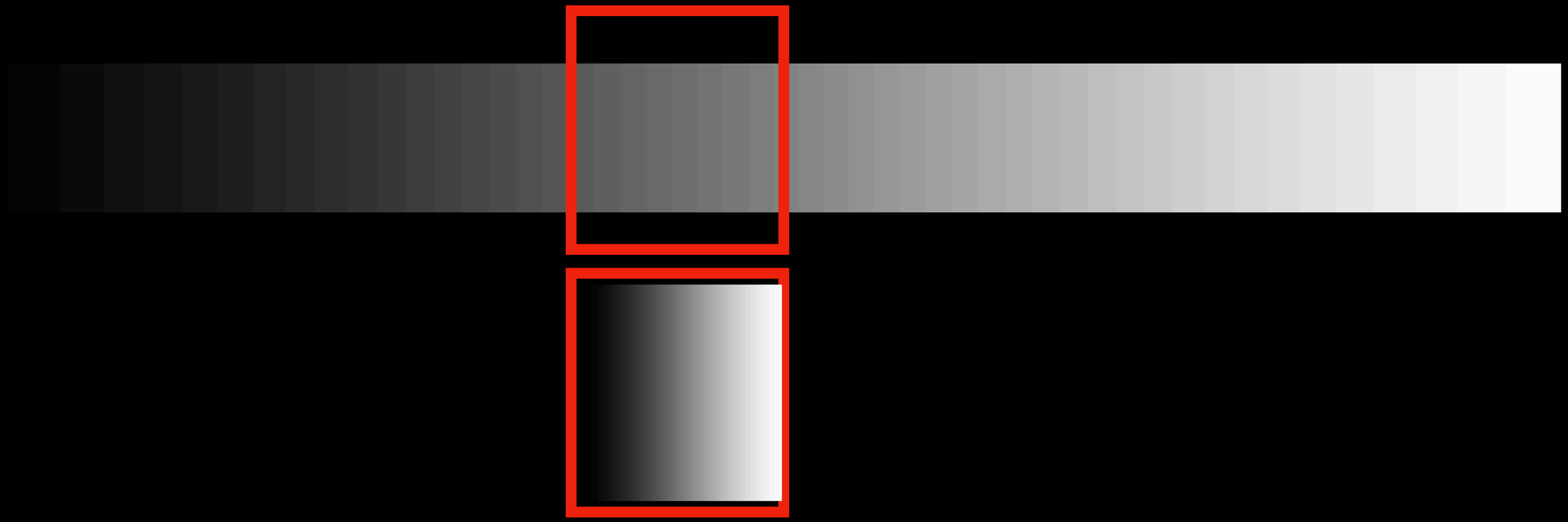
[Wronski et al.]
https://arxiv.org/pdf/1905.03277.pdf

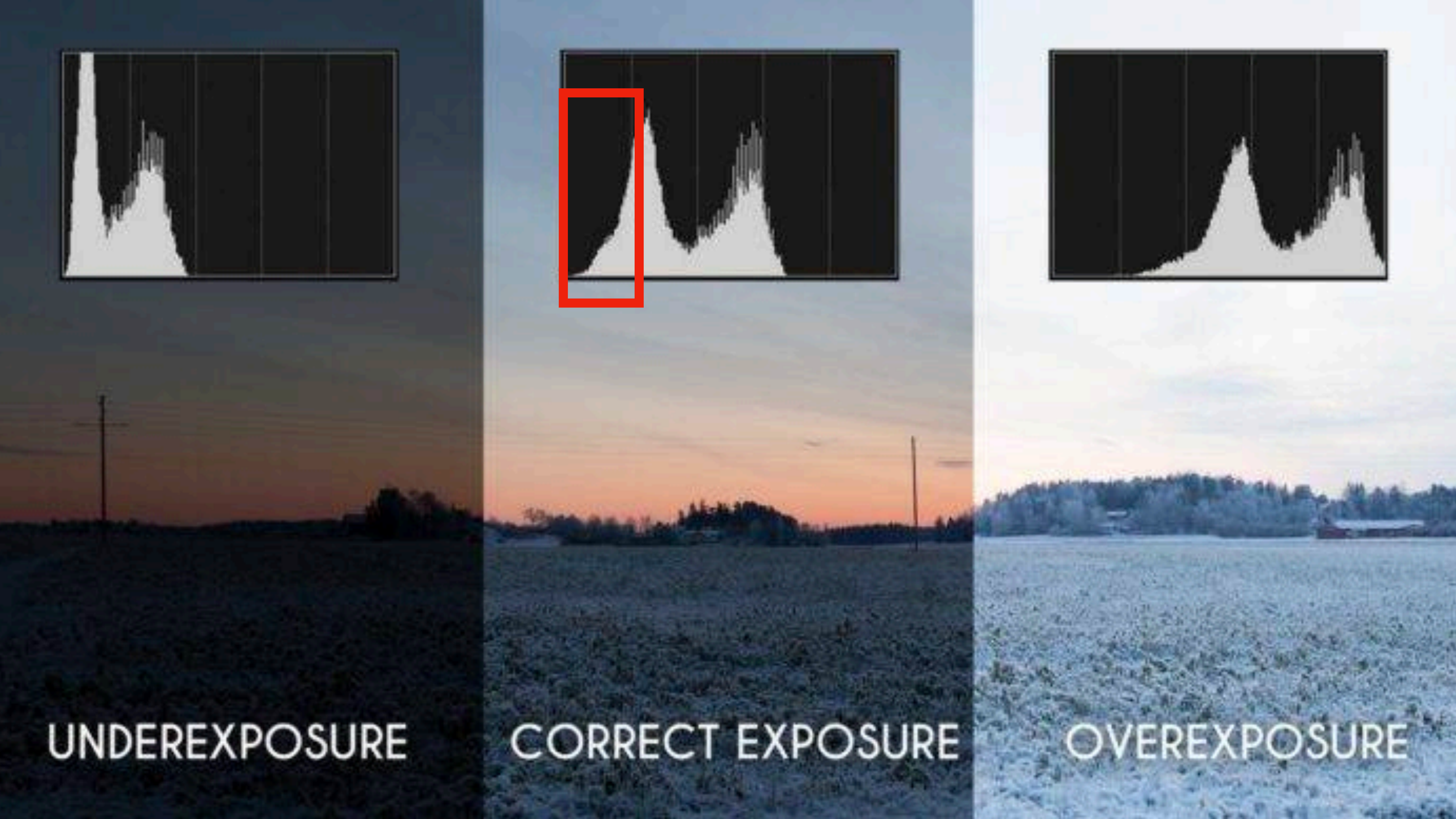
[Wronski et al]

https://arxiv.org/pdf/1905.03277.pdf

Align
Merge

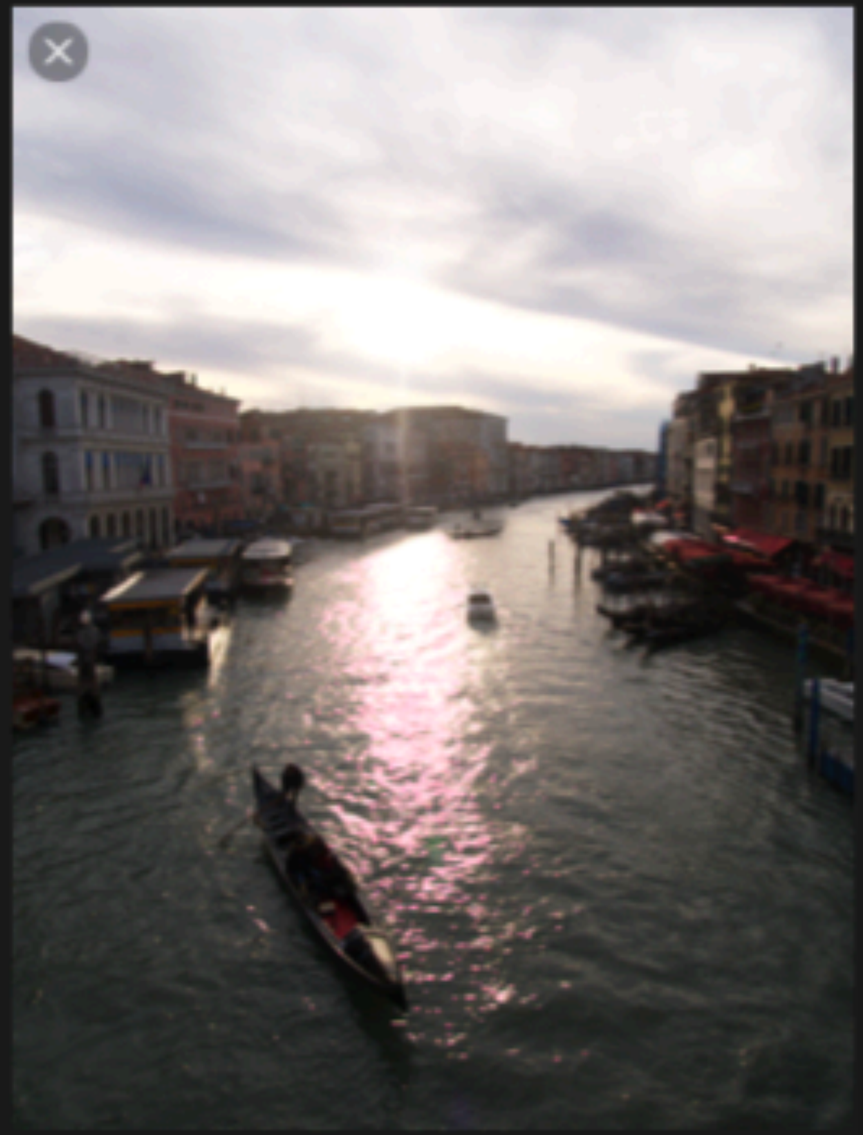
Background	Luminance (candelas per square meter)
Horizon sky	
Moonless overcast night	0.00003
Moonless clear night	0.0003
Moonlit overcast night	0.003
Moonlit clear night	0.03
Deep twilight	0.3
Twilight	3
Very dark day	30
Overcast day	300
Clear day	3,000
Day with sunlit clouds	30,000
Daylight fog	
Dull	300–1,000
Typical	1,000–3,000
Bright	3,000–16,000
Ground	
Overcast day	30–100
Sunny day	300
Snow in full sunlight	16,000




UNDEREXPOSURE
CORRECT EXPOSURE
OVEREXPOSURE

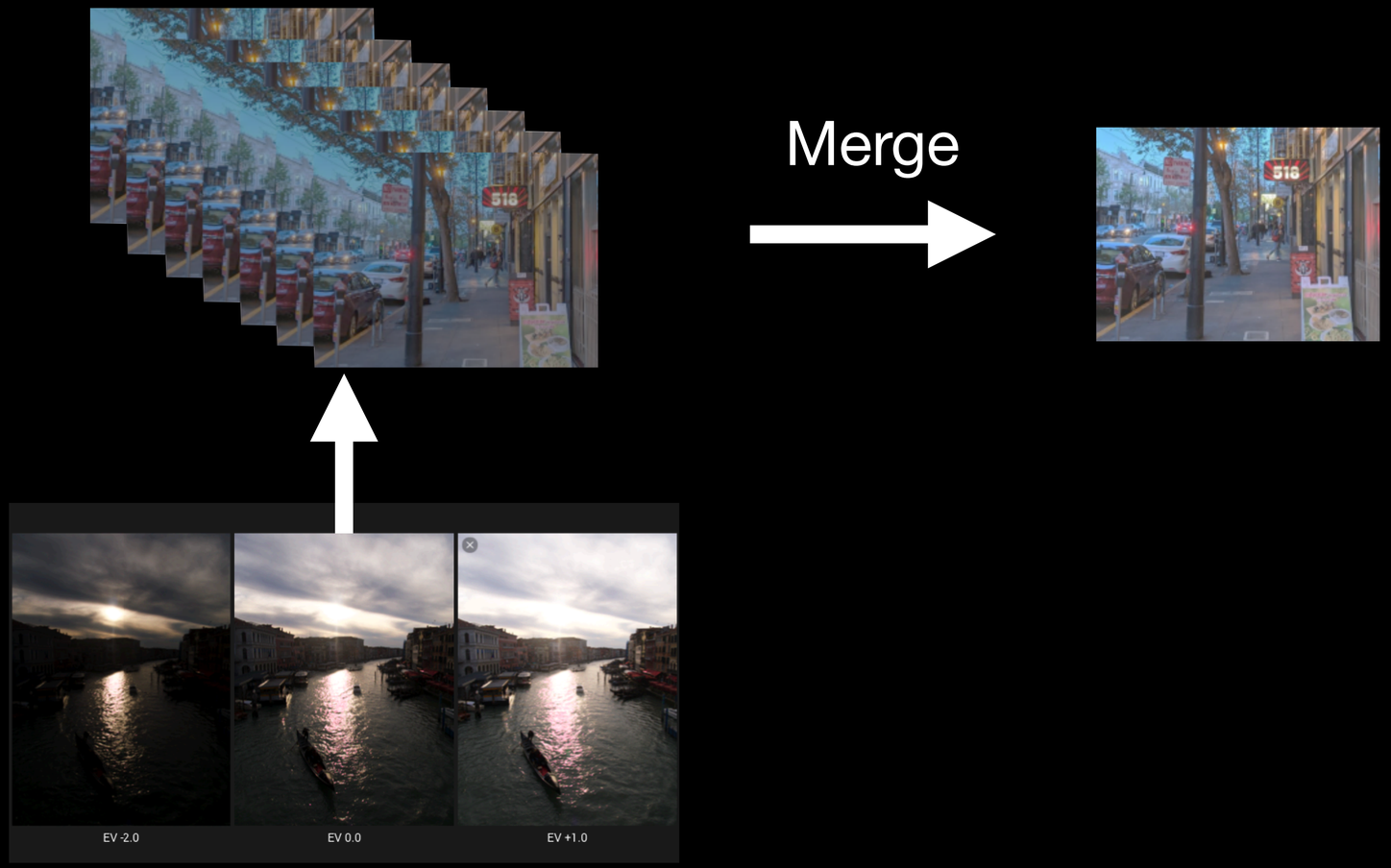
EV -2.0

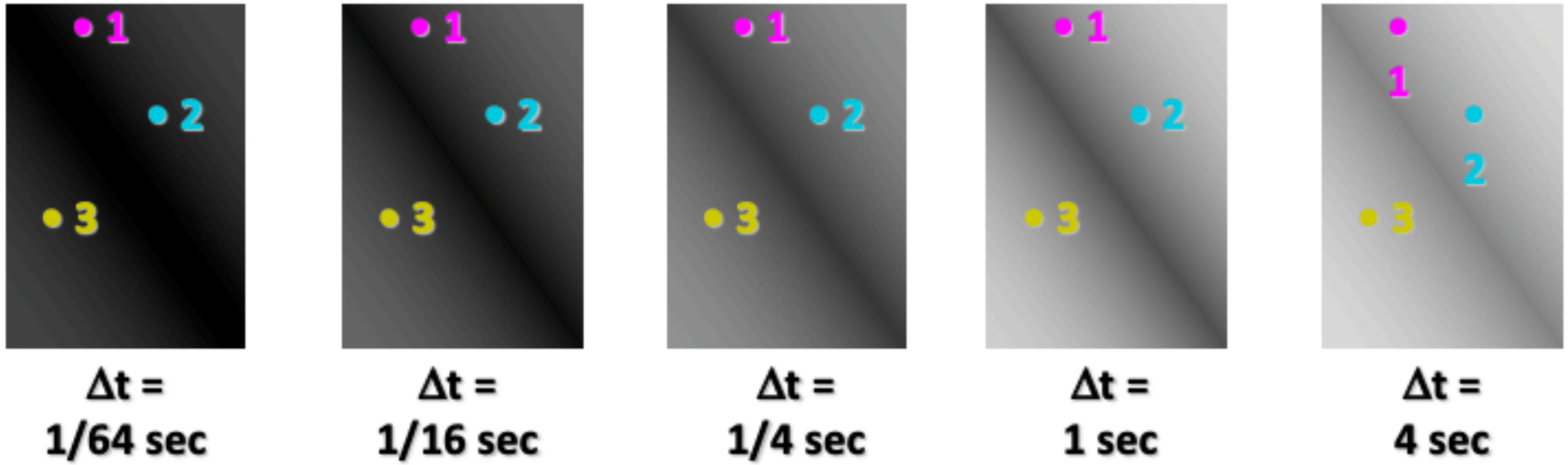
EV 0.0



EV +1.0

Align
Merge
EV -2.0
EV 0.0
EV +1.0


Merge
EV -2.0
EV 0.0
EV +1.0



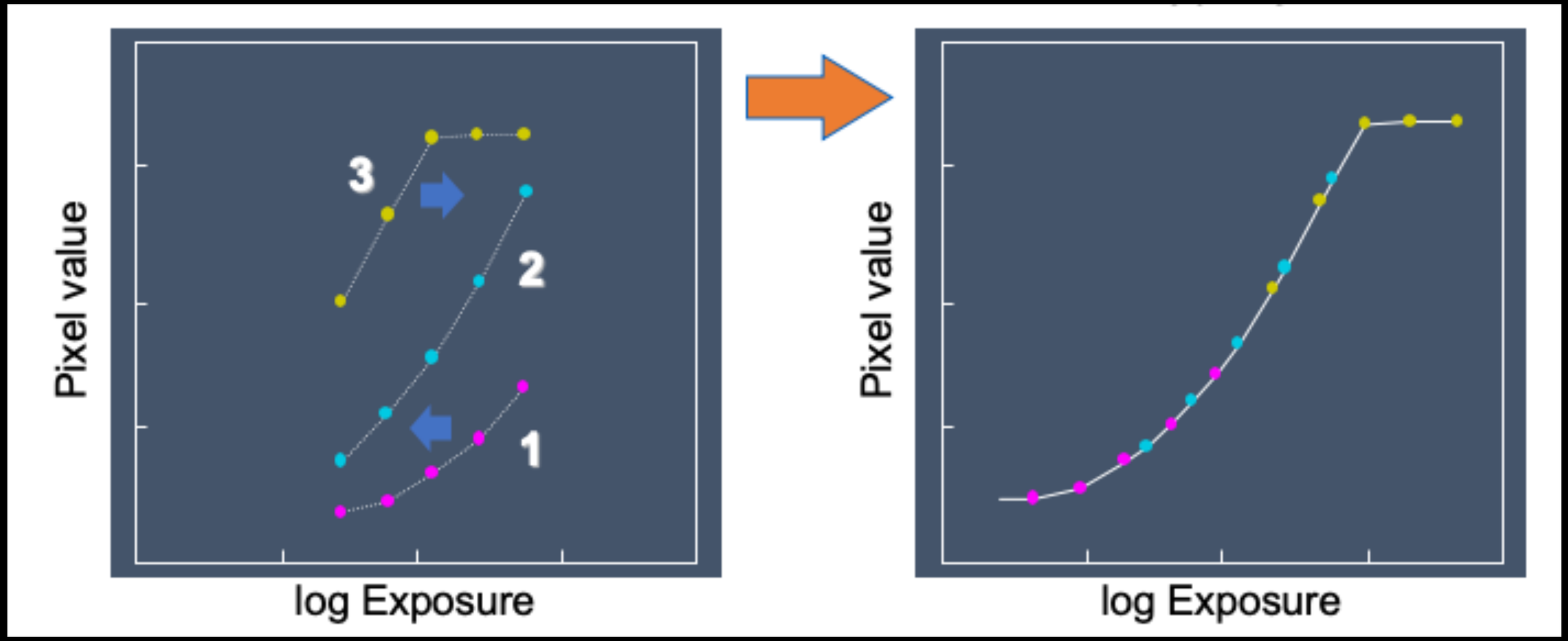
$$\text{Pixel Value } Z = f(\text{Exposure})$$

