Matting and compositing

Digital Visual Effects, Spring 2005

Yung-Yu Chuang

2005/4/27

Announcements

DigiVFX

- Project #2 was due yesterday.
- Project #3 will be assigned next Wednesday.
- Grading proportion change. (15%,20%,20%,30%)

Outline

DigiVFX

- Traditional matting and compositing
- Natural image matting
- Video matting
- Shadow matting
- Environment matting

Traditional matting and compositing

Photomontage

The Two Ways of Life, 1857, Oscar Gustav Rejlander
Printed from the original 32 wet collodion negatives.

Photographic compositions

Lang Ching-shan

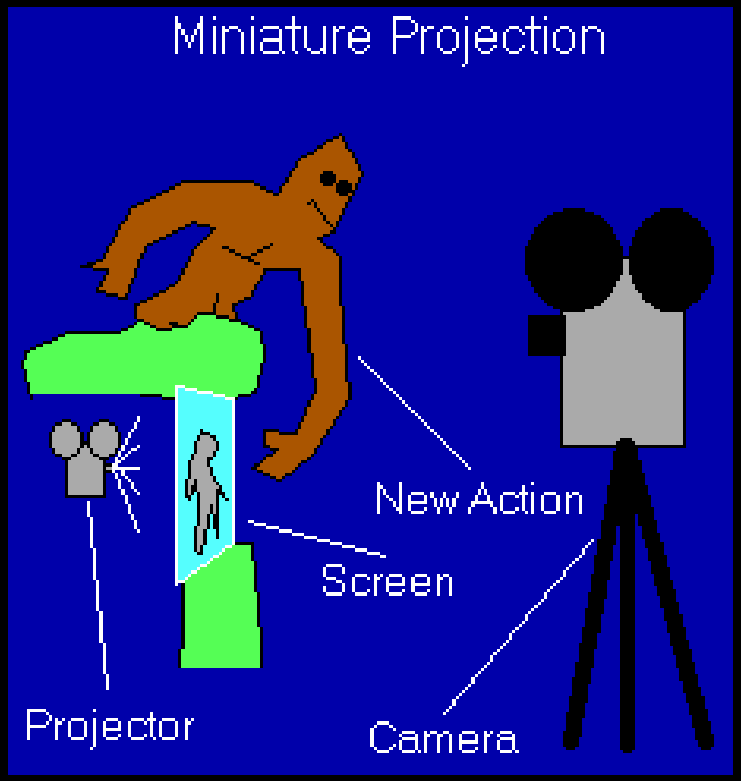
Use of mattes for compositing

The Great Train Robbery (1903) matte shot

Use of mattes for compositing

The Great Train Robbery (1903) matte shot

Optical compositing



King Kong (1933) Stop-motion + optical compositing

Digital matting and compositing

The lost world (1925)

Miniature, stop-motion

The lost world (1997)

Computer-generated images

Digital matting and compositing

King Kong (1933)

Optical compositing

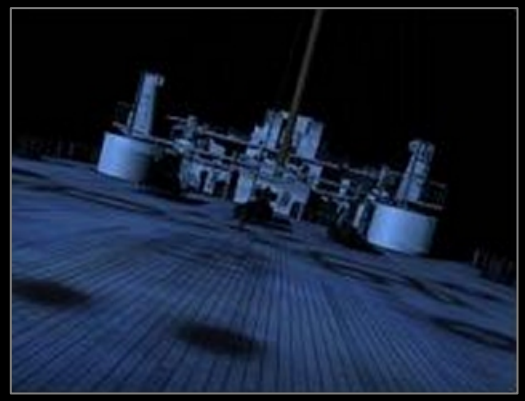
Jurassic Park III (2001)

Blue-screen matting,
digital composition,
digital matte painting

Digital matting: bluescreen matting

Forrest Gump (1994)

- The most common approach for films.
- Expensive, studio setup.
- Not a simple one-step process.



Titanic

Matting and compositing

background
replacement

background
editing

Matting and Compositing

Color difference method (Ultimatte)

$C=F+\overline{\alpha}B$

Blue-screen photograph

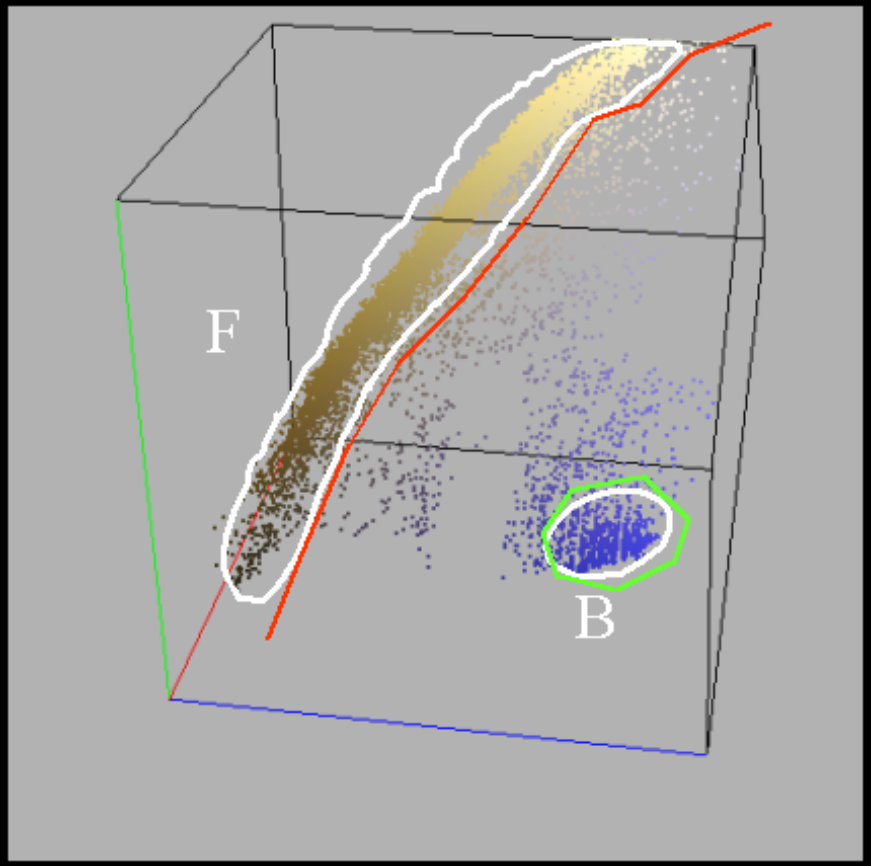
F

Spill suppression if B>G then B=G

$\overline{\alpha}$

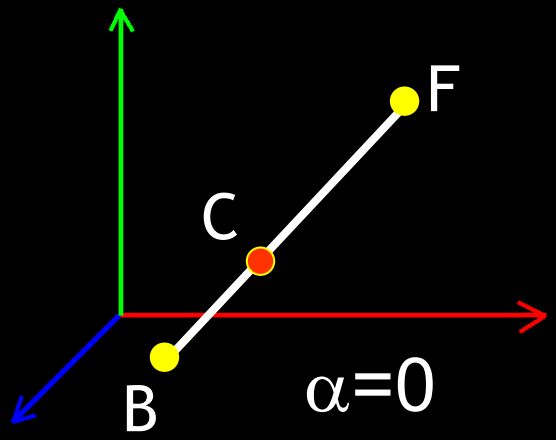
Matte creation $\overline{\alpha}$=B-max(G,R)

Chroma-keying (Primatte)



F α B

foreground color alpha matte background plate

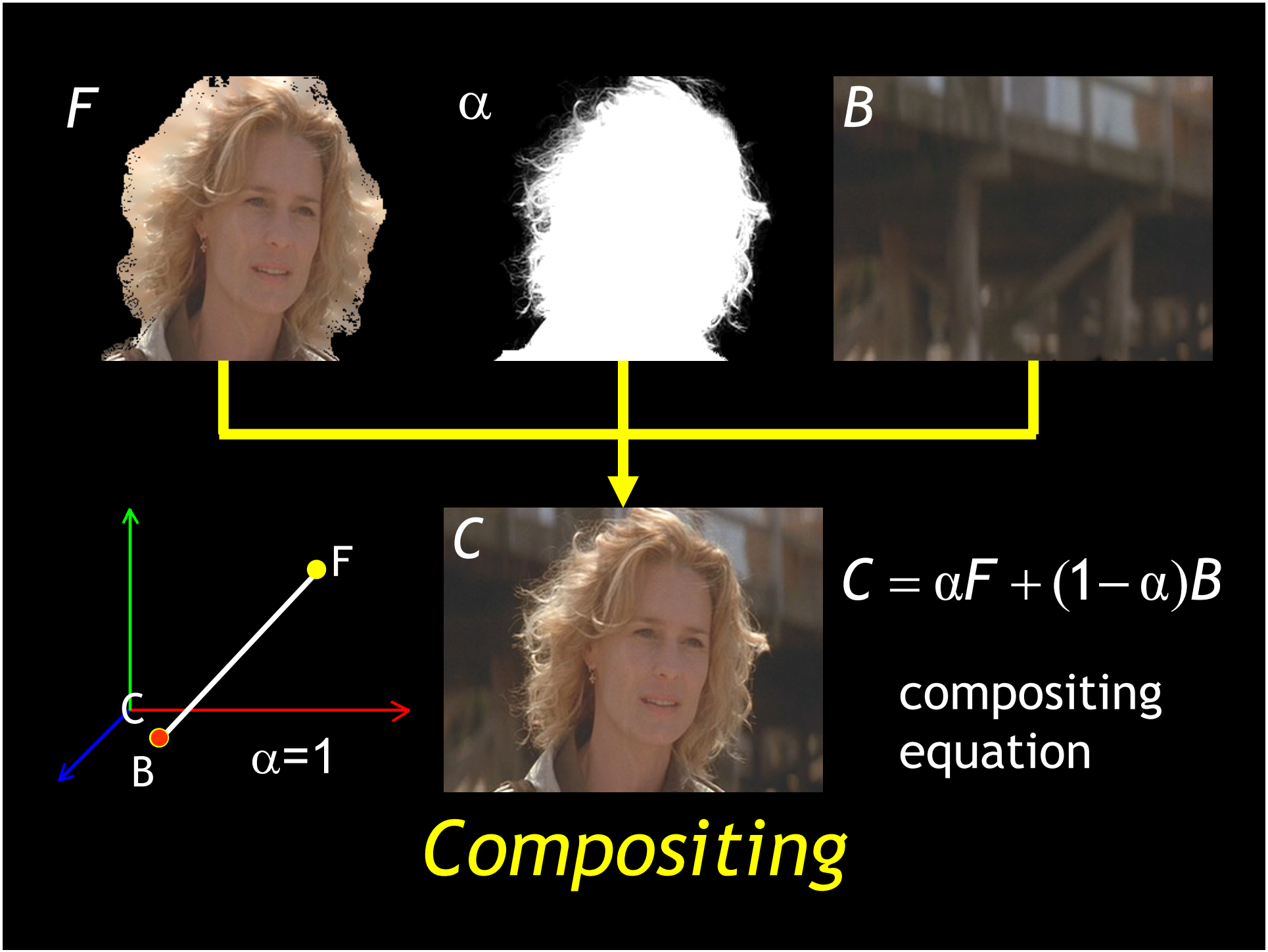


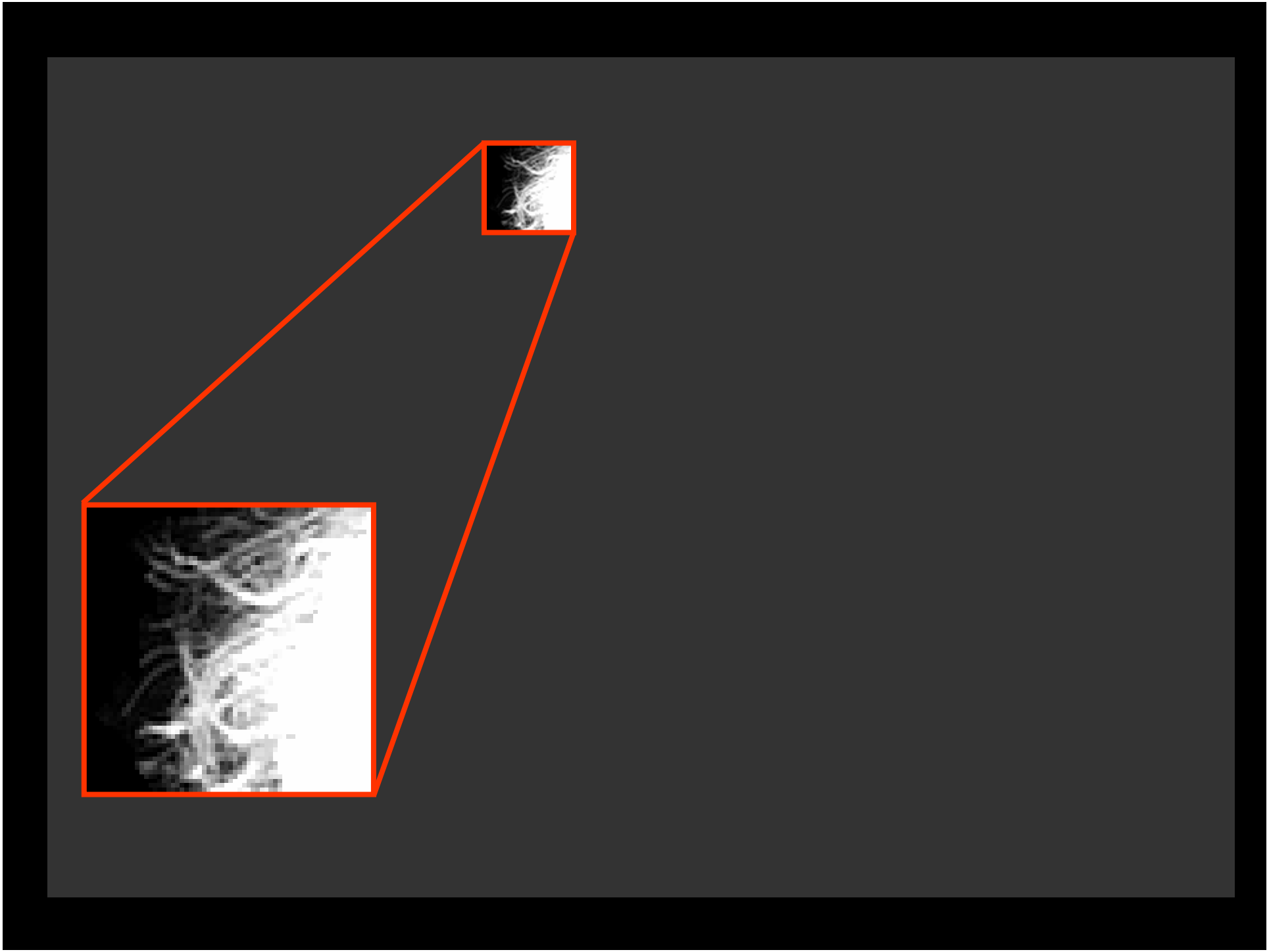
C

$$C = \alpha F + (1-\alpha)B$$

compositing equation

Compositing


F
α
B
C
F
C
B
α=1
$C = \alpha F + (1-\alpha)B$
compositing equation
Compositing



observation

$$C = \alpha F + (1-\alpha)B$$

compositing equation

Matting

Three approaches:

1 reduce #unknowns

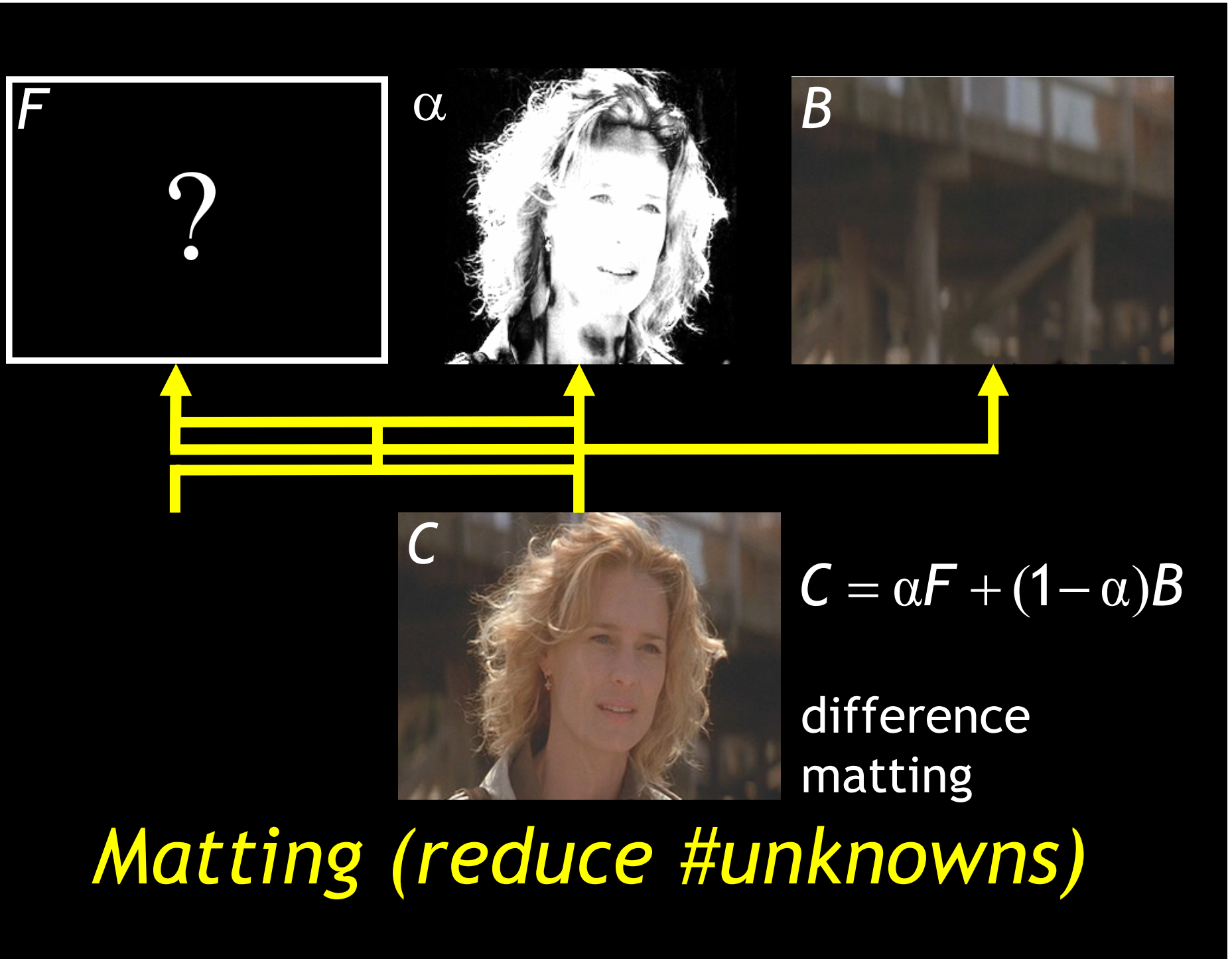
2 add observations

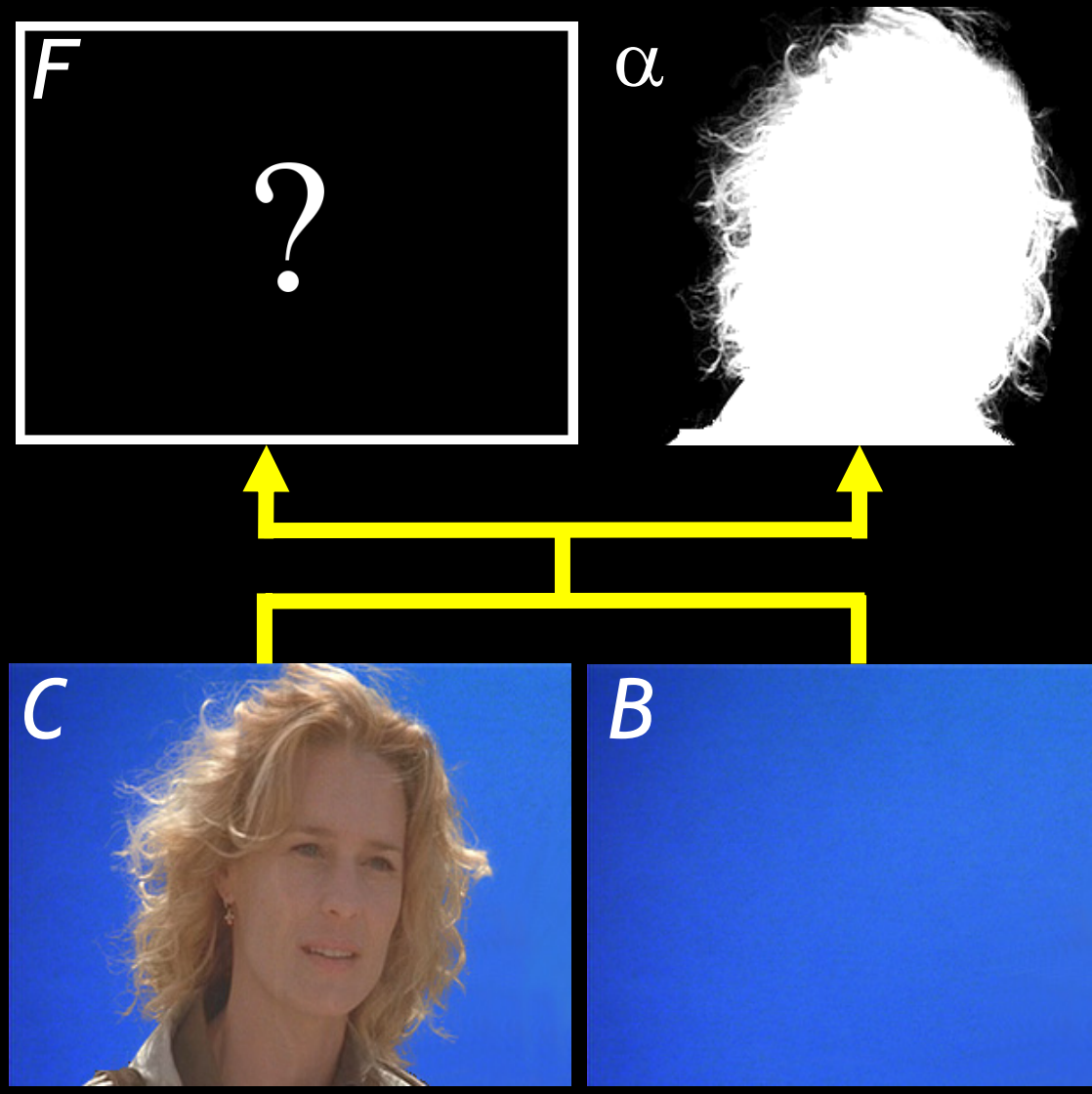
3 add priors

$$C = \alpha F + (1-\alpha)B$$

compositing equation

Matting

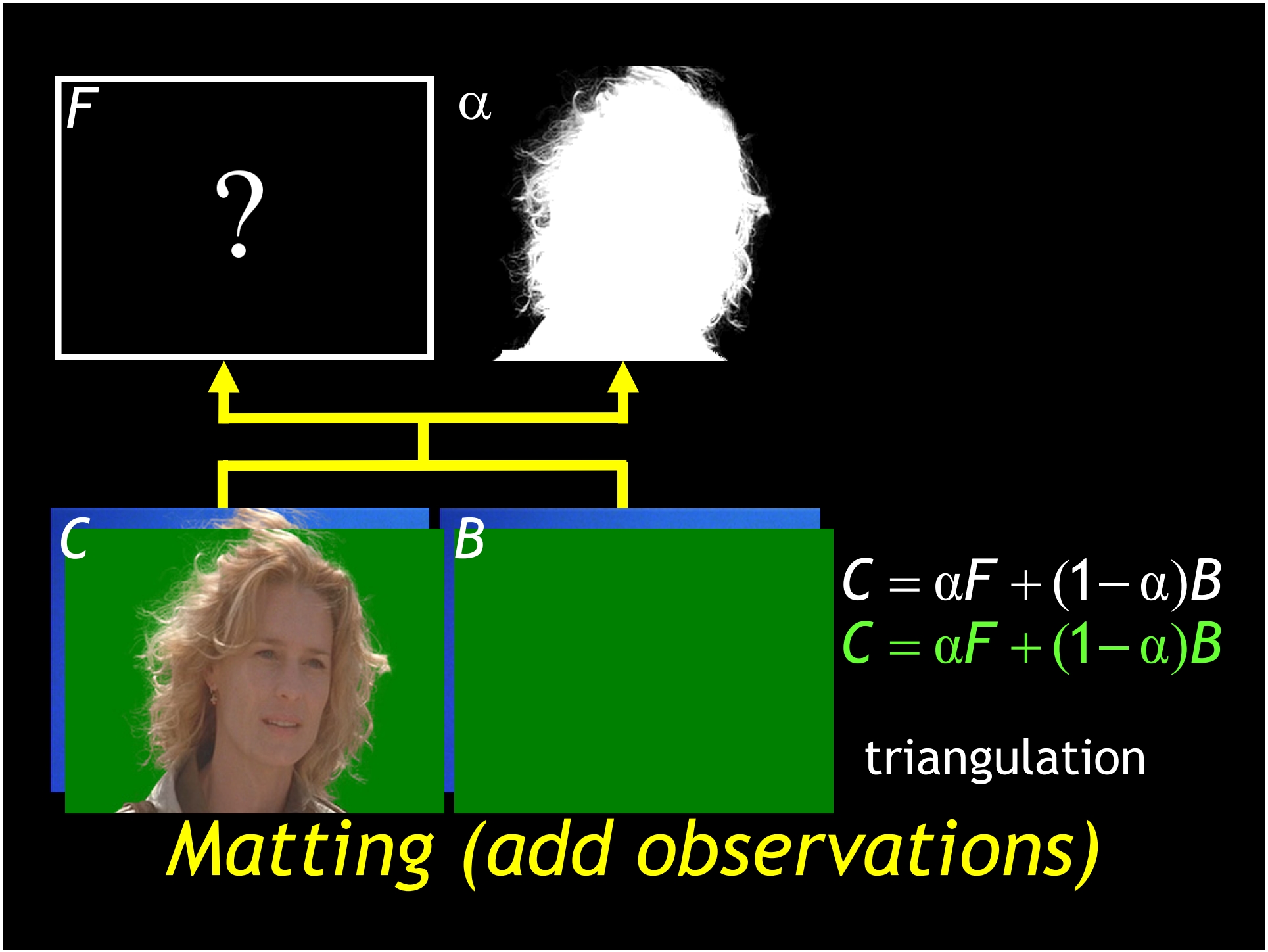

F
?
α
B
C
$C = \alpha F + (1-\alpha)B$
difference
matting
Matting (reduce #unknowns)

