

# Computational Photography

Instructor: Sanjeev J. Koppal

MWF

1145am-1235pm

BEN 328

# Acknowledgements

Some slides from  
Narasimhan (Carnegie Mellon),  
Zickler (Harvard),  
and  
Efros (Berkeley)

Canvas?

# Presentation groups?

# Depicting Our World: The Start

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Prehistoric Painting, Lascaux Cave, France  
~ 13,000 -- 15,000 B.C.

# Depicting Our World: Middle Ages

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The Empress Theodora with her court.  
Ravenna, St. Vitale 6th c.

# Participation

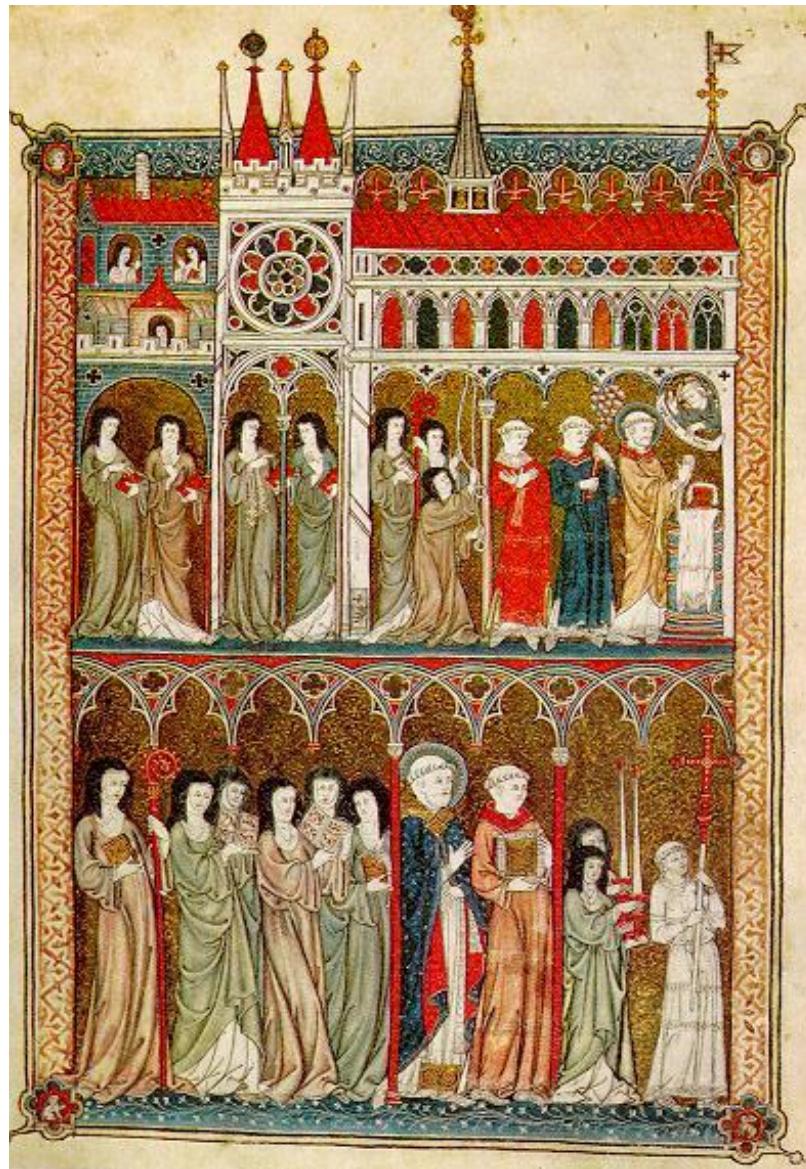
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*What is strange about that image?*

# Depicting Our World: Middle Ages

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Nuns in Procession. French ms. ca. 1300.

# Depicting Our World: Renaissance

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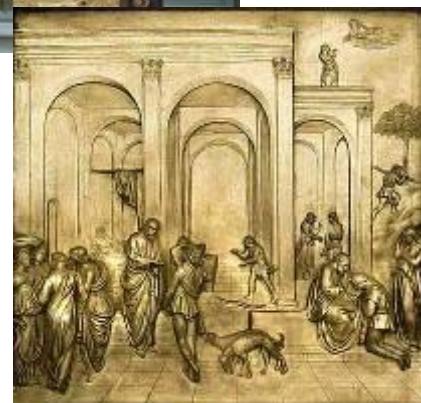
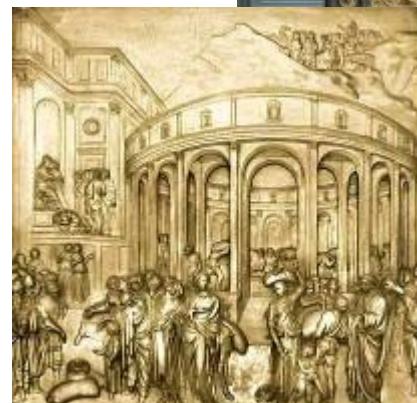
North Doors (1424)



Lorenzo  
Ghiberti  
(1378-1455)

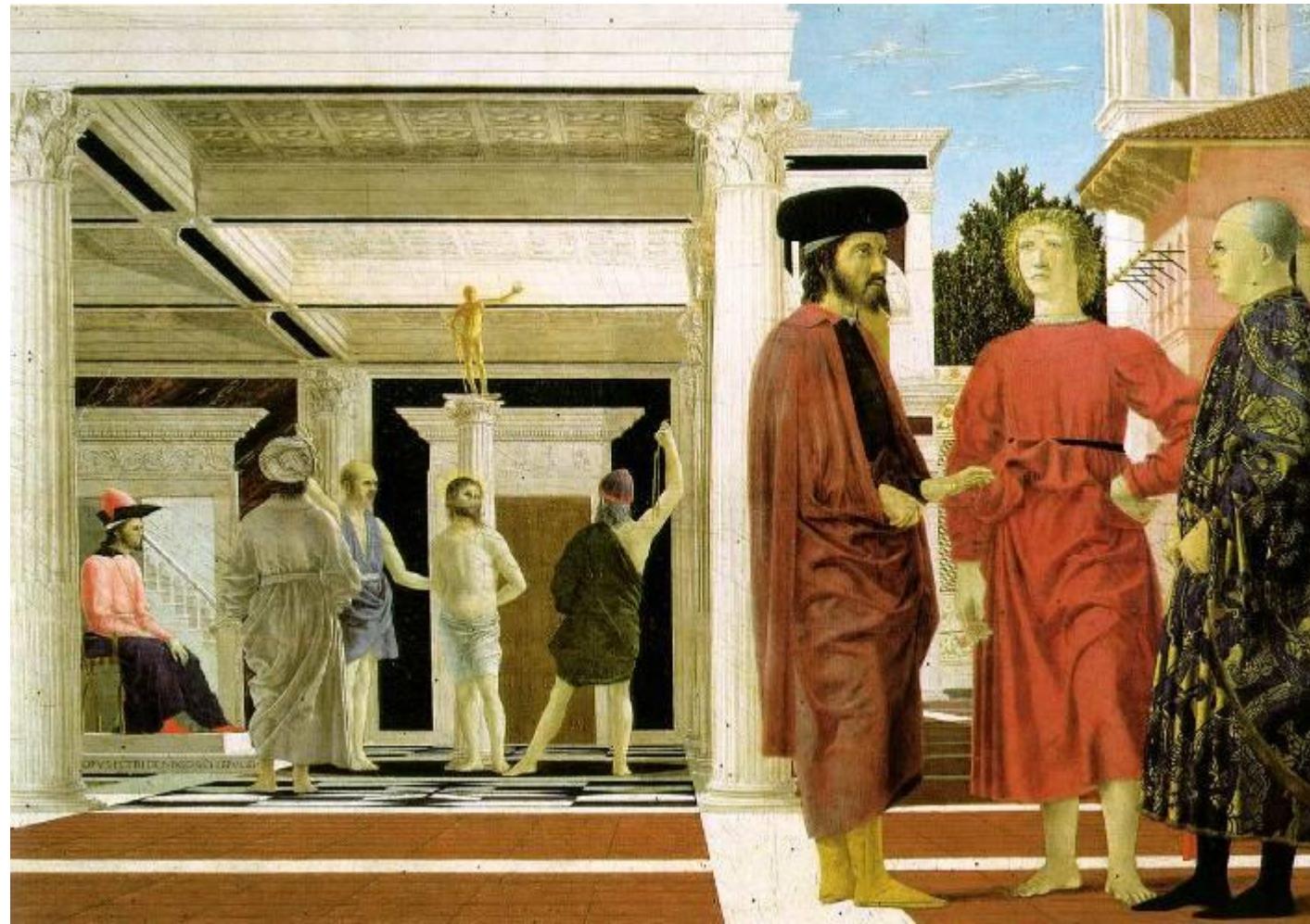


East Doors (1452)



# Depicting Our World: Renaissance

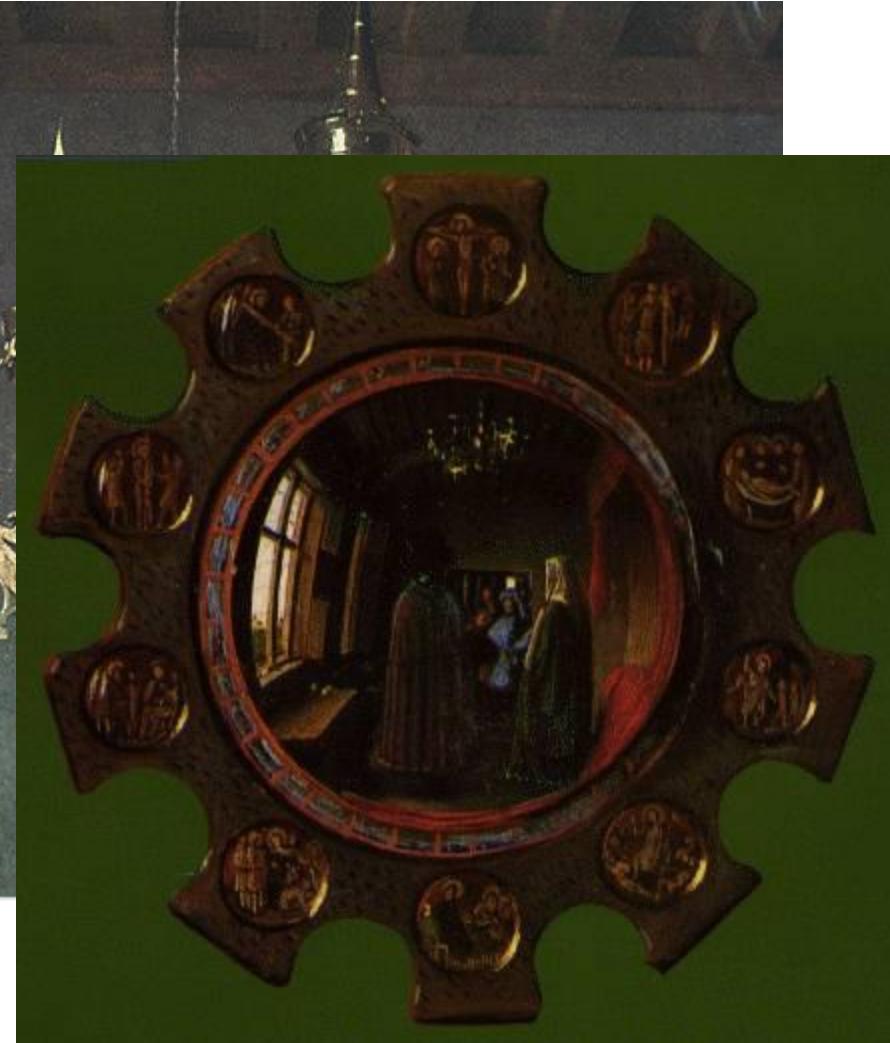
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**Piero della Francesca,**  
*The Flagellation* (c.1469)

# Depicting Our World: Toward Perfection

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**Jan van Eyck, *The Arnolfini Marriage* (c. 1434)**