$$\text{Exposure} = \text{Radiance} \times \Delta t$$

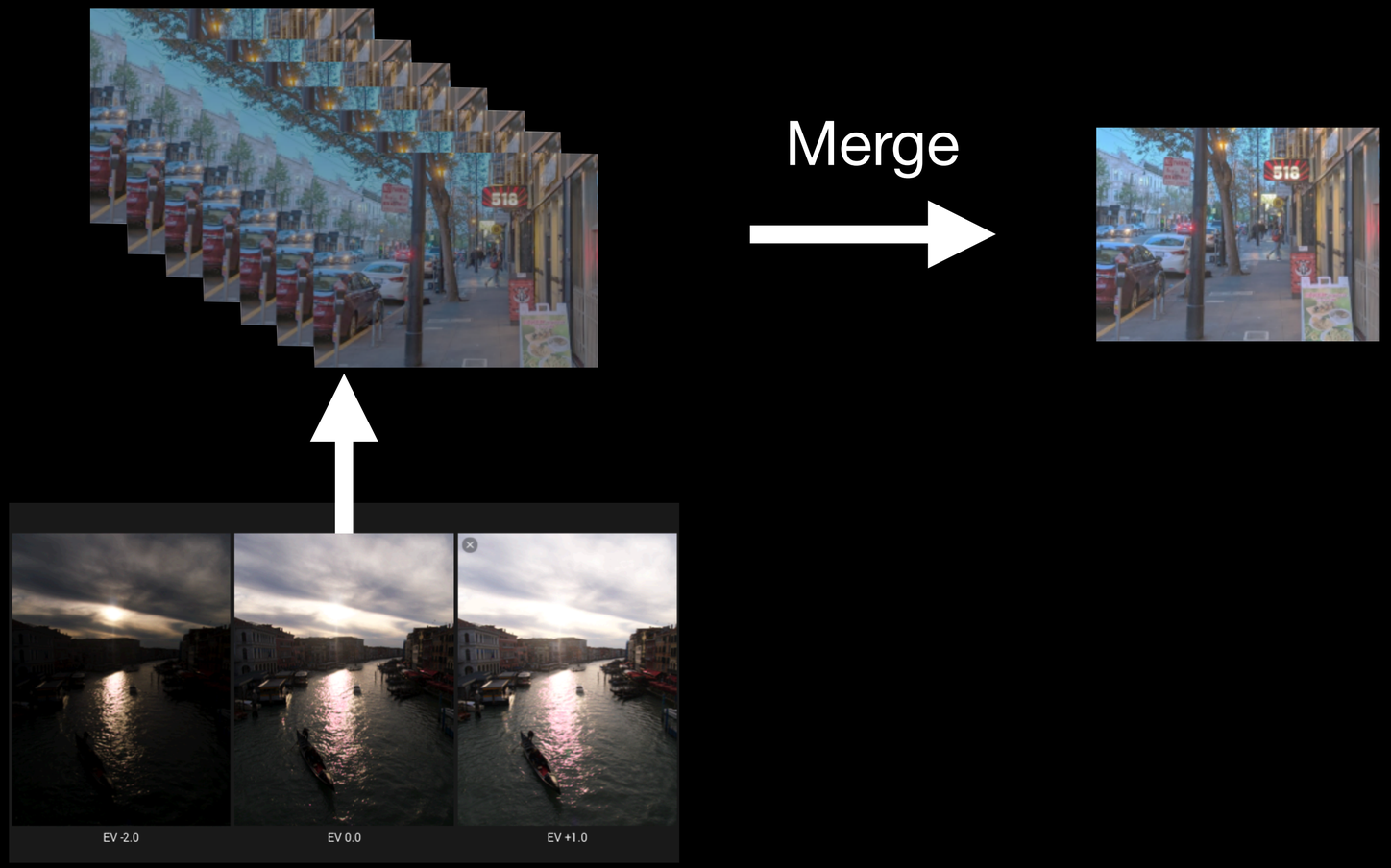
$$\log \text{Exposure} = \log \text{Radiance} + \log \Delta t$$

[Debevec et al]

[Richard Szeliski]

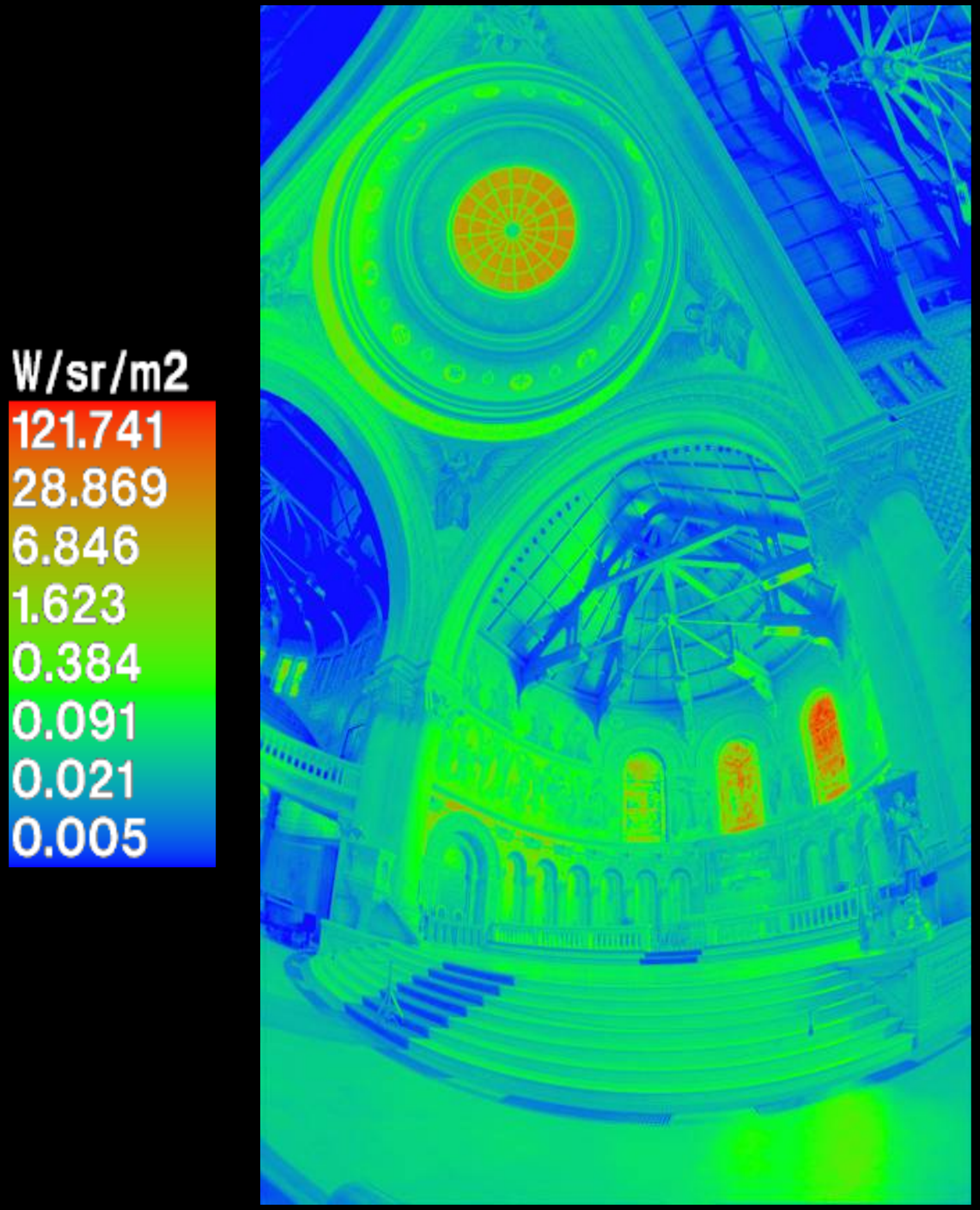


[Debevec et al]
[Richard Szeliski]


Merge
EV -2.0
EV 0.0
EV +1.0

Align
Merge
EV -2.0
EV 0.0
EV +1.0

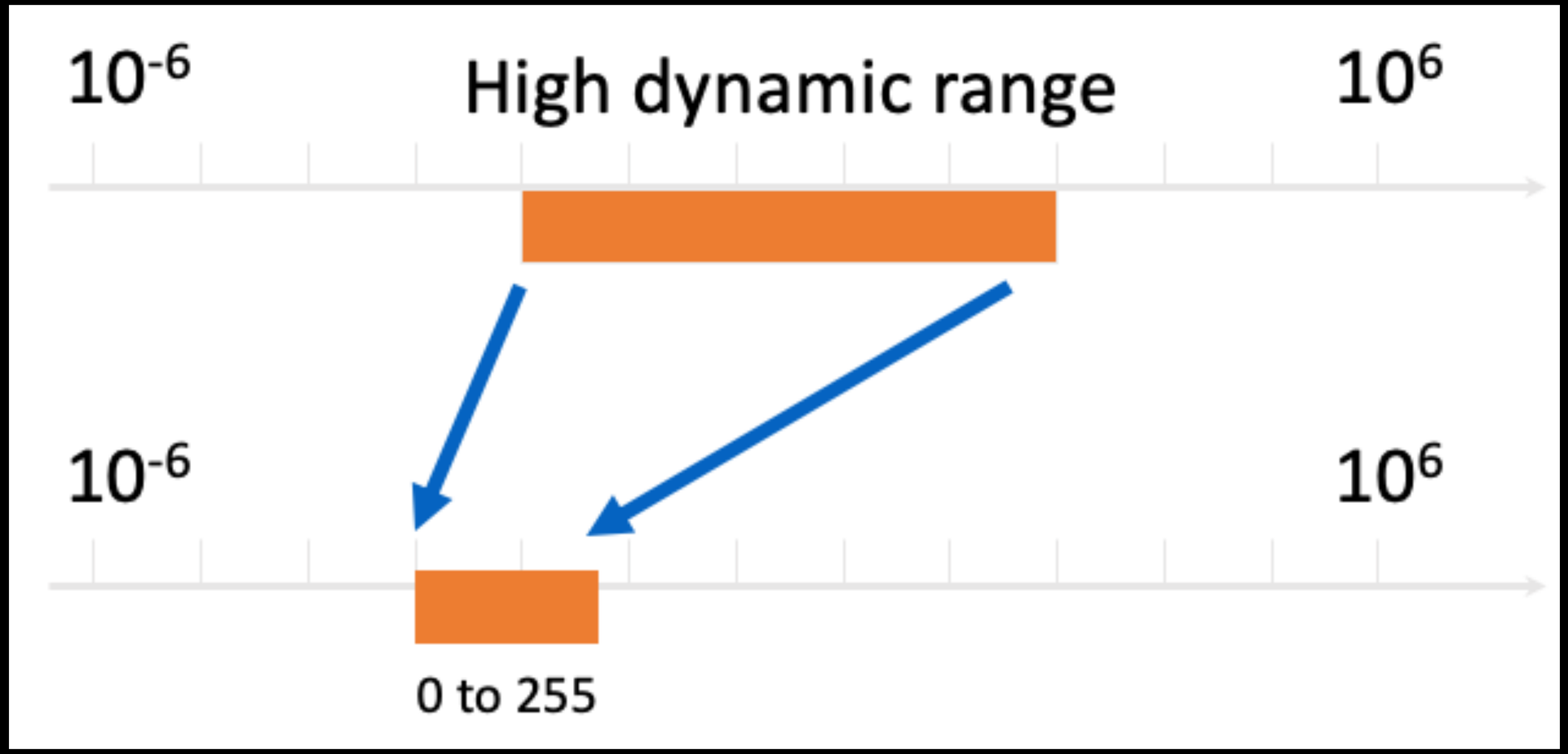
Align
Merge



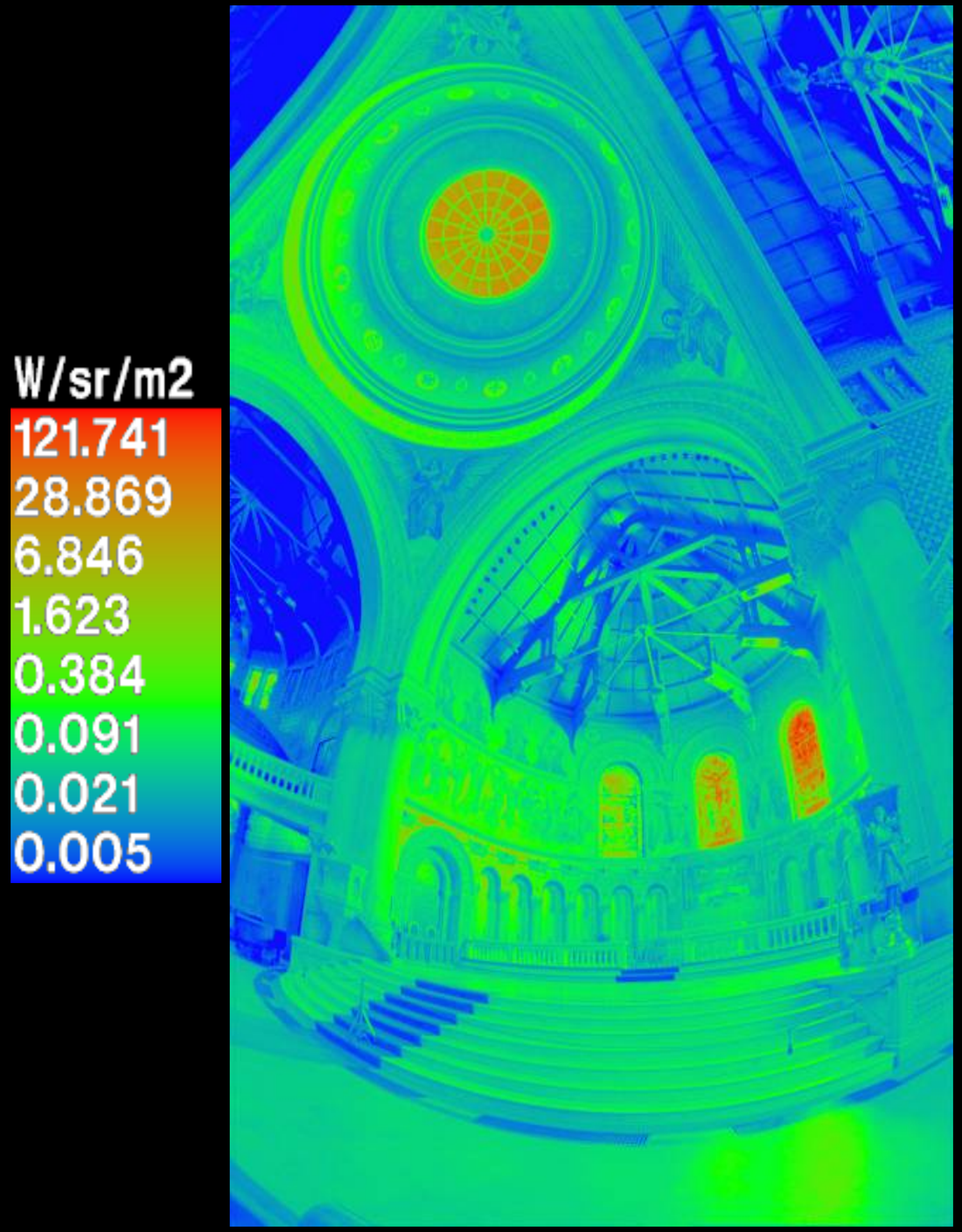
[Debevec et al]