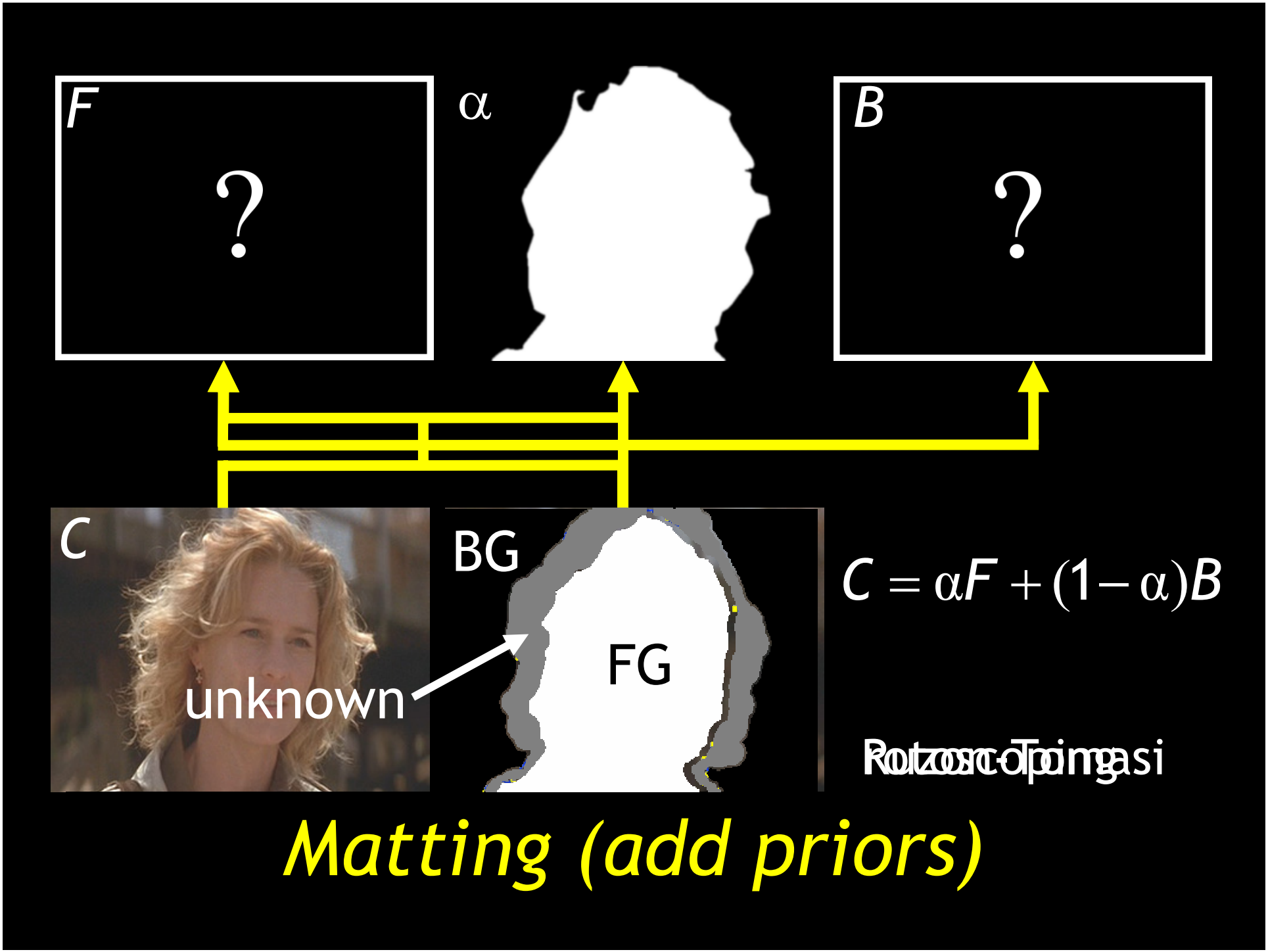


$$C = \alpha F + (1-\alpha)B$$

blue screen matting

Matting (reduce #unknowns)


F
?
α
C
B
$C = \alpha F + (1-\alpha)B$
$C = \alpha F + (1-\alpha)B$
triangulation
Matting (add observations)


F
?
α
B
?
C
unknown
BG
FG
$C = \alpha F + (1-\alpha)B$
Matting (add priors)

Bayesian image matting

posterior probability

likelihood

priors

$$\arg\max_{F,B,\alpha} P(F,B,\alpha \mid C)$$

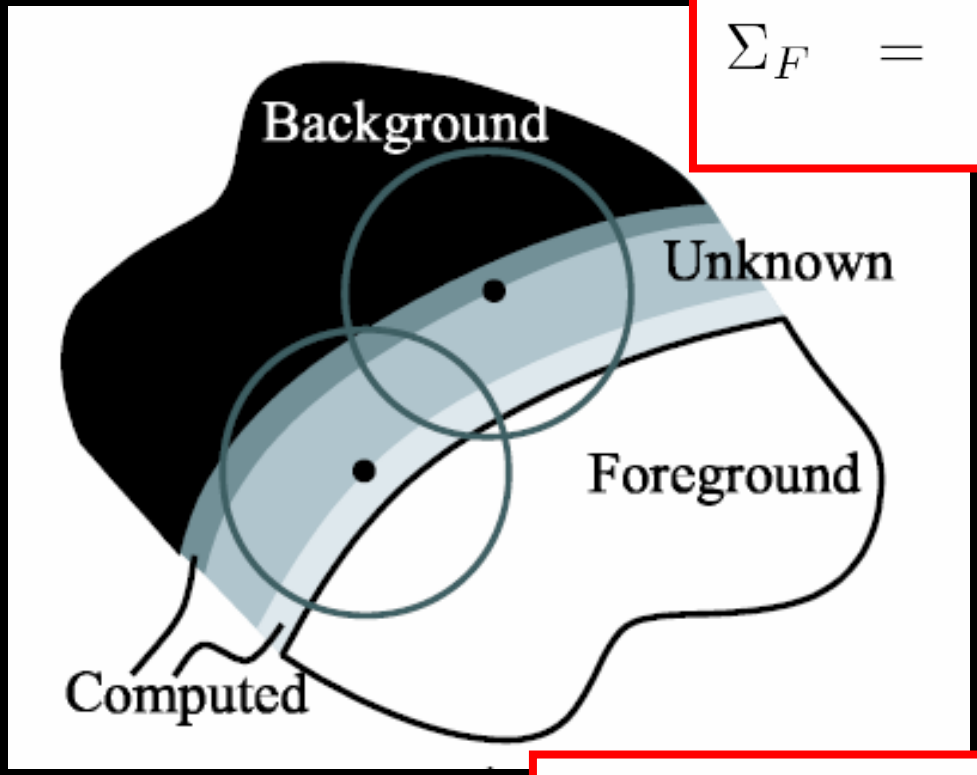
$$= \arg\max_{F,B,\alpha} P(C \mid F,B,\alpha)\, P(F)\, P(B)\, P(\alpha) / P(C)$$

$$L(C \mid F,B,\alpha) = -\|C - \alpha F - (1-\alpha)B\|^2 / \sigma_C^2$$

Bayesian framework

$$\overline{F} = \frac{1}{W} \sum_{i \in N} w_i F_i$$

$$\Sigma_F = \frac{1}{W} \sum_{i \in N} w_i (F_i - \overline{F}) (F_i - \overline{F})^T$$



$$L(F) = -(F - \overline{F})^T \Sigma_F^{-1} (F - \overline{F}) / 2$$

Priors

repeat

1. fix alpha

$$\begin{bmatrix} \Sigma_F^{-1} + I\alpha^2/\sigma_C^2 & I\alpha(1-\alpha)/\sigma_C^2 \\ I\alpha(1-\alpha)/\sigma_C^2 & \Sigma_B^{-1} + I(1-\alpha)^2/\sigma_C^2 \end{bmatrix} \begin{bmatrix} F \\ B \end{bmatrix} = \begin{bmatrix} \Sigma_F^{-1}\overline{F} + C\alpha/\sigma_C^2 \\ \Sigma_B^{-1}\overline{B} + C(1-\alpha)/\sigma_C^2 \end{bmatrix}$$