# Depicting Our World: Ongoing Quest

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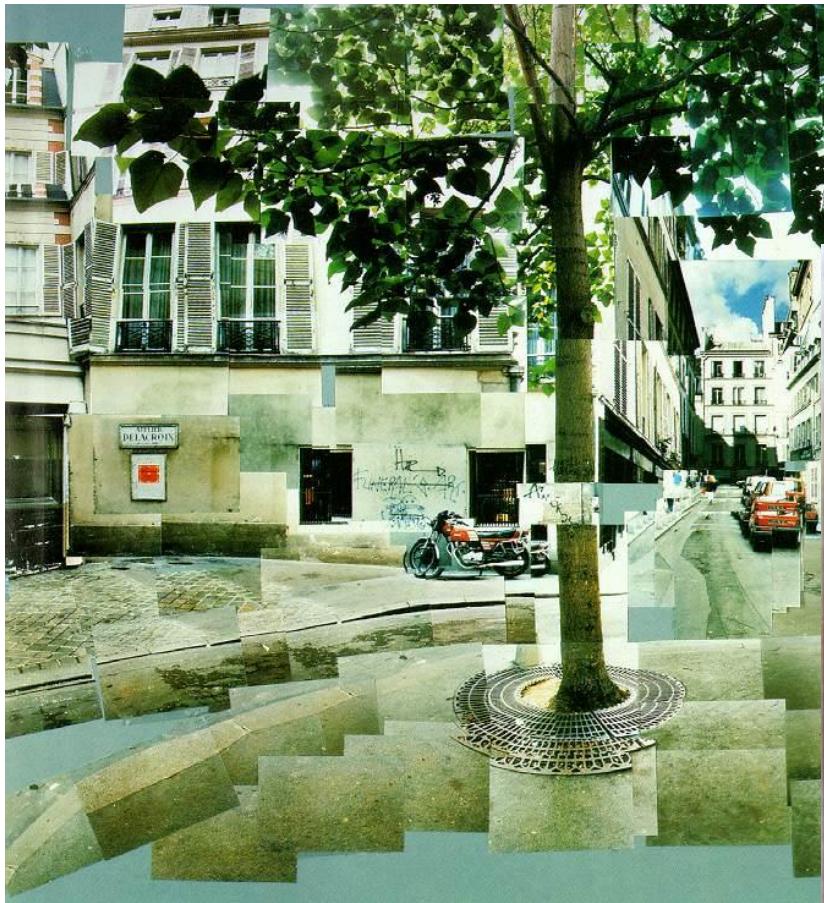
Pablo Picasso



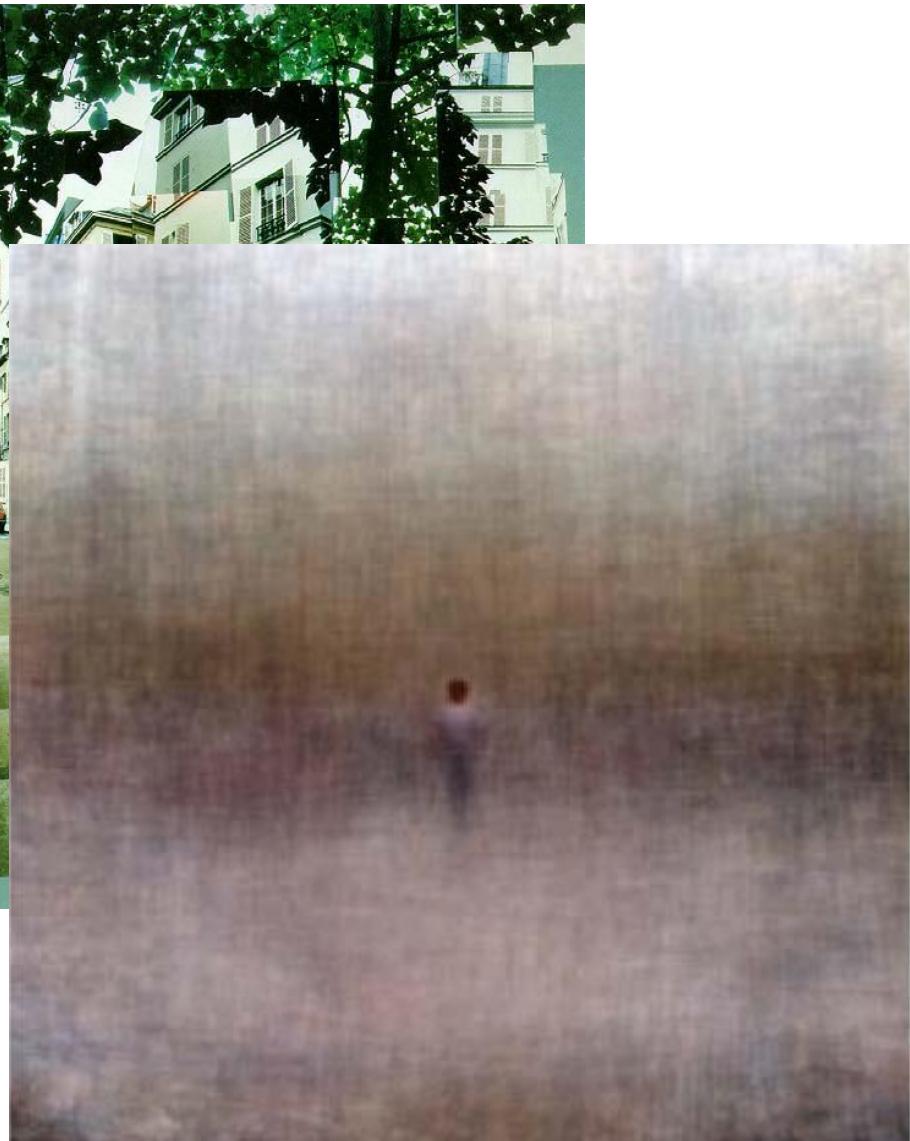
Marc Chagall

# Depicting Our World: Ongoing Quest

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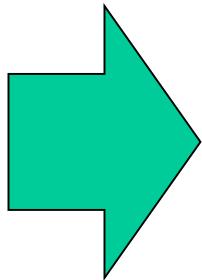
David Hockney, 1985



Antonio Torralba & Aude Oliva (2002)

# It took a while to go from depiction to art

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# Photographs

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*Still Life*, Louis Jacques Mandé Daguerre, 1837

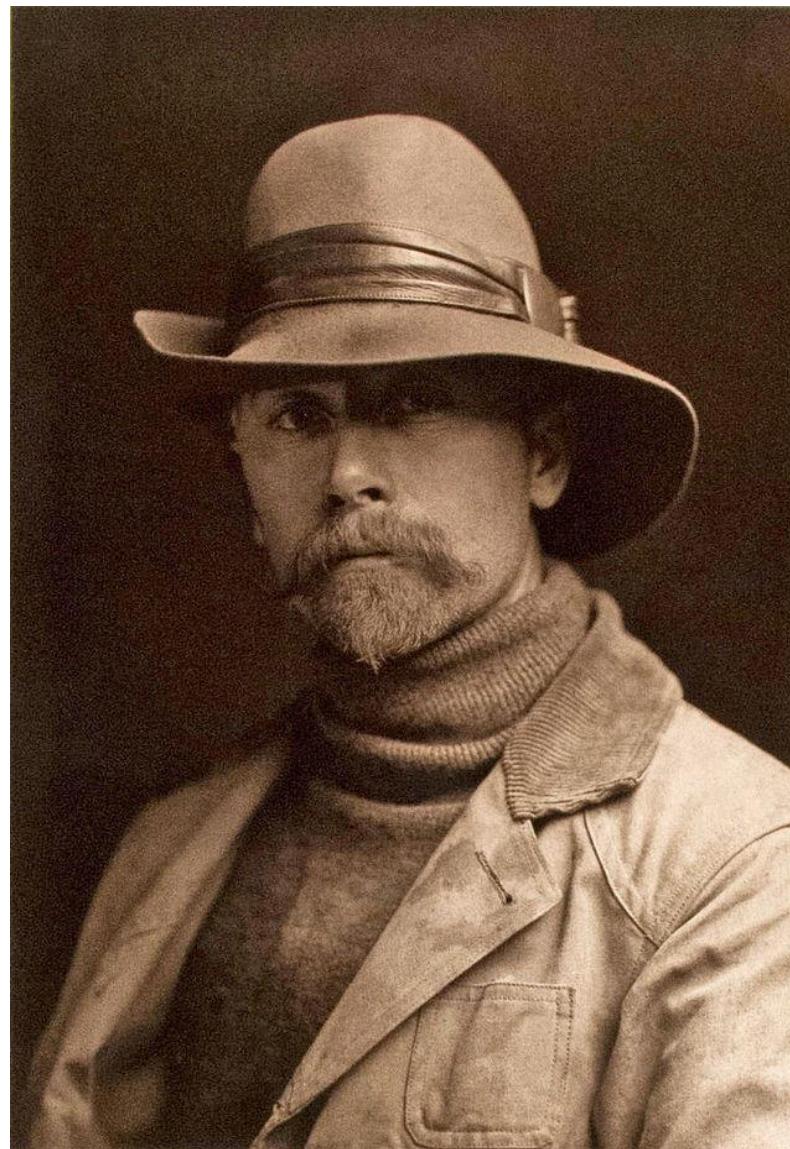
# Portraits

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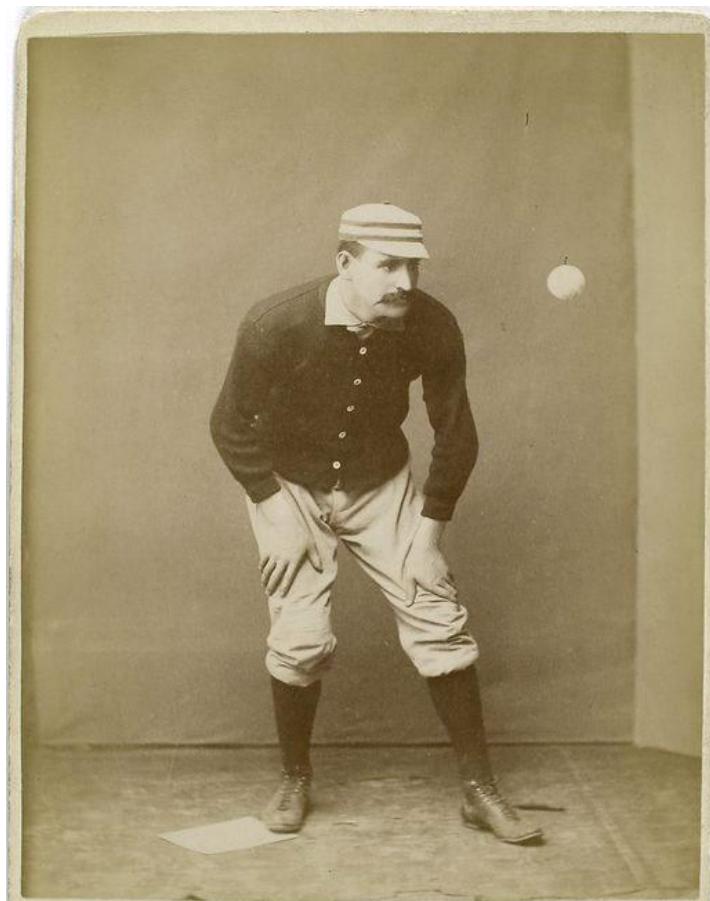
# Portraits

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# News and Sports

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*Gray*

1068 and 1070 TREMONT ST.,  
BOSTON, MASS.

# Ansel Adams

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*The Tetons and the Snake River (1942)*

# Participation

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*Why would that picture  
be special?*

# Manipulating the imaging process

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# Photoshopping

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Andreas Gursky, *99 Cent II Diptychon*, 2001

# Participation

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*How much would you pay  
for that picture?*

# Manipulating the imaging process

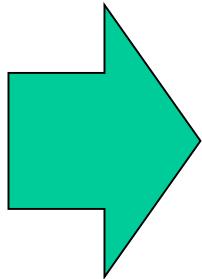
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\$3.34 million, for the first print!

# It took a while to go from depiction to art

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# Lesson 1

At some point,  
people use technology to  
create expressions rather than depict.