Demo

https://viewer.openhdr.org/

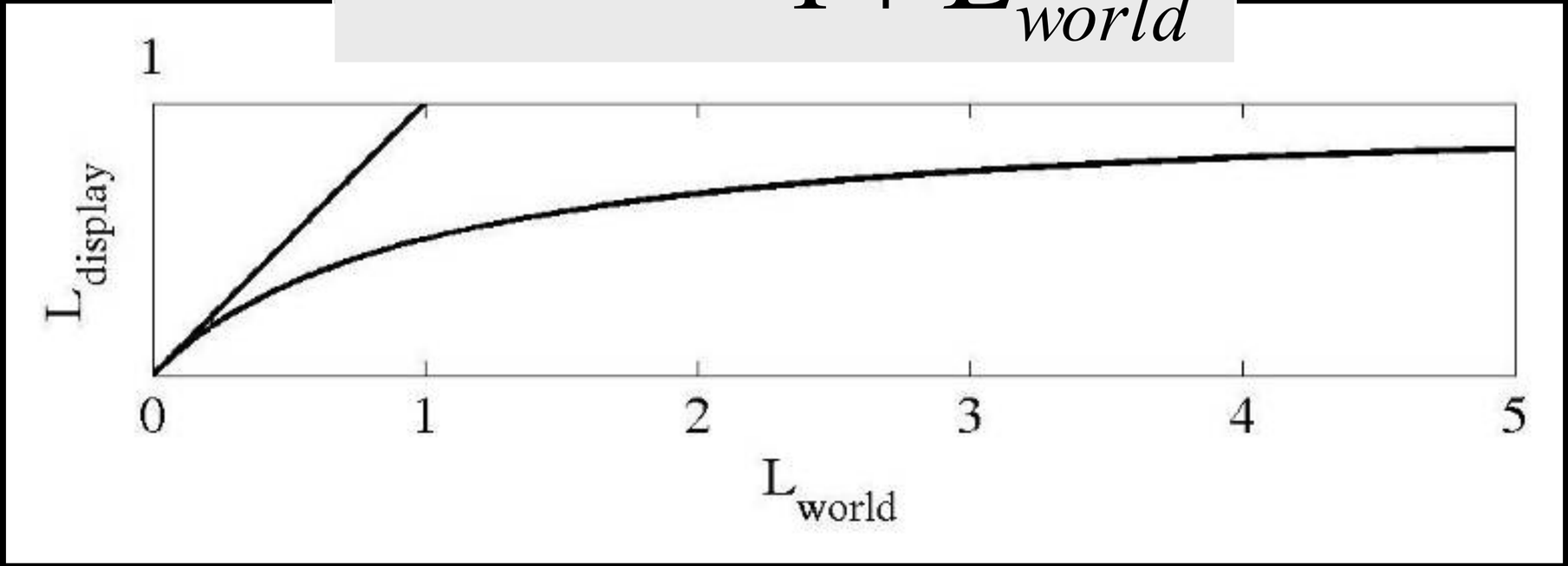


[Richard Szeliski]

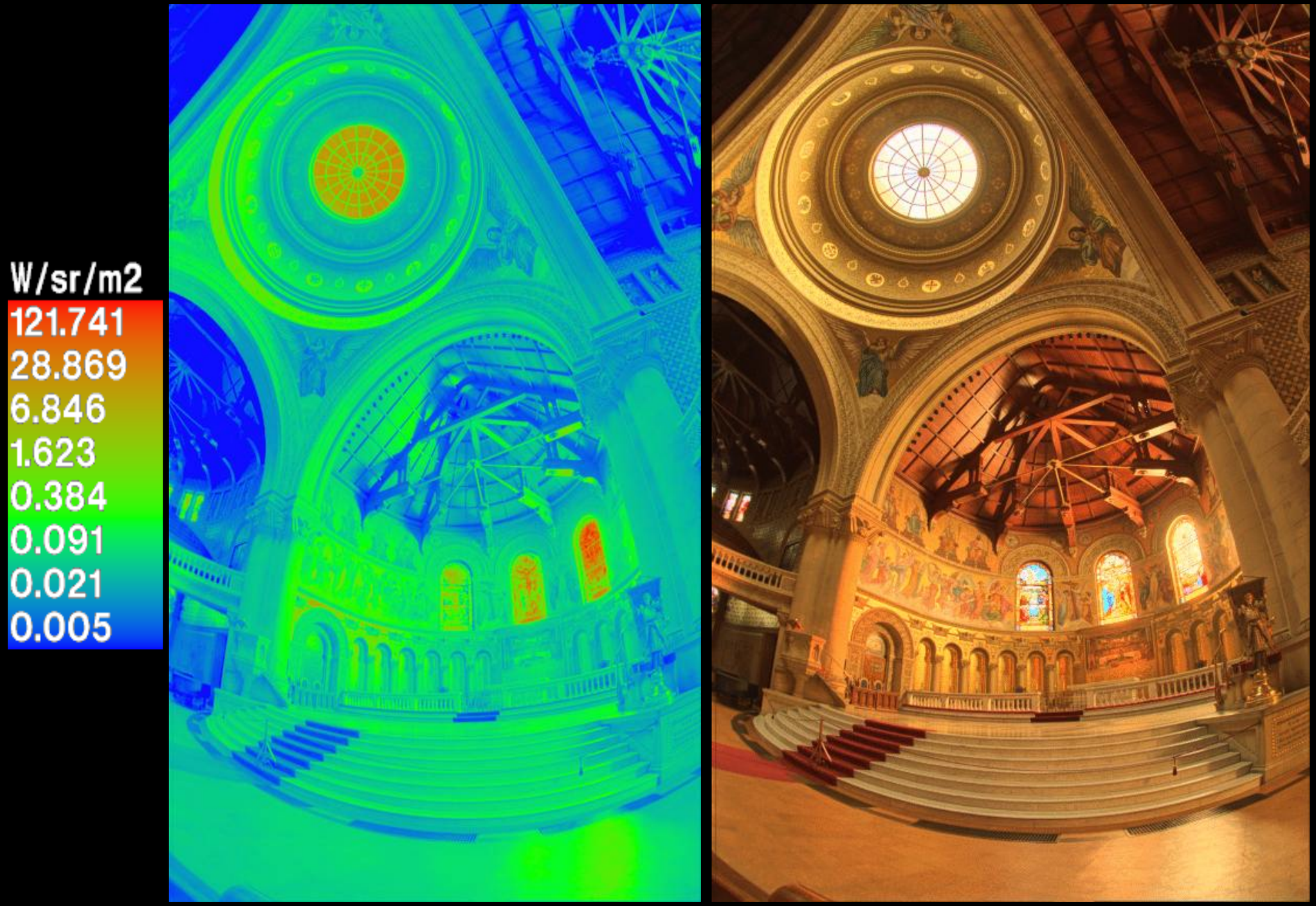


[Debevec et al]

$$L_{display} = \frac{L_{world}}{1 + L_{world}}$$



[Debevec et al]



[Debevec et al]

Chapter 1.5

Flash

[Hoppe et al]

http://hhoppe.com/proj/flash/

How to Take the Best Profile Picture

Put your best self forward.

OkCupid Follow

Aug 10, 2010 · 5 min read

2. Flash is not your friend.

"The hard light of a flash often ages the appearance of its subject by accentuating wrinkles and blemishes [...] For example, a 28 year-old who used a flash looks similar to a 35 year-old who didn't."

https://theblog.okcupid.com/dont-be-ugly-by-accident-b378f261dea4

[Hoppe et al]

http://hhoppe.com/proj/flash/

[Hoppe et al]
http://hhoppe.com/proj/flash/

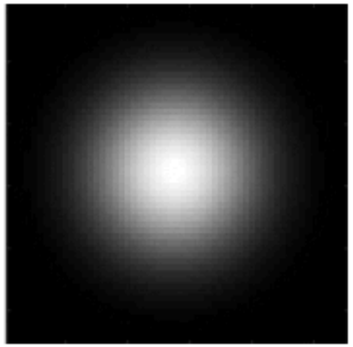
[Hoppe et al]
http://hhoppe.com/proj/flash/

Merge

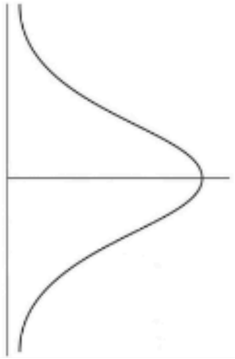
$$BF[I]_p = \frac{1}{W_p} \sum_{q \epsilon S} G_{\sigma_s}(||p-q||) G_{\sigma_r}(|I_p - I_q|) I_q$$

Normalization Factor

Space Weight



Range Weight



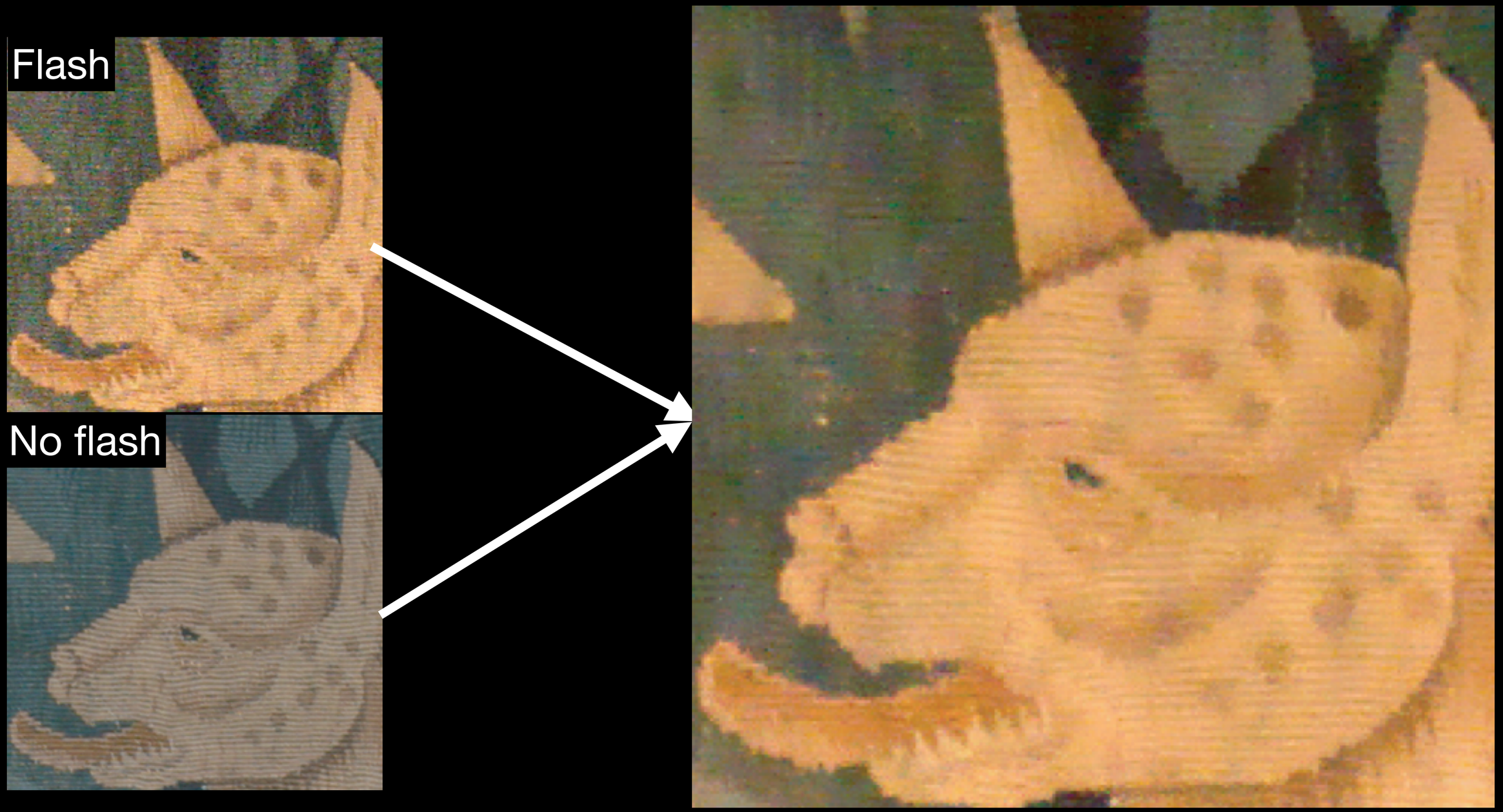
Bilateral filter

[Hoppe et al]

http://hhoppe.com/proj/flash/

[Hoppe et al]

http://hhoppe.com/proj/flash/



[“Digital Photography with Flash and No-Flash Image Pairs”, Petschnigg, Agrawala, Hoppe, Szeliski, Cohen, and Toyama]

[Hoppe et al]

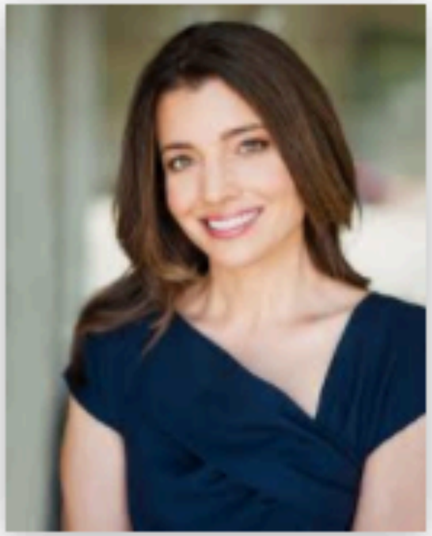
http://hhoppe.com/proj/flash/

[Hoppe et al]
http://hhoppe.com/proj/flash/

Chapter 2

Depth of field

Shallow
Deep



15 Women Who Are To...
pinterest.com

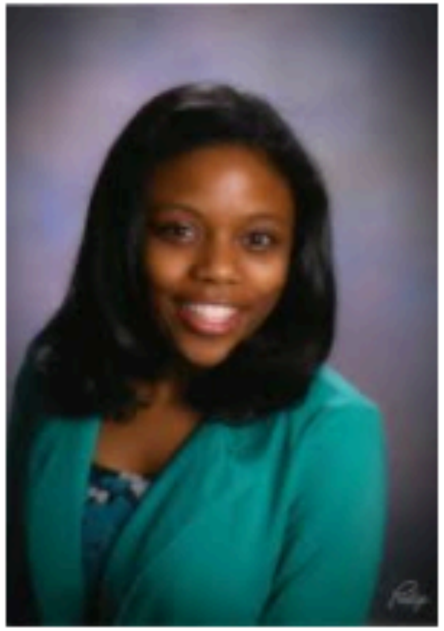
professional outdoor headshots - Google ...
pinterest.com

Professional Portrait Photography - San ...
ellasophiephoto.com

Ella Bessette: Bay Area...
ellabessette.com

Professional Portrait P...
brianshumway.com

Black Women to Know ...
pinterest.com



Tech Lady Portrait: Rub...
ladvin.tech

Hov
vau

f/stop & pic attractiveness

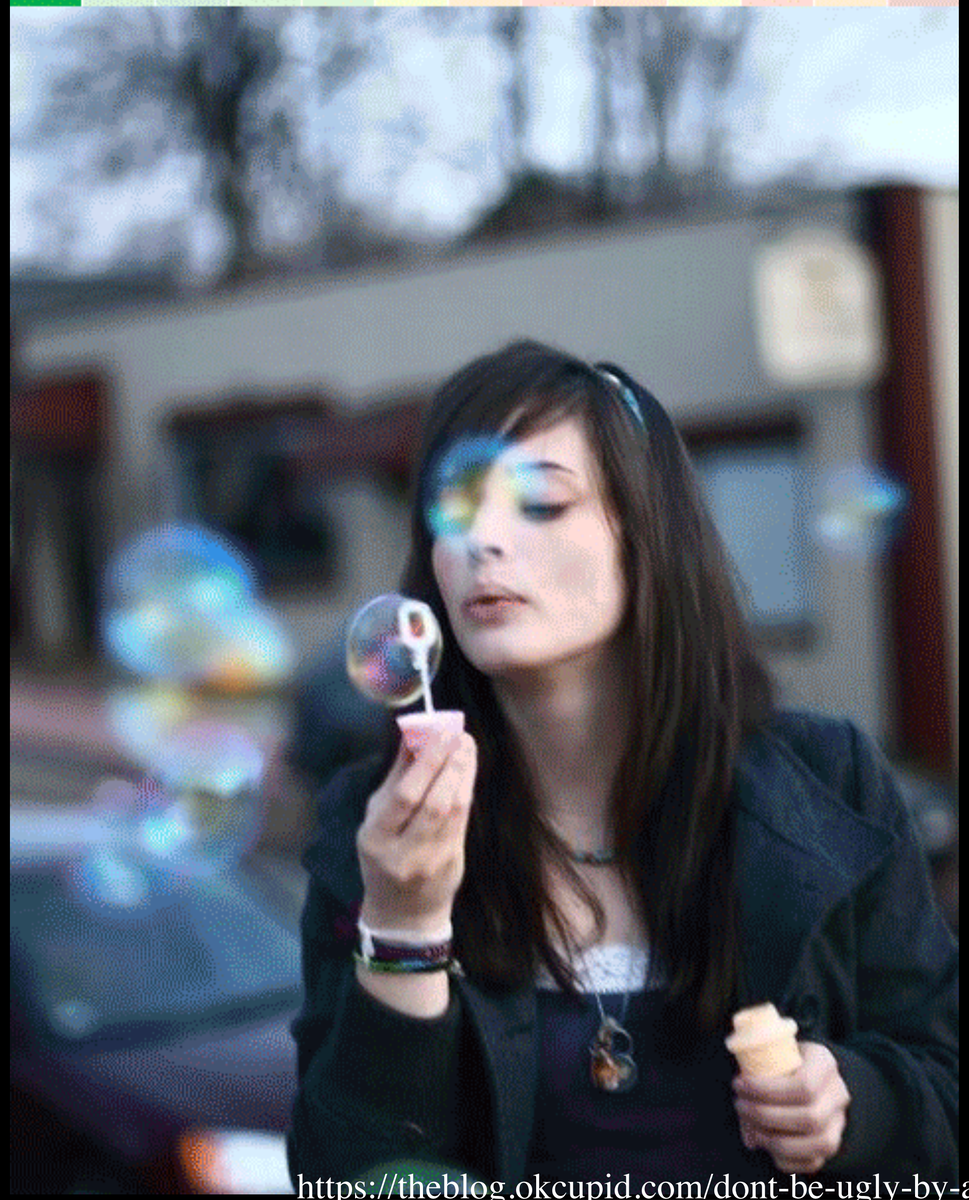
depth of field

f/1.2	f/1.4	f/1.8	f/2.2	f/2.8	f/3.5	f/4.5	f/5.6	f/6.3	f/7.1	f/11	f/18	f/22
+.06	+.05	+.06	+.05	+.04	+.01	-.01	-.02	-.01	+.01	-.02	-.01	-.03