2. fix F and B

$$\alpha = \frac{(C-B)\cdot(F-B)}{\|F-B\|^2}$$

until converge

Optimization

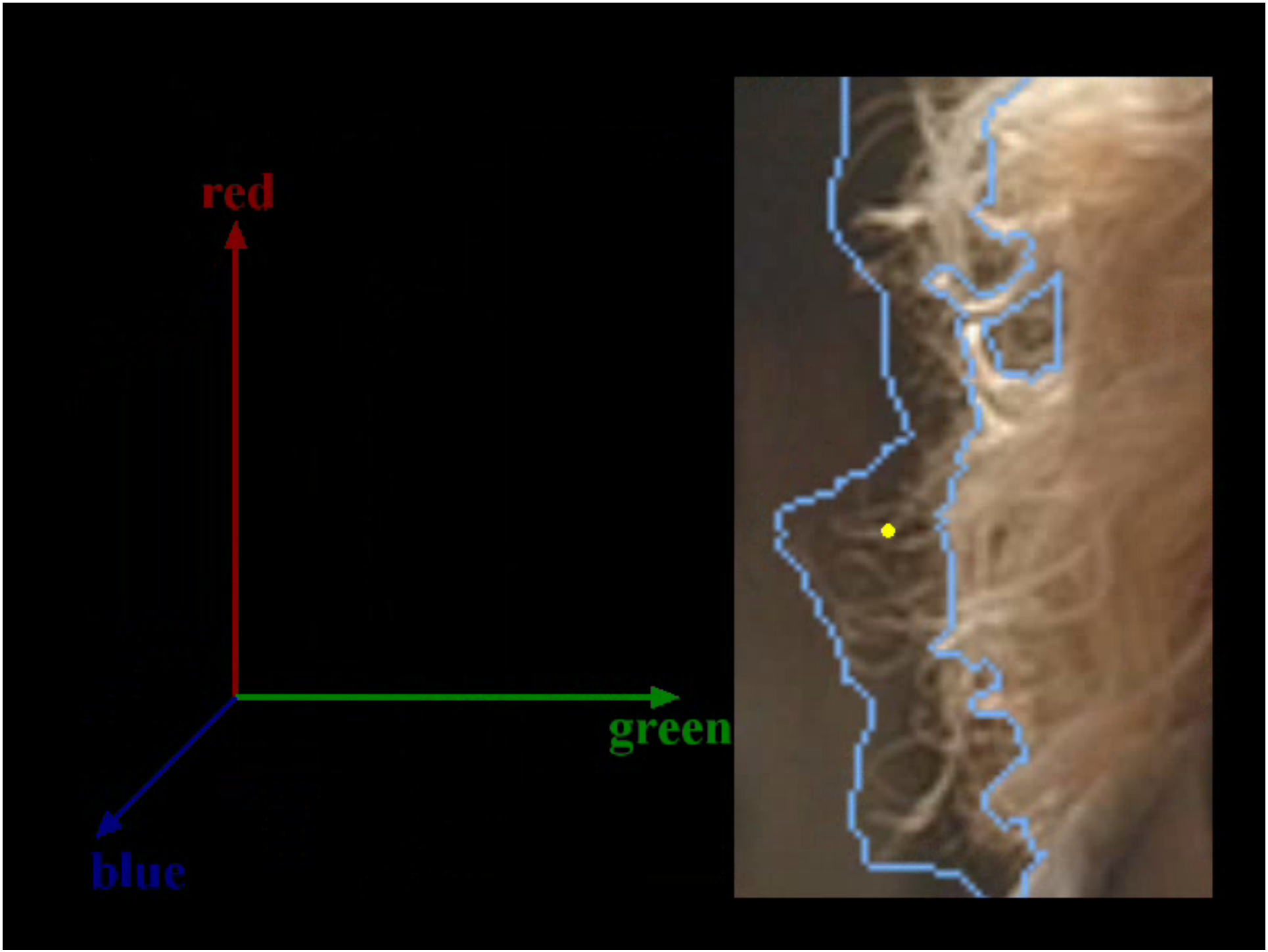
Bayesian image matting

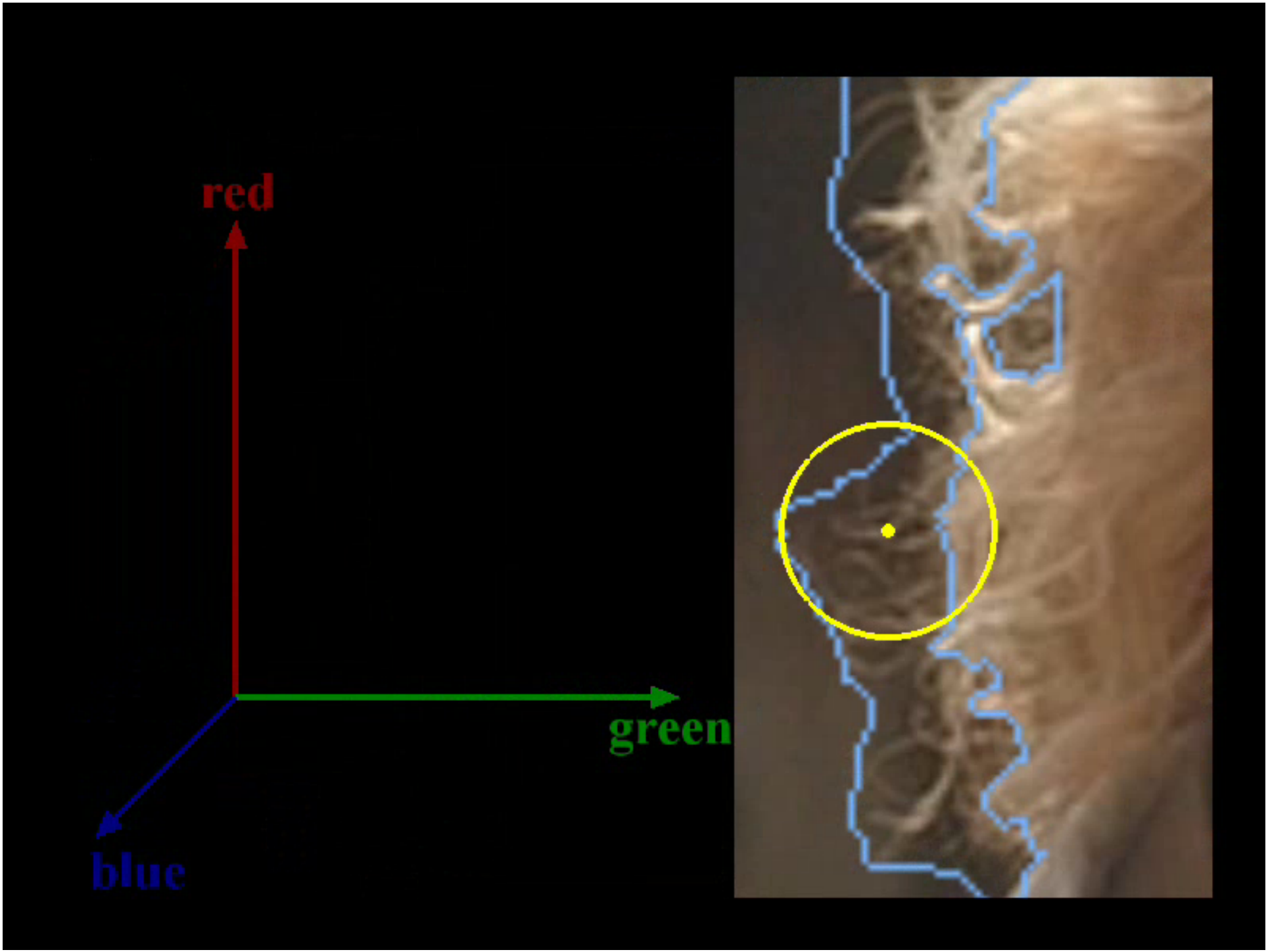
Bayesian image matting

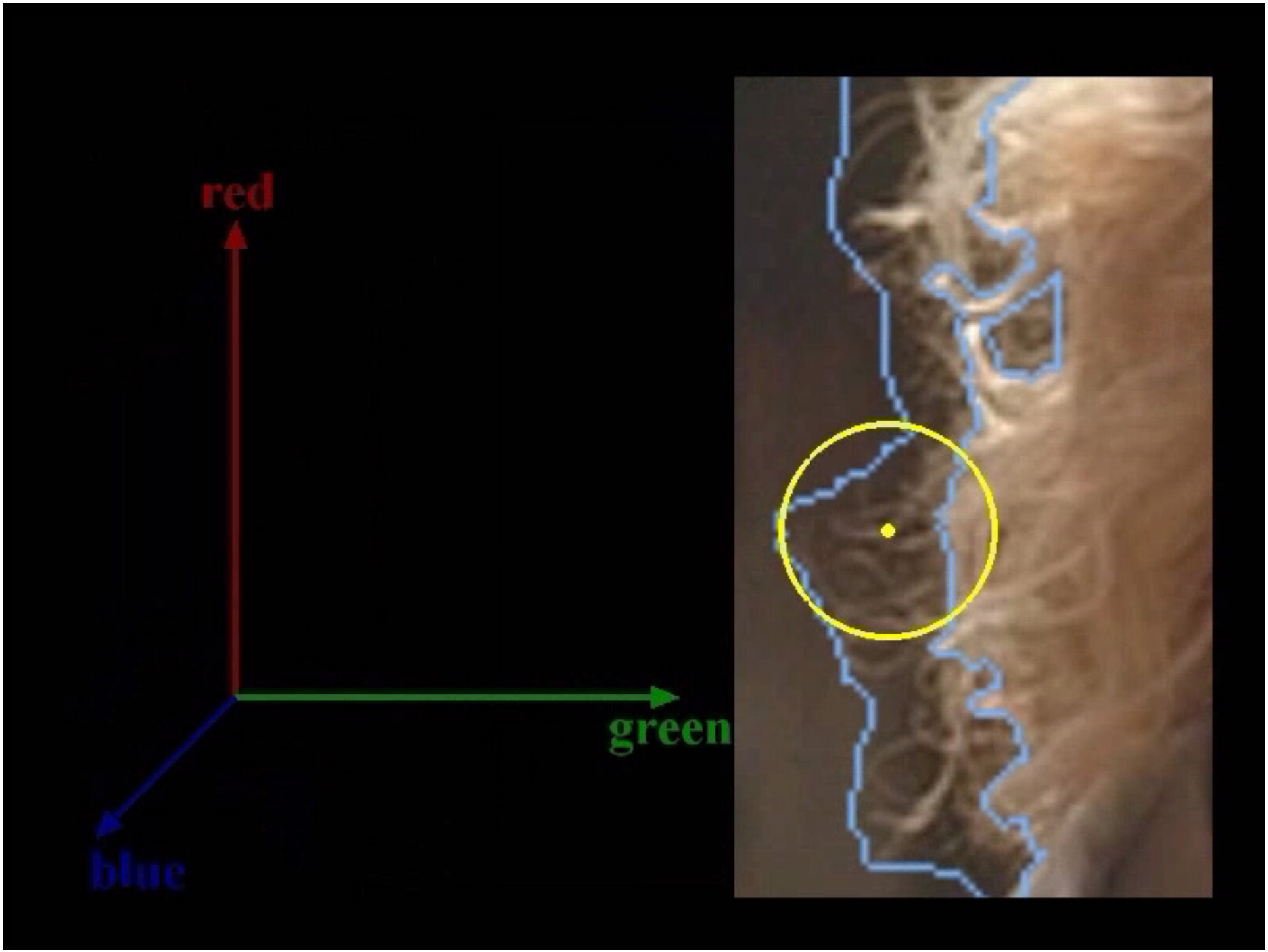
Bayesian image matting

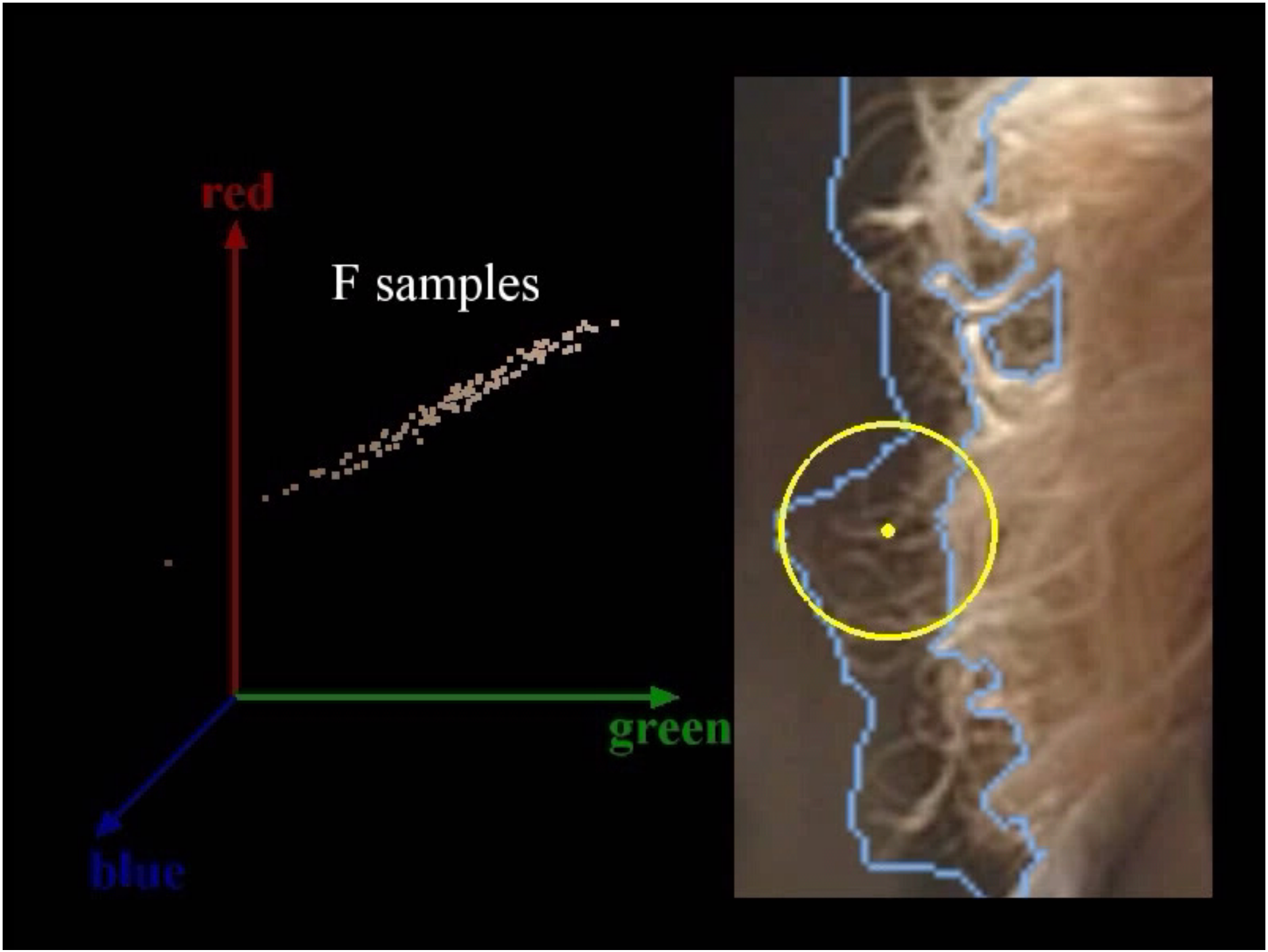
Bayesian image matting

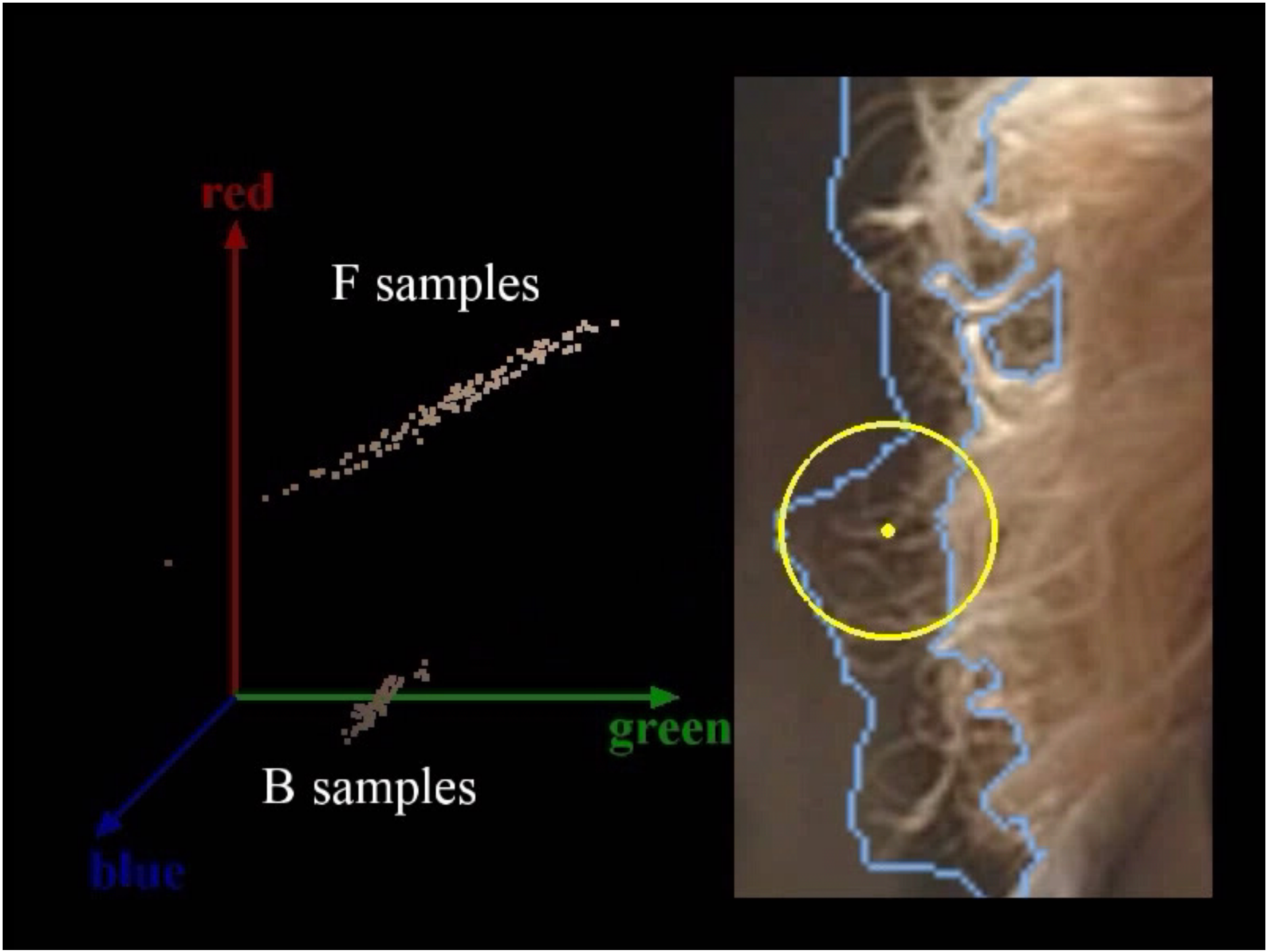
Bayesian image matting

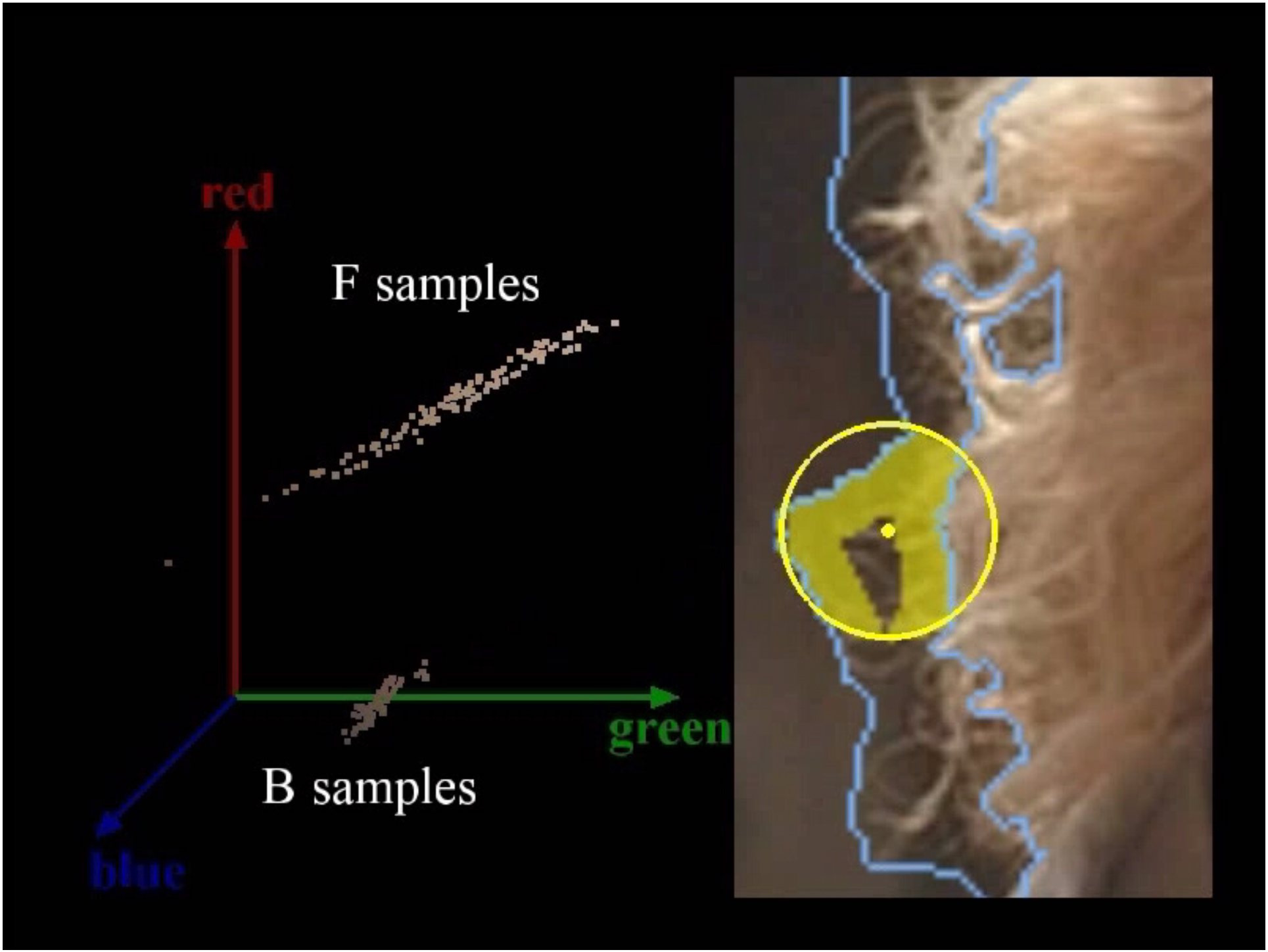

red
green
blue

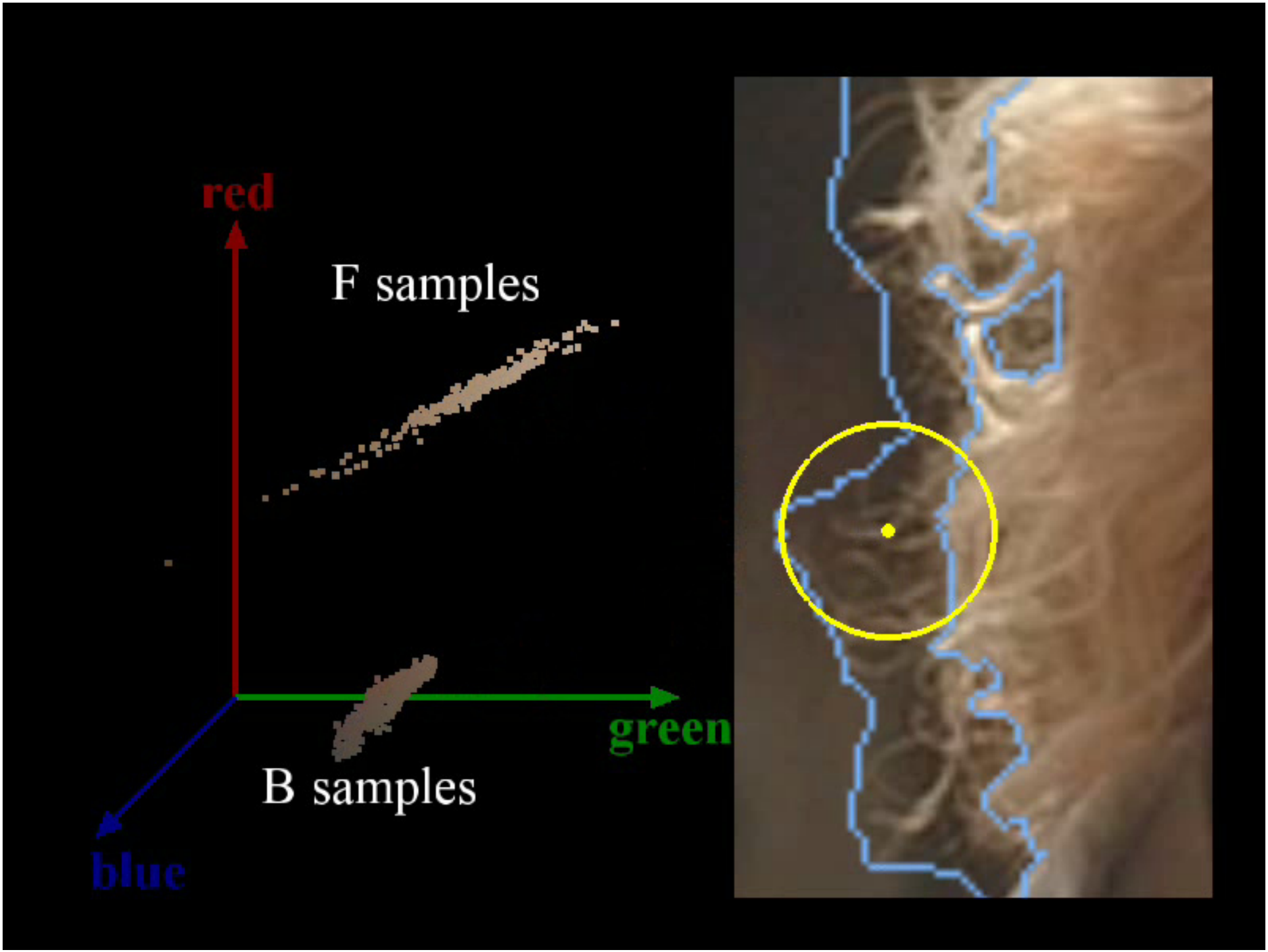

red
green
blue

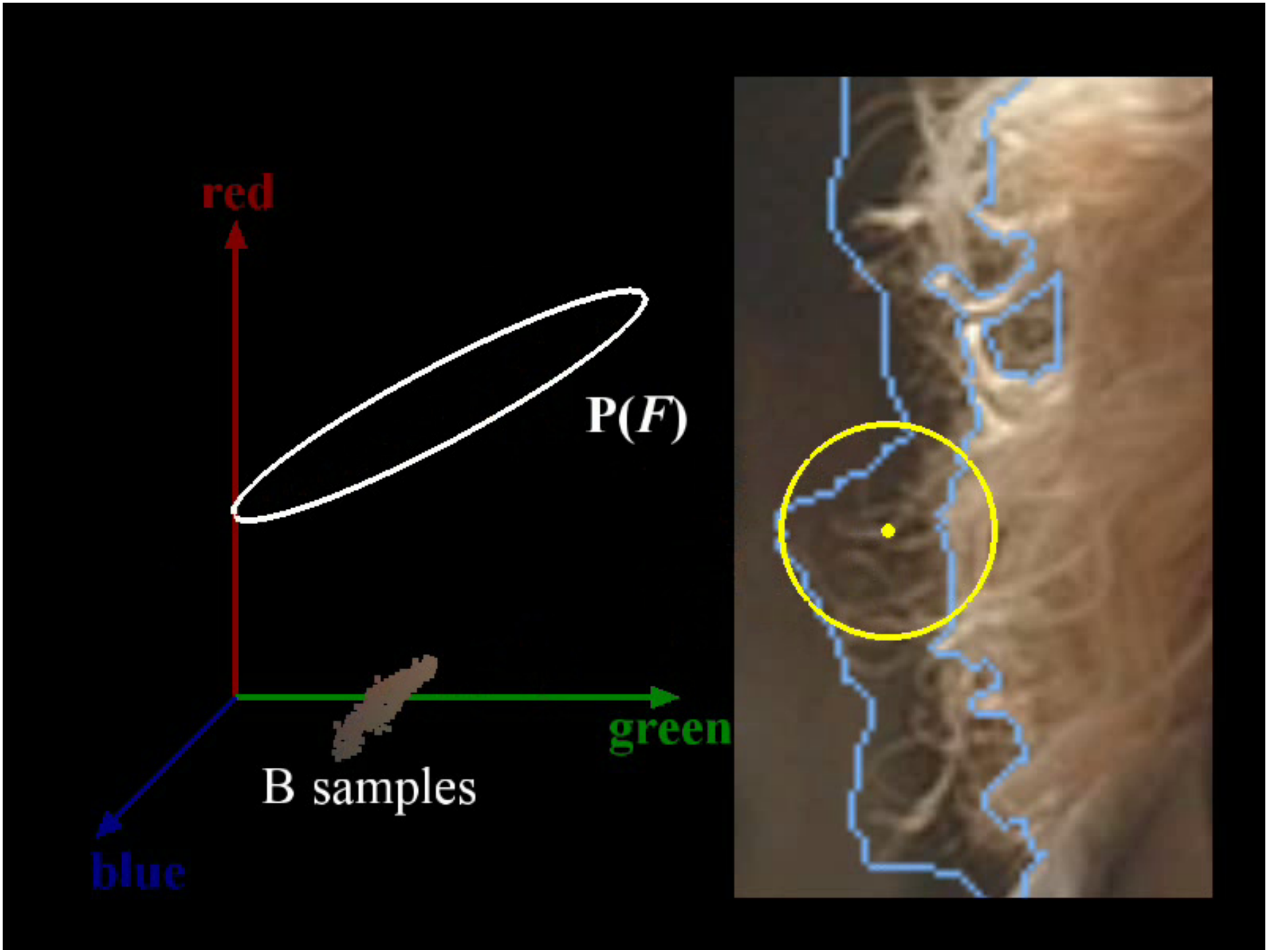

red
green
blue

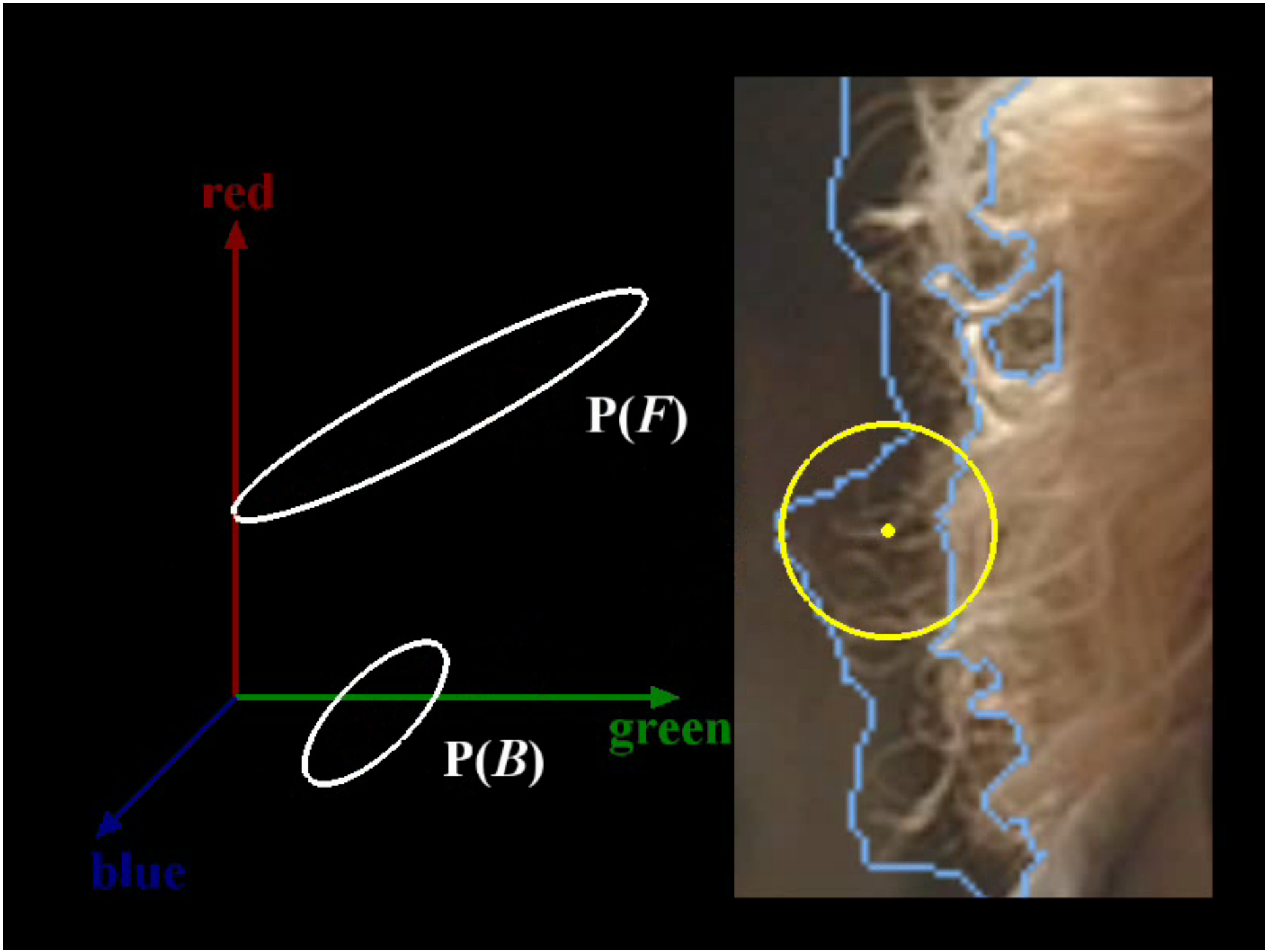

red
F samples
green
blue

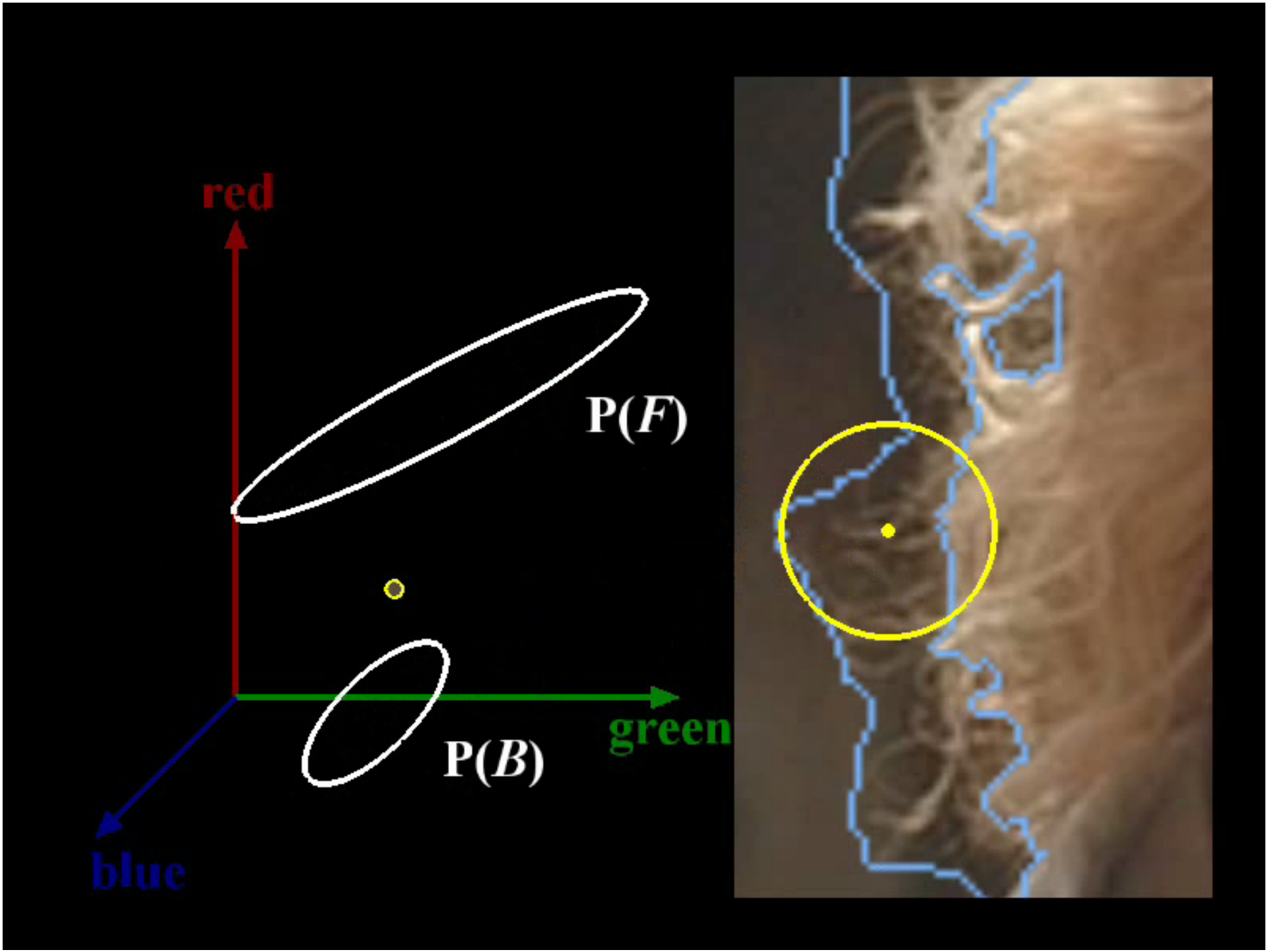

red
F samples
green
B samples
blue

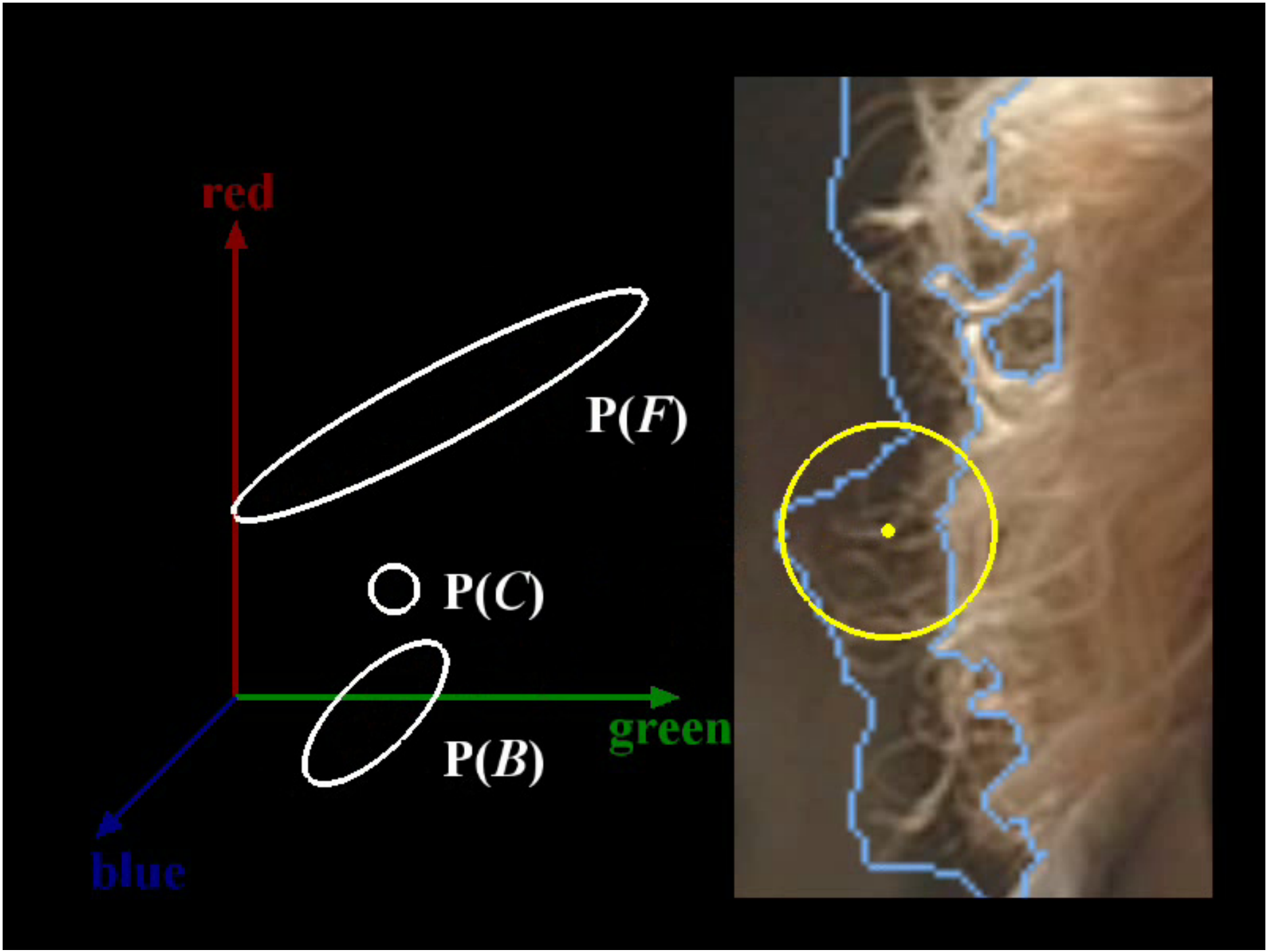