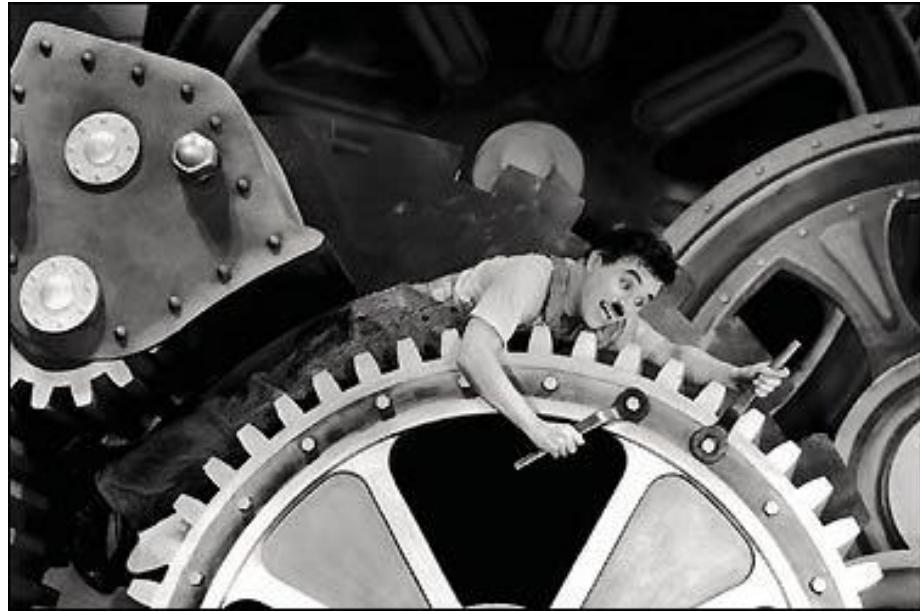
# Movies

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# It didn't take long to go from depiction to art

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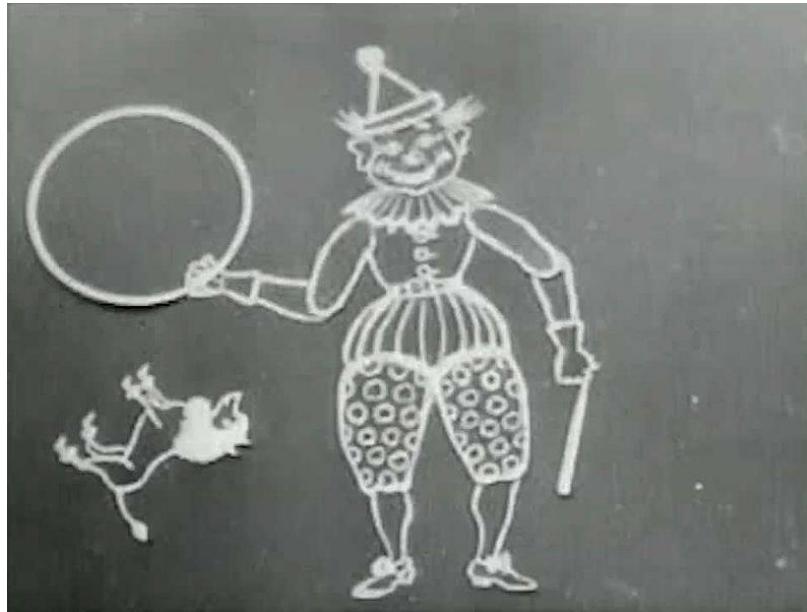
Chaplin, Modern Times



The Oyster Princess

# It didn't take long to go from depiction to art

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Early animation

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How can computation help?

# Non-photo realistic rendering

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Aaron Hertzmann

# Non-photo realistic rendering

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Source image



“Impressionist”



“Expressionist”



“Pointillist”

Aaron Hertzmann

# Non-photo realistic rendering

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Source image



“Impressionist”



“Expressionist”



“Colorist Wash”

Aaron Hertzmann

# Non-photo realistic rendering

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Aaron Hertzmann

# Participation

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*Would the algorithm be different from  
images to video?*

# Lesson 2

Increasing a dimension,  
to time, color or anything else  
always means a new algorithm.

# Bilateral Filtering

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(a) Input



(b) Abstracted output

Paris et al.

# How can computation help?

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[https://www.youtube.com/watch?v=IVDxfDNq2VU&feature=player\\_detailpage#t=78](https://www.youtube.com/watch?v=IVDxfDNq2VU&feature=player_detailpage#t=78)

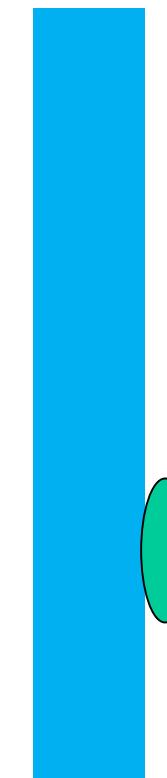
# Imaging tears

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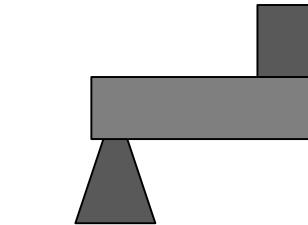
Refractive index,  $n$



Droplet rate  $r$



$d$



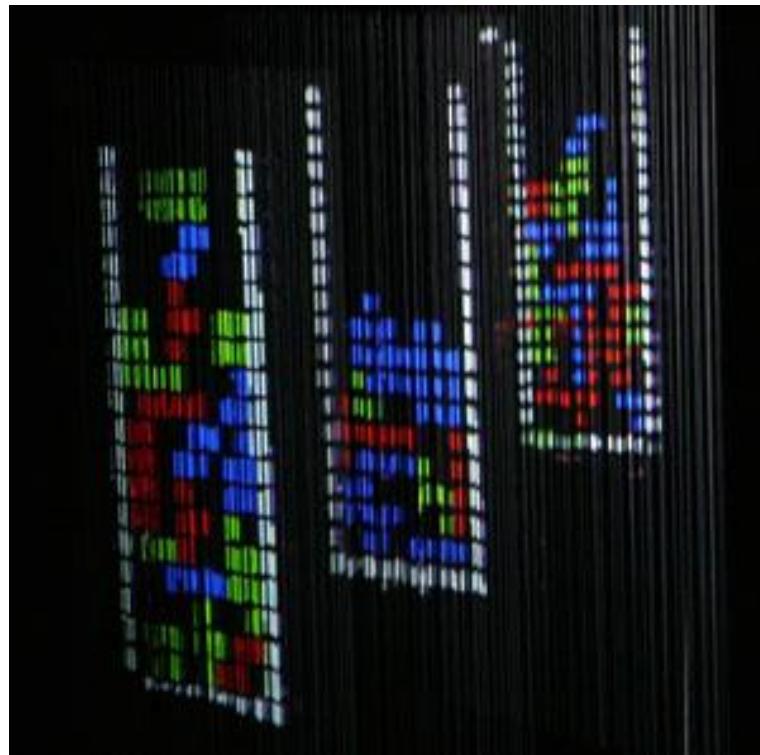
Light source



Drop size,  $S$   
Material,  $M$

# Applications

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Barnum et al.

# Applications

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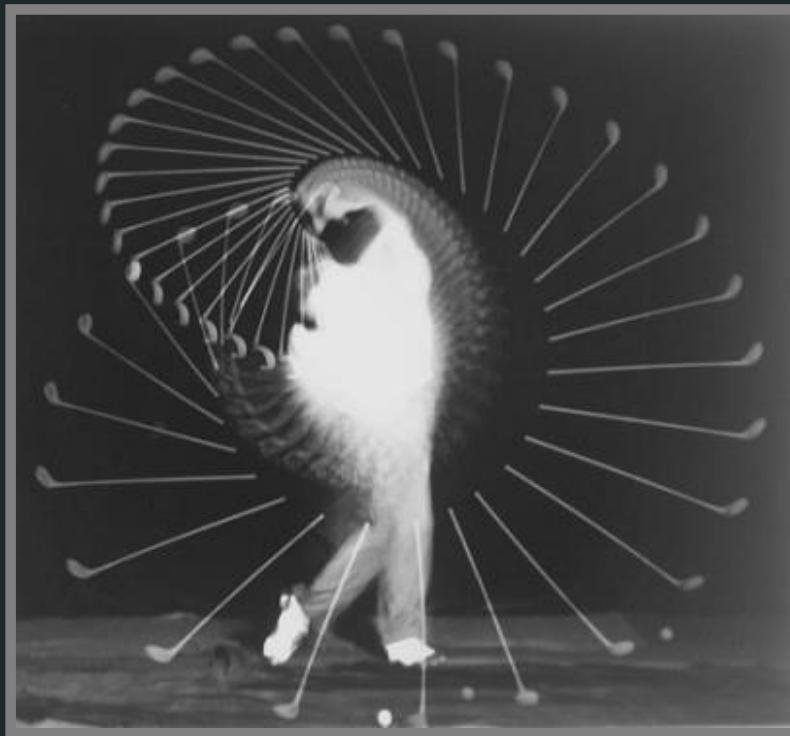


Garg et al.

# Lesson 3

Unlike, painting->photo->movies,  
computation allows  
only imagination to limit us.

# Strobe photography



*Densmore Shute Bends the Shaft*  
(Harold Edgerton, 1938)

# Today



Strobe kit



Splash



Dancer

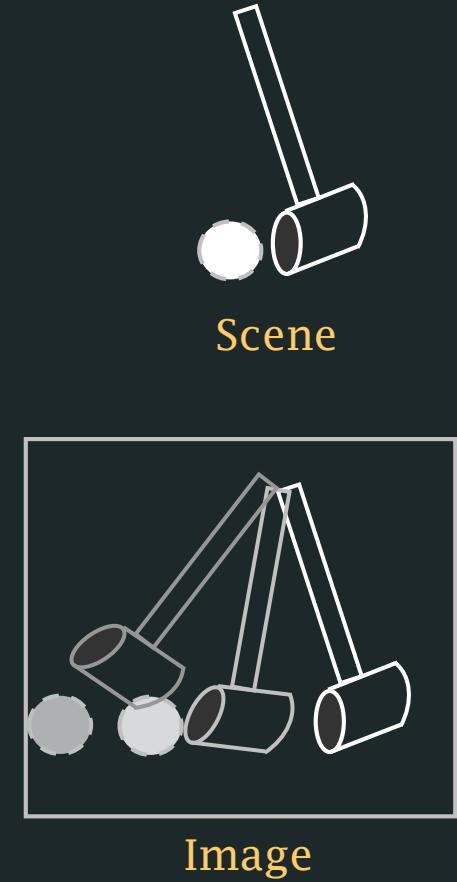
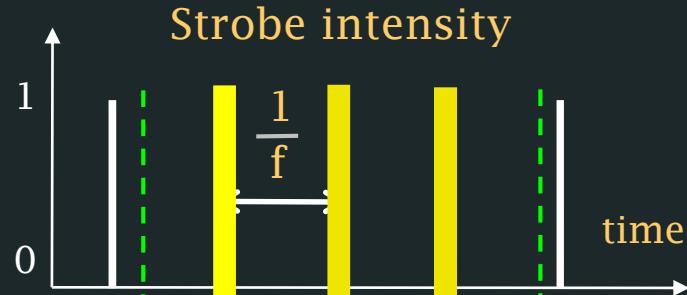


Hammer



Incense

# High-frequency illumination

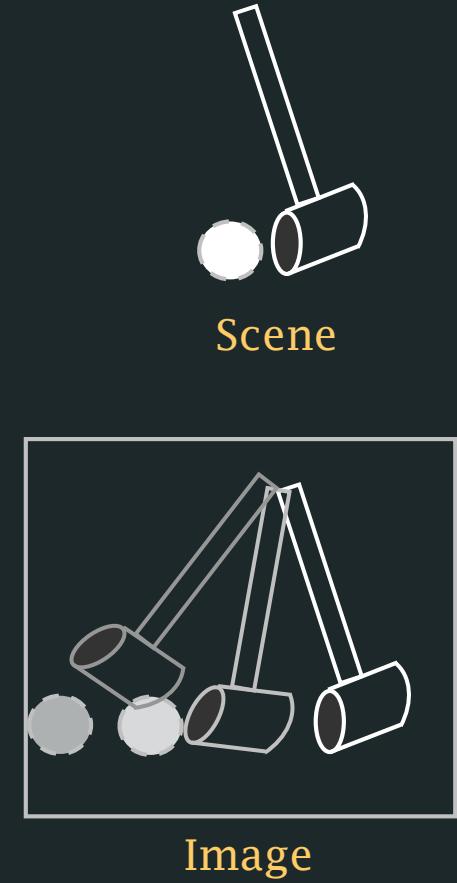
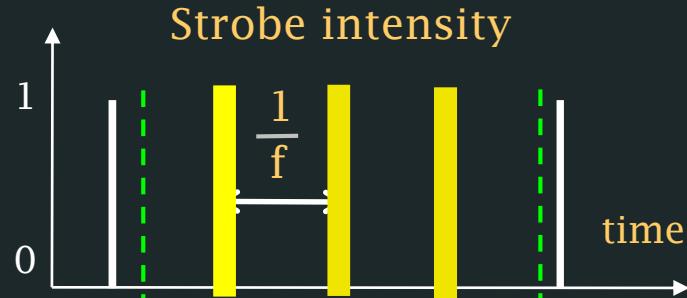


# Participation

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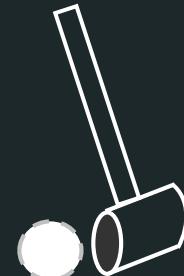
*Can we tell how many “copies”  
of the object we would see?*