f/stop & pic attractiveness

depth of field

f/1.2	f/1.4	f/1.8	f/2.2	f/2.8	f/3.5	f/4.5	f/5.6	f/6.3	f/7.1	f/11	f/18	f/22
+.06	+.05	+.06	+.05	+.04	+.01	-.01	-.02	-.01	+.01	-.02	-.01	-.03



https://theblog.okcupid.com/dont-be-ugly-by-accident-b378f261dea4

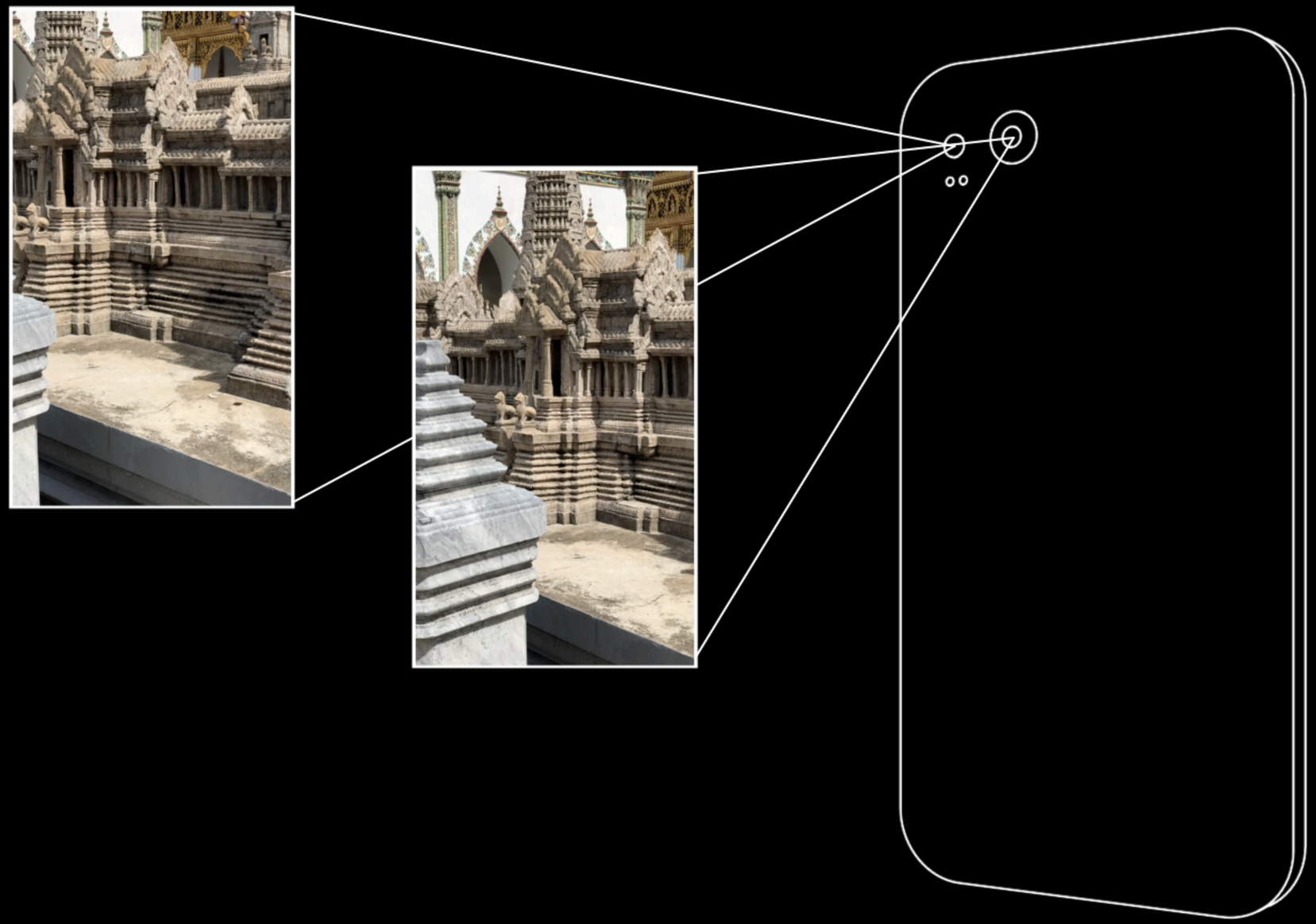
iPhone
Nikon
D850

Depth

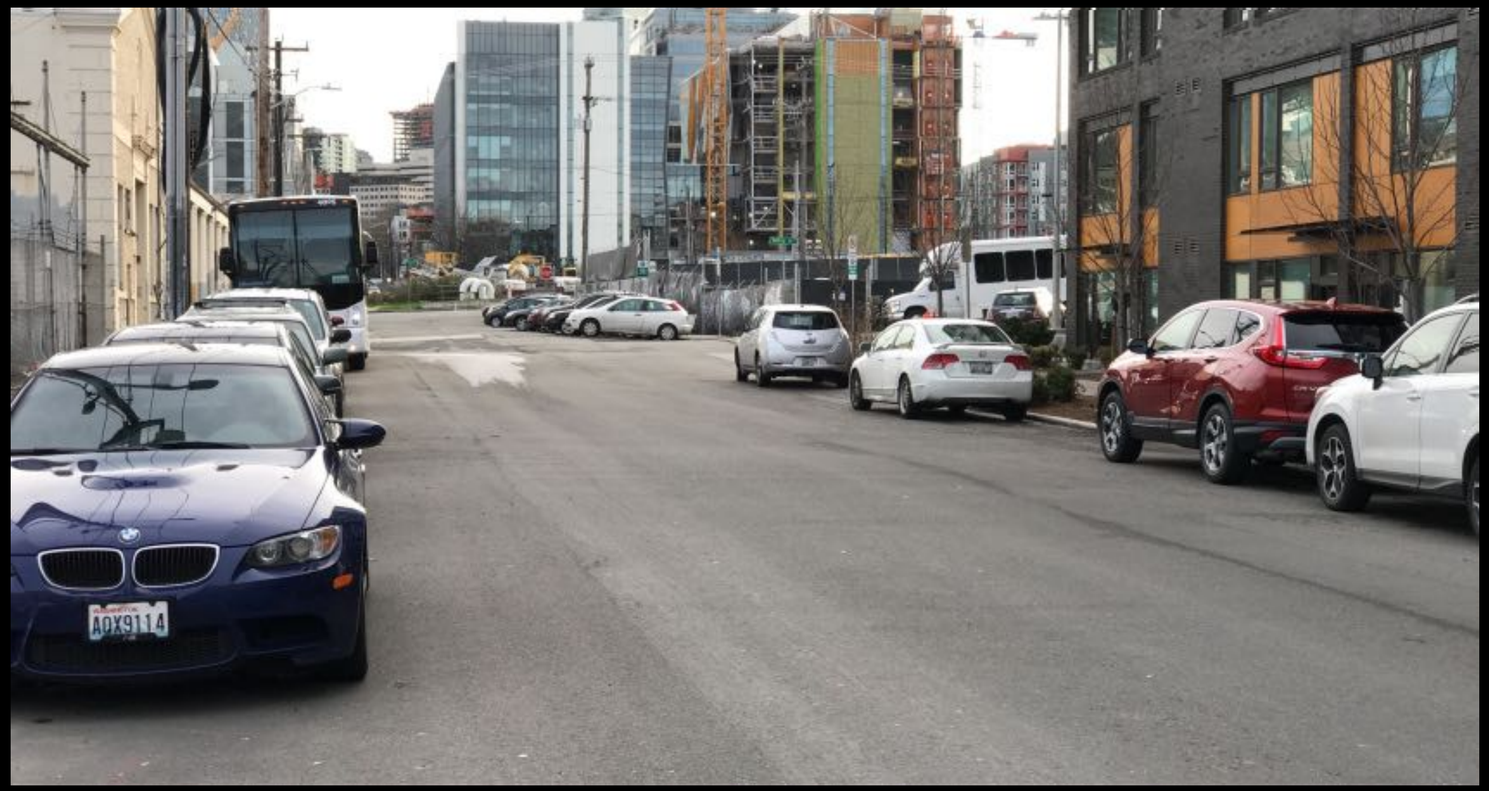
https://ai.googleblog.com/2017/10/portrait-mode-on-pixel-2-and-pixel-2-xl.html

16 CAMERA LENSES
MIR
powered by light
ZEISS

[Hedman et al]

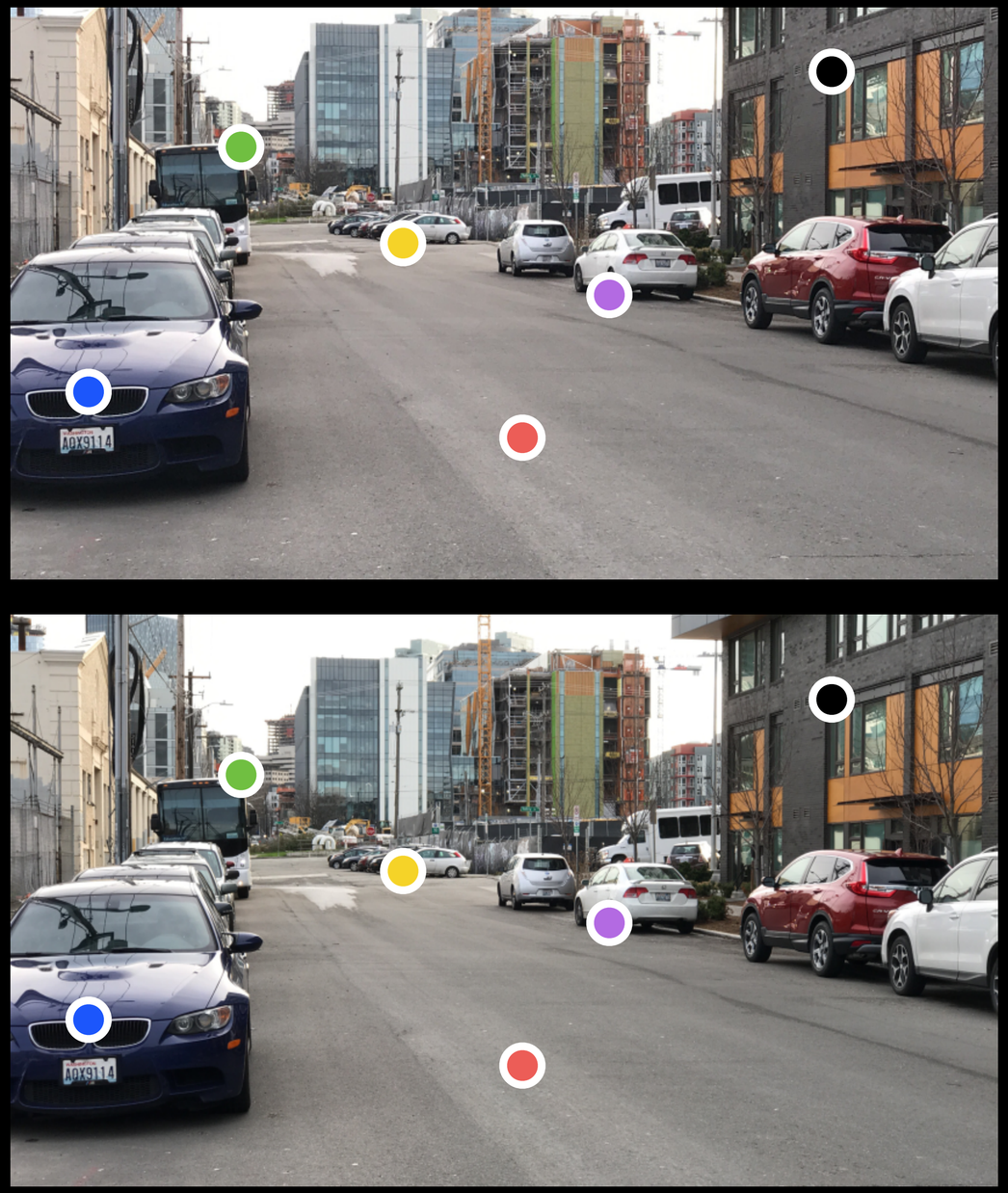


[Hedman et al]



[Hedman et al]