red
F samples
green
B samples
blue

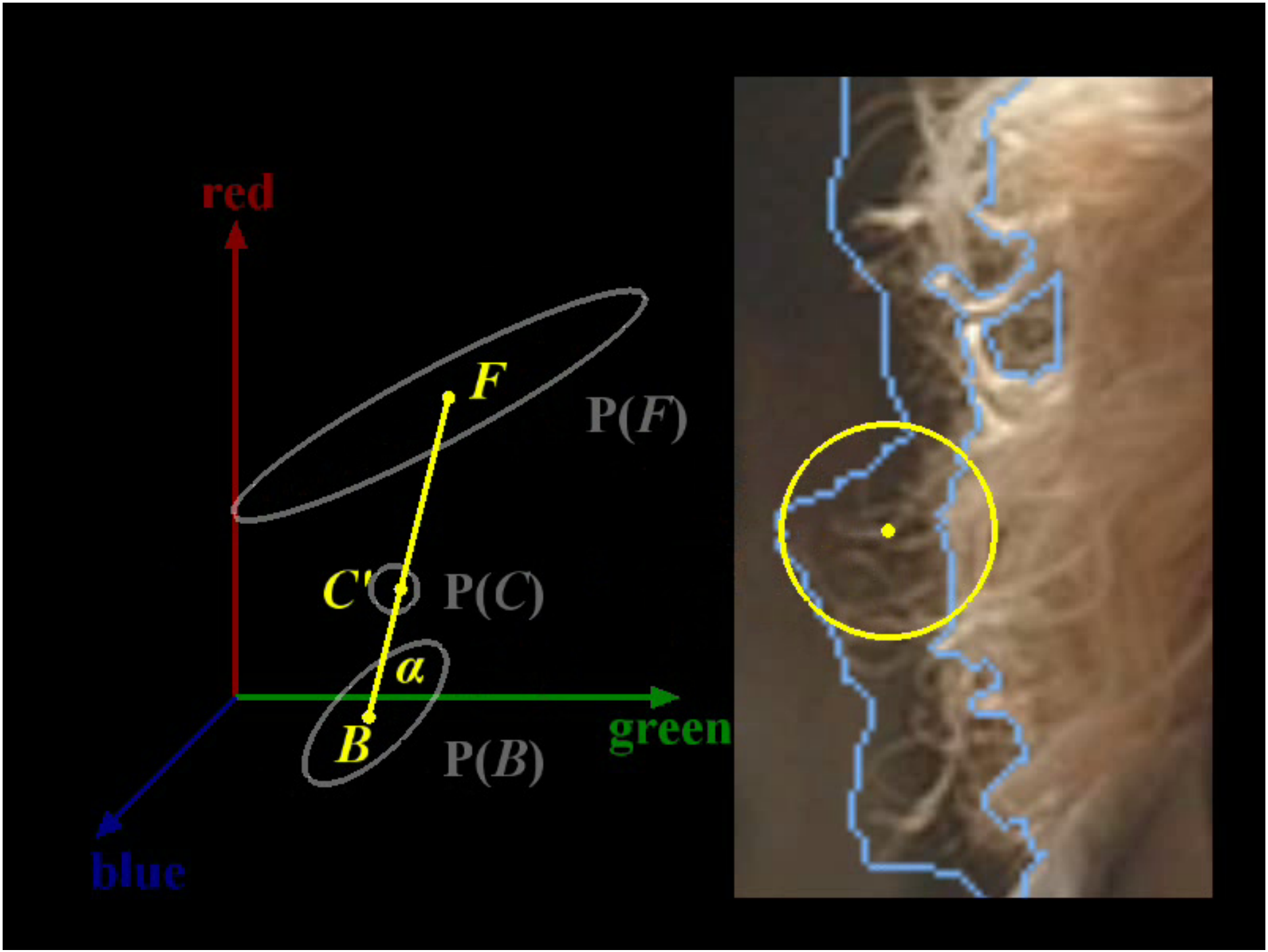

red
F samples
green
B samples
blue


red
P(F)
green
B samples
blue


red
P(F)
green
P(B)
blue


red
P(F)
P(B)
green
blue


red
P(F)
P(C)
P(B)
green
blue


red
F
P(F)
C'
P(C)
α
B
P(B)
green
blue

alpha

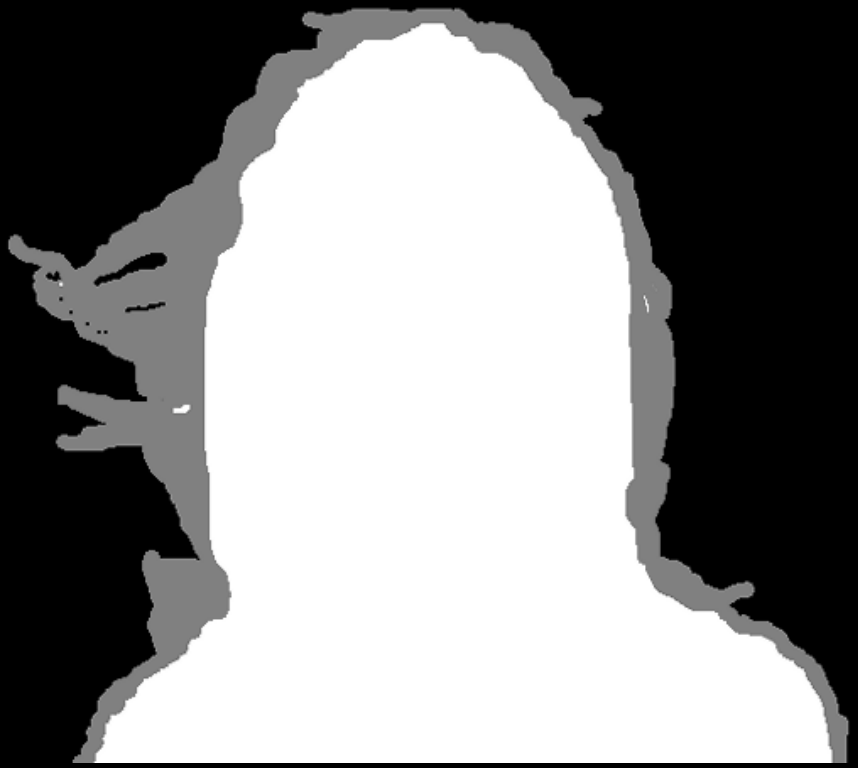
Results

input

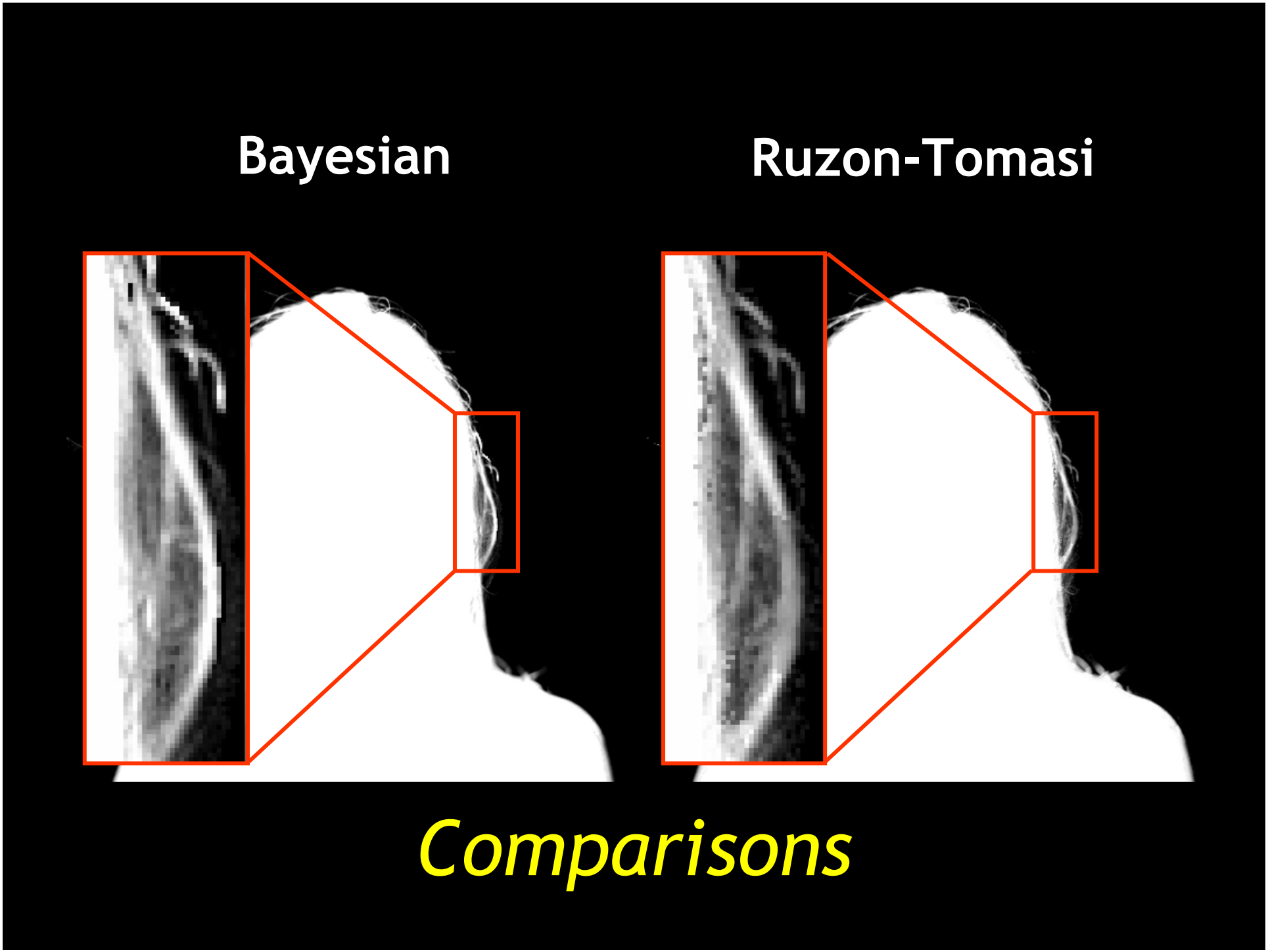
composite

Results

trimap



Comparisons


Bayesian
Ruzon-Tomasi
Comparisons

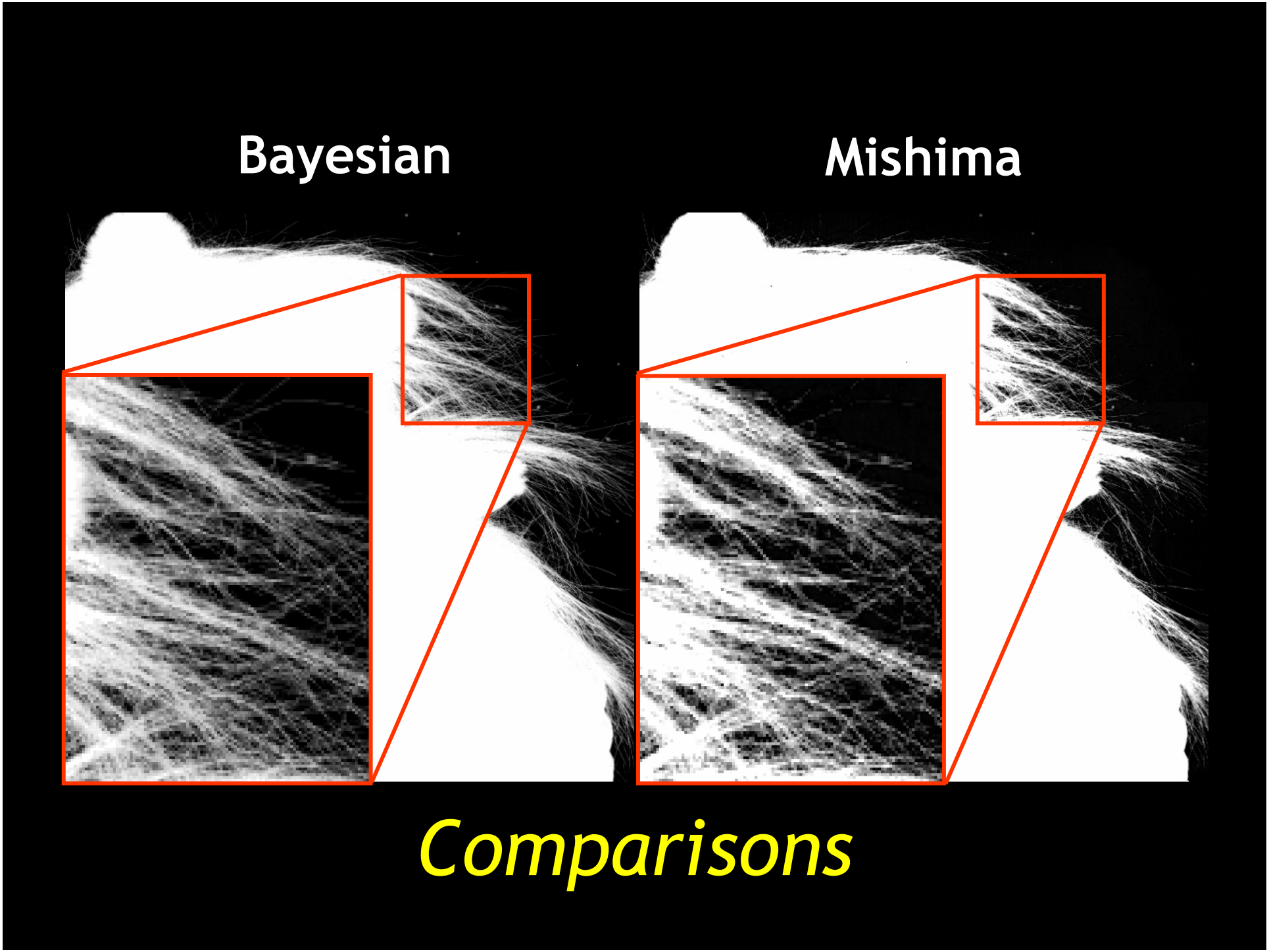
Bayesian

Ruzon-Tomasi

Comparisons

input image

Comparisons


Bayesian
Mishima
Comparisons

Bayesian

Mishima

Comparisons

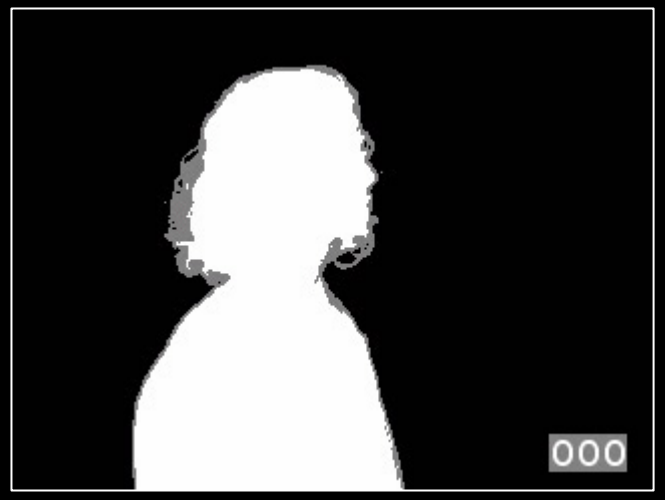
Video matting

input
video

Video matting

input
video

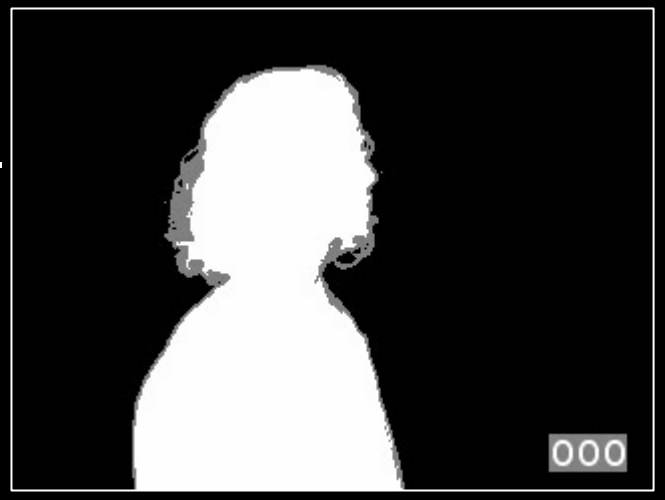