# High-frequency illumination



Maximum number of scene copies =  $Tf$

# Selecting the strobe-light



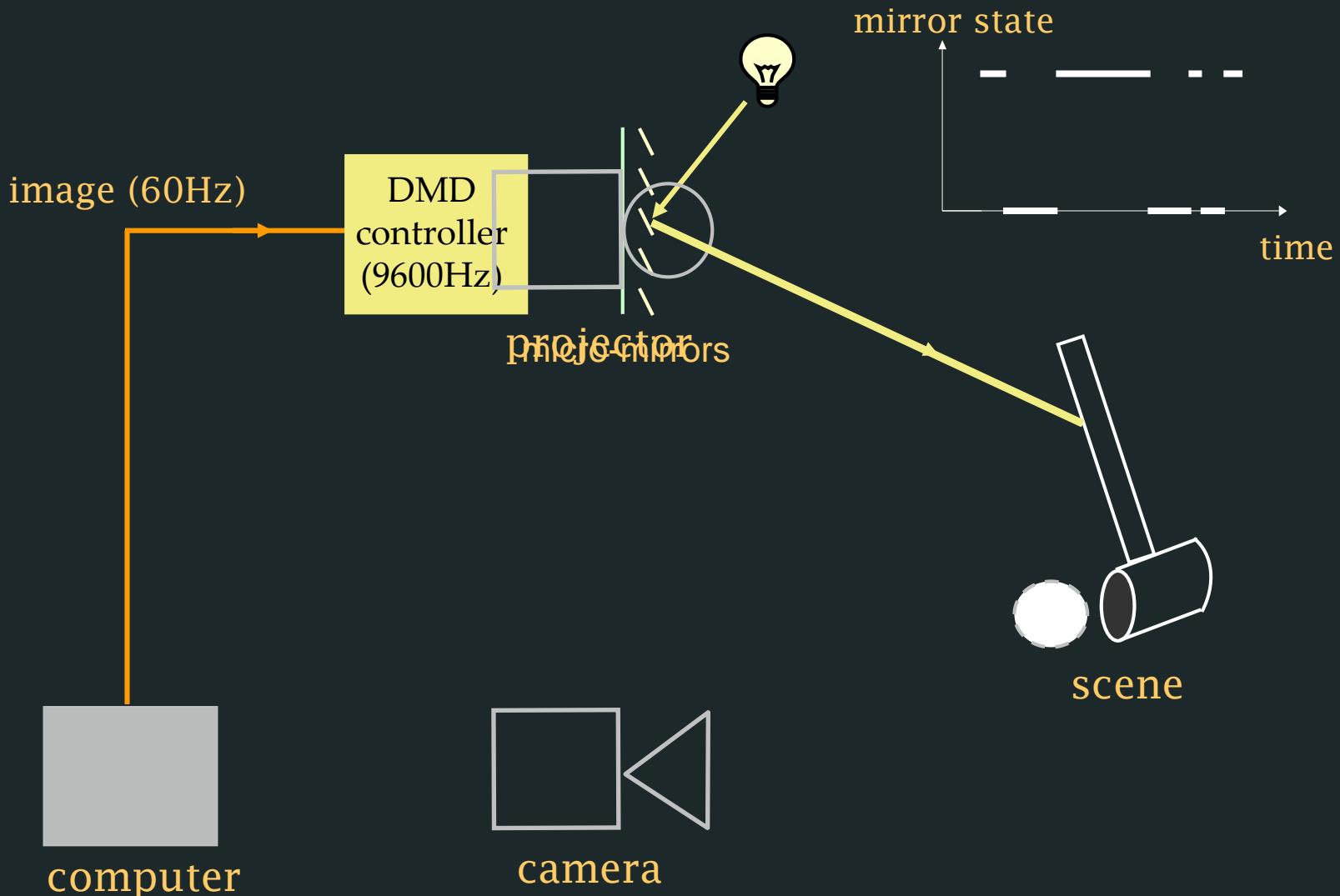
LEDs



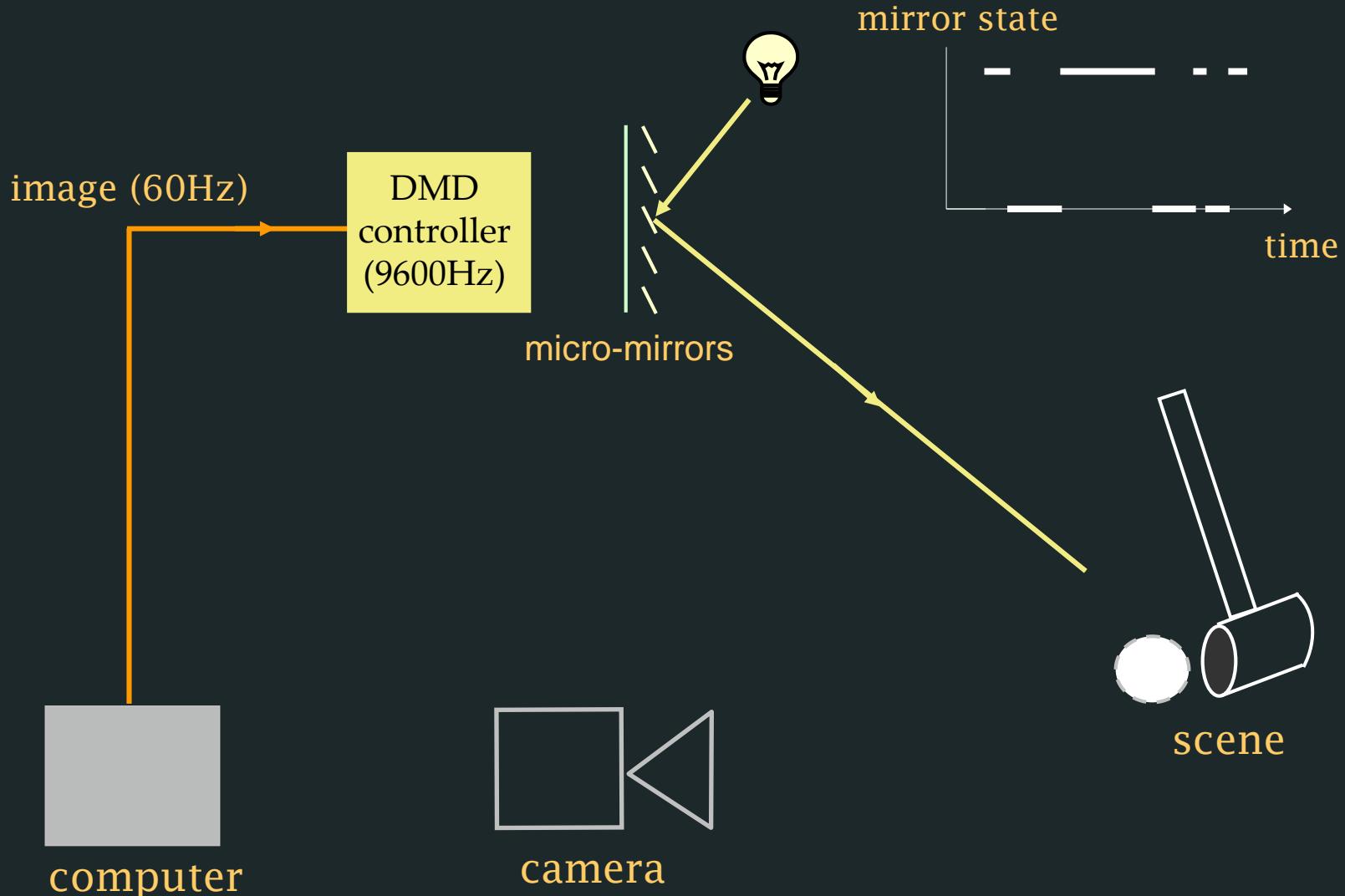
DLP projector



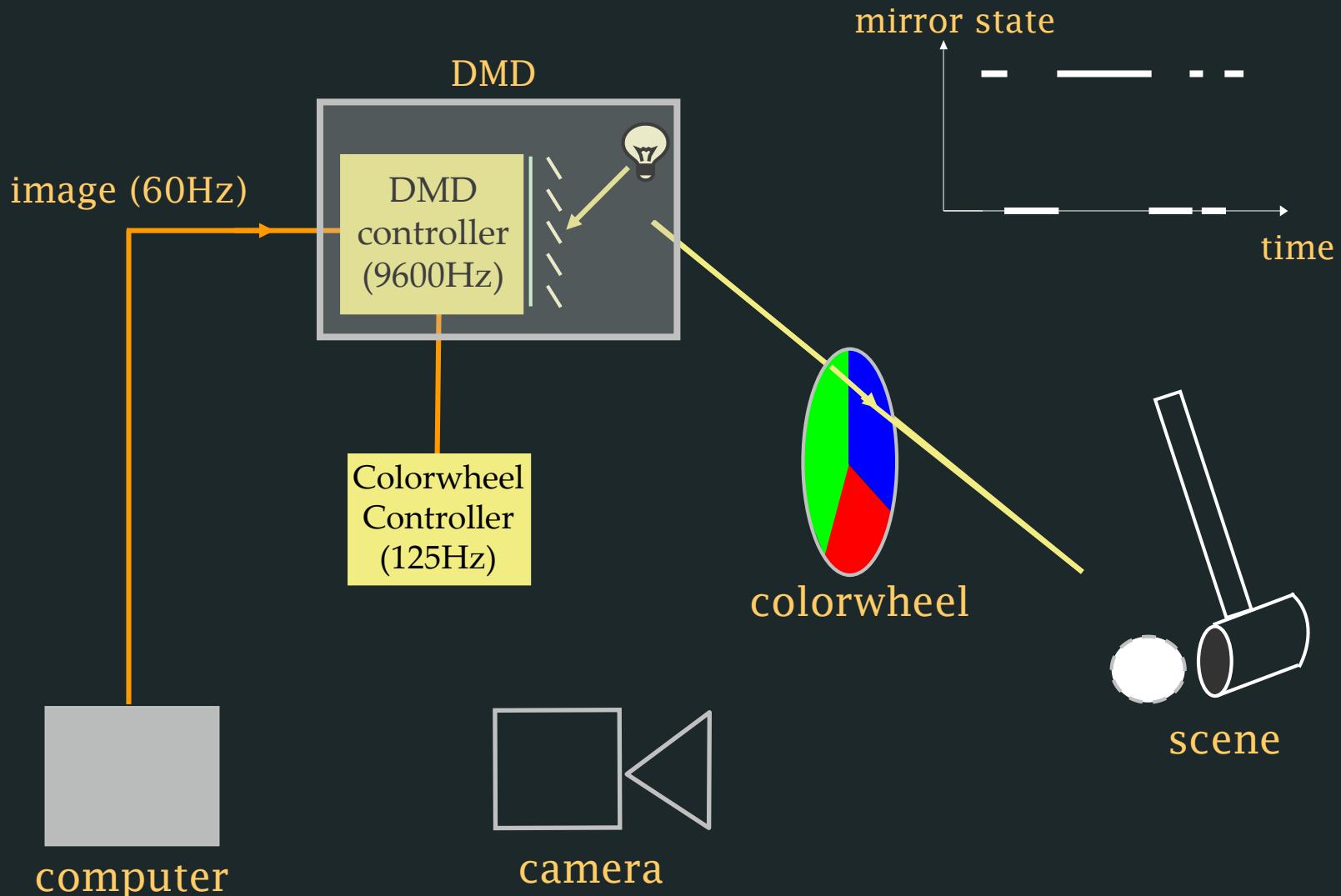
# Inside a DLP projector



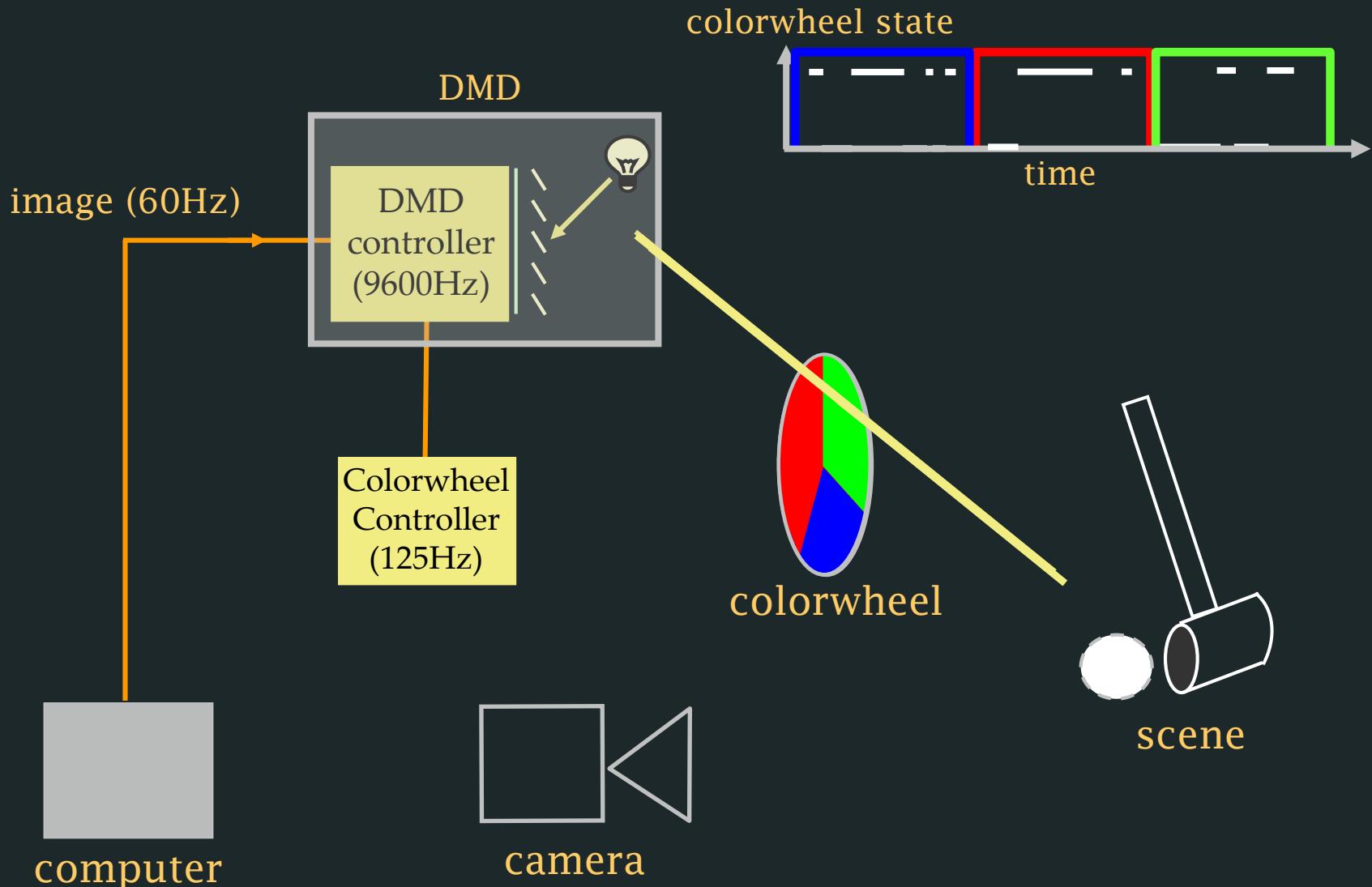
# Inside a DLP projector



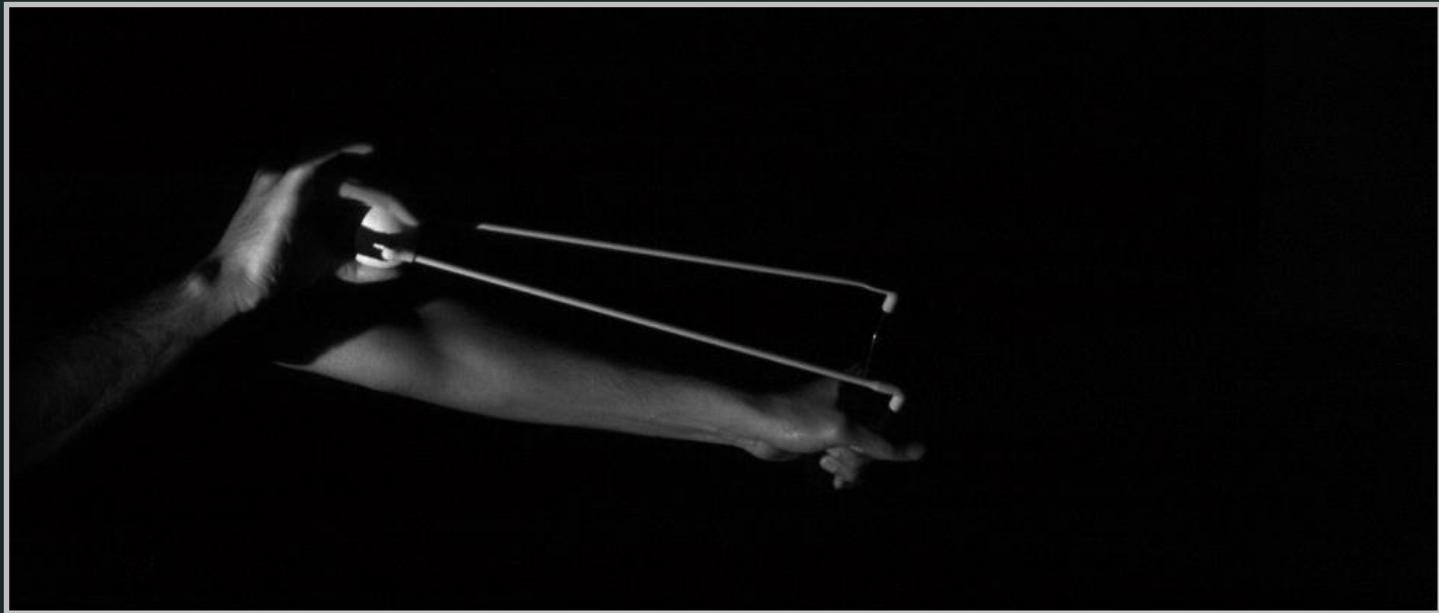
# Inside a DLP projector



# Inside a DLP projector

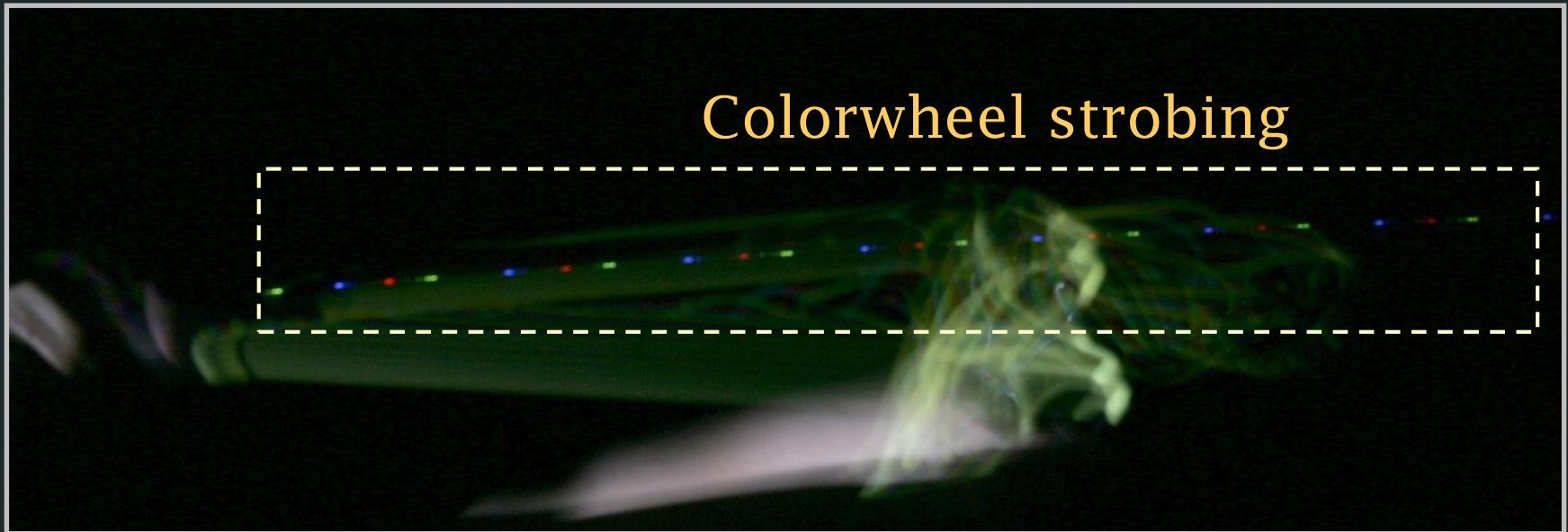