AQX9114



Optical stabilization

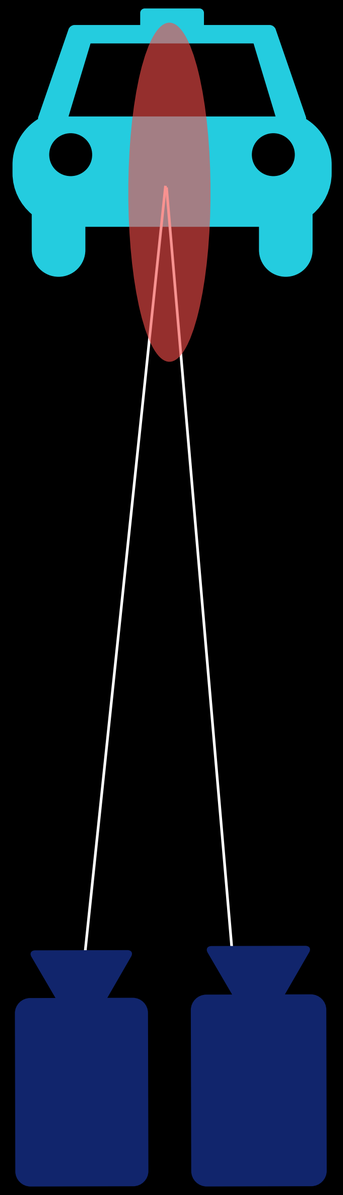
Auto-focus

Gravity

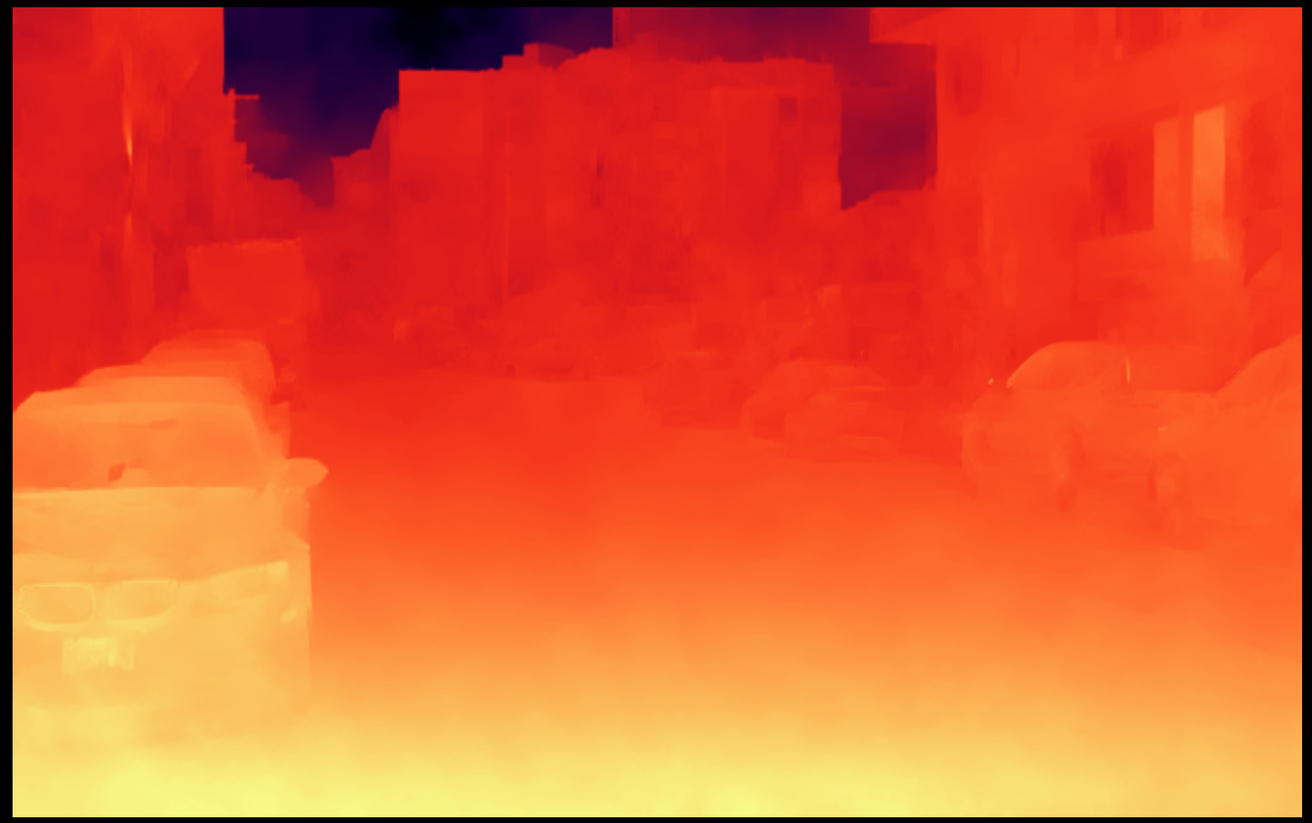
Temperature

Rolling shutter

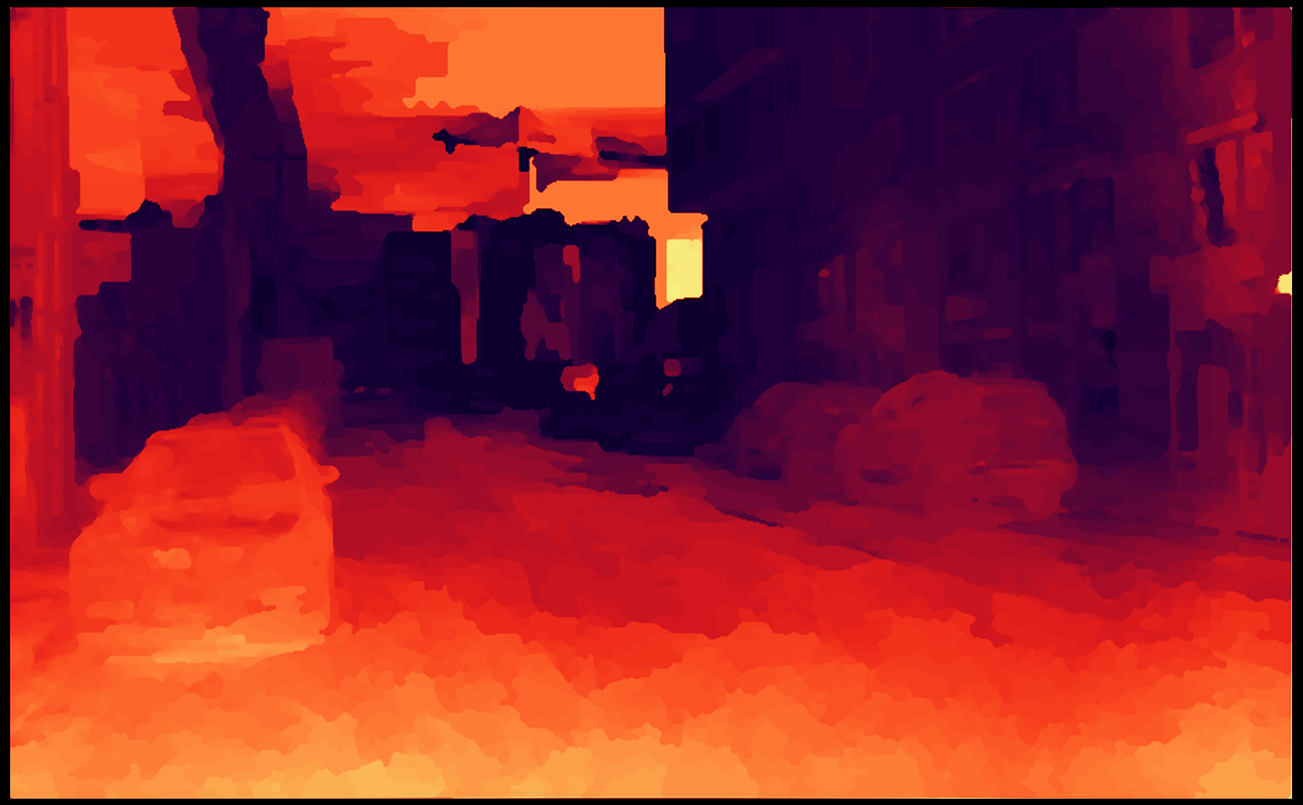
Edge-aware filters



[Hedman et al]

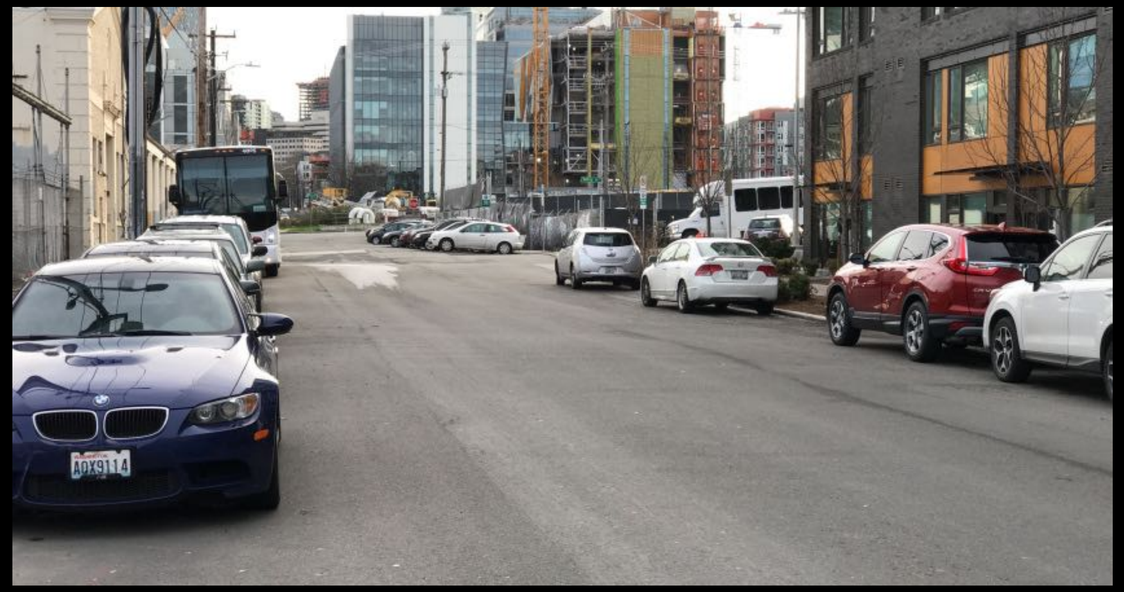


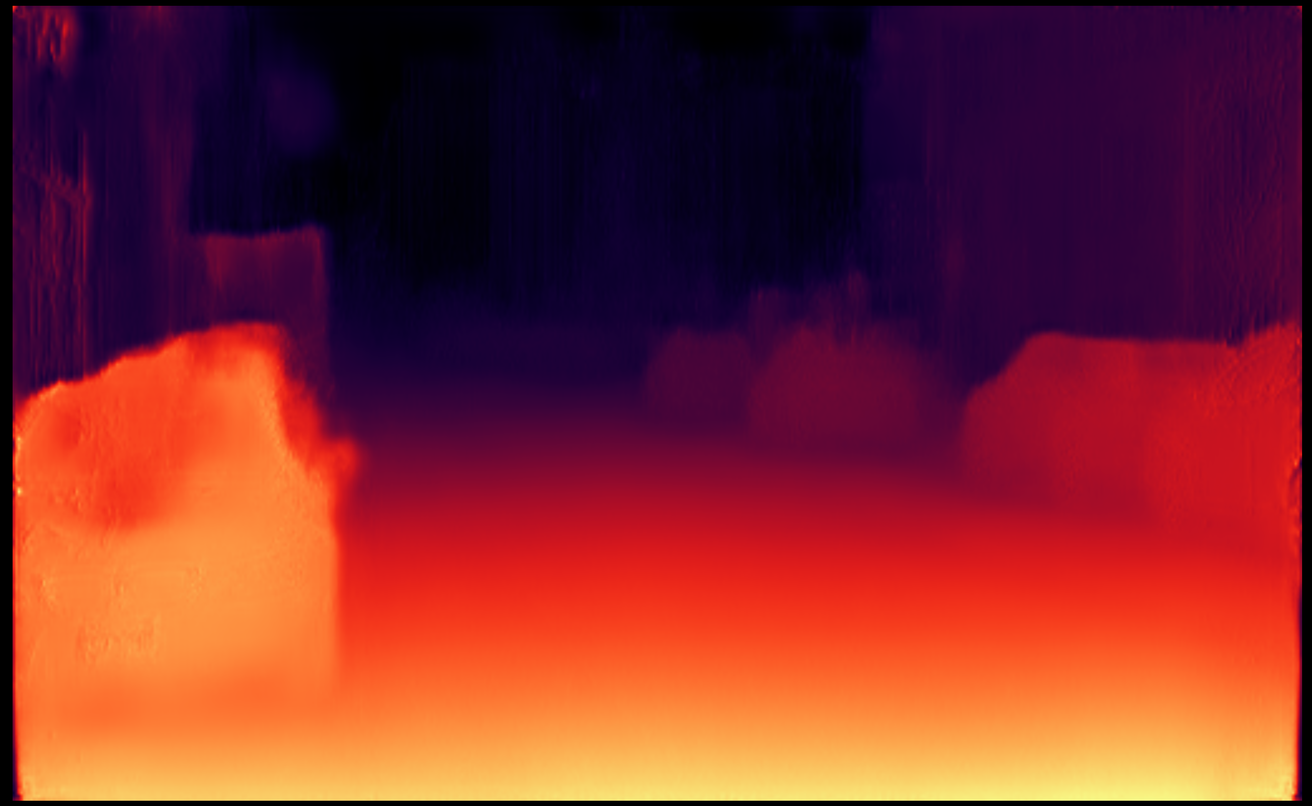
[Hedman et al]



Small motion clip [Ha2016]

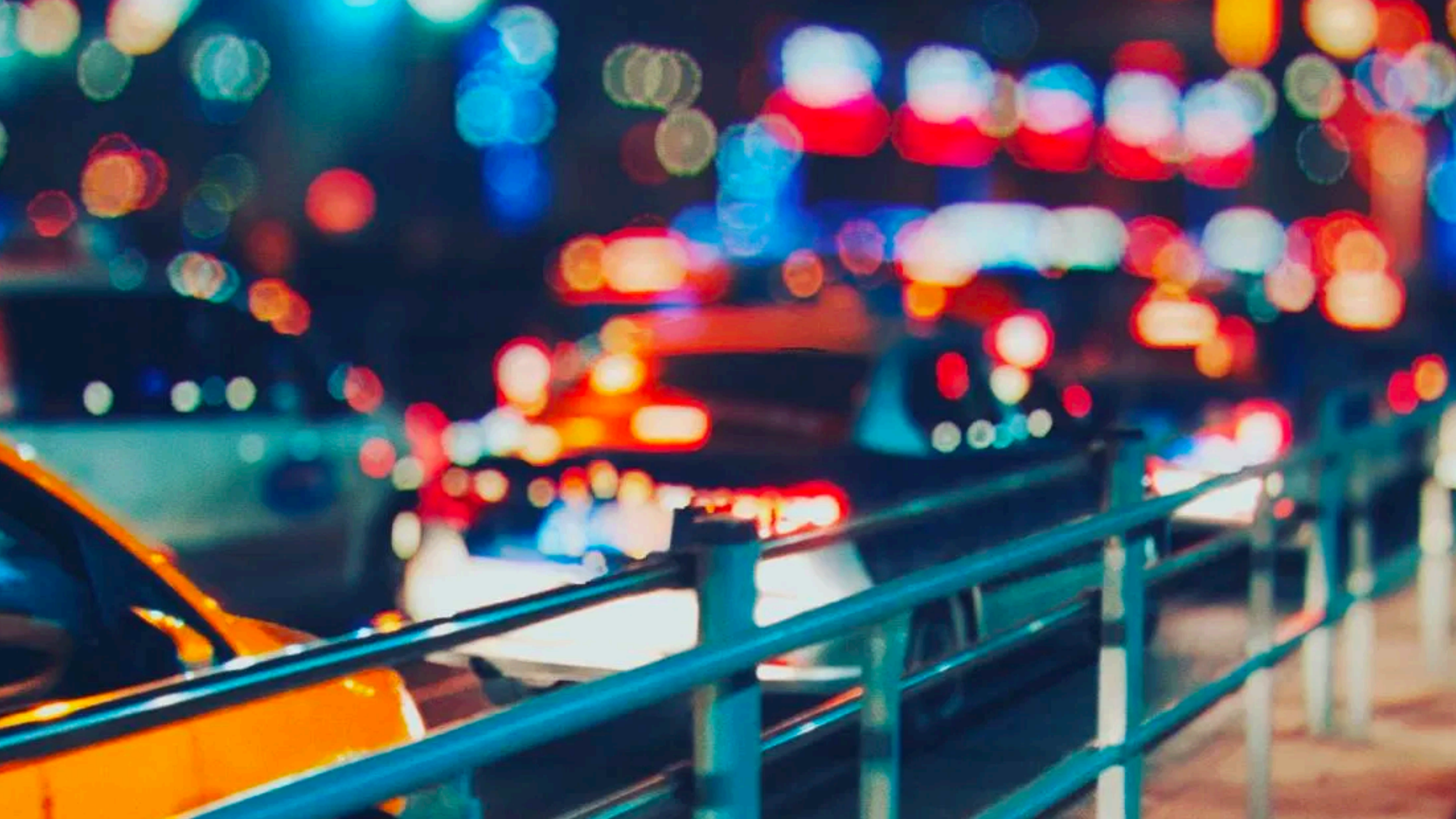
[Hedman et al]



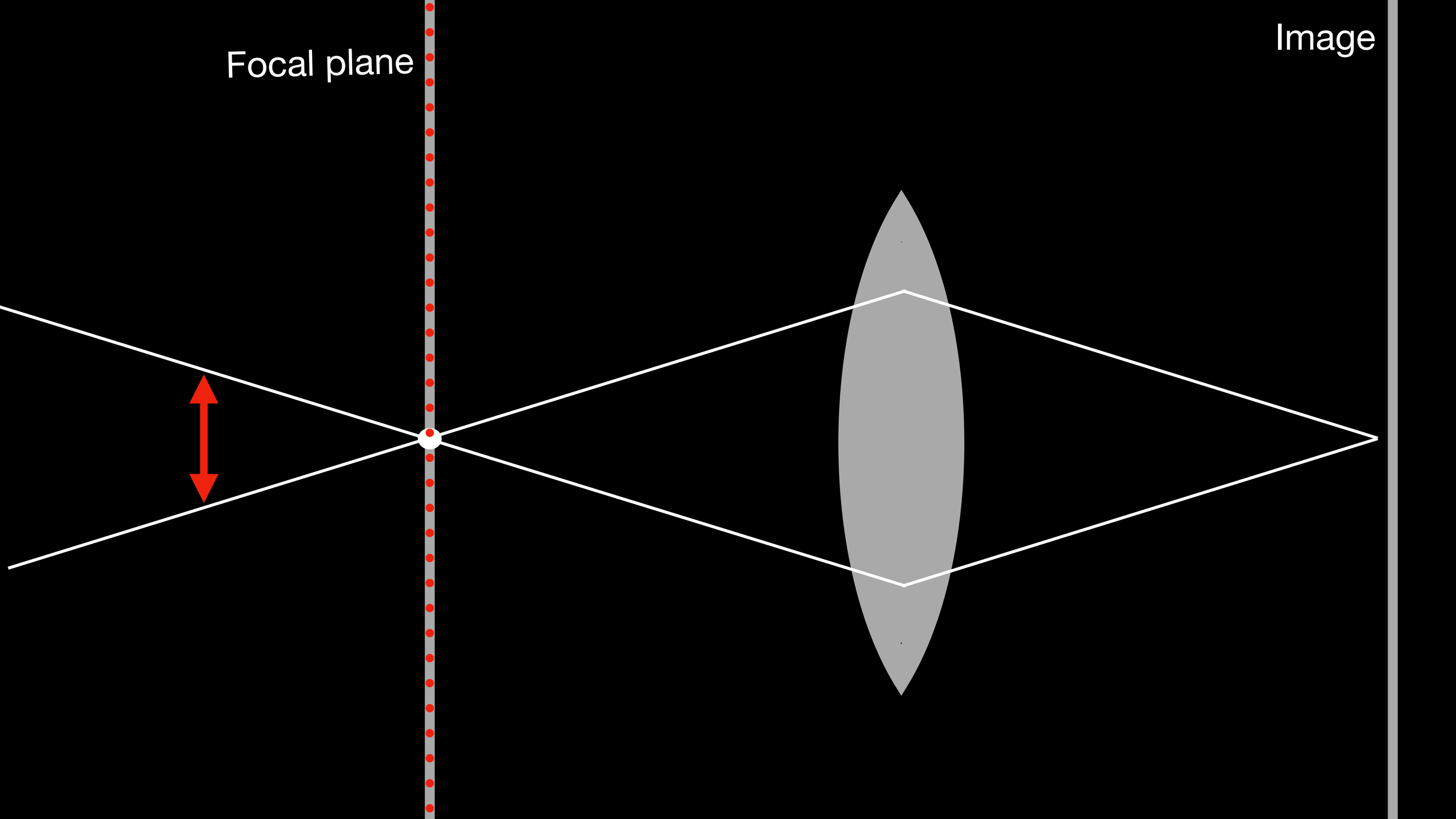


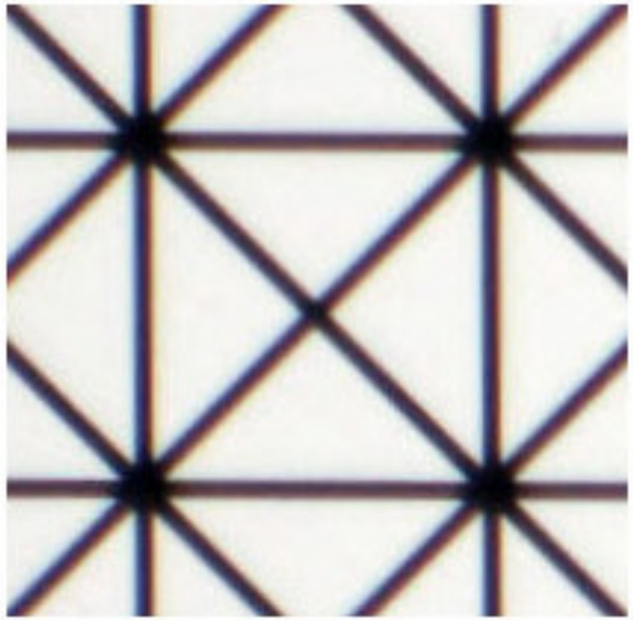
Single view depth [Godard2017]