input
key
trimaps



Video matting

input video

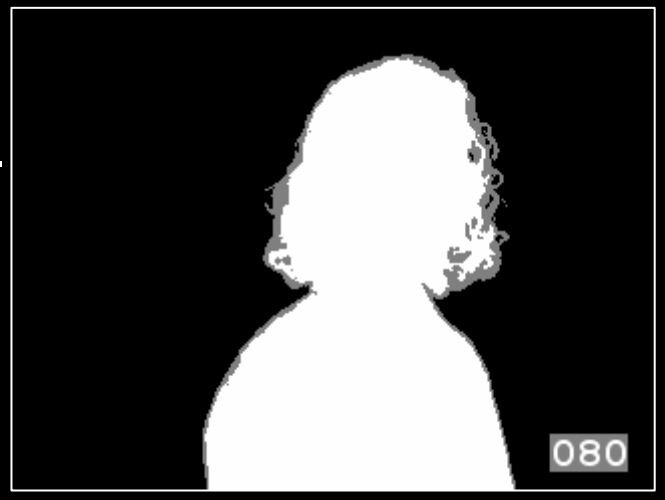
interpo-lated trimaps



Video matting

input video

interpo-lated trimaps



output alpha

Video matting

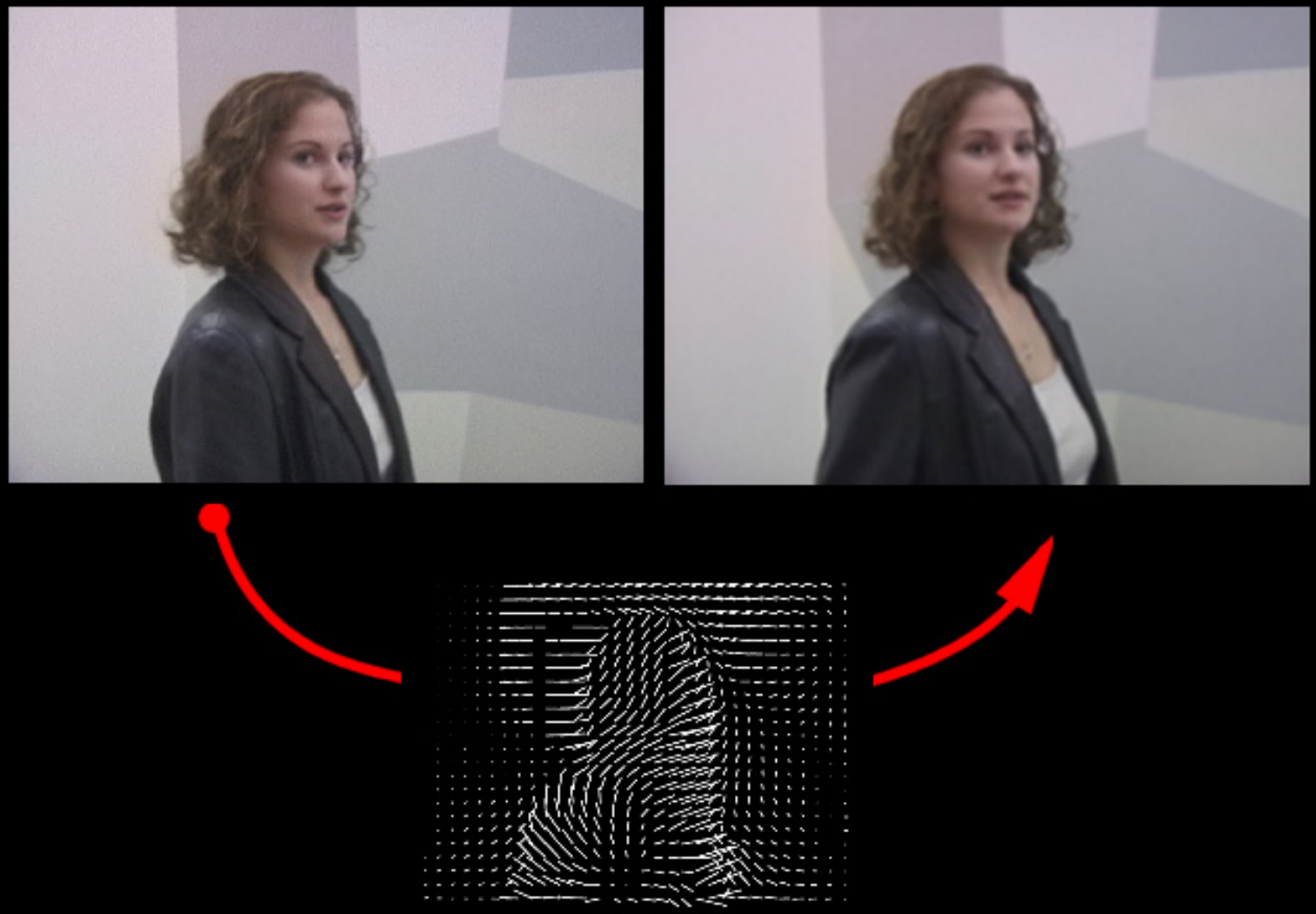
input video

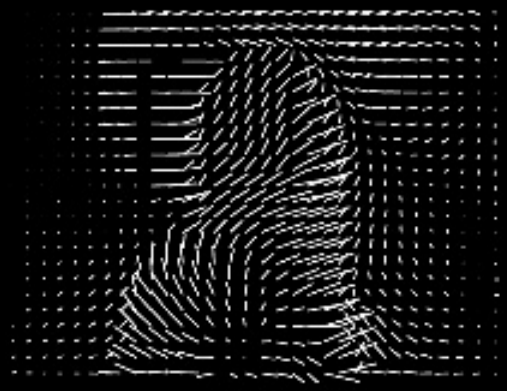
Compo-site

interpo-lated trimaps

output alpha

Video matting


optical flow



optical flow


t
t+1
t+2
t+3


t
t+1
t+2
t+3


t
t+1
t+2
t+3


t
t+1
t+2
t+3


t
t+1
t+2
t+3

Sample composite

Garbage mattes

Garbage mattes

Background estimation

Background estimation

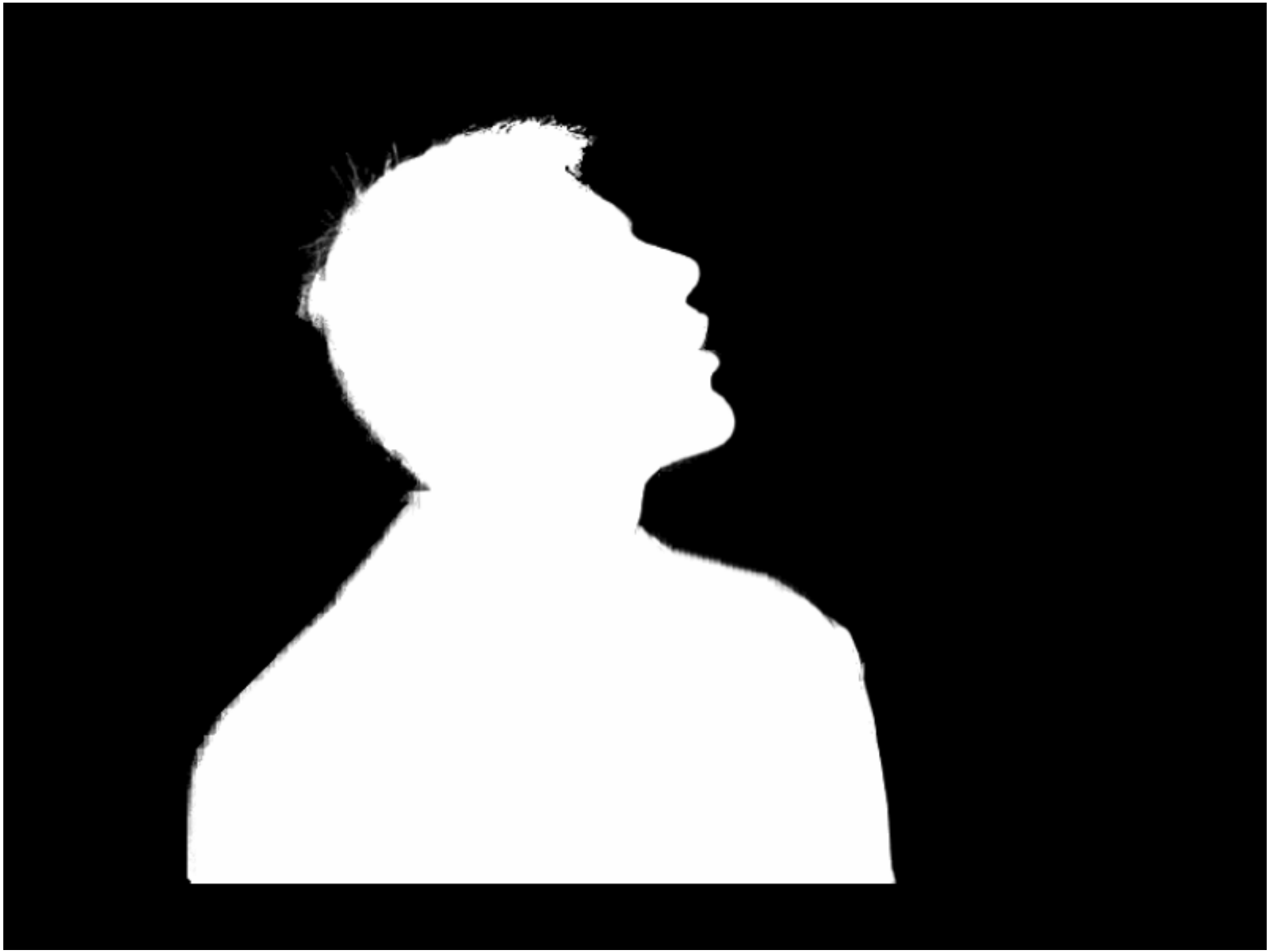

Alpha matte

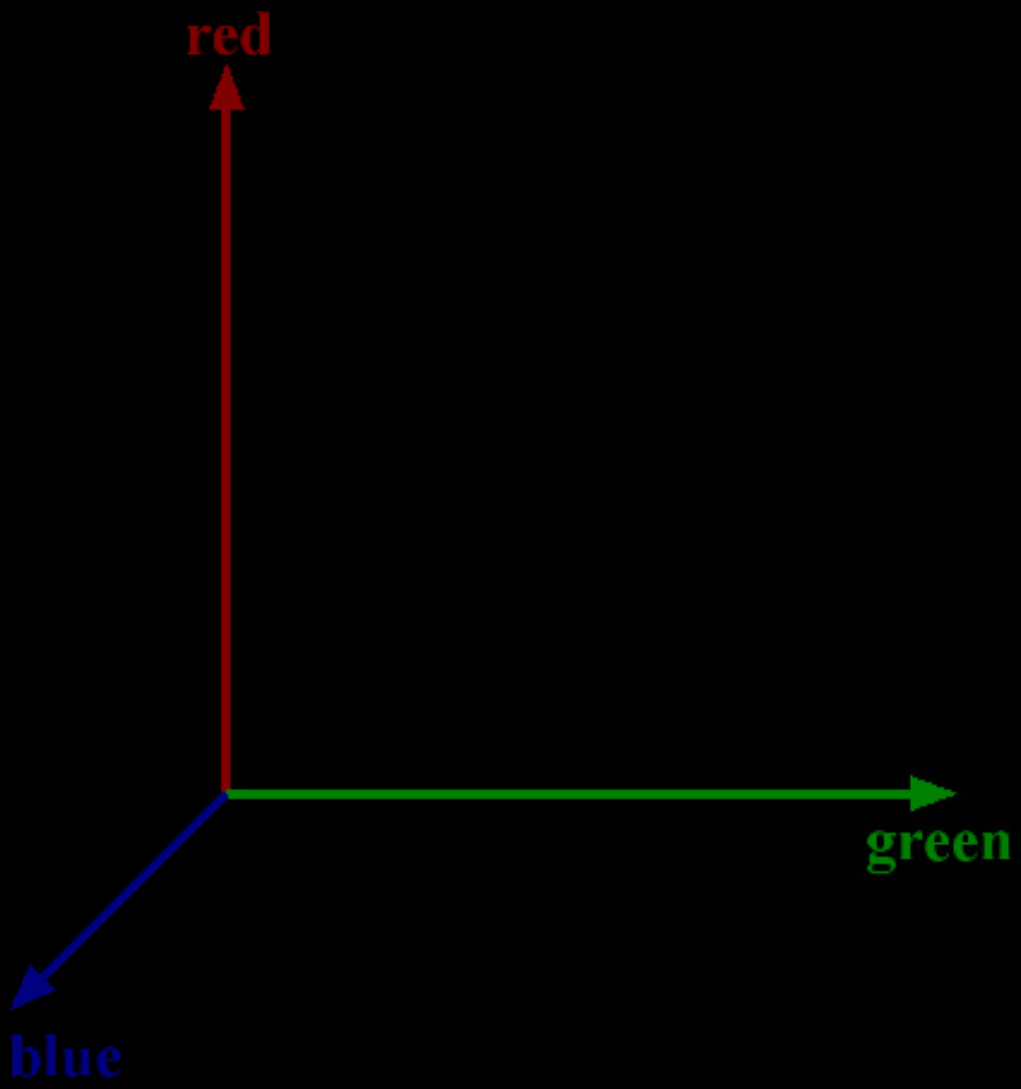
without background

with background

Comparison

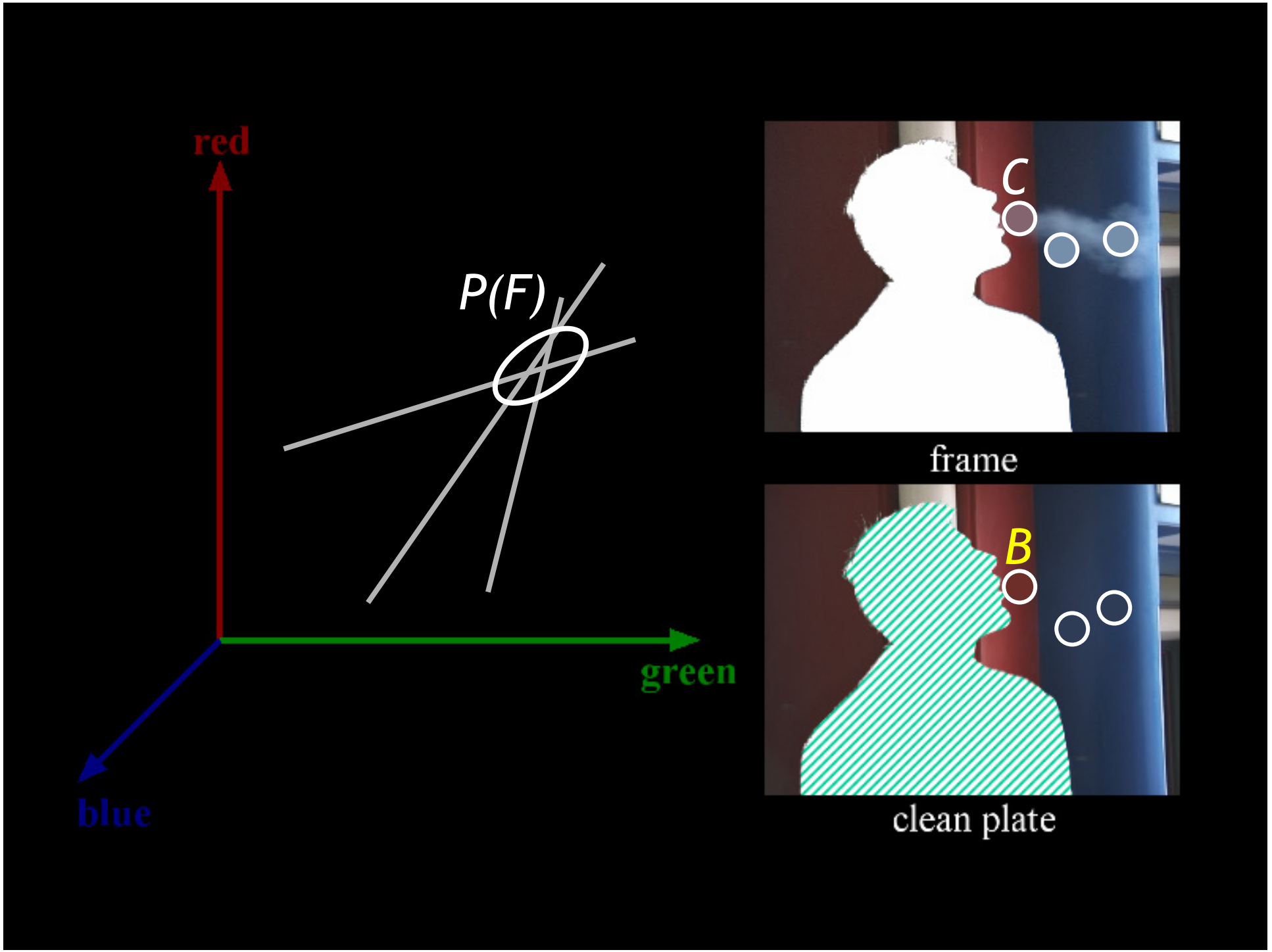

input
composite