# DLP photography



Slingshot at 250Hz

# DLP photography



Slingshot at 1Hz

# DLP photography



Slingshot at 1Hz

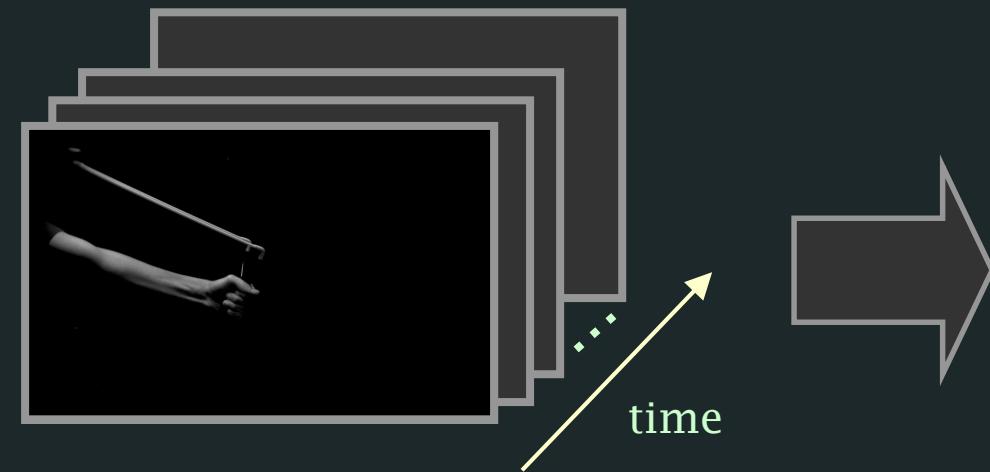
High-speed scenes (>> 125Hz)

# Slingshot under fluorescent light



1000Hz : No motion blur

# Shape-time photography



1000Hz : No motion blur

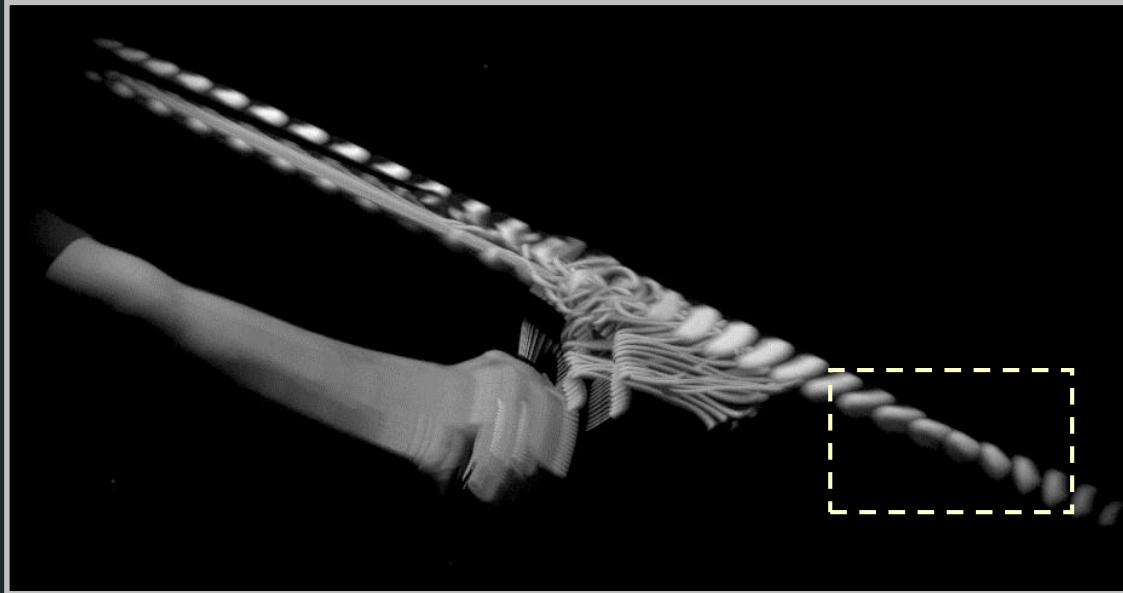


Summary image

# Lesson 4

From a video block, you can  
create, algorithmically, a new image.