[Hedman et al]

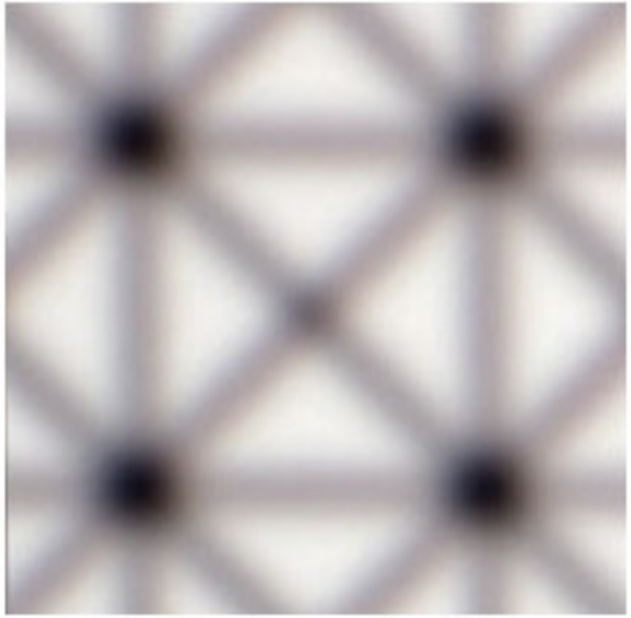


https://ai.googleblog.com/2017/10/portrait-mode-on-pixel-2-and-pixel-2-xl.html


Focal plane
Image

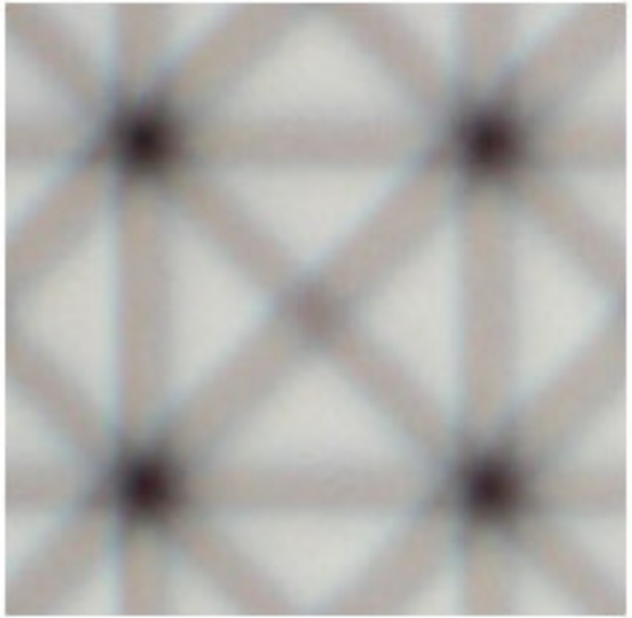


In focus



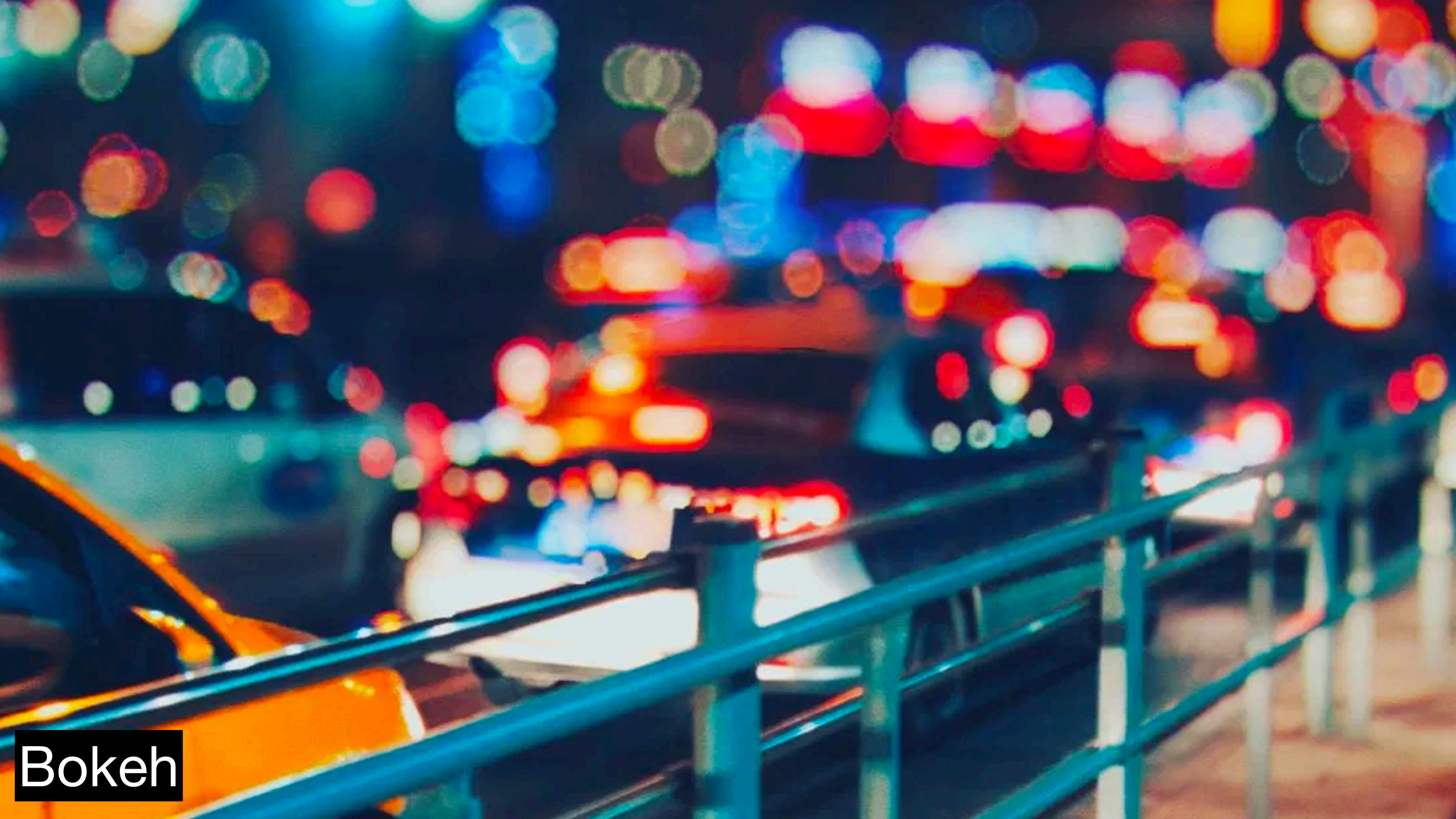
Simple Gaussian blur

Focus further away



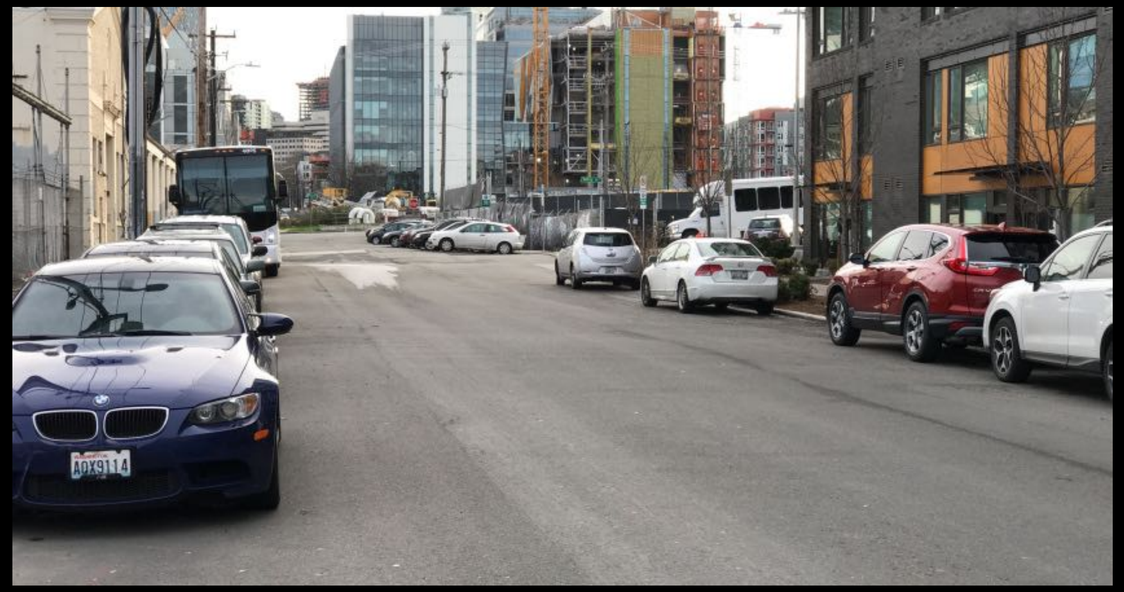
Focus closer

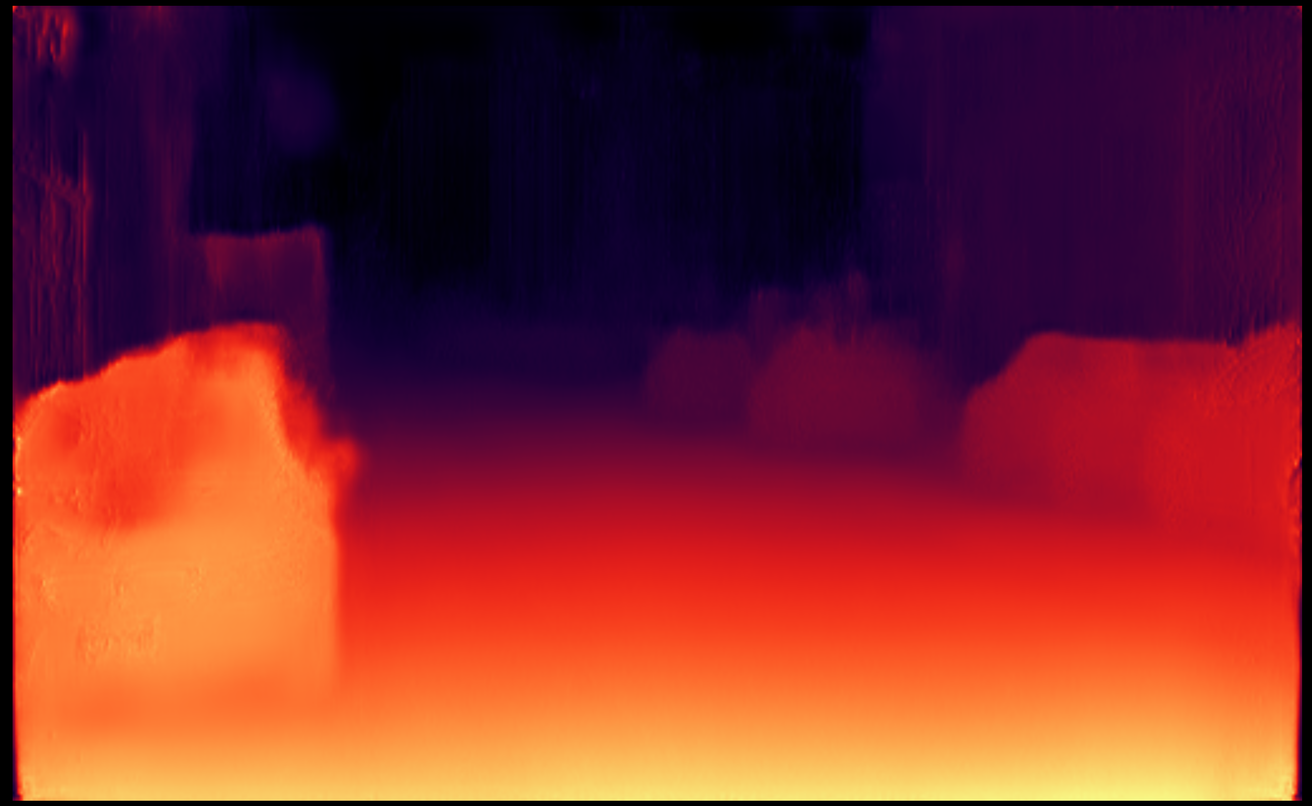
http://www.bobatkins.com/photography/technical/bokeh.html


Bokeh

https://ai.googleblog.com/2017/10/portrait-mode-on-pixel-2-and-pixel-2-xl.html

https://ai.googleblog.com/2017/10/portrait-mode-on-pixel-2-and-pixel-2-xl.html





Single view depth [Godard2017]

[Hedman et al]

Semantic object segmentation

https://ai.googleblog.com/2017/10/portrait-mode-on-pixel-2-and-pixel-2-xl.html

https://ai.googleblog.com/2017/10/portrait-mode-on-pixel-2-and-pixel-2-xl.html

Chapter 3

The future of photography

What can’t cameras do?

https://www.youtube.com/watch?v=I_8ZH1Ggjk0

[SIGGRAPH 2019]

Handheld Multi-Frame Super-Resolution

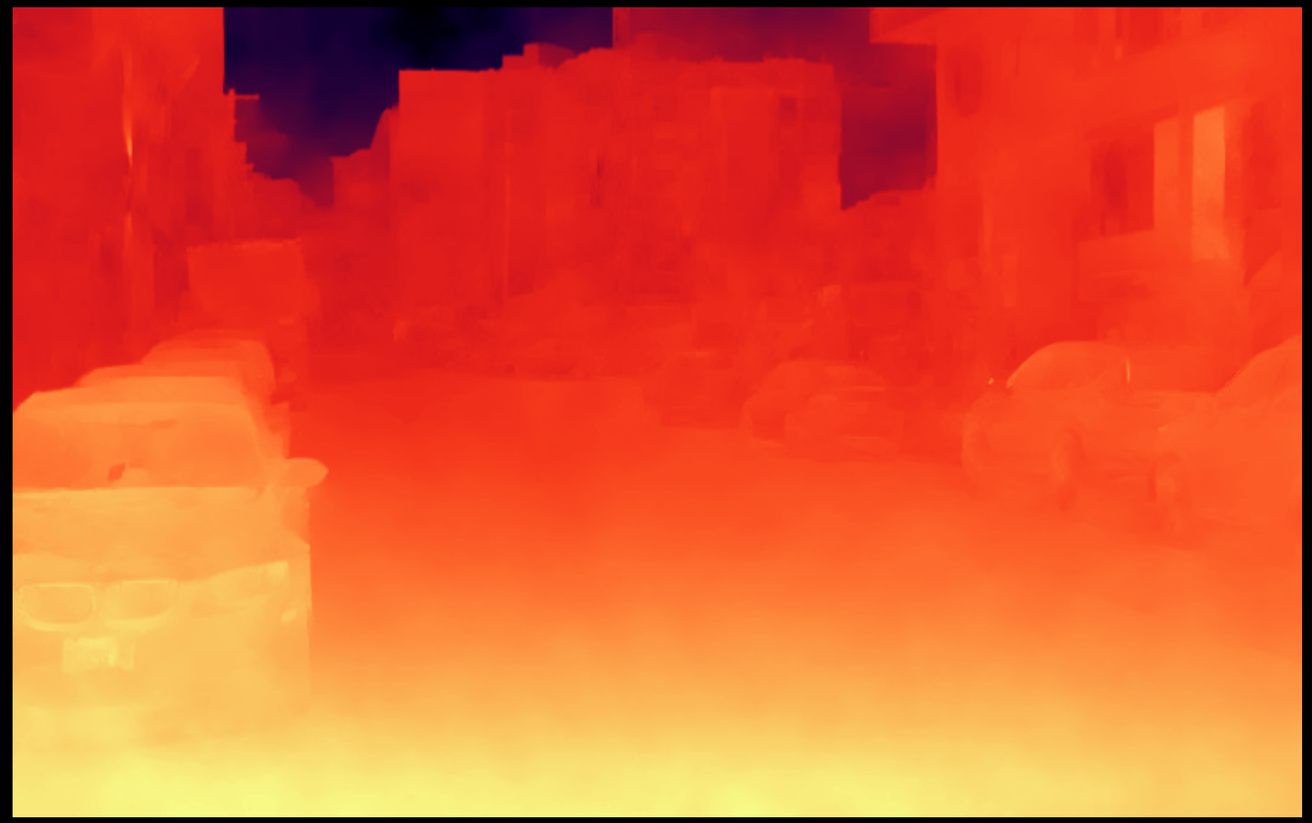
[Wronski et al]