frame

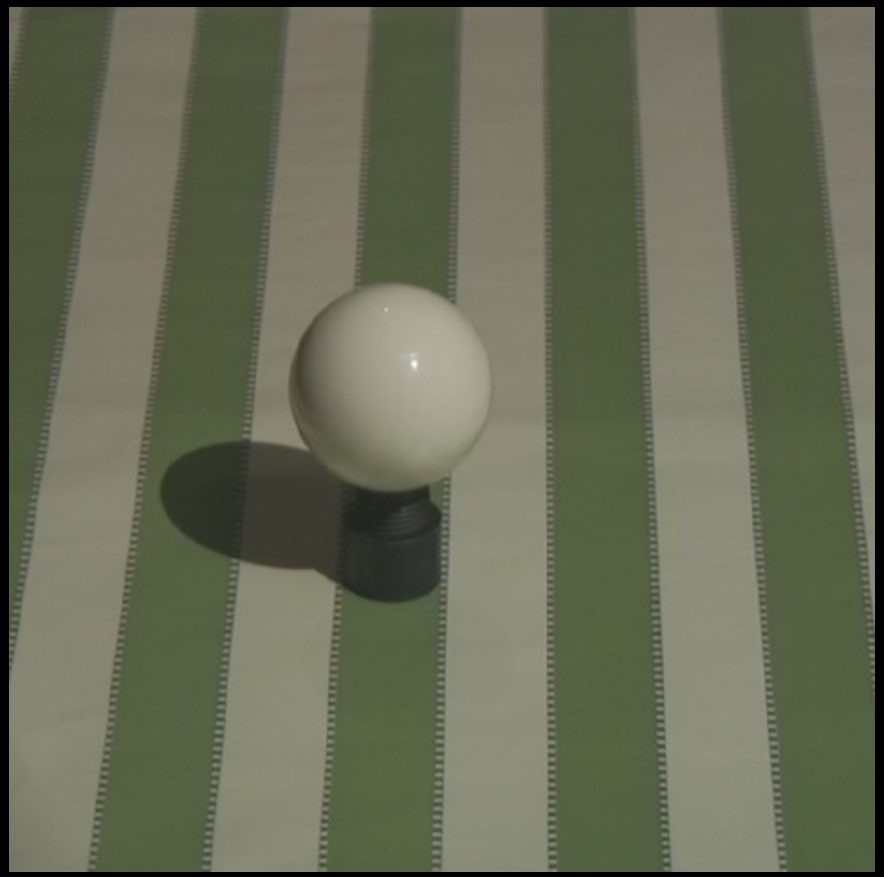
clean plate


red
green
blue
P(F)
C
frame
B
clean plate

Shadow matting
and compositing

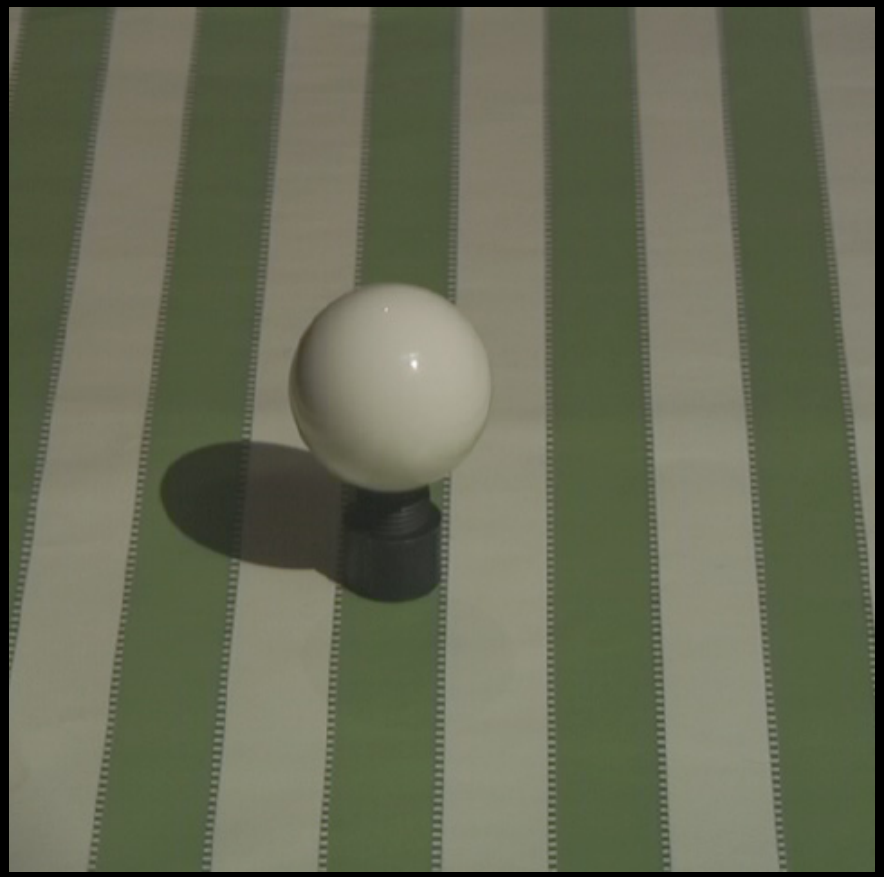
source scene

target background



blue screen image

target background



blue screen composite

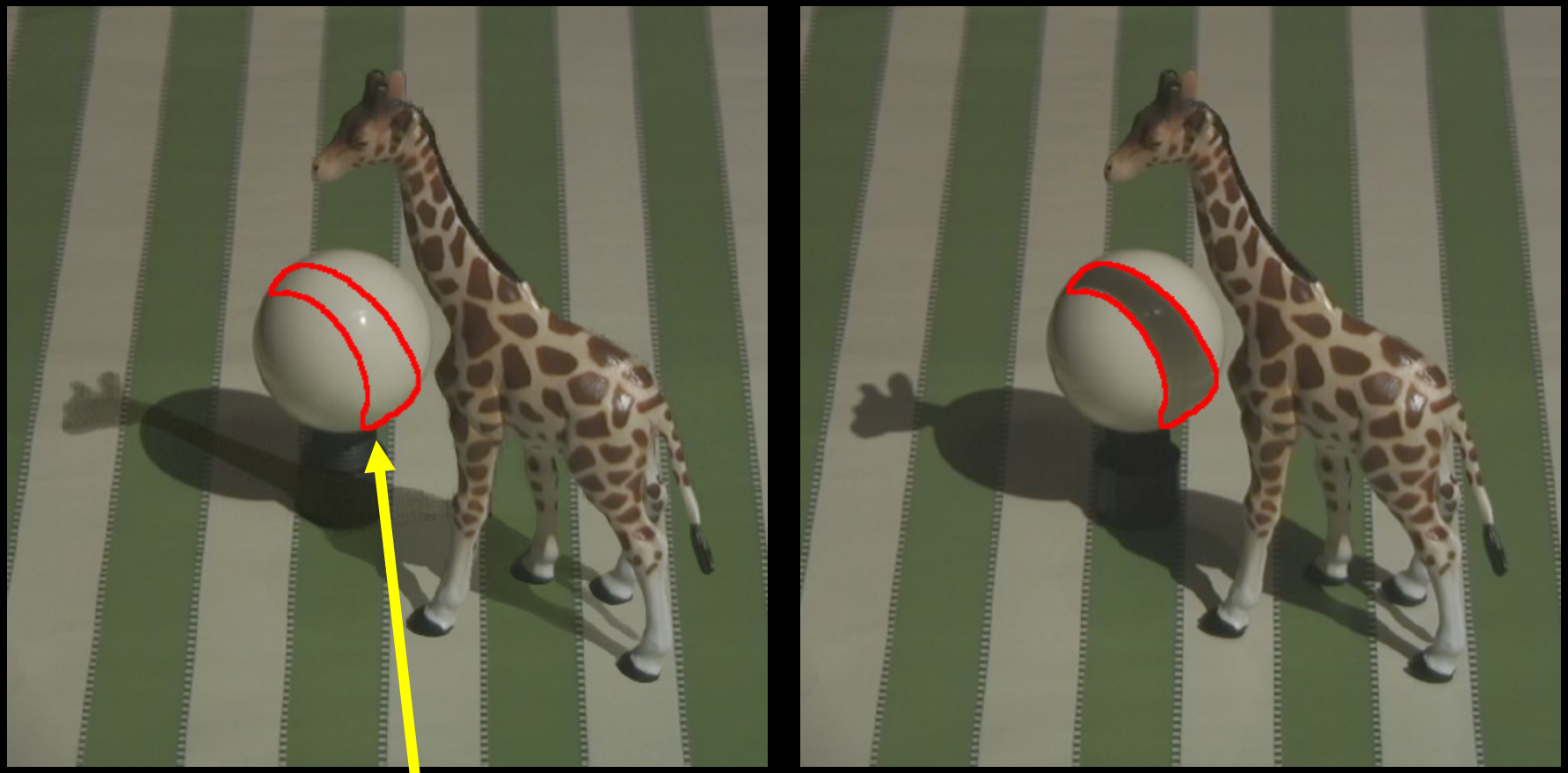
target background

blue screen composite

photograph

blue screen composite

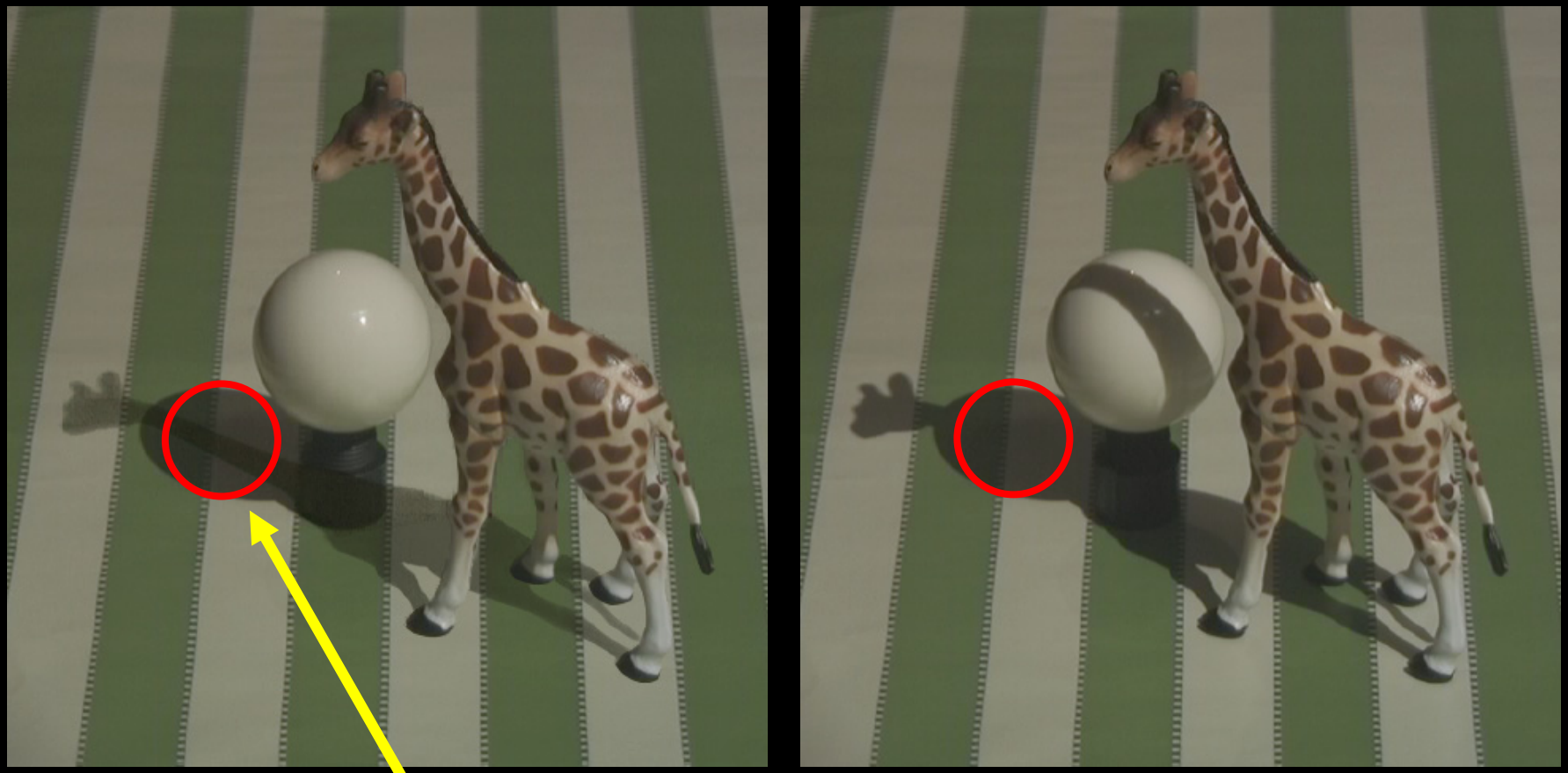
photograph



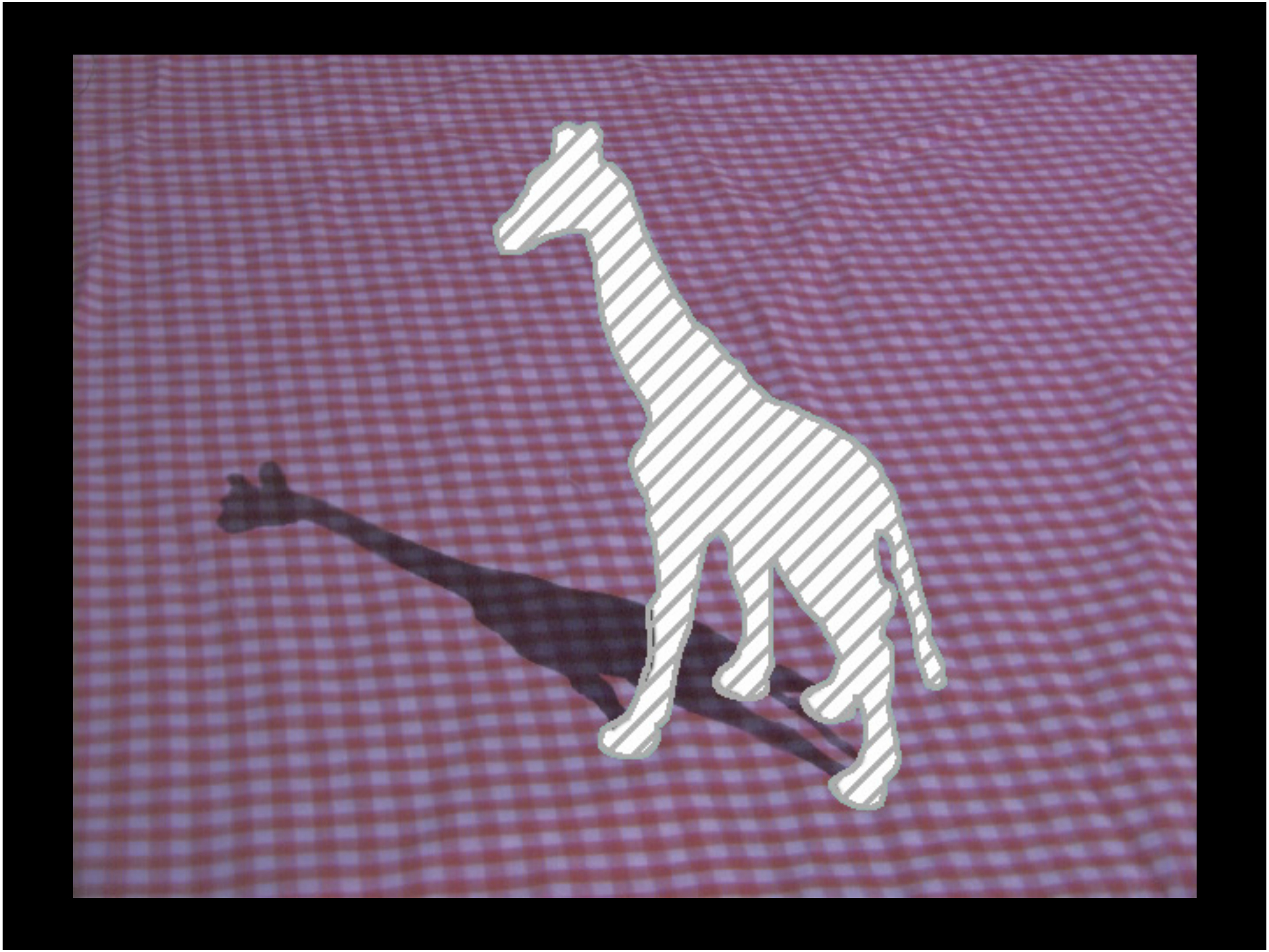
Geometric errors

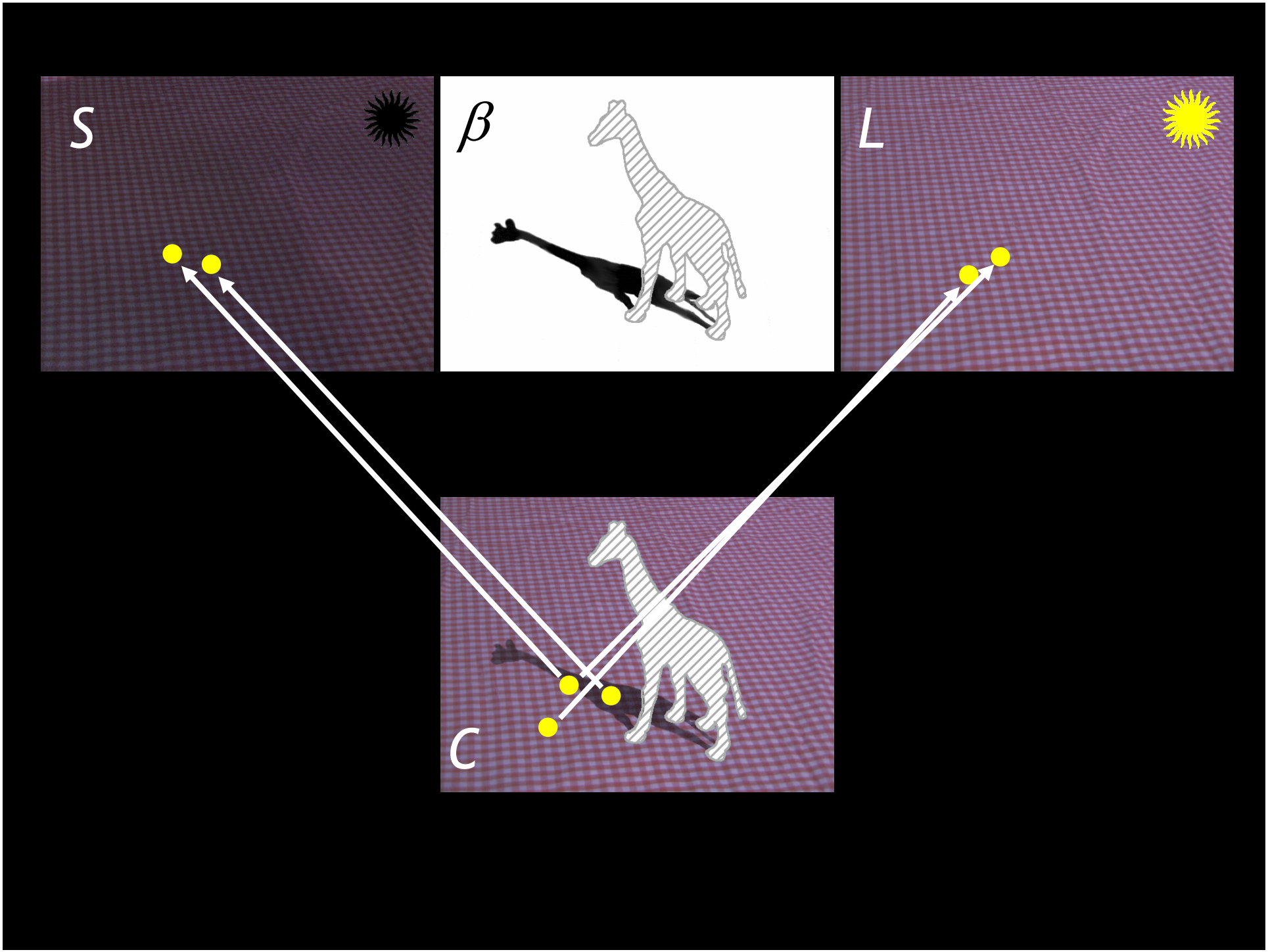
blue screen composite

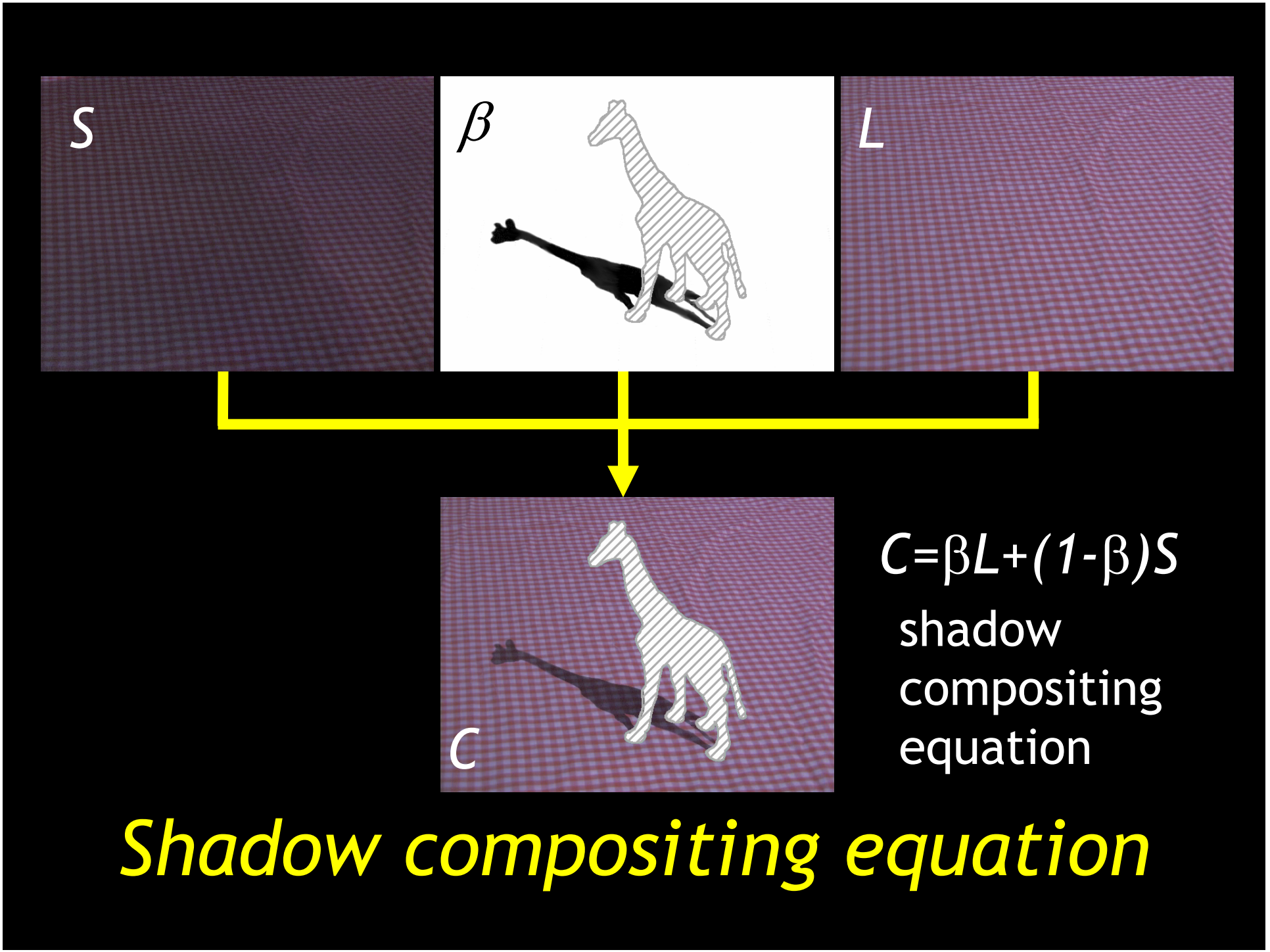
photograph

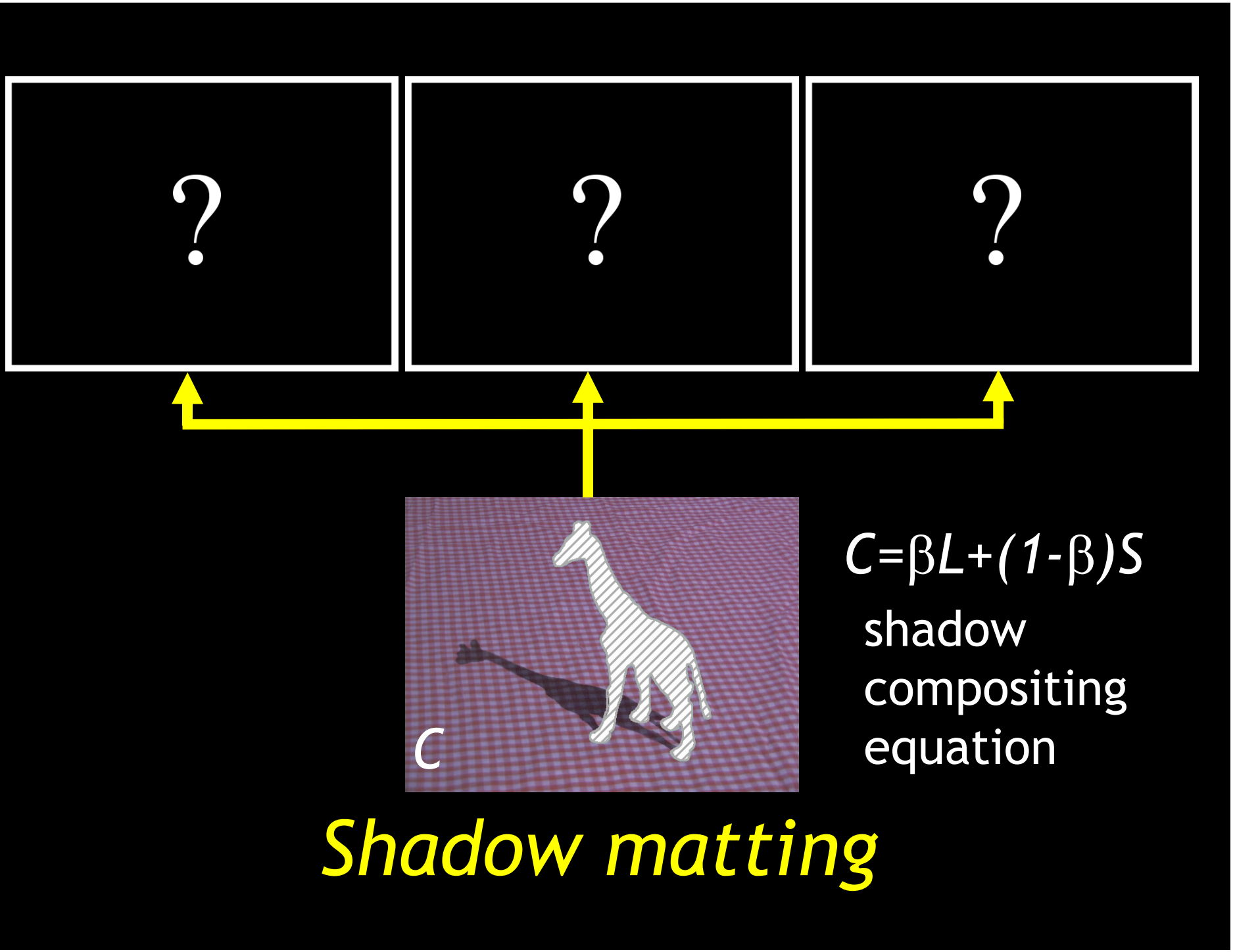


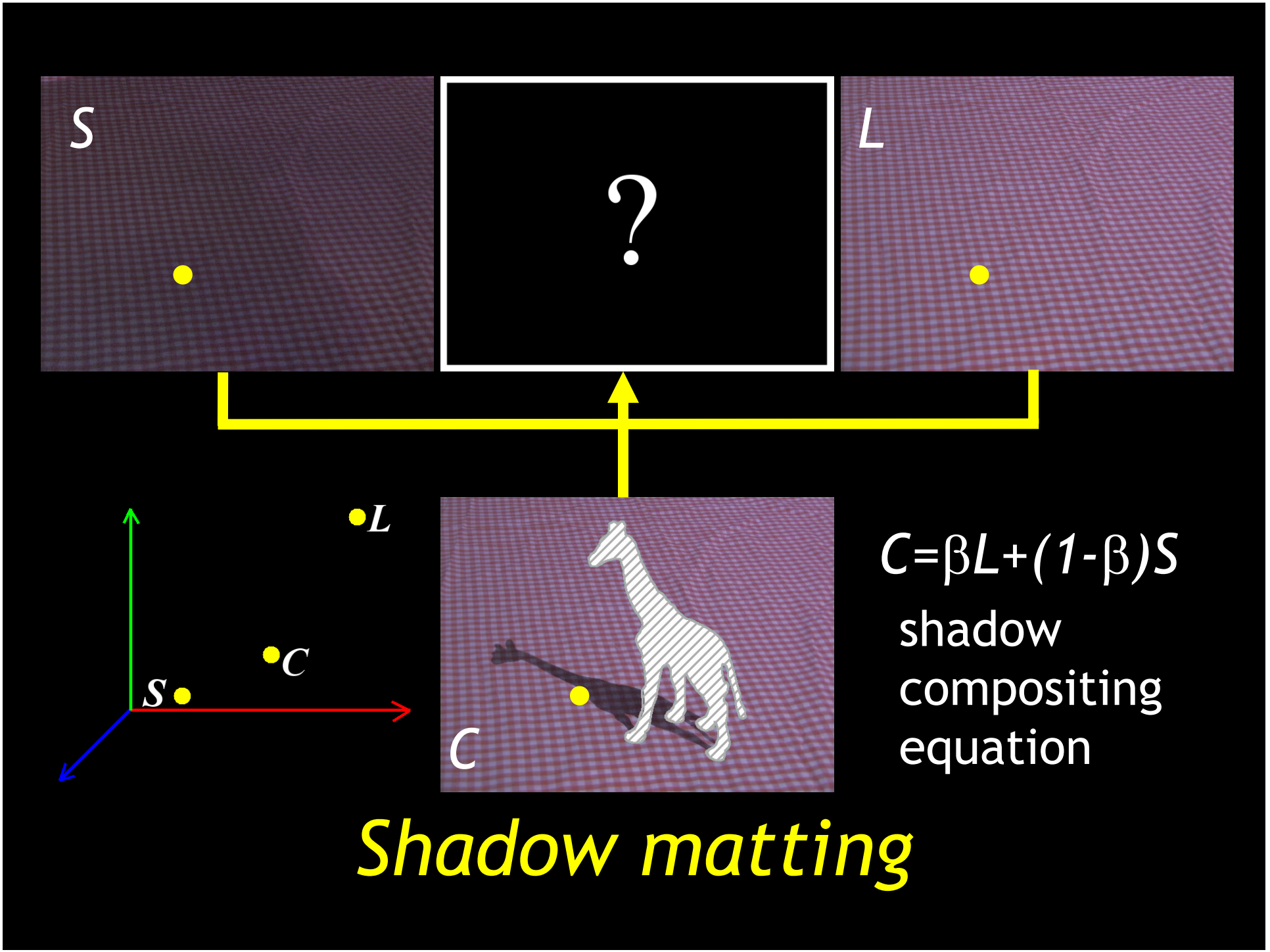
Photometric errors

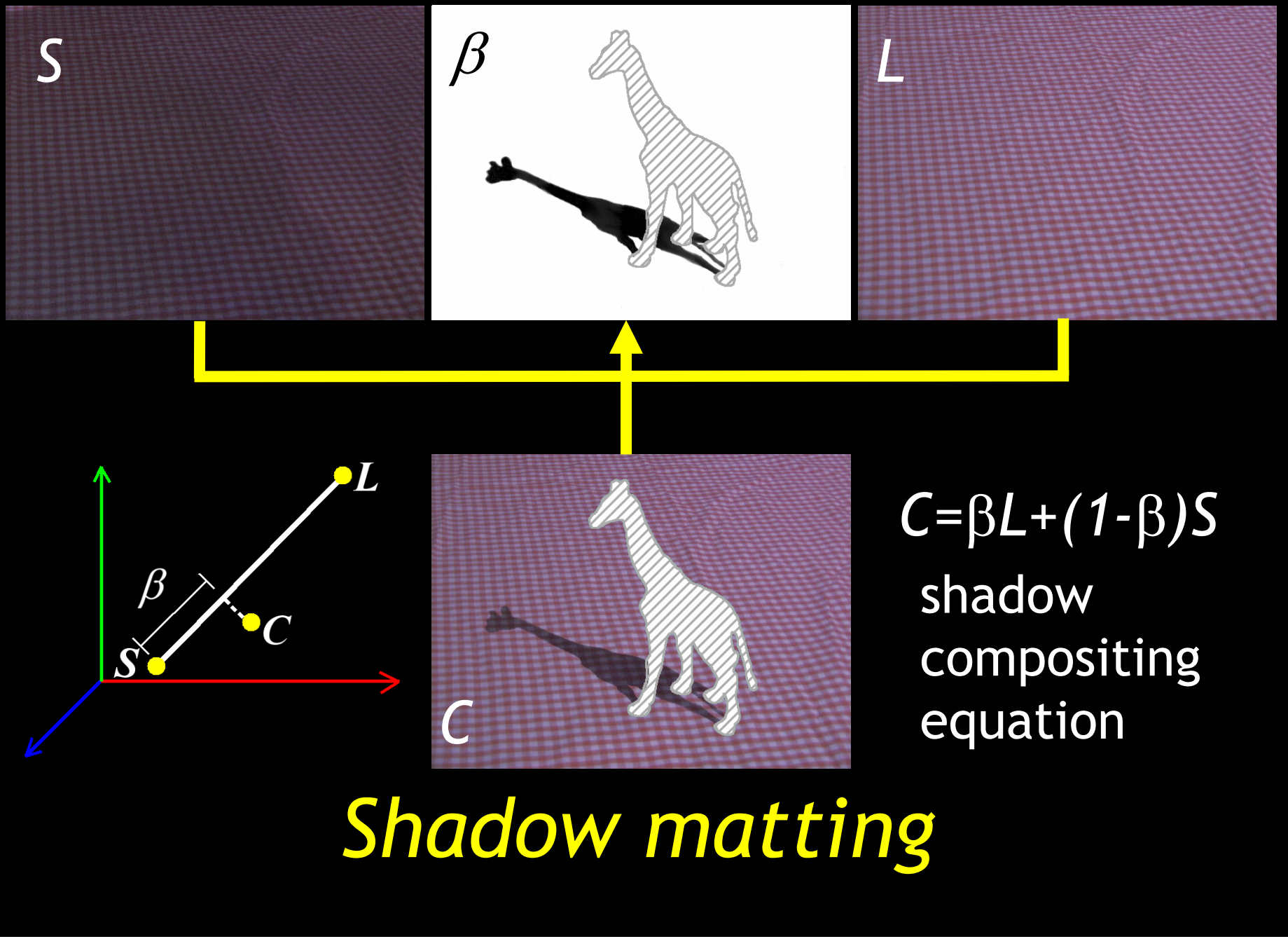