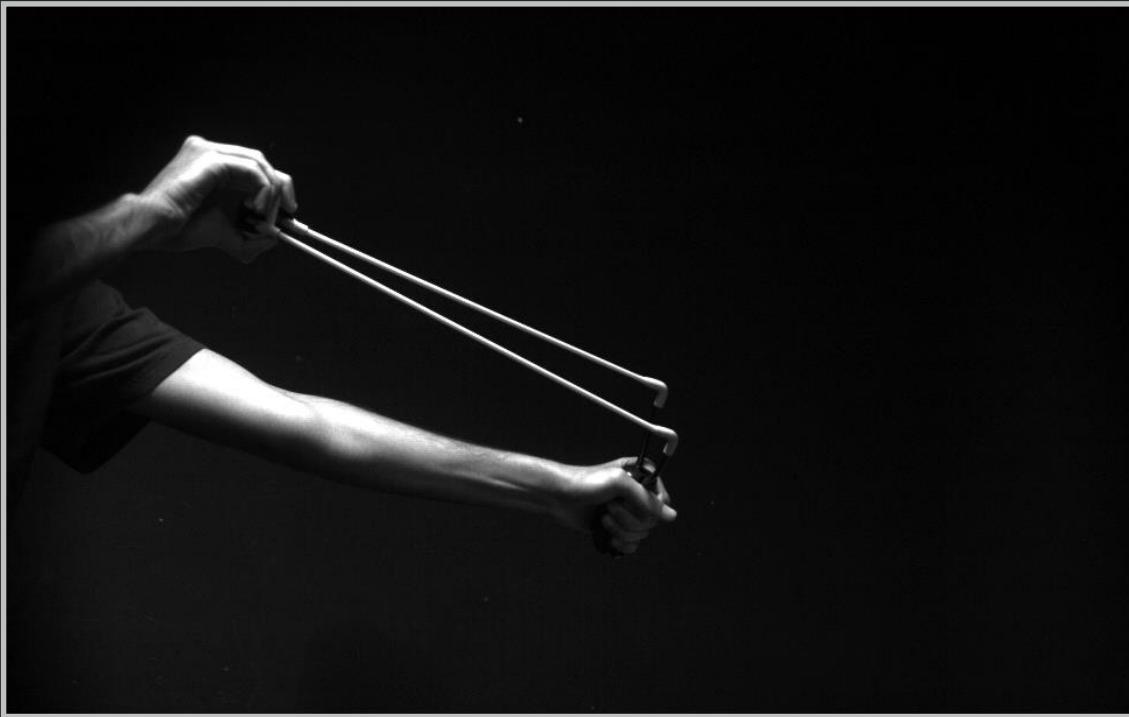
# Shape-time photography



Summary image

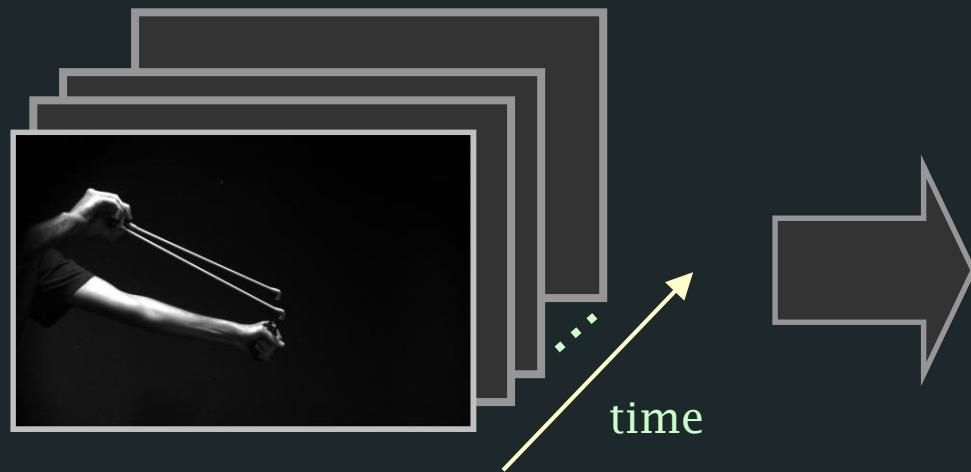
High-frequency  
pattern

# Lower frame rate



250Hz : Motion blur

# Shape-time photography



250Hz : Motion blur

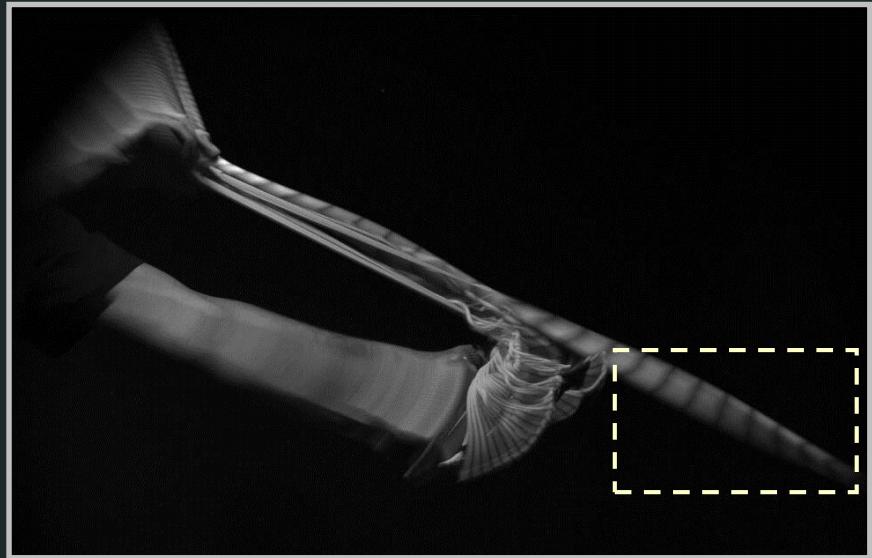


Summary image

# Comparison under fluorescent lighting



1000Hz with no motion blur



250Hz with motion blur

# Lower frame-rate under DLP illumination



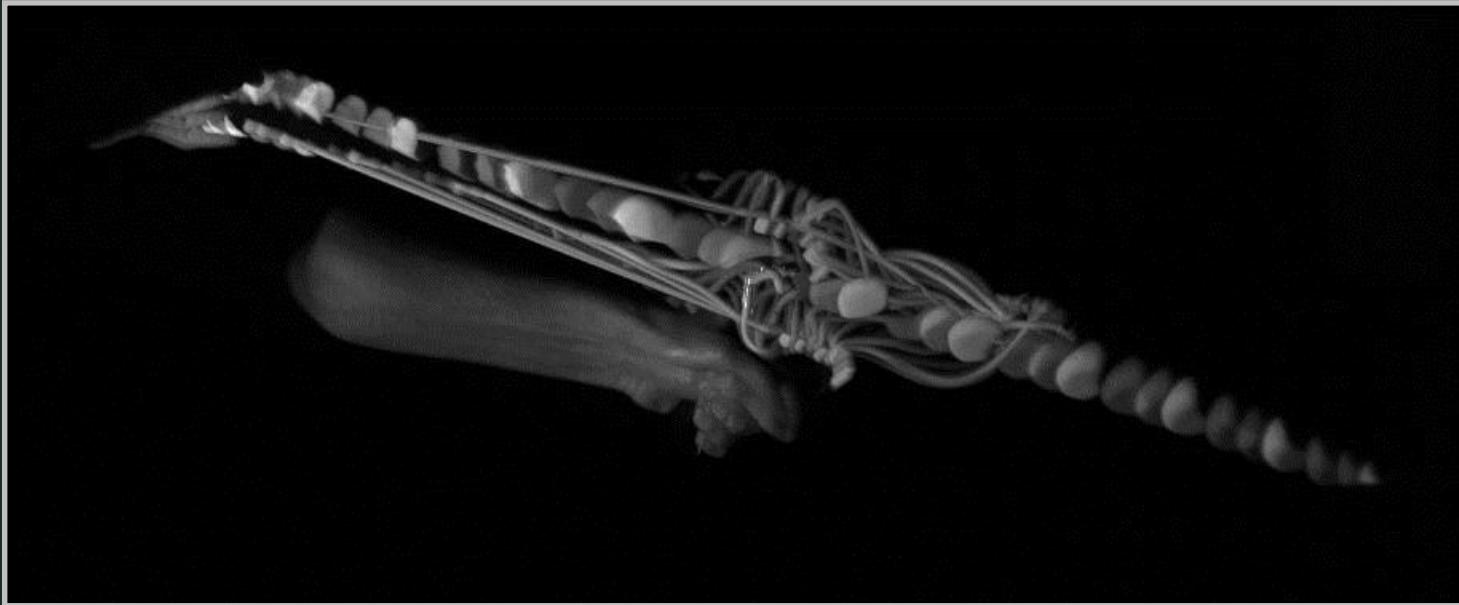
250Hz: High frequency blur

# Single frame with object copies



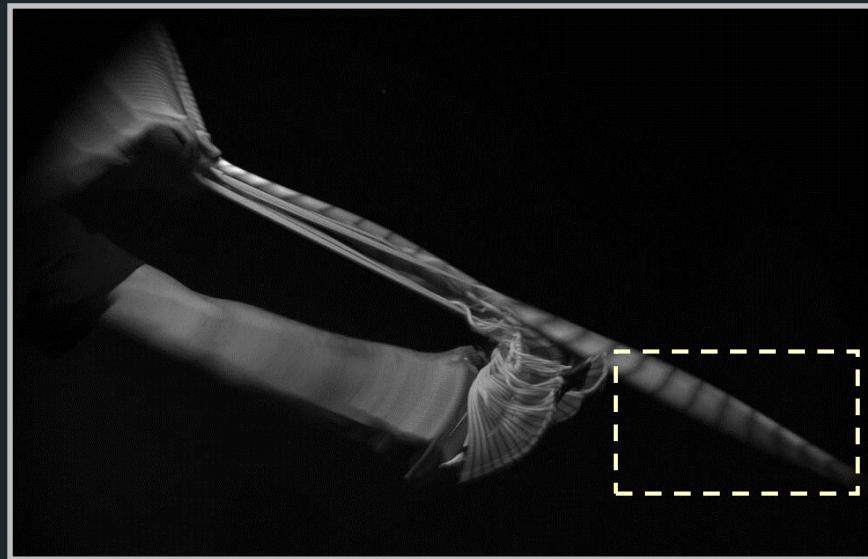
250Hz: High frequency blur

# Summary

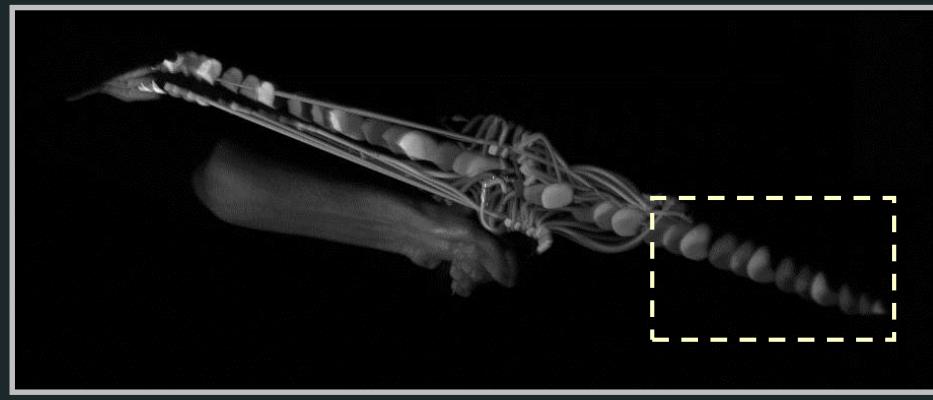


250Hz: High frequency blur

# DLP vs. Fluorescent

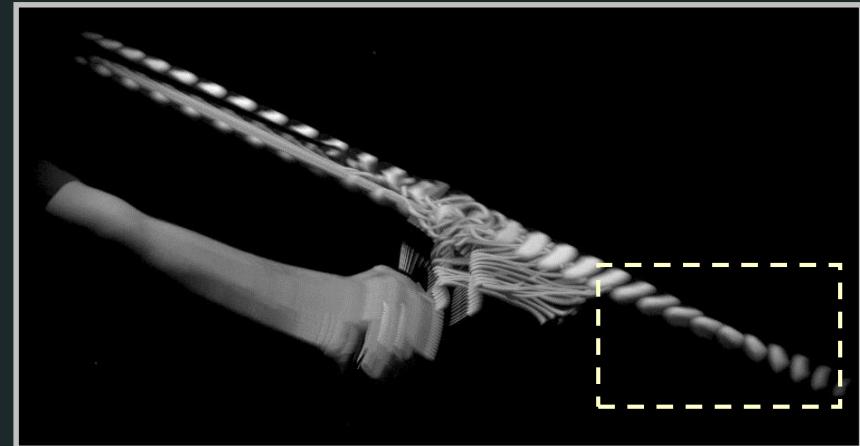