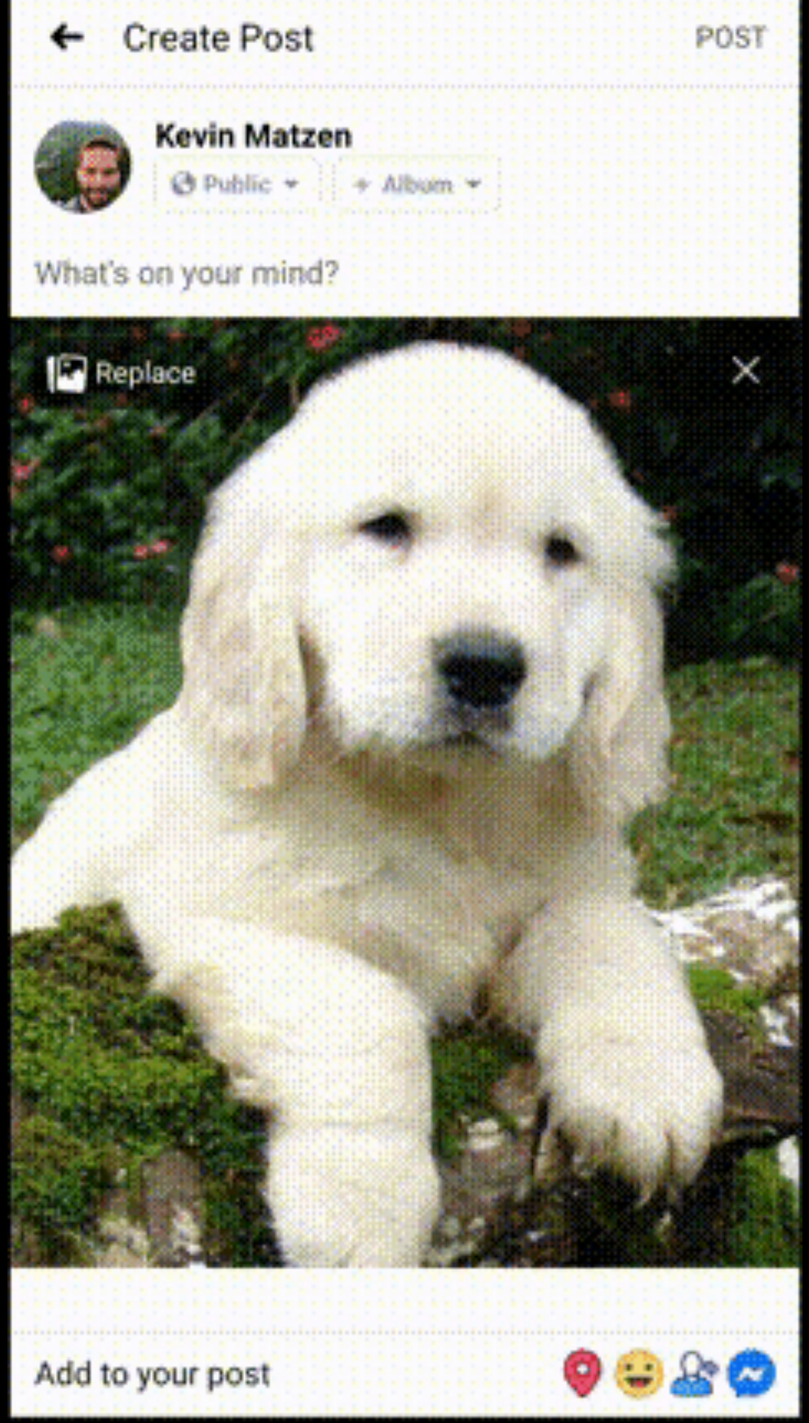
https://sites.google.com/view/handheld-super-res/

Lytro + light field cameras

ADX9114

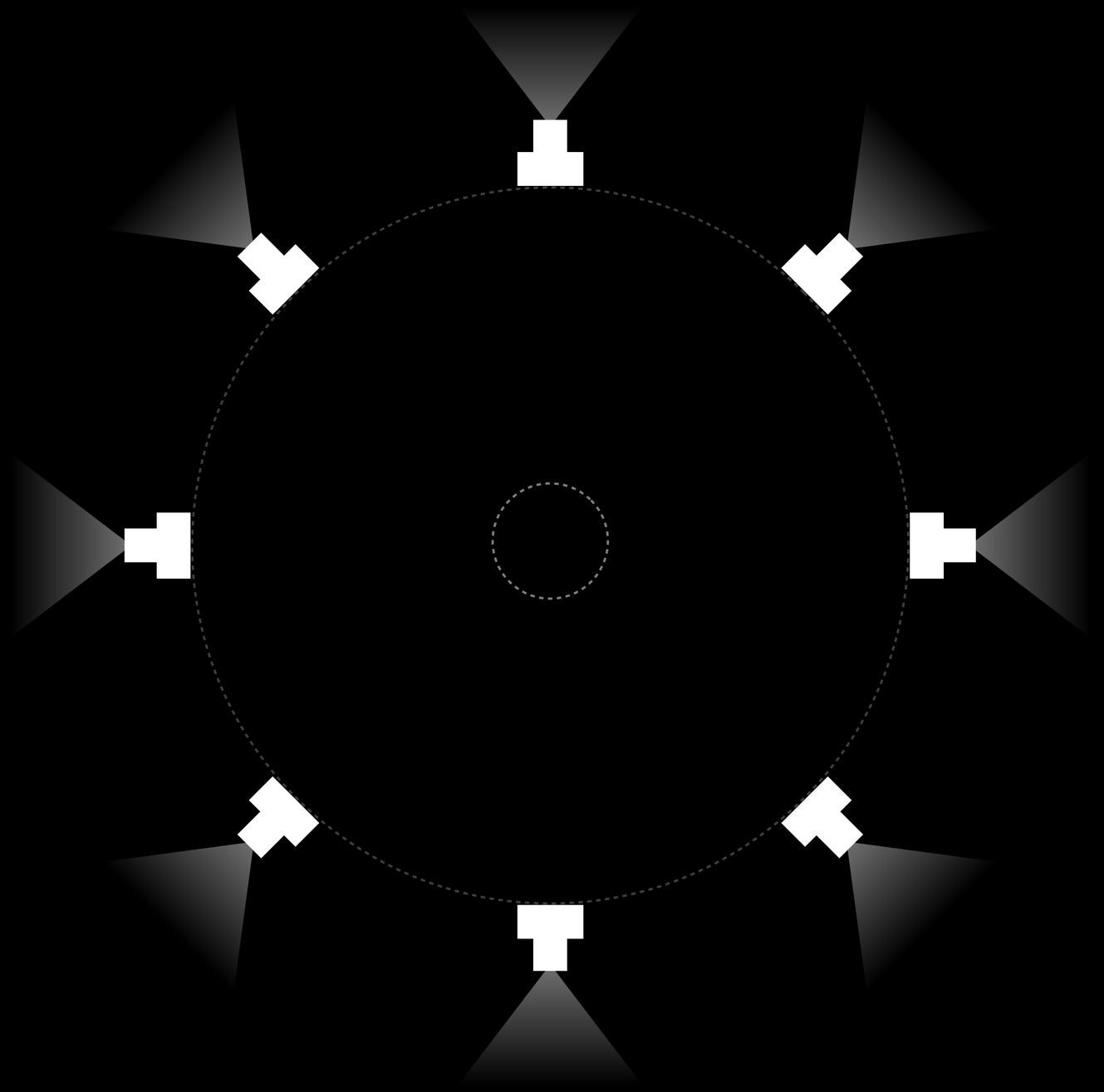
ADX9114




Create Post
POST
Kevin Matzen
Public
Album
What's on your mind?
Replace
Add to your post

[Hedman et al]

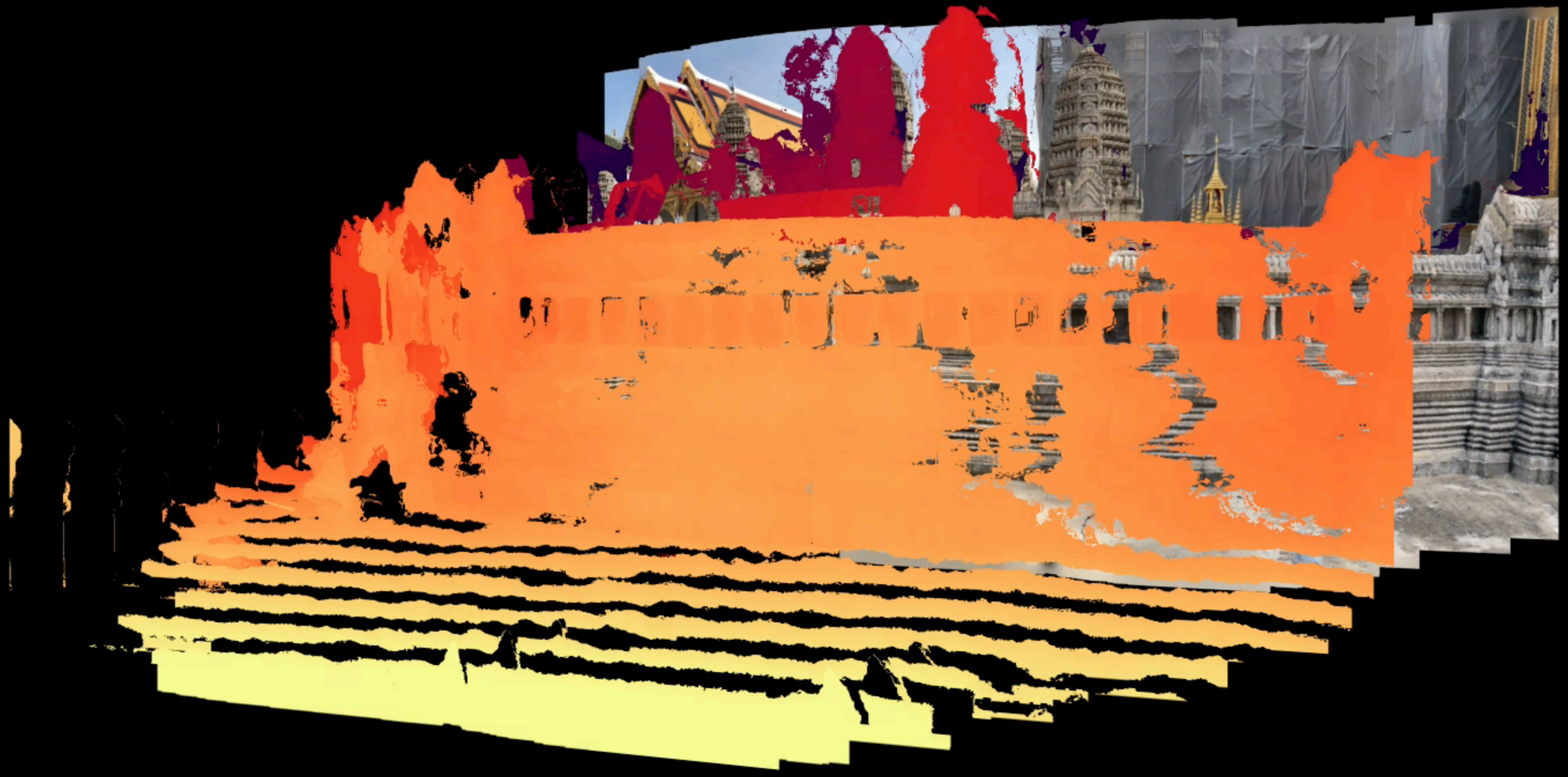
[Hedman et al]



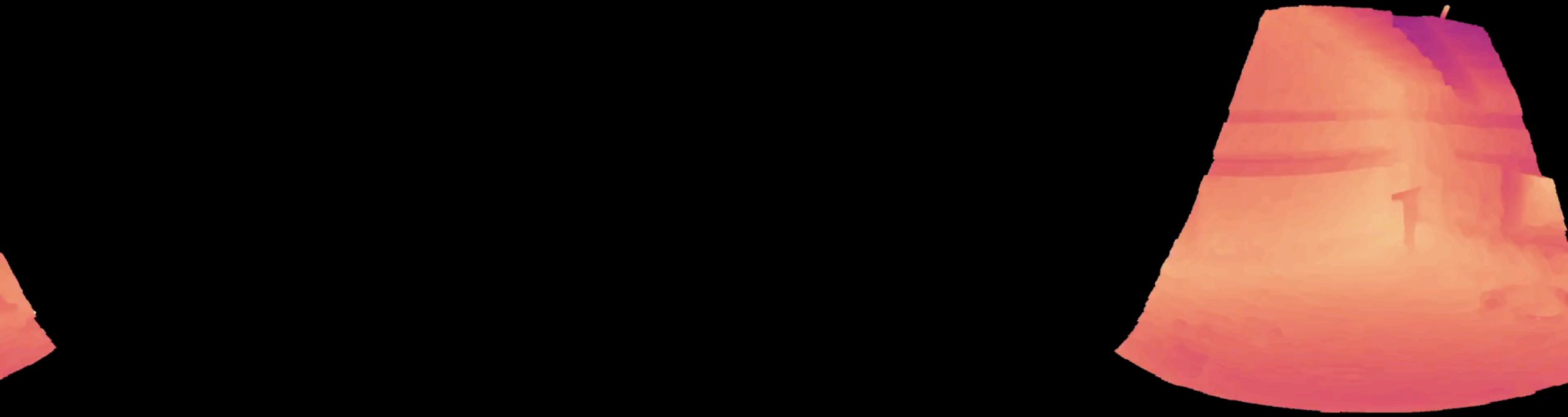
[Hedman et al]

[Hedman et al]

[Hedman et al]

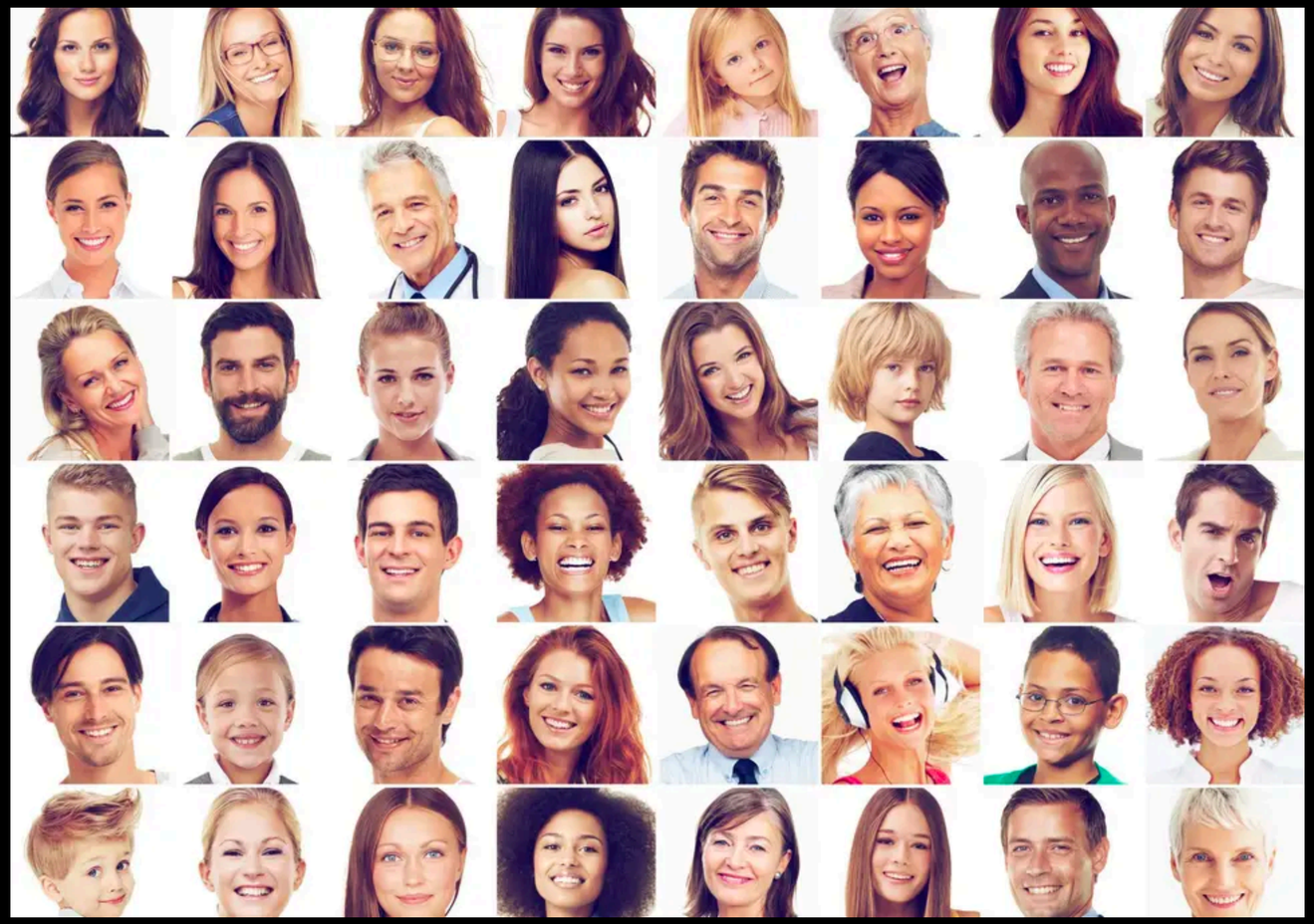


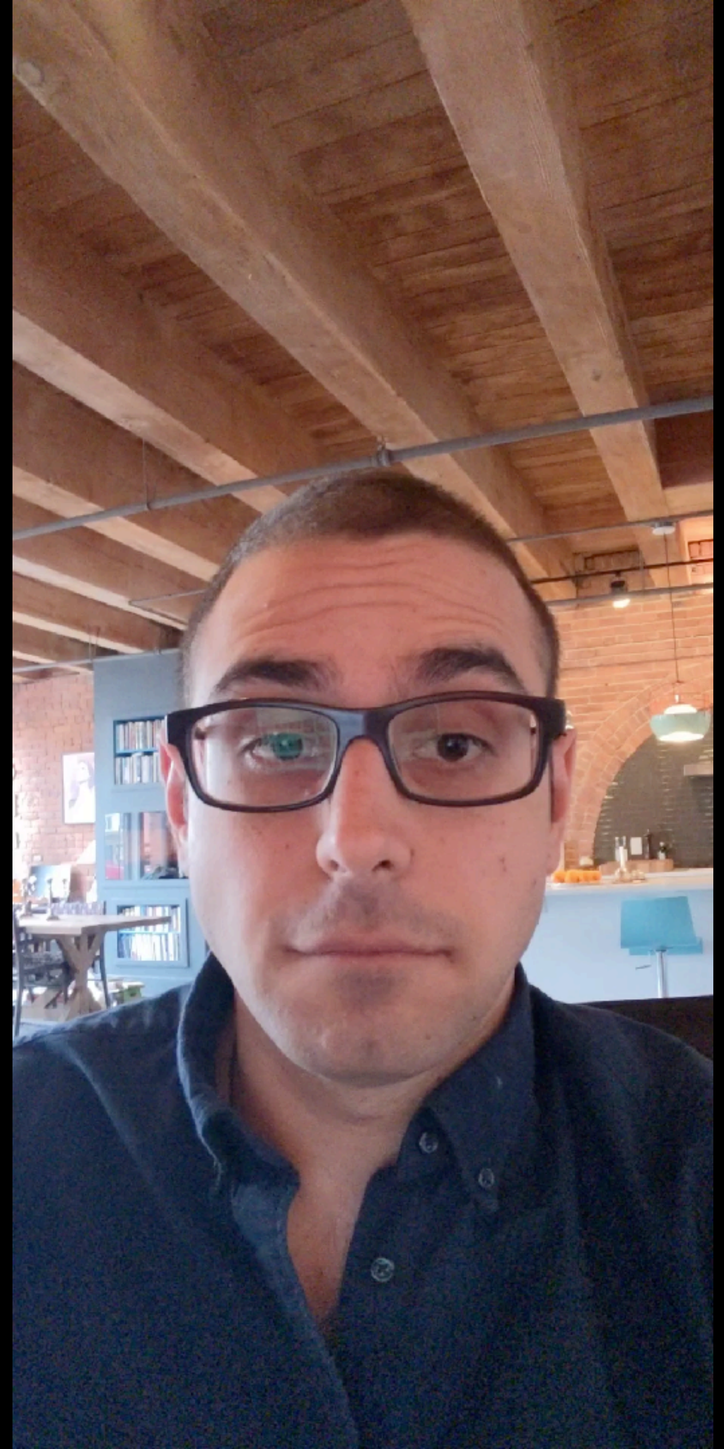
[Hedman et al]