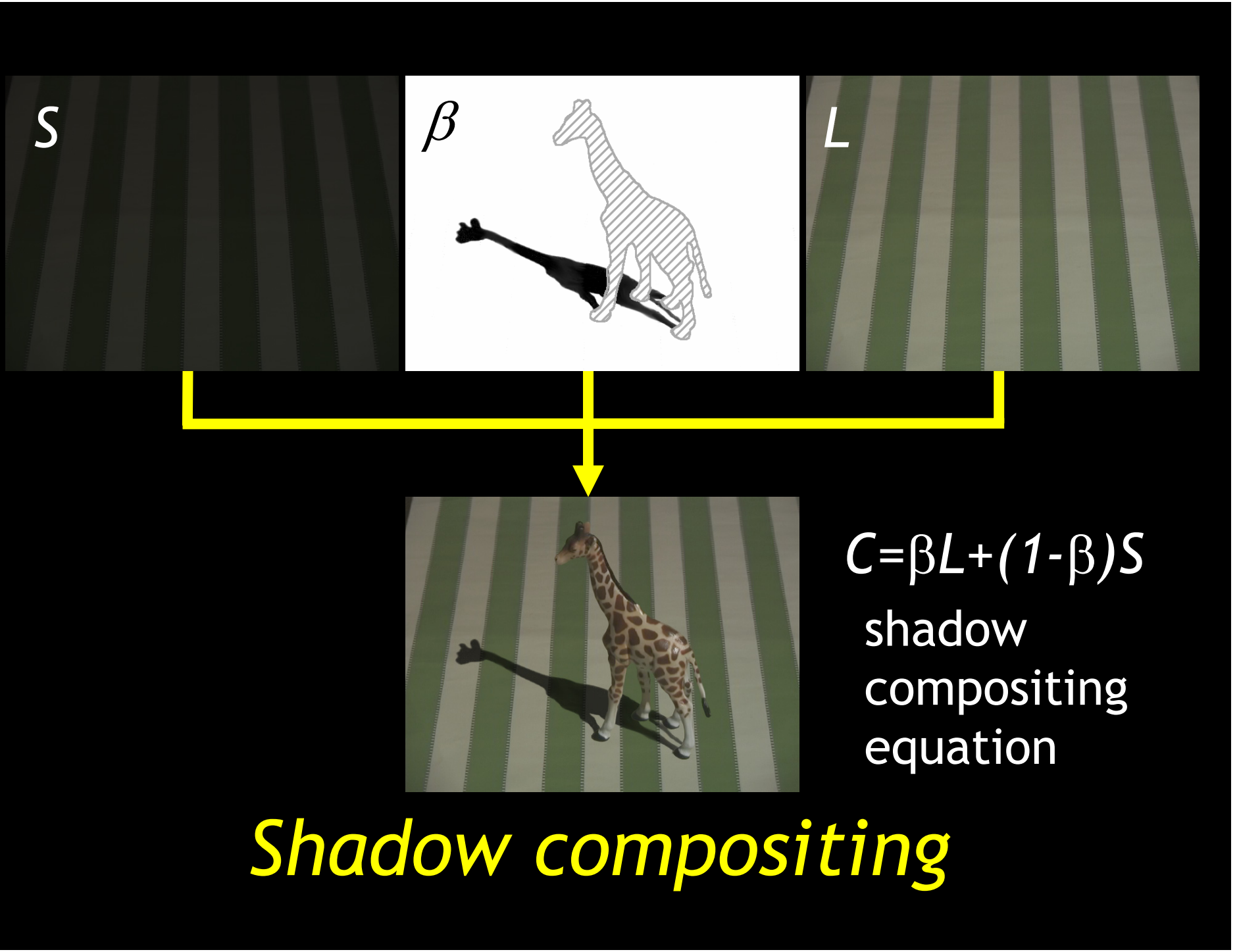

S
β
L
C

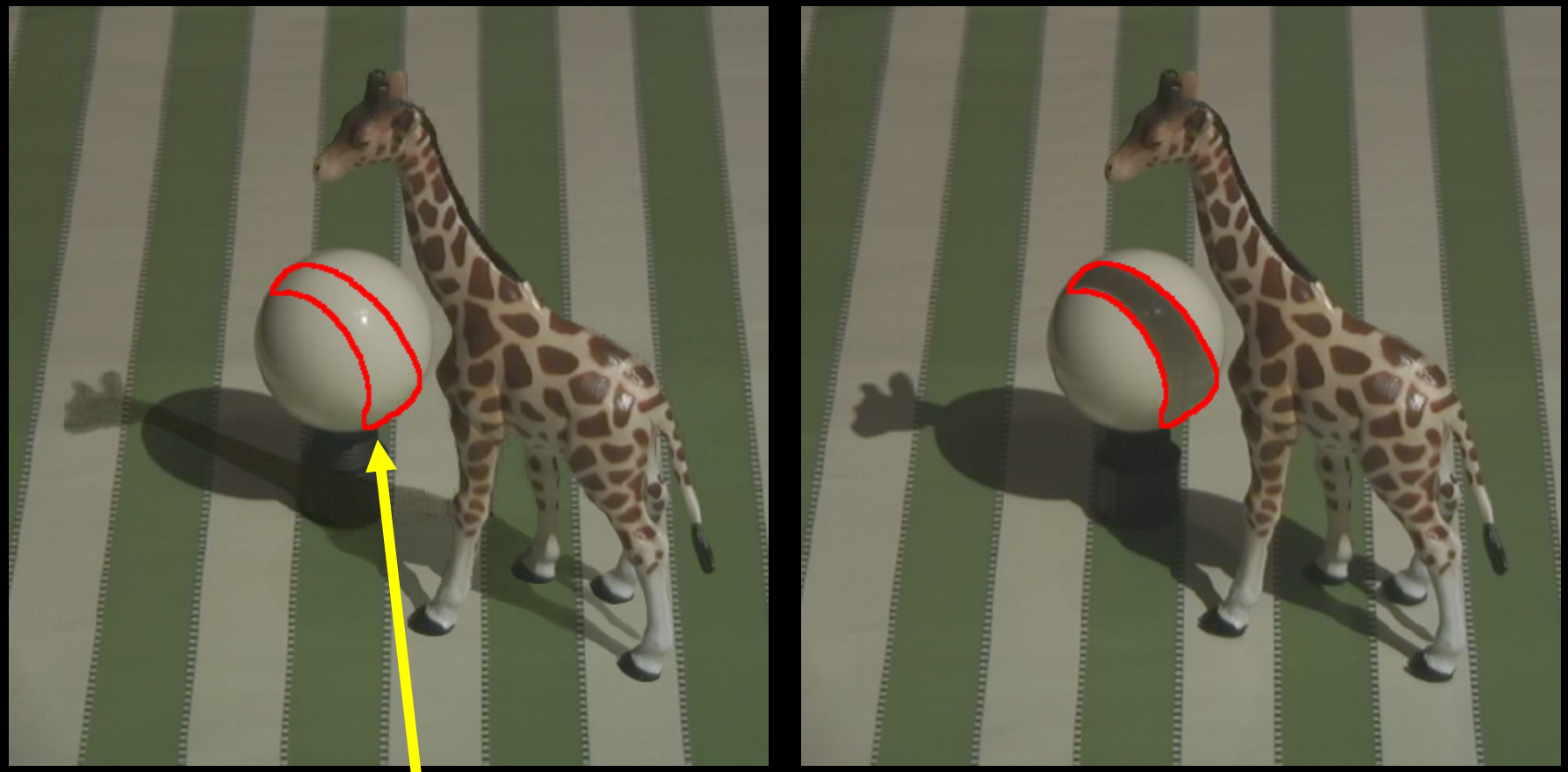

S
β
L
C
C=βL+(1-β)S
shadow
compositing
equation
Shadow compositing equation


?
?
?
C
C=βL+(1-β)S
shadow
compositing
equation
Shadow matting


S
?
L
L
C
S
C
C=βL+(1-β)S
shadow
compositing
equation
Shadow matting

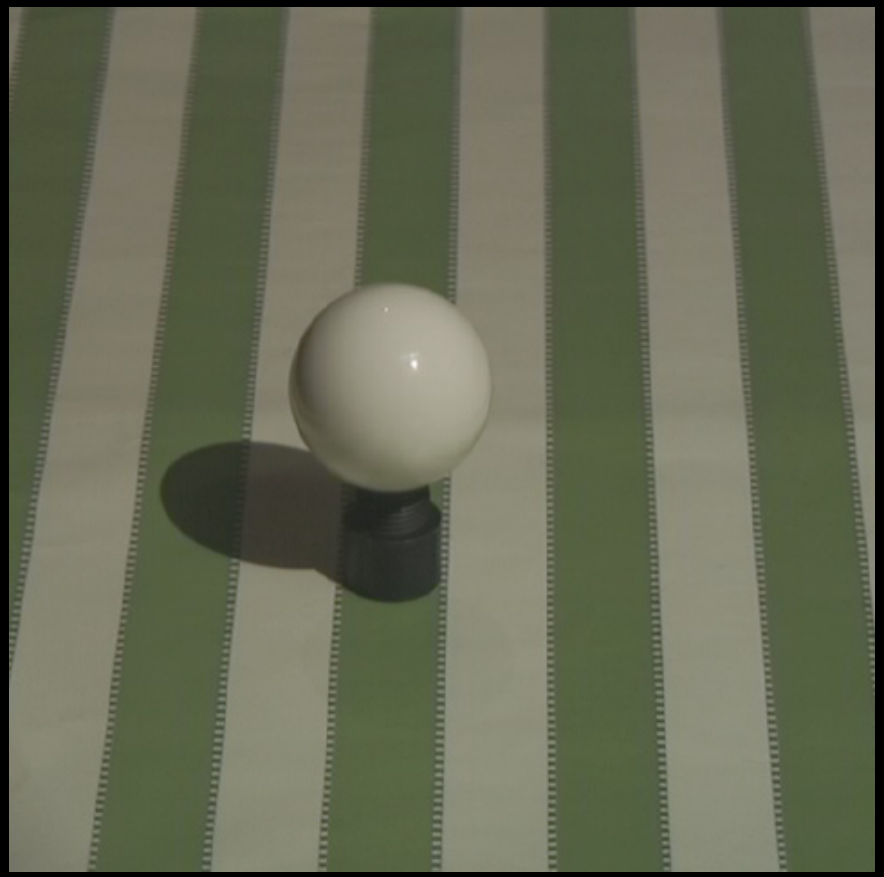

S
β
L
L
β
C
S
C
C=βL+(1-β)S
shadow
compositing
equation
Shadow matting


S
β
L
C=βL+(1-β)S
shadow
compositing
equation
Shadow compositing

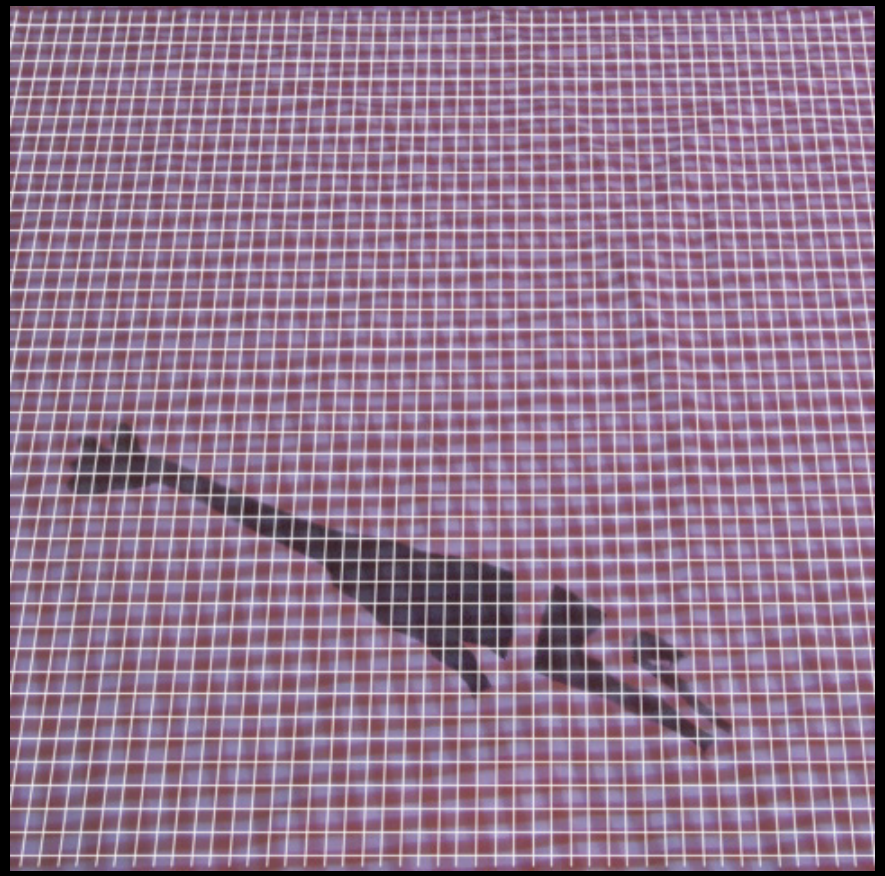

Geometric errors

source scene

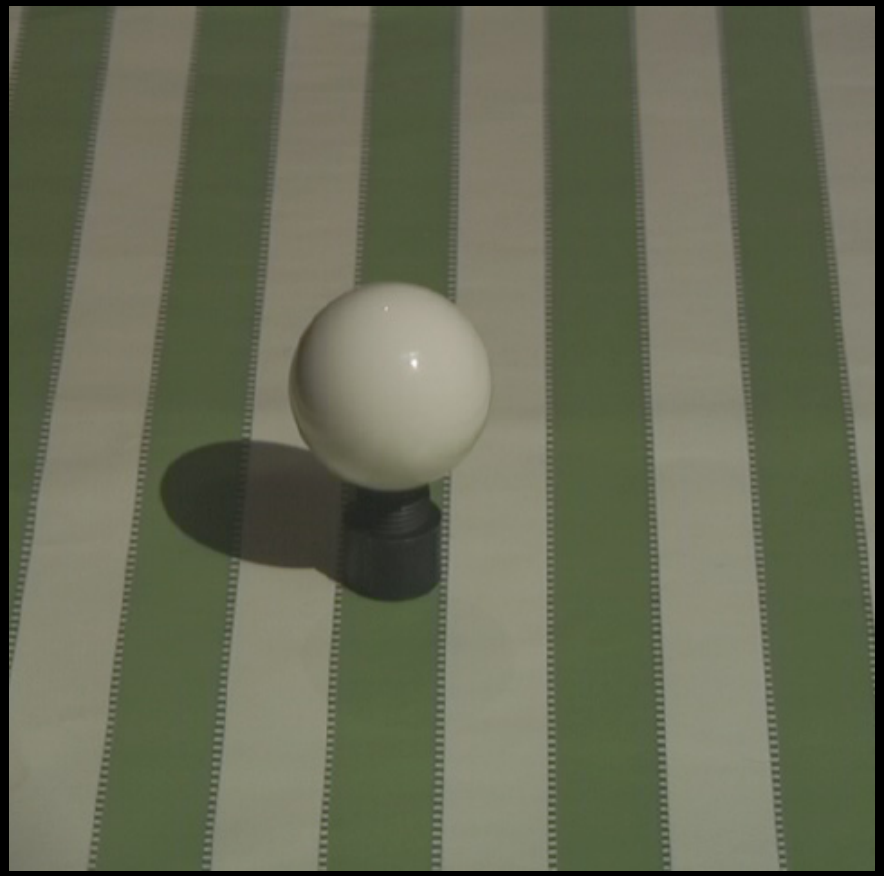
target background



source scene

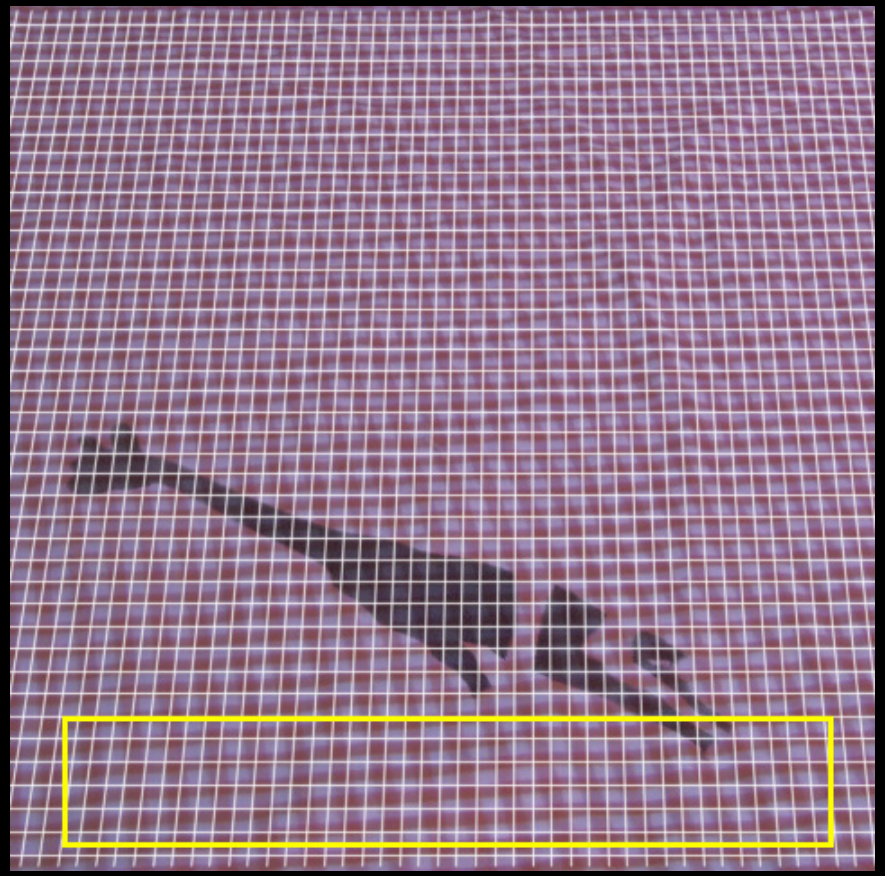


target background

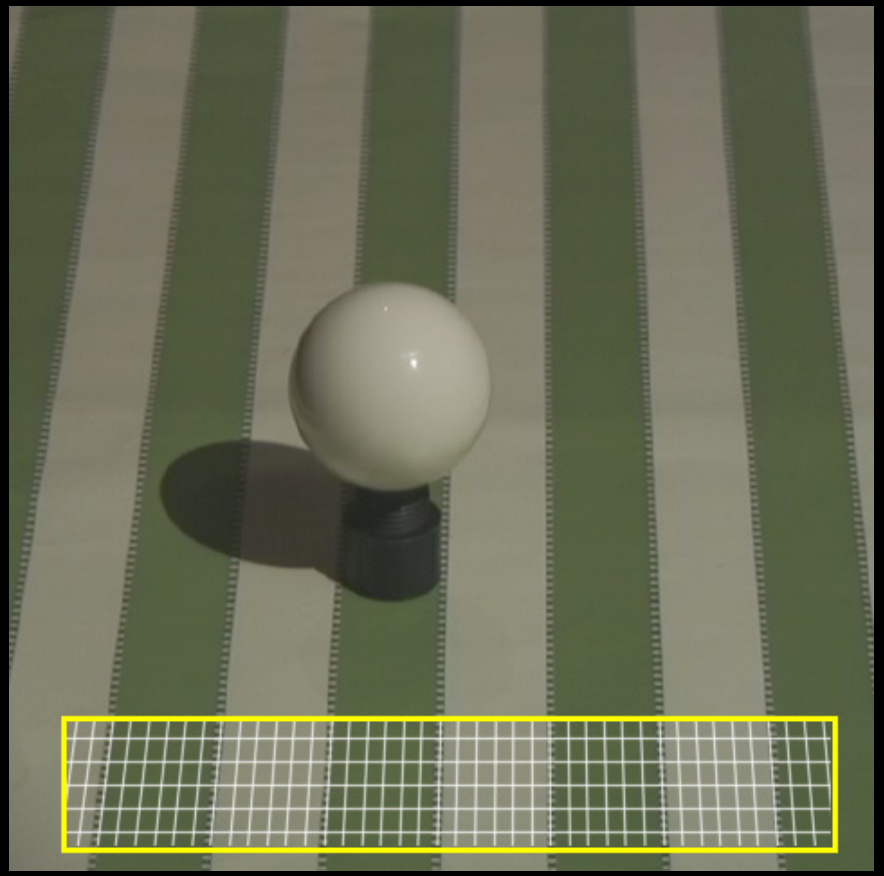


Requirement #1

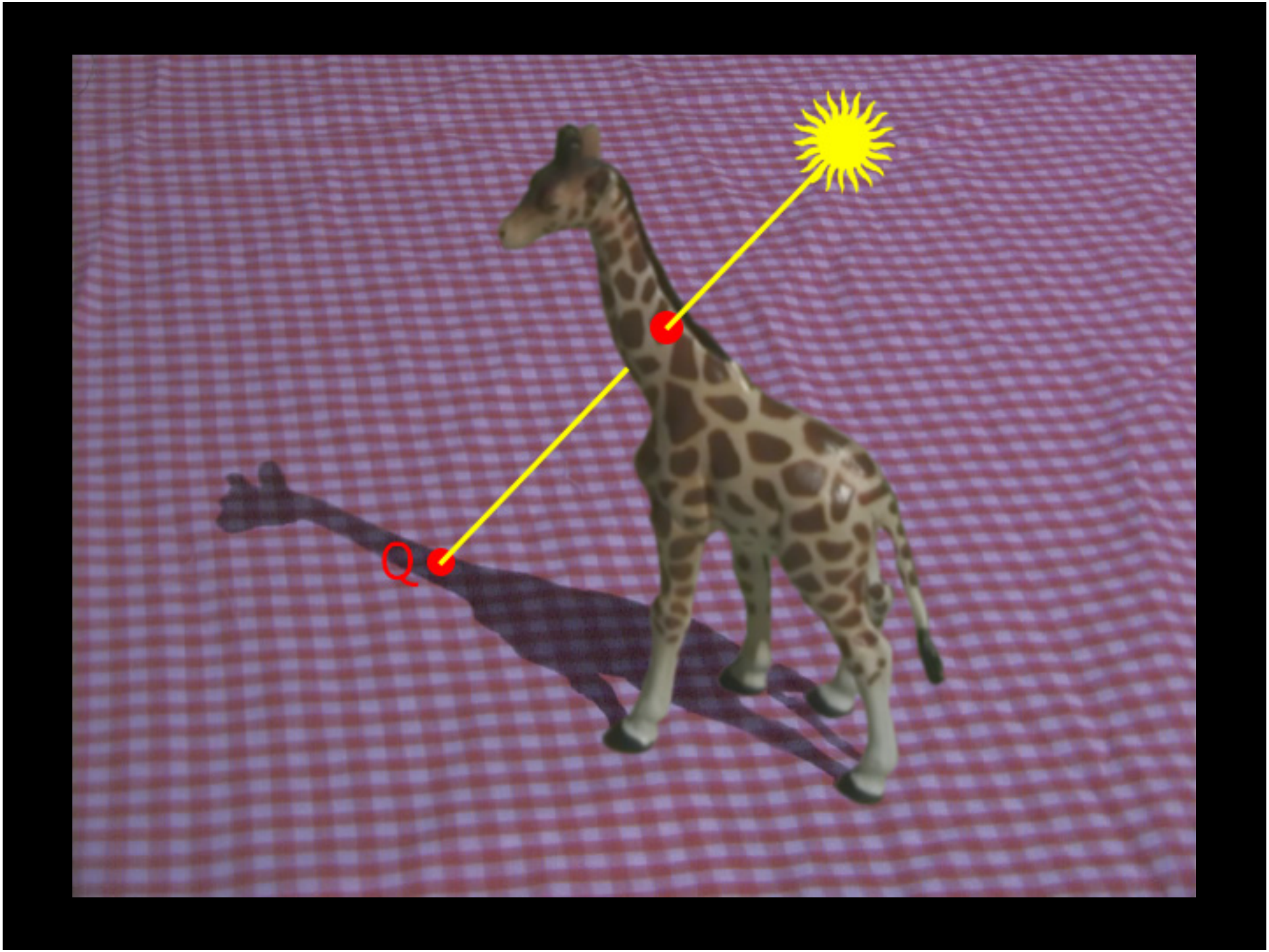
source scene

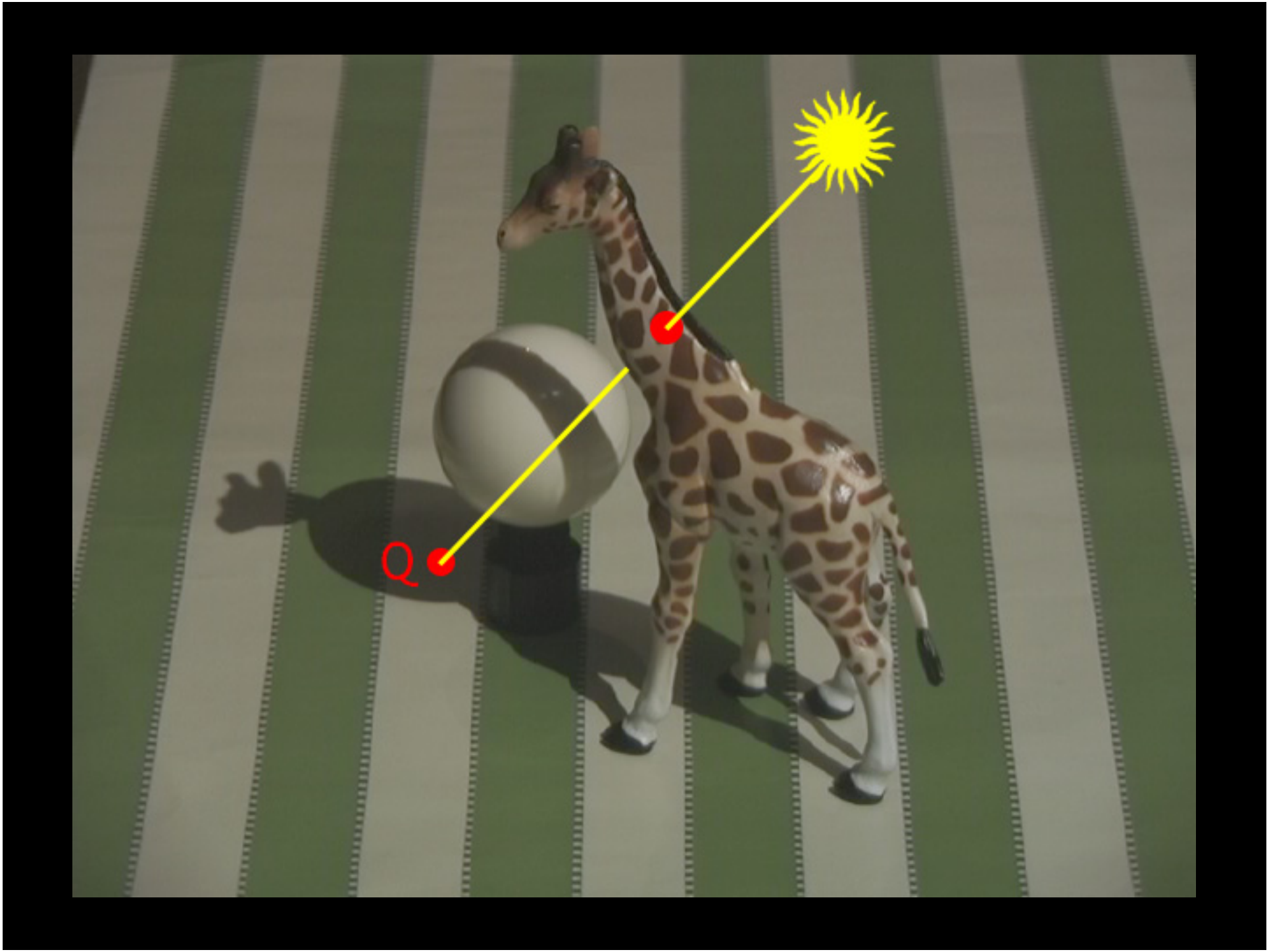


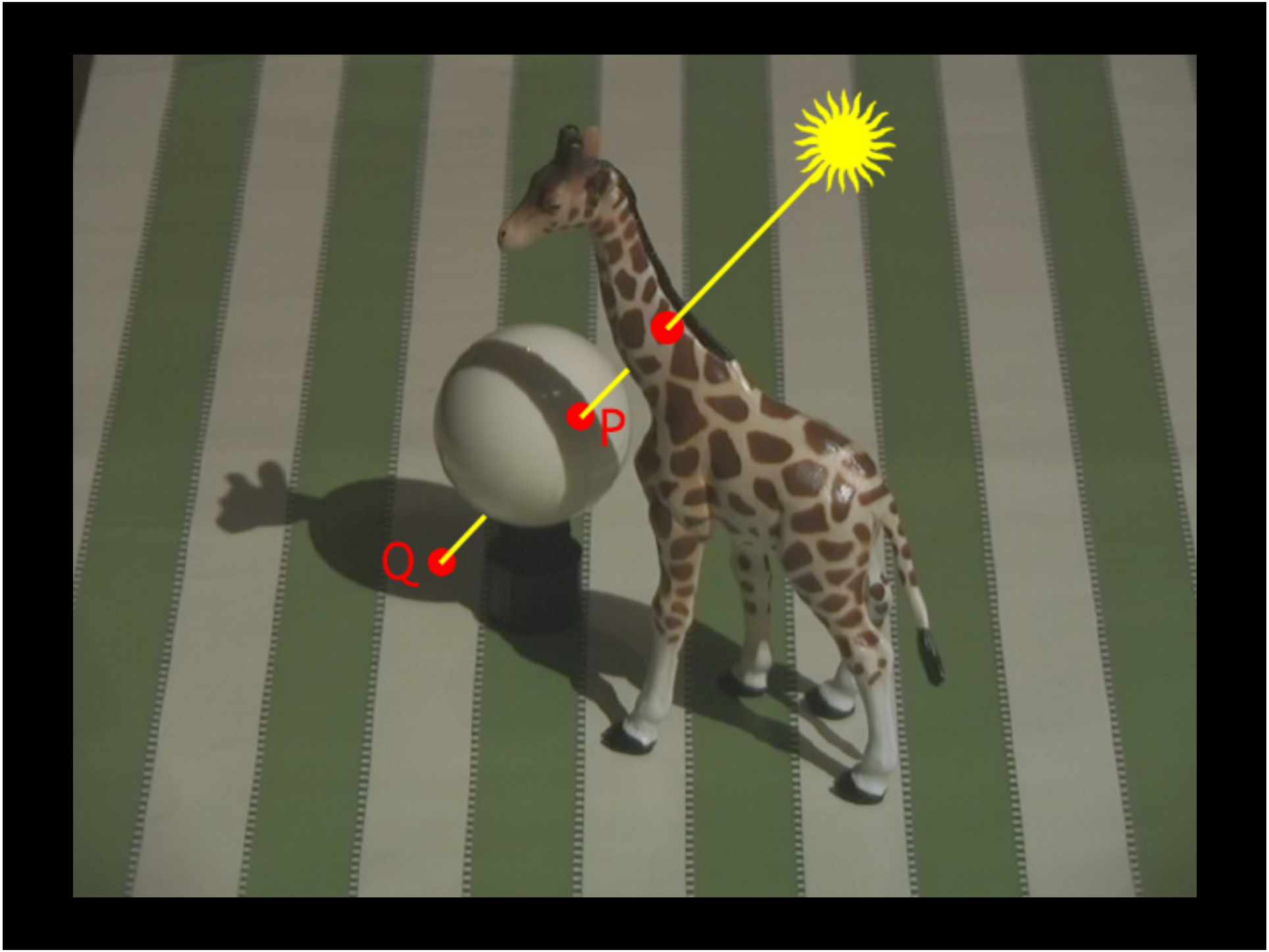
target background

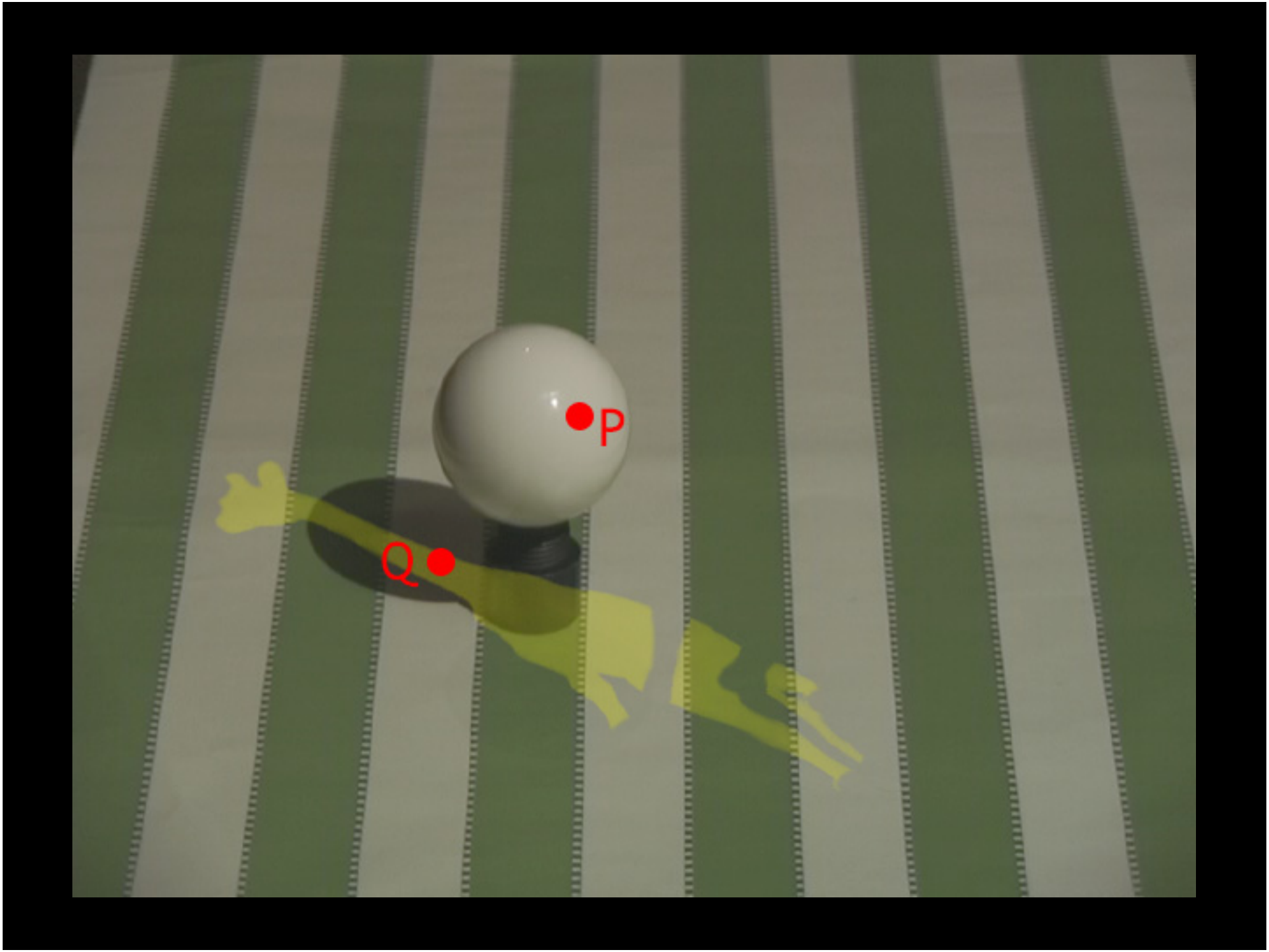


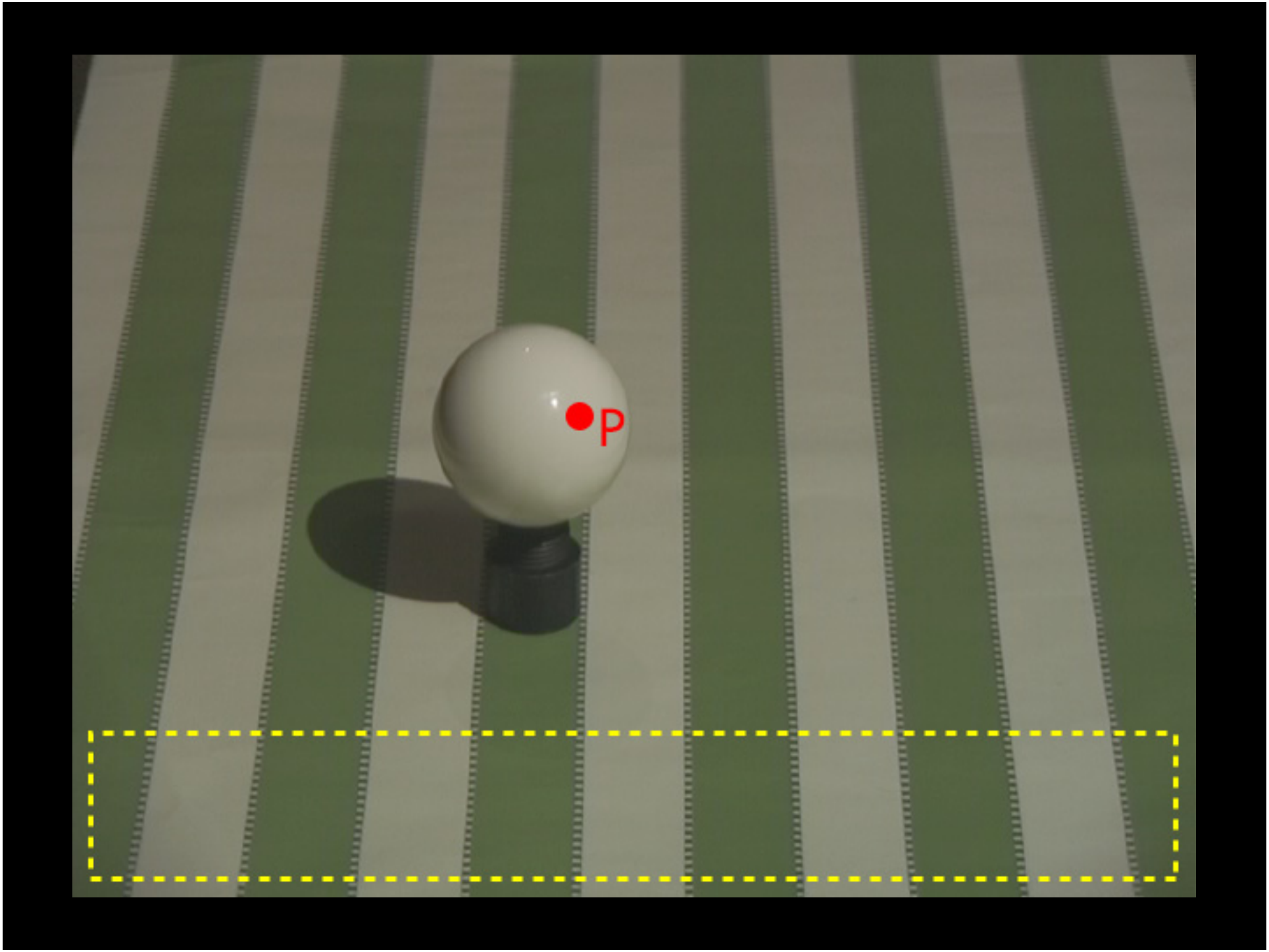
Requirement #2

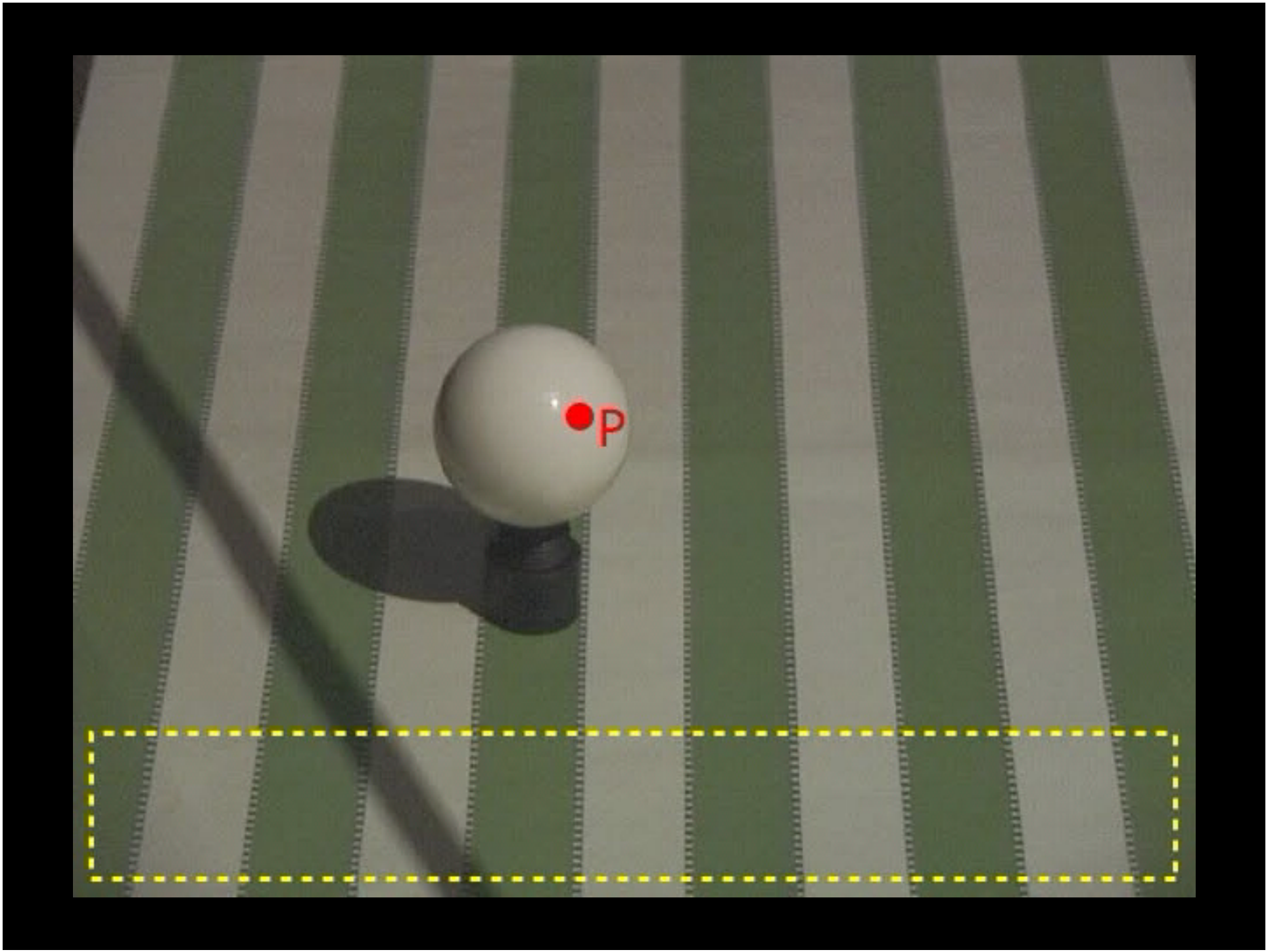

Q

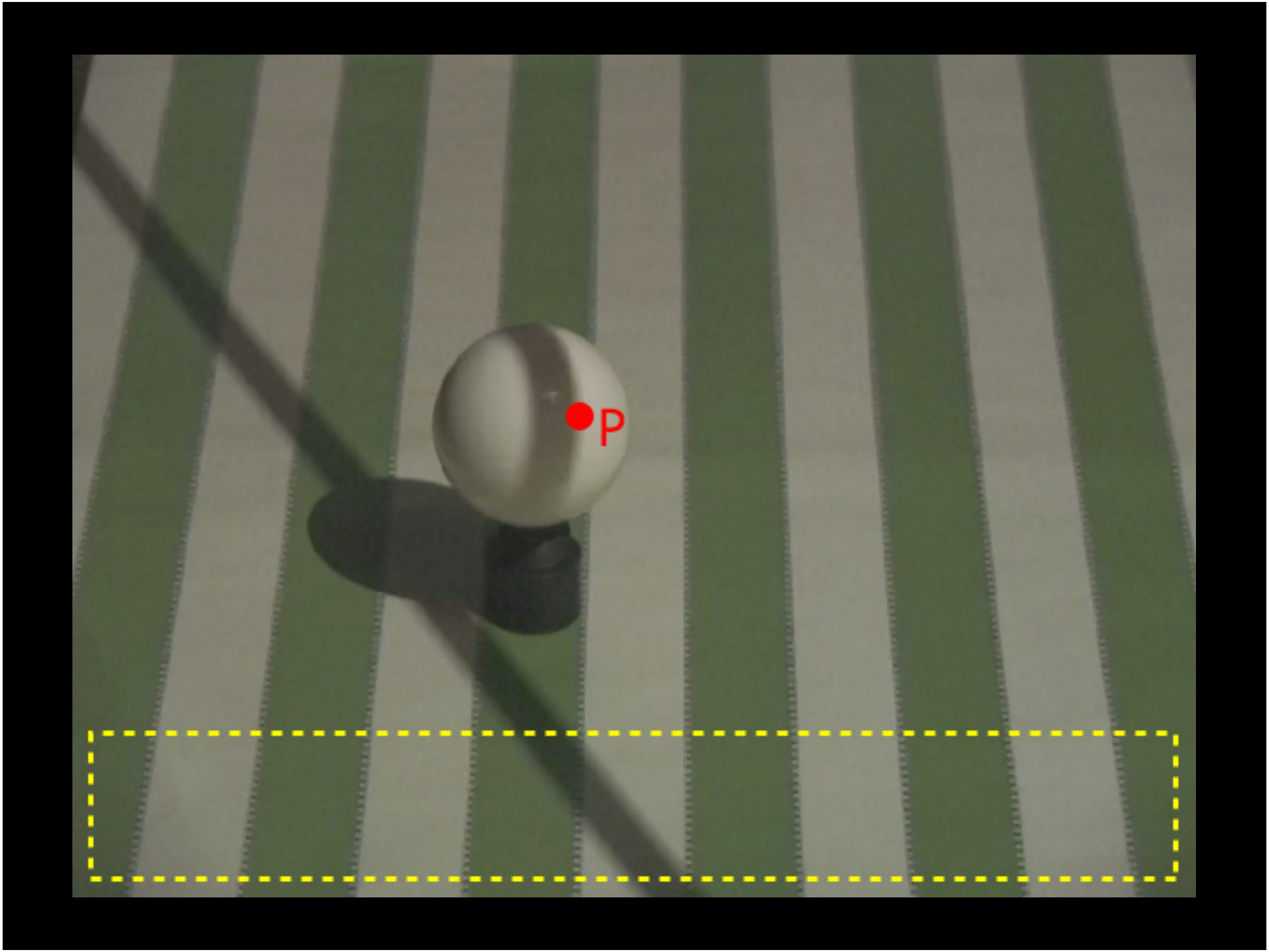

Q

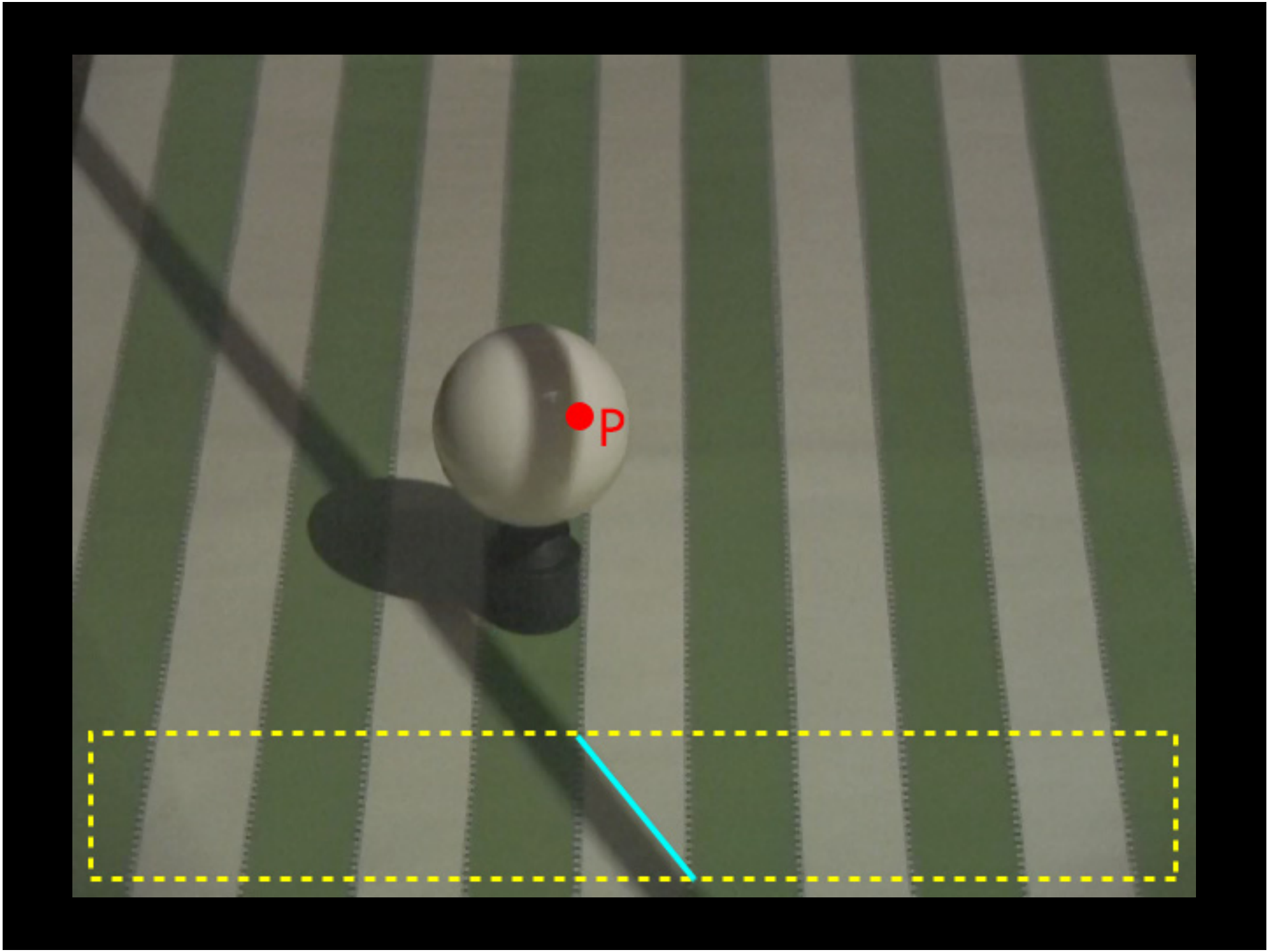

P
Q

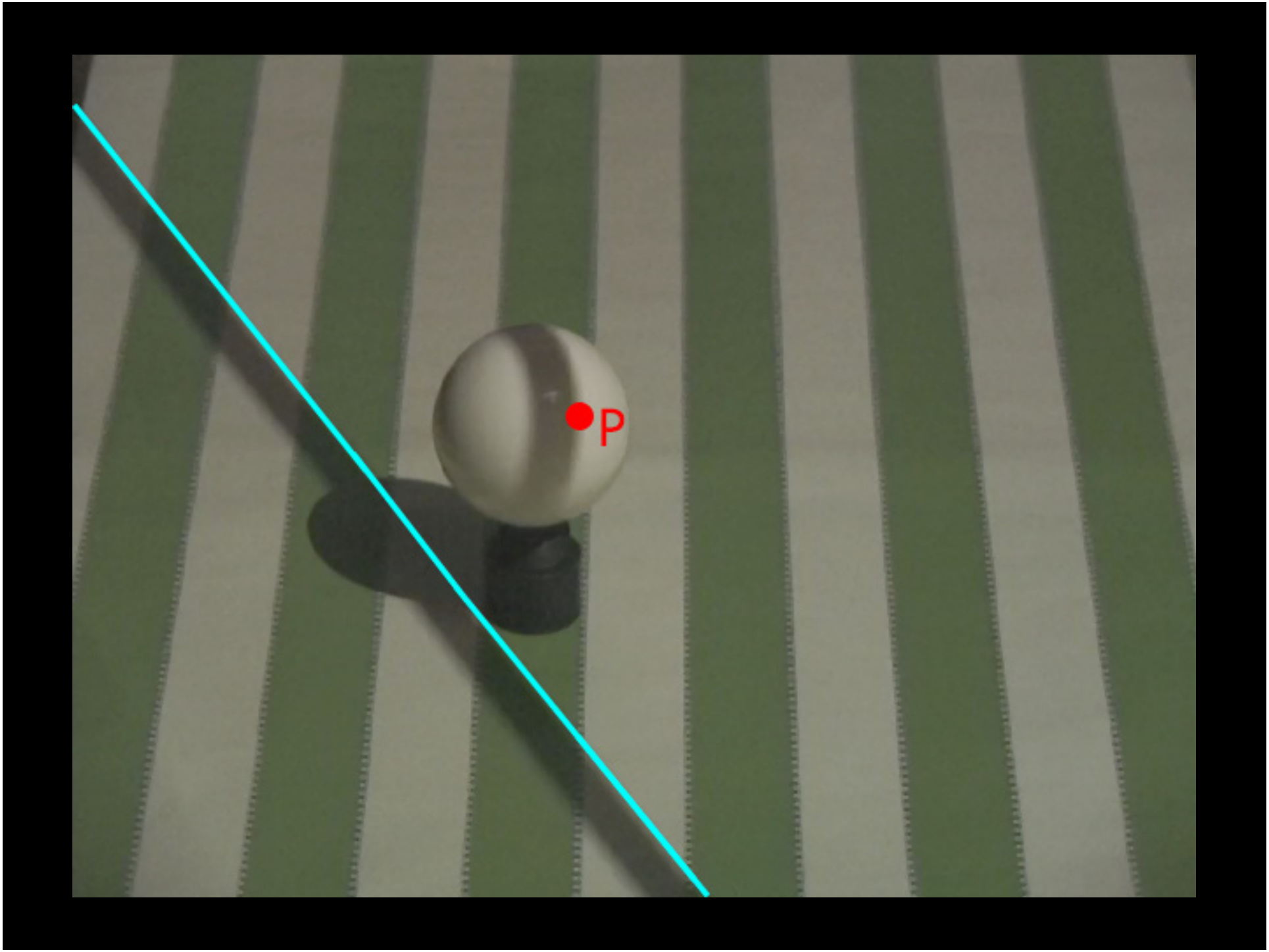

P
Q

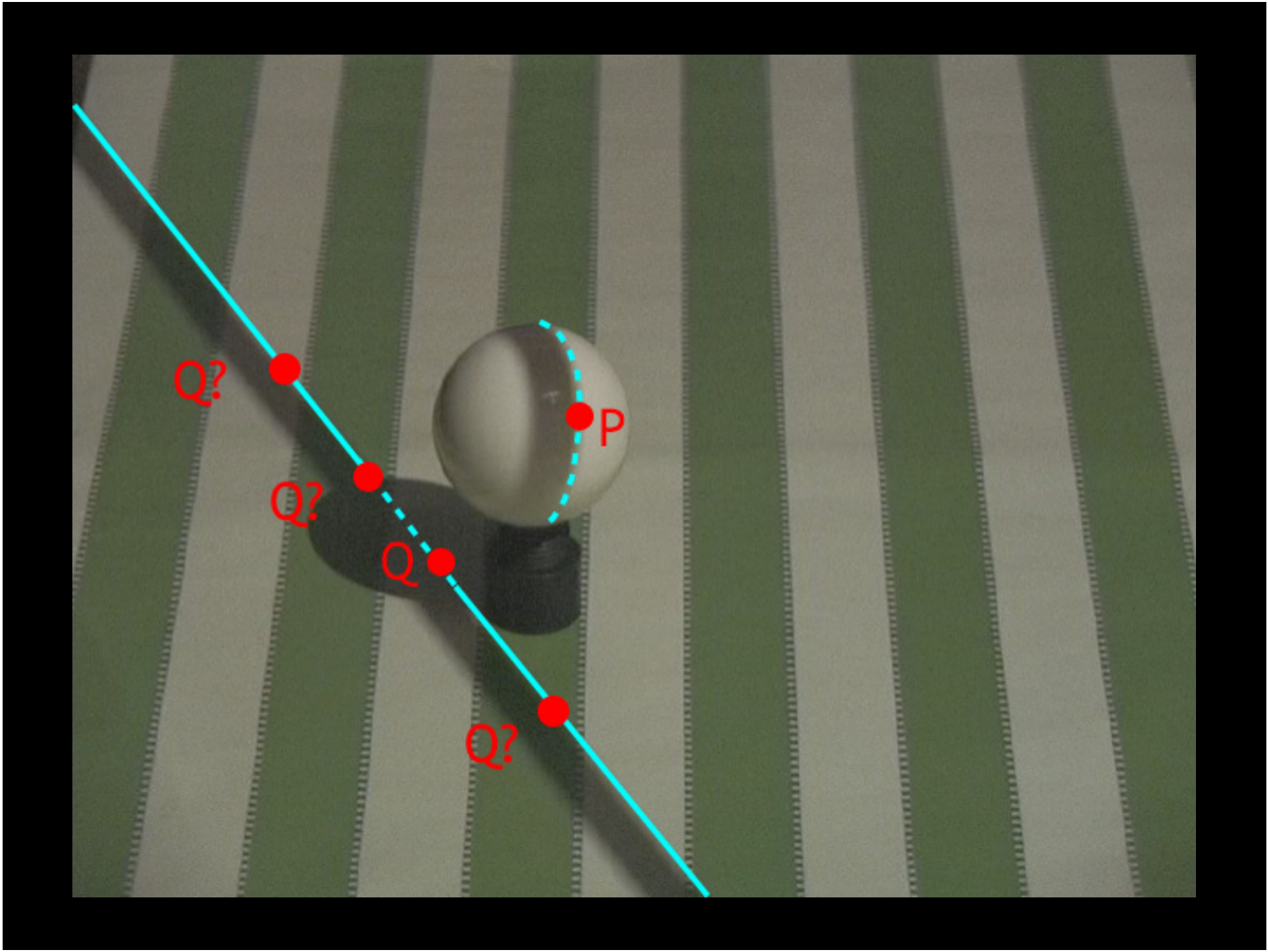

P

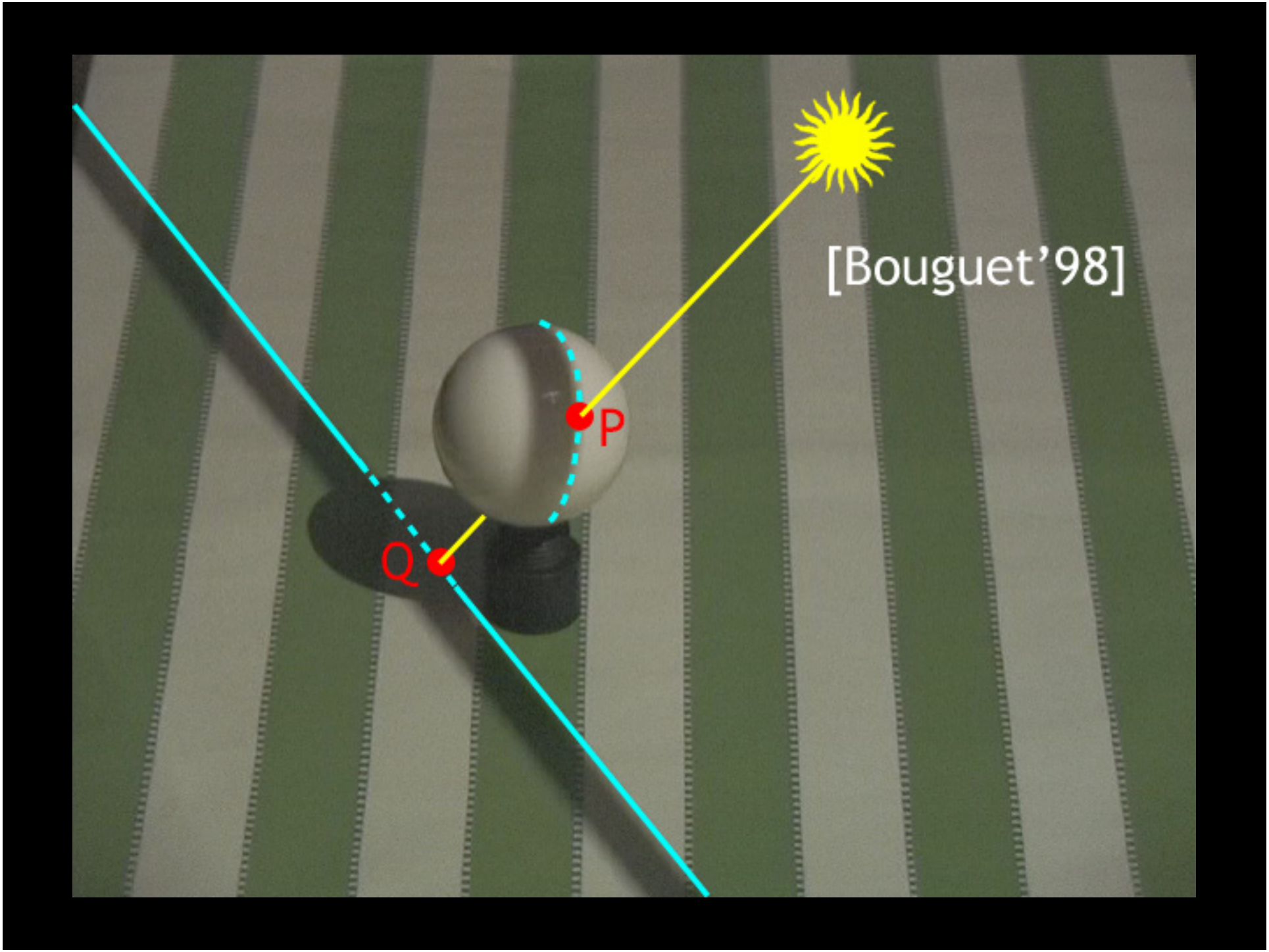

P

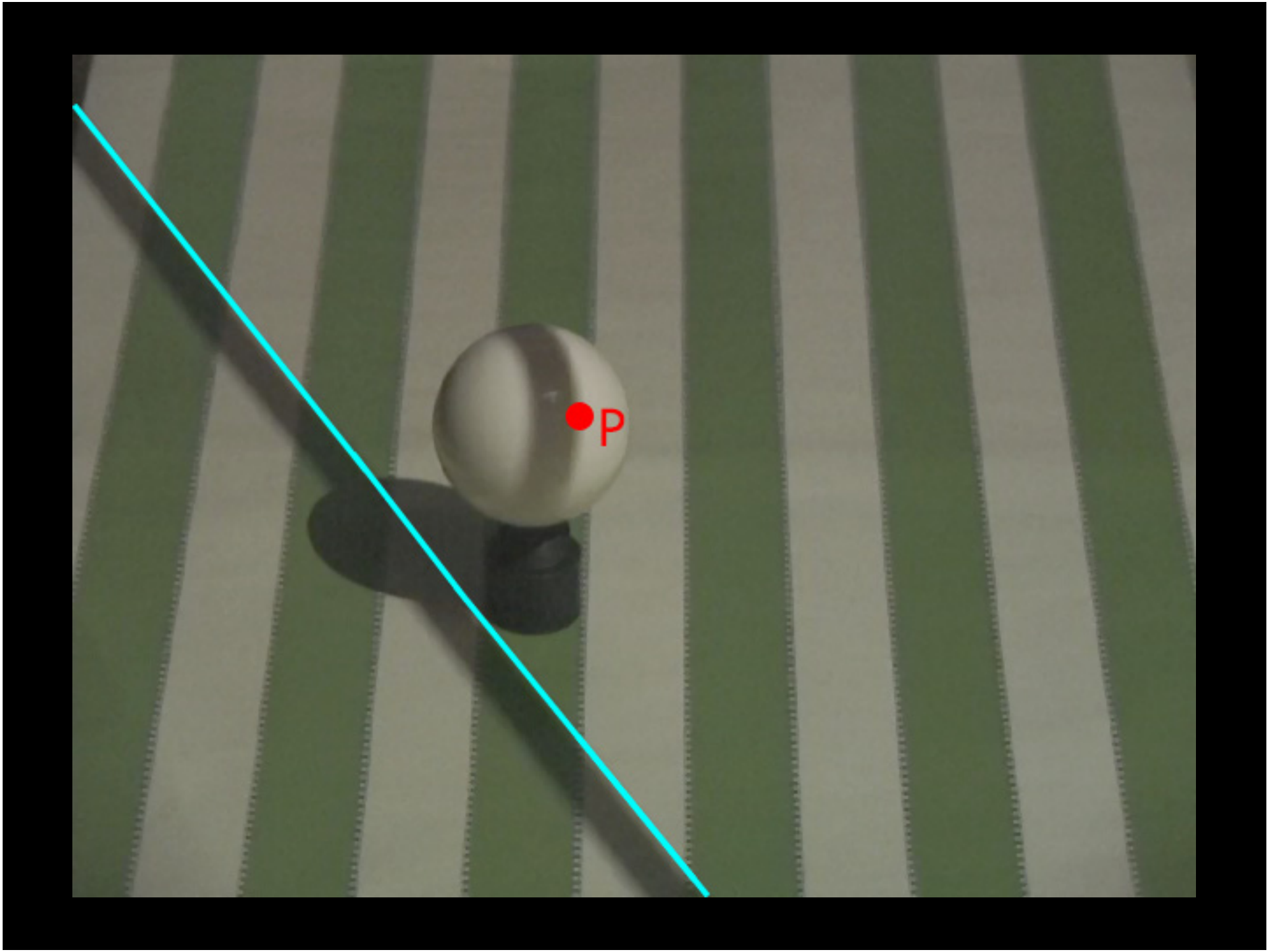

P

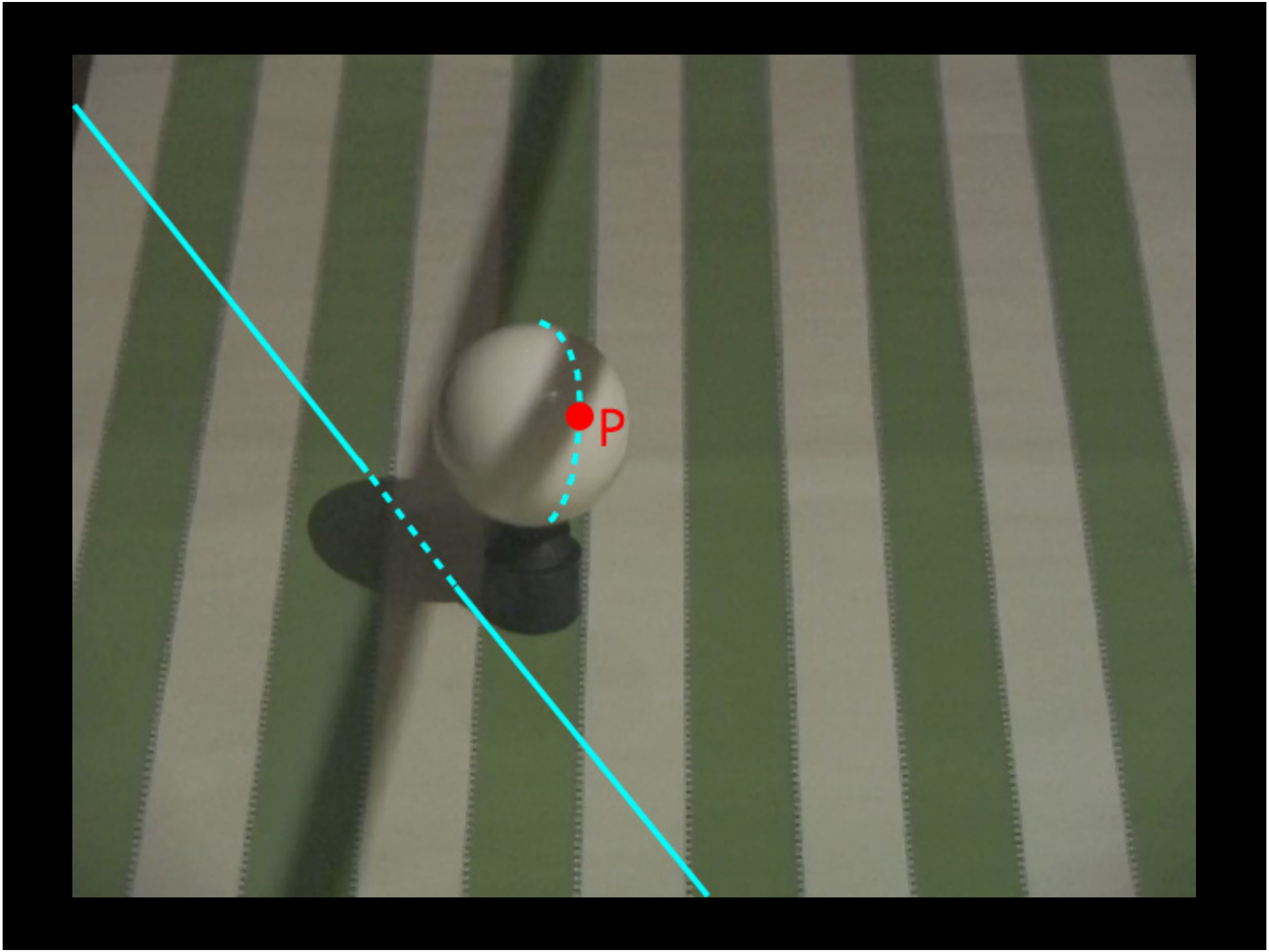

P

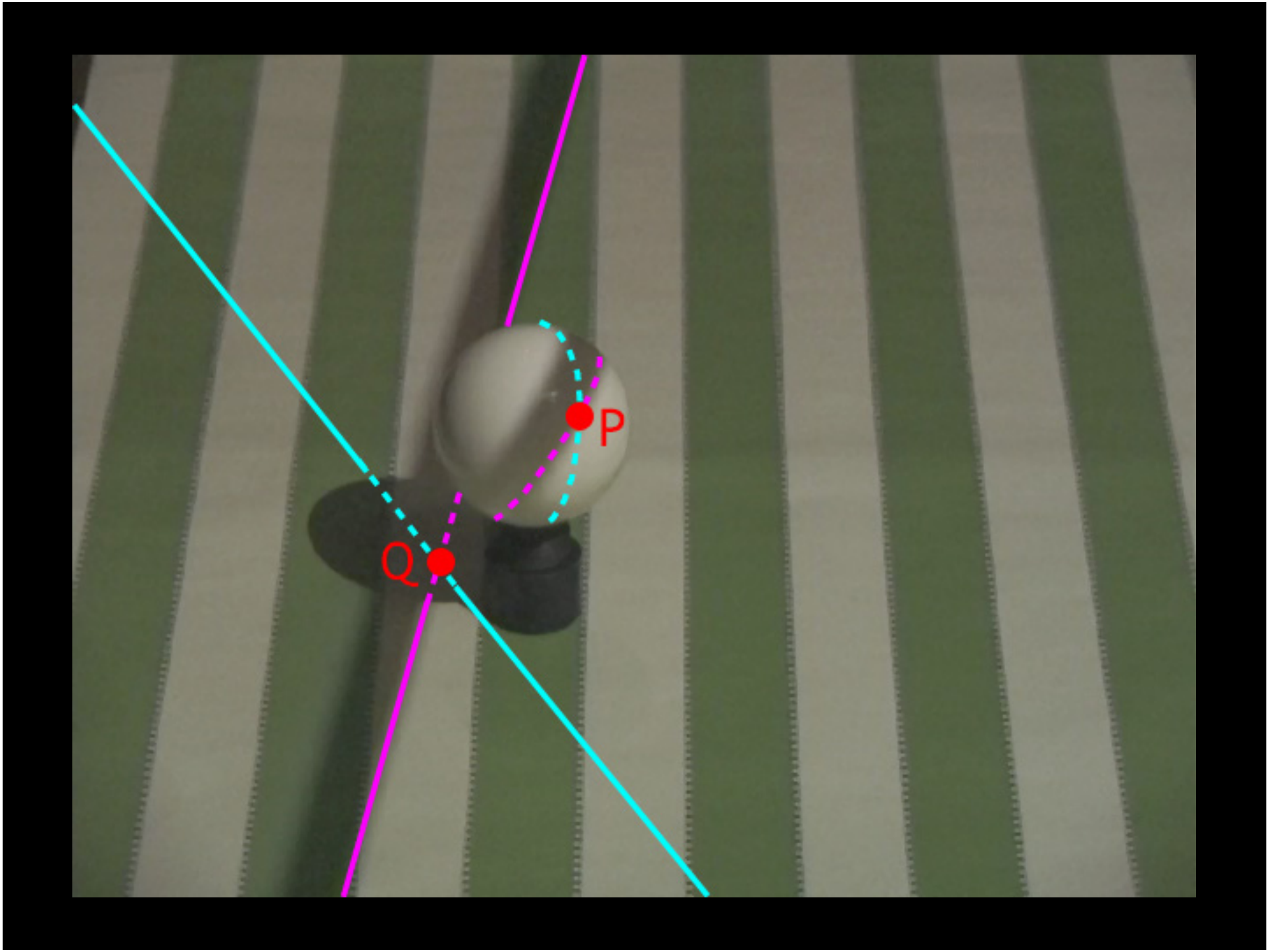

P

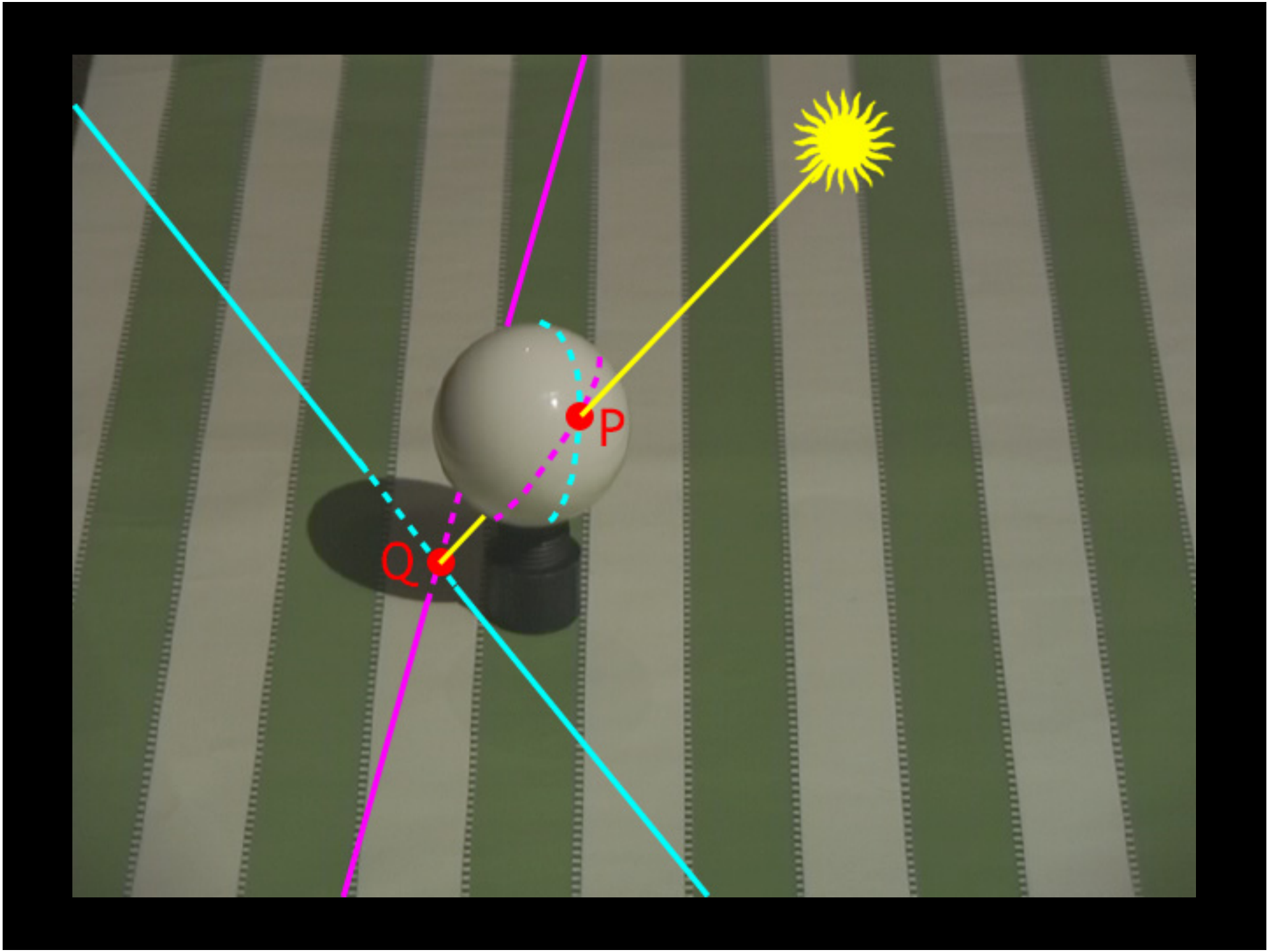

Q?
Q?
Q
P
Q?

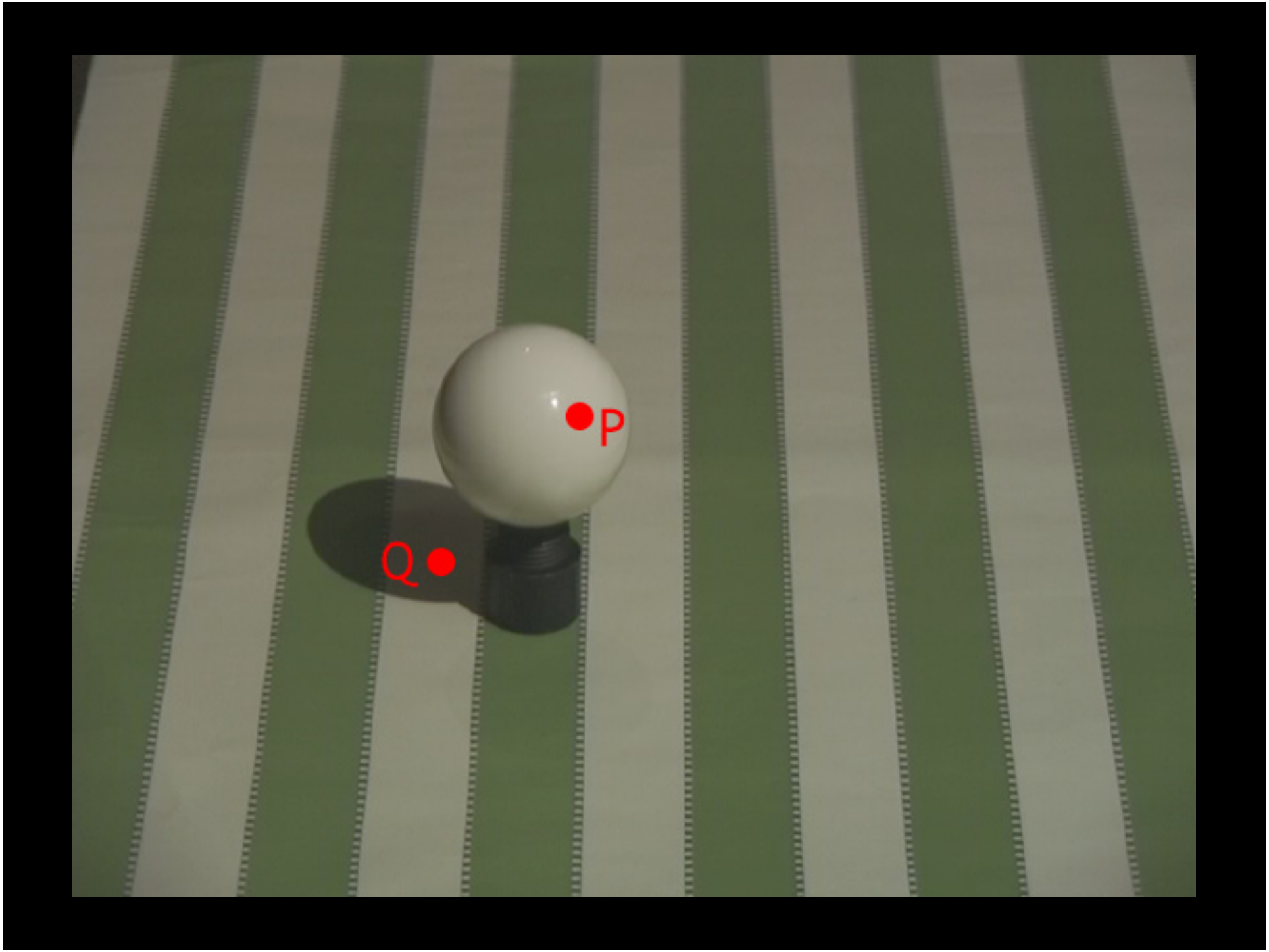

[Bouguet'98]
P
Q