250Hz with motion blur

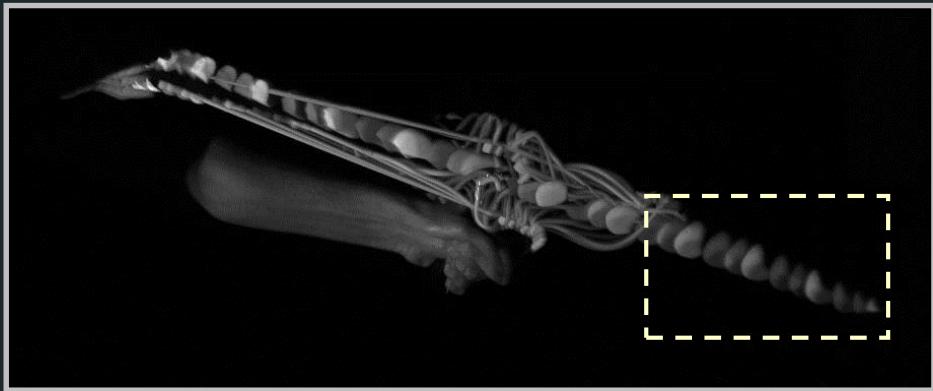


250Hz with no motion blur

# DLP allows capture at lower frame rate



1000Hz with no motion blur



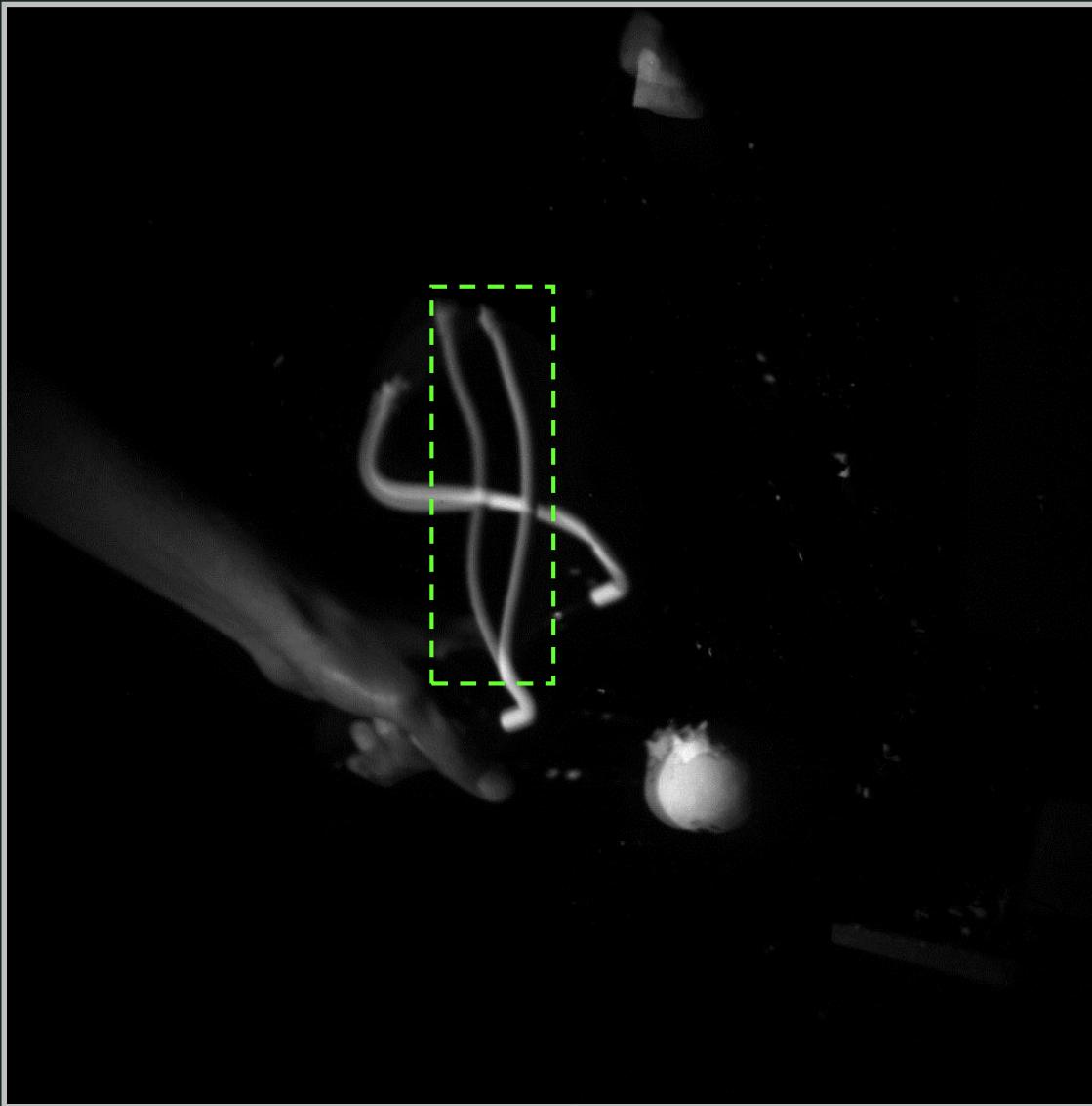
250Hz with no motion blur

# Slingshot in action



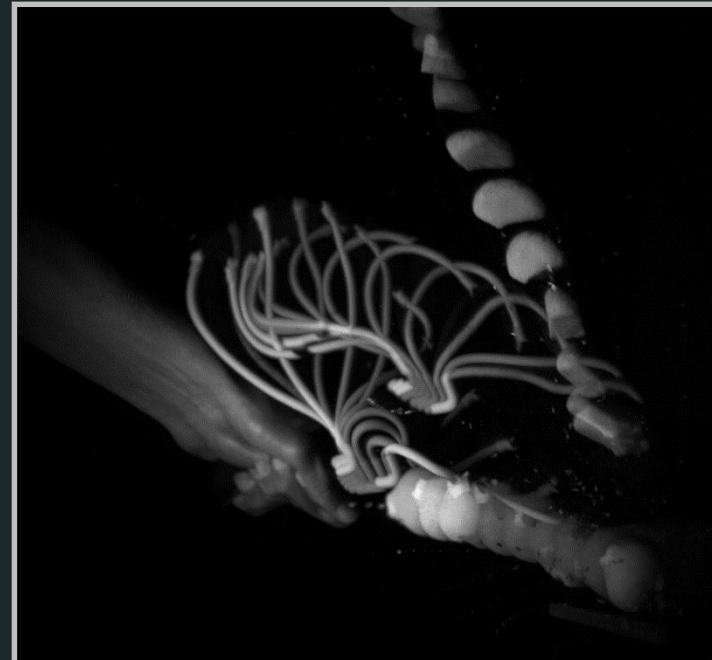
250Hz

# Strobing in single frames

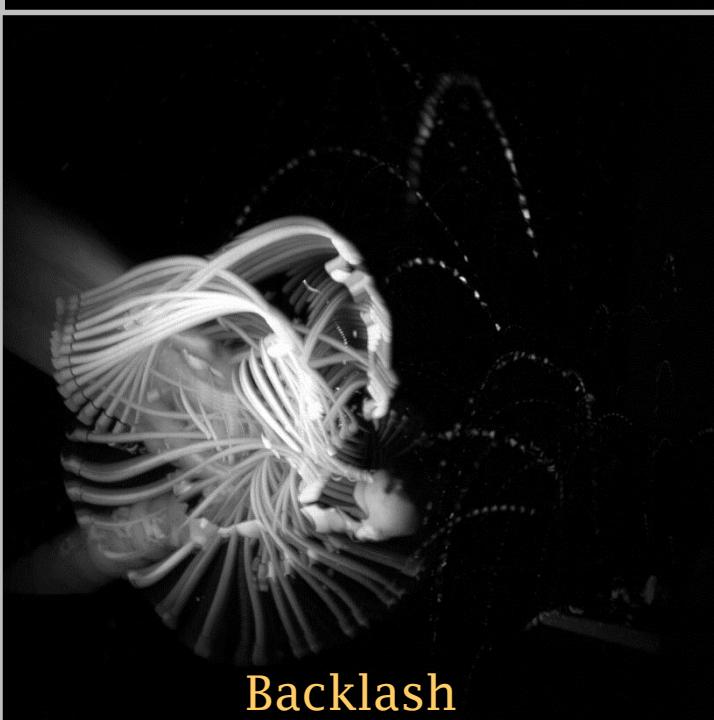




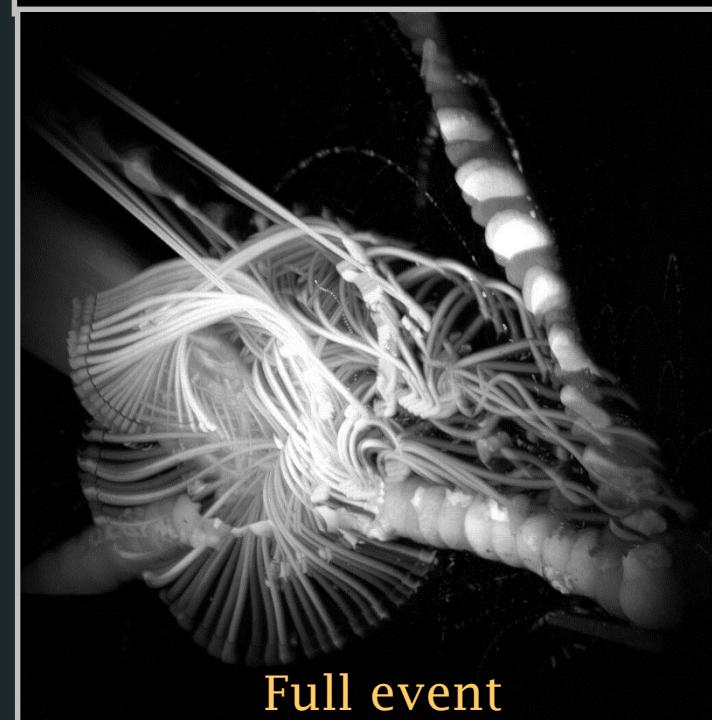
Impact



Ricochet

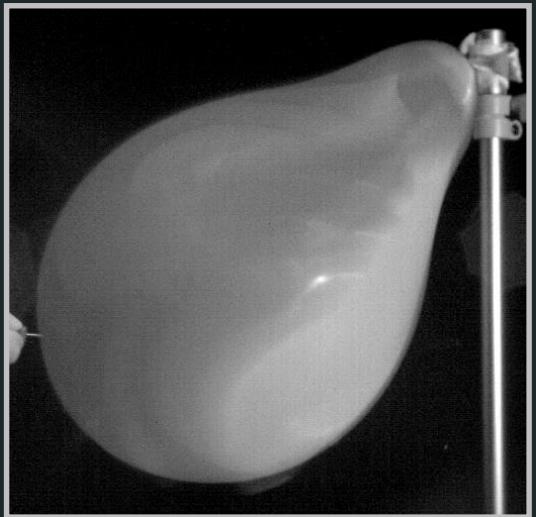


Backlash



Full event

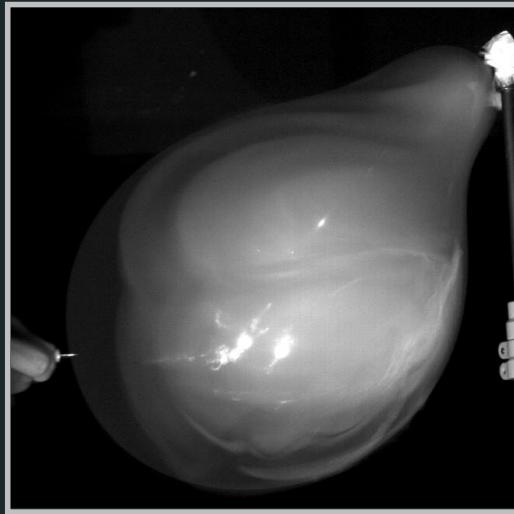
# 10000Hz air balloon burst



3000Hz under fluorescent



3000Hz under a single DLP



500Hz with three DLP projectors

# Illustrating motion

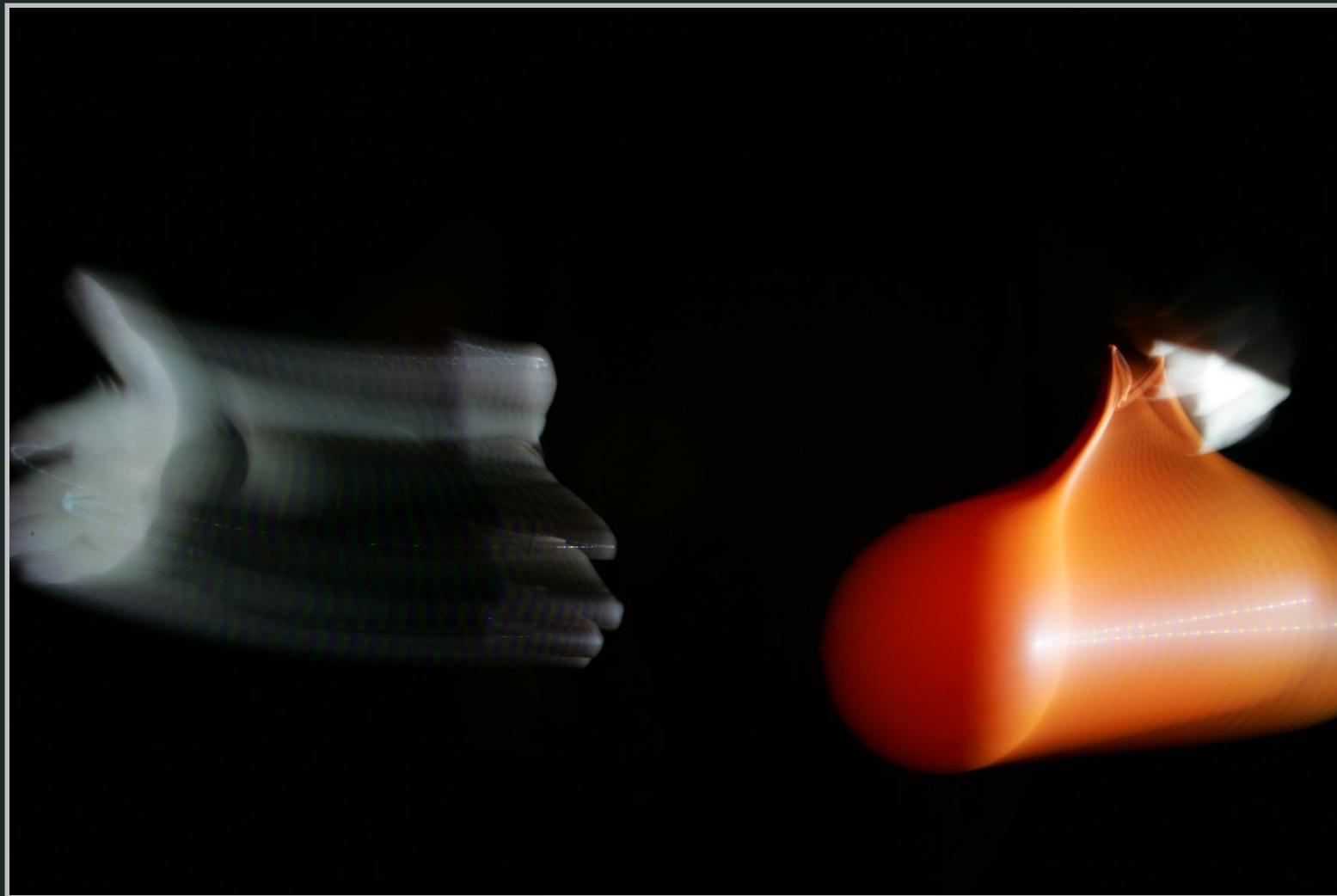