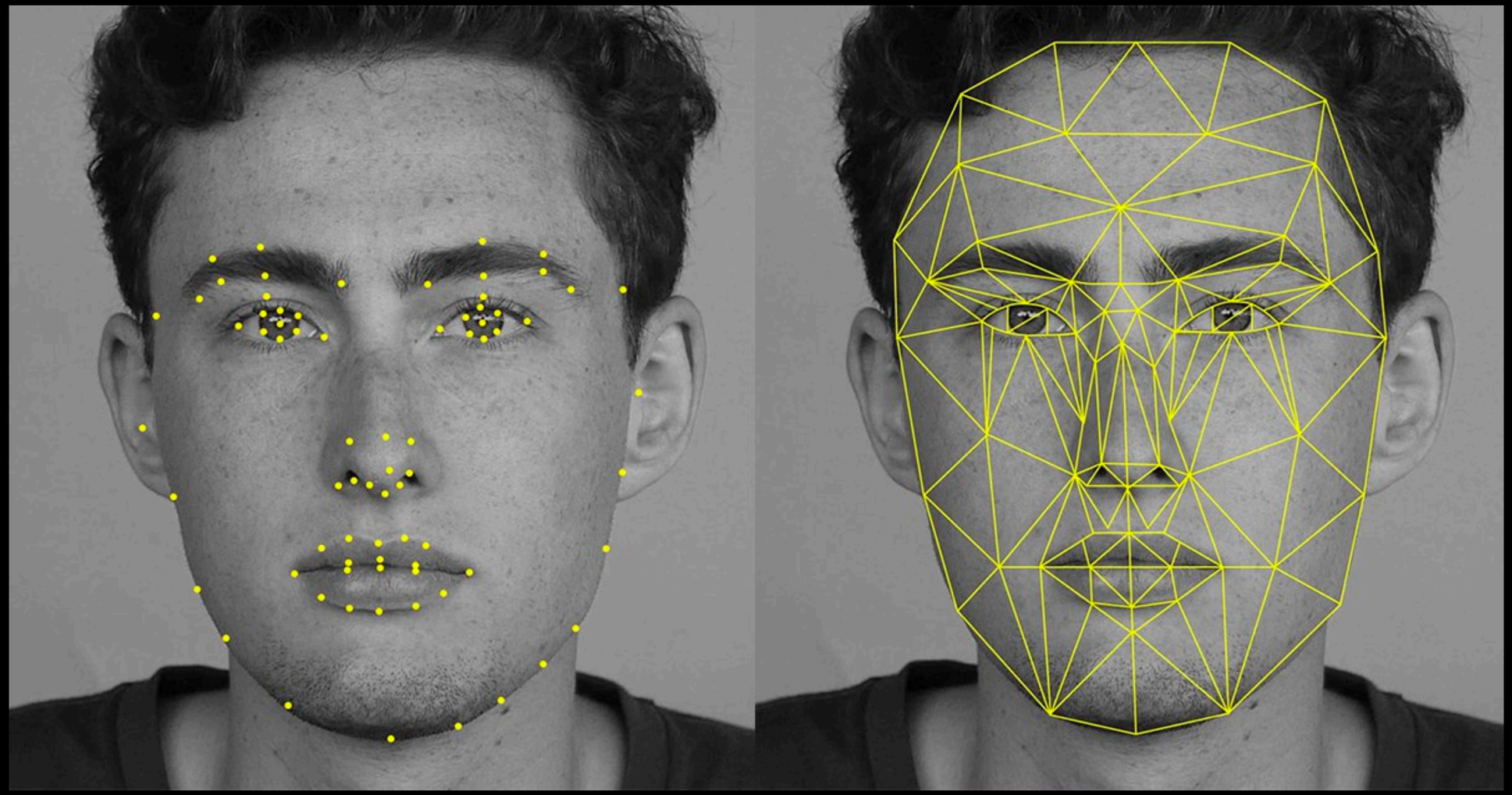


[Hedman et al]

[Hedman et al]







https://technabob.com/blog/wp-content/uploads/2010/02/cosmetic-mirror-by-shiseido.jpg

[Shih et al]

https://people.csail.mit.edu/yichangshih/wide_angle_portrait/sig19_shih_slide_export.pdf

[Shih et al]

https://people.csail.mit.edu/yichangshih/wide_angle_portrait/sig19_shih_slide_export.pdf

Perspective projection

- faces
- background

Stereographic projection

- faces
- background

[Shih et al]

https://people.csail.mit.edu/yichangshih/wide_angle_portrait/sig19_shih_slide_export.pdf

[Hedman et al]

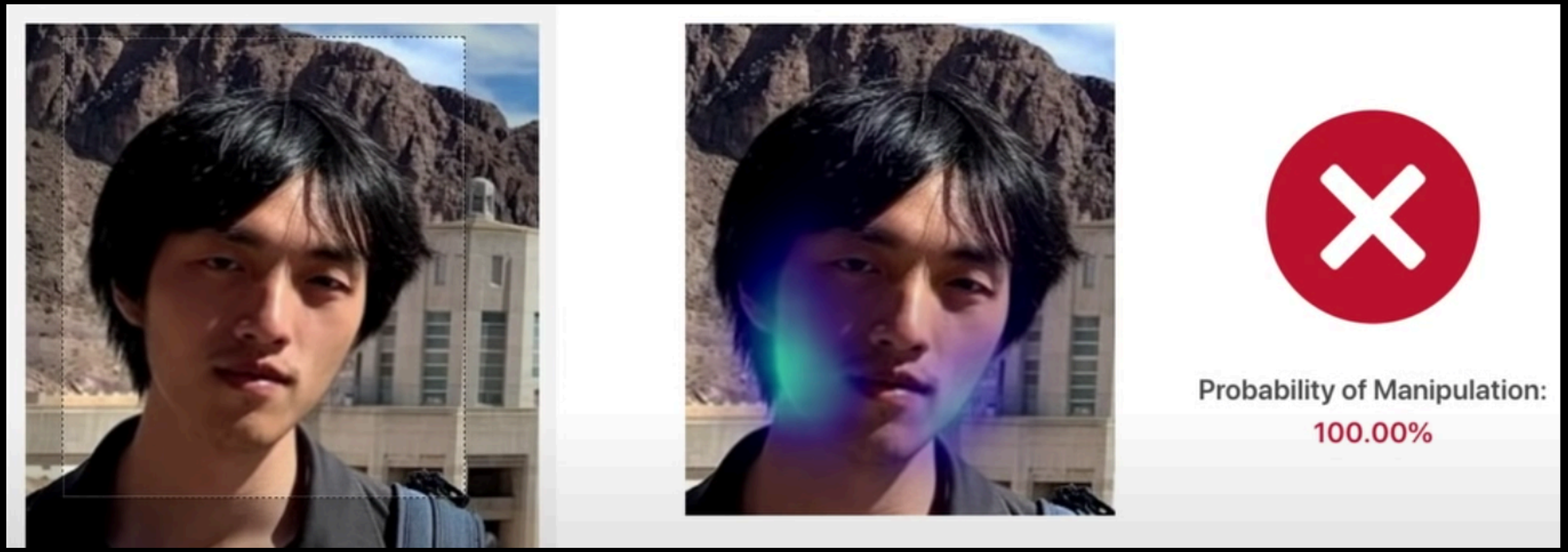
Animating Faces

A single model animates all images given only a single source image

https://www.youtube.com/watch?v=VQgYPv8tb6A
http://papers.neurips.cc/paper/8935-first-order-motion-model-for-image-animation.pdf

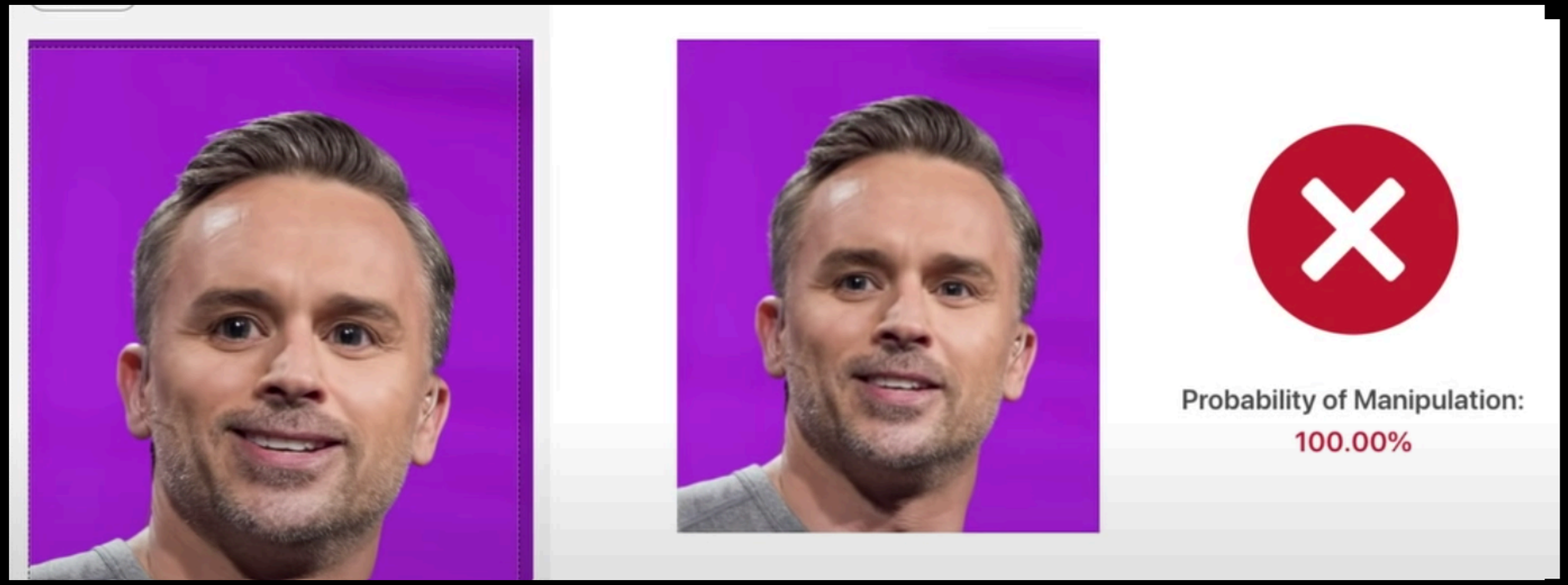
What makes a good photograph?

Detecting deep fakes



[Adobe]

Detecting deep fakes



[Adobe]

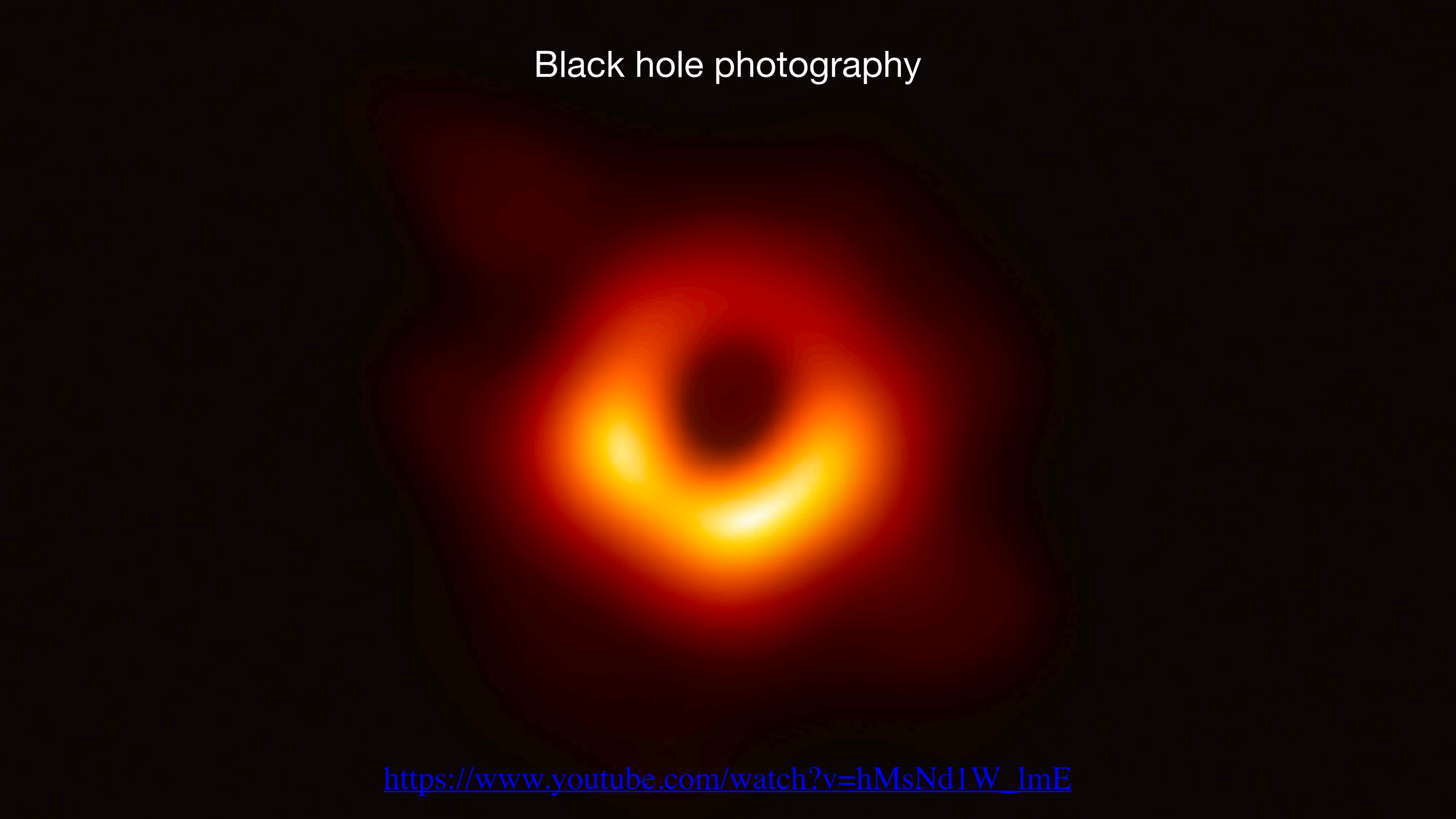
References:

https://ai.googleblog.com/2014/10/hdr-low-light-and-high-dynamic-range.html
https://ai.googleblog.com/2019/11/astrophotography-with-night-sight-on.html
https://ai.googleblog.com/2018/11/night-sight-seeing-in-dark-on-pixel.html
https://theblog.okcupid.com/dont-be-ugly-by-accident-b378f261dea4
https://www.timothybrooks.com/tech/hdr-plus/
https://ai.googleblog.com/2017/10/portrait-mode-on-pixel-2-and-pixel-2-xl.html
https://arxiv.org/abs/1812.08861
https://sites.google.com/view/handheld-super-res/

Slides + materials borrowed from:

[Szeliski] http://szeliski.org/Book/2ndEdition.htm
[Seitz] https://docs.google.com/presentation/d/13BZeGNF6MyNMWAnBETzf3hT41QR3ktL46UhZMshkkOw/edit
[Hedman et al] https://richardt.name/publications/capture4vr/
[Debevec et al] http://www.pauldebevec.com/Research/HDR/ & http://www.pauldebevec.com/Research/HDR/debevec-siggraph97.pdf
[Hedman et al] http://visual.cs.ucl.ac.uk/pubs/instant3d/
[Hoppe et al] http://hhoppe.com/proj/flash/
[Efros] http://graphics.cs.cmu.edu/courses/15-463/2005_fall/www/463.html
https://www.youtube.com/watch?v=VQgYPv8tb6A

Black hole photography



https://www.youtube.com/watch?v=hMsNd1W_lmE

Let’s enhance

https://www.youtube.com/watch?v=Vxq9yj2pVWk