# Illustrating motion

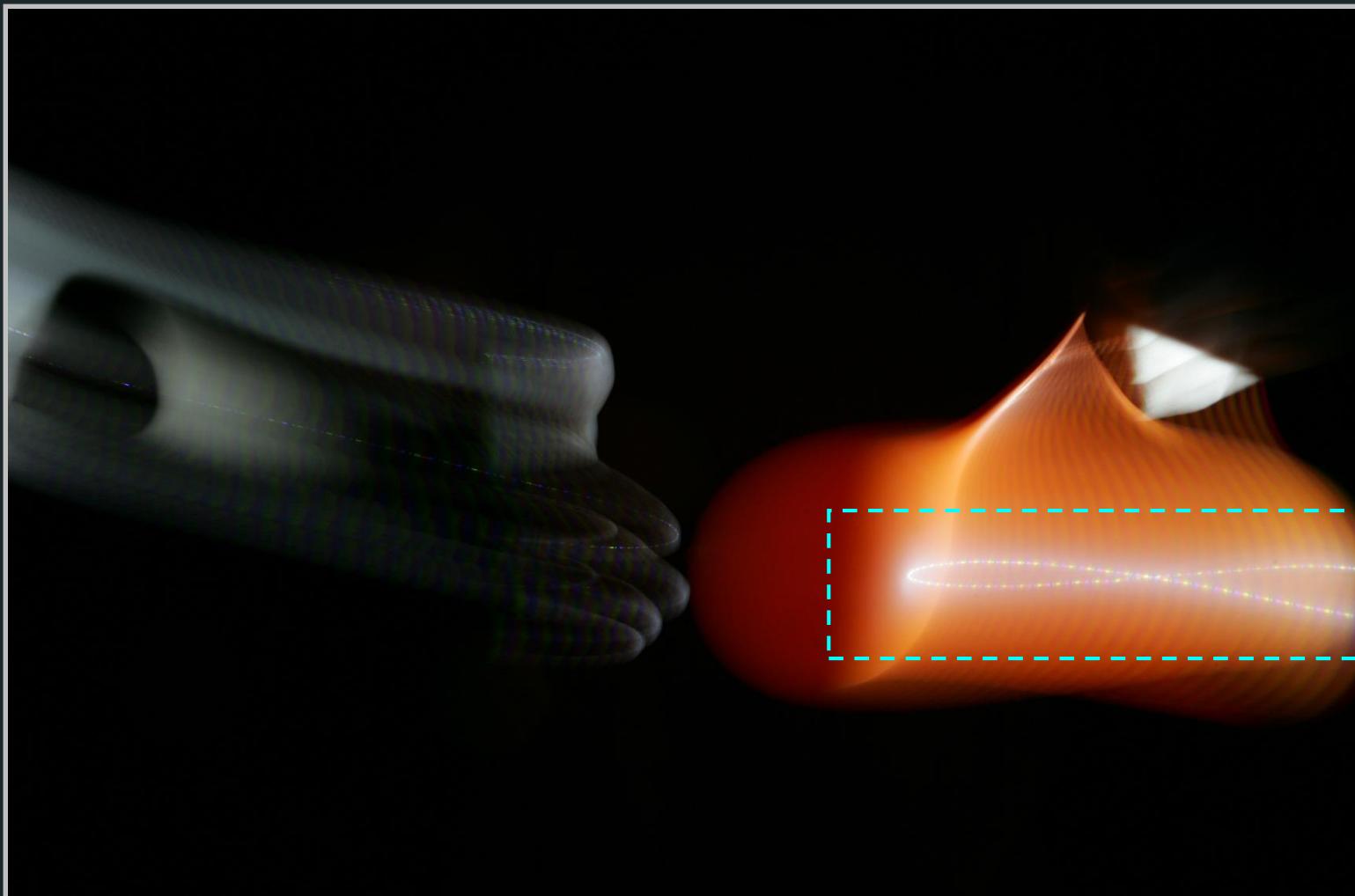


Real-time scenes (~ 125Hz)  
Color-wheel effect

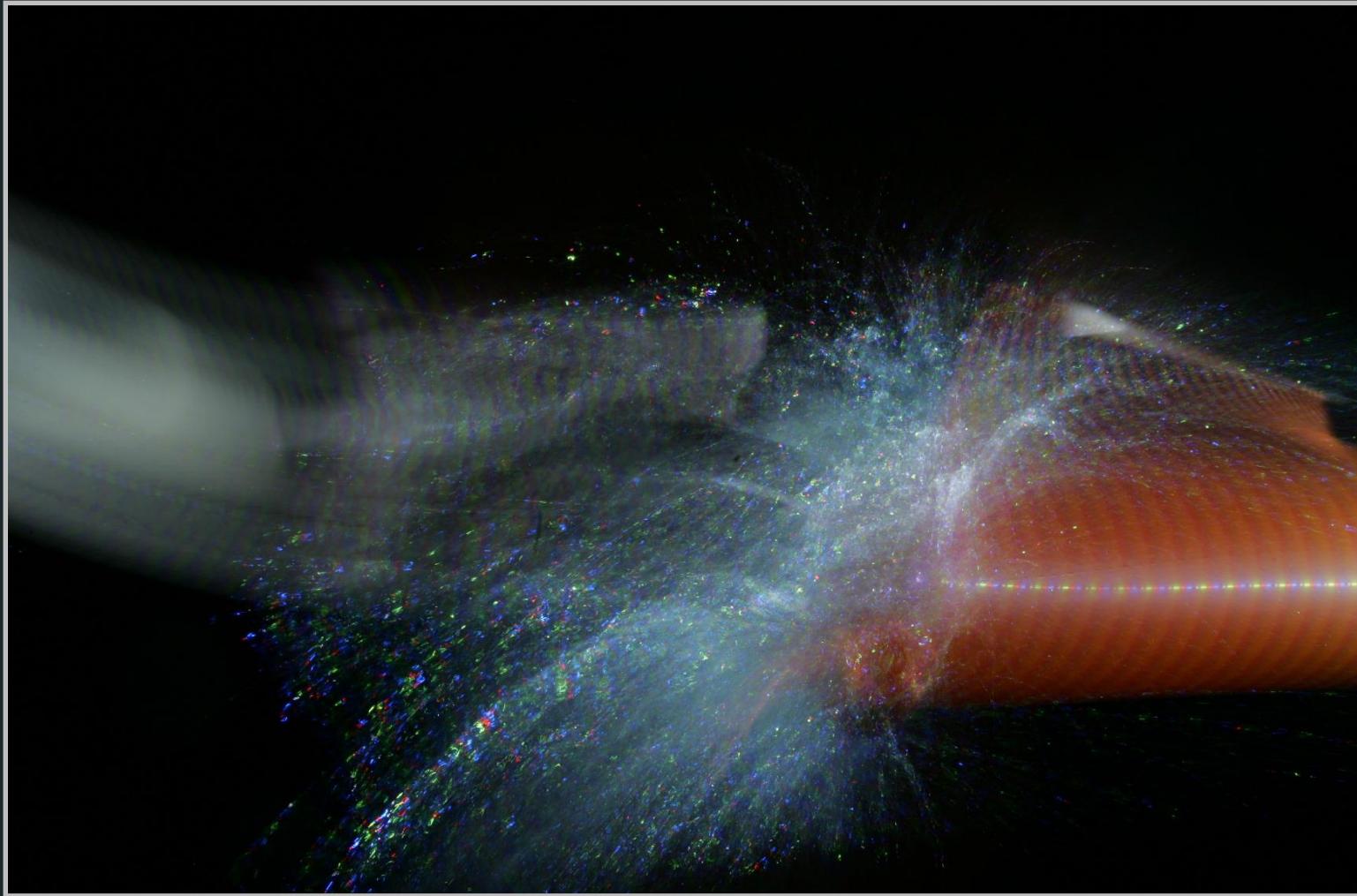
# Water balloon: Start



# Water balloon: First try



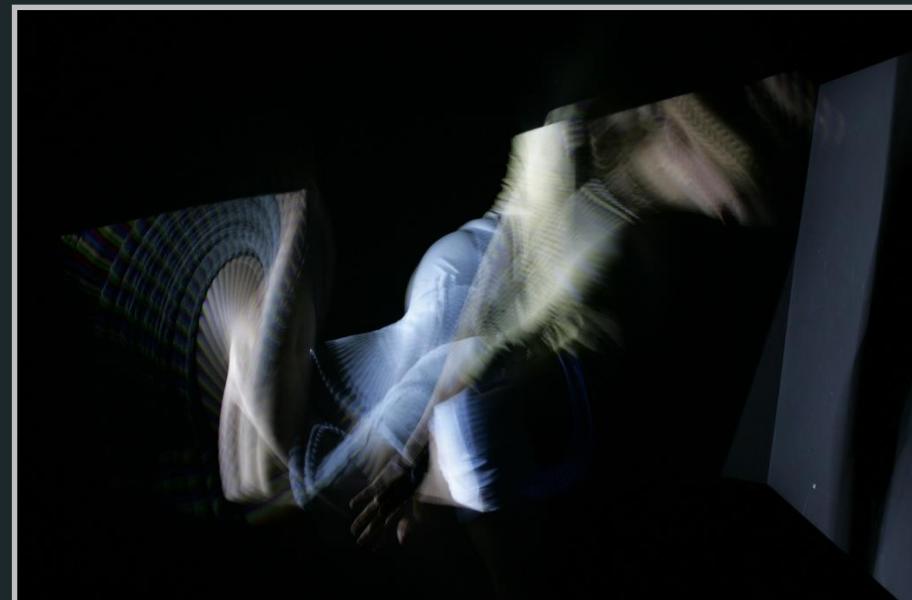
# Water balloon: Second try



# Ballet video



# DLP photographs



# Motion summary



# Thank you

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Lesson summary:

1. At some point, people use technology to create expressions rather than depict.
2. Increasing a dimension, to time, color or anything else always means a new algorithm.
3. Unlike, painting->photo->movies, computation allows only imagination to limit us.
4. From a video block, you can create, algorithmically, a new image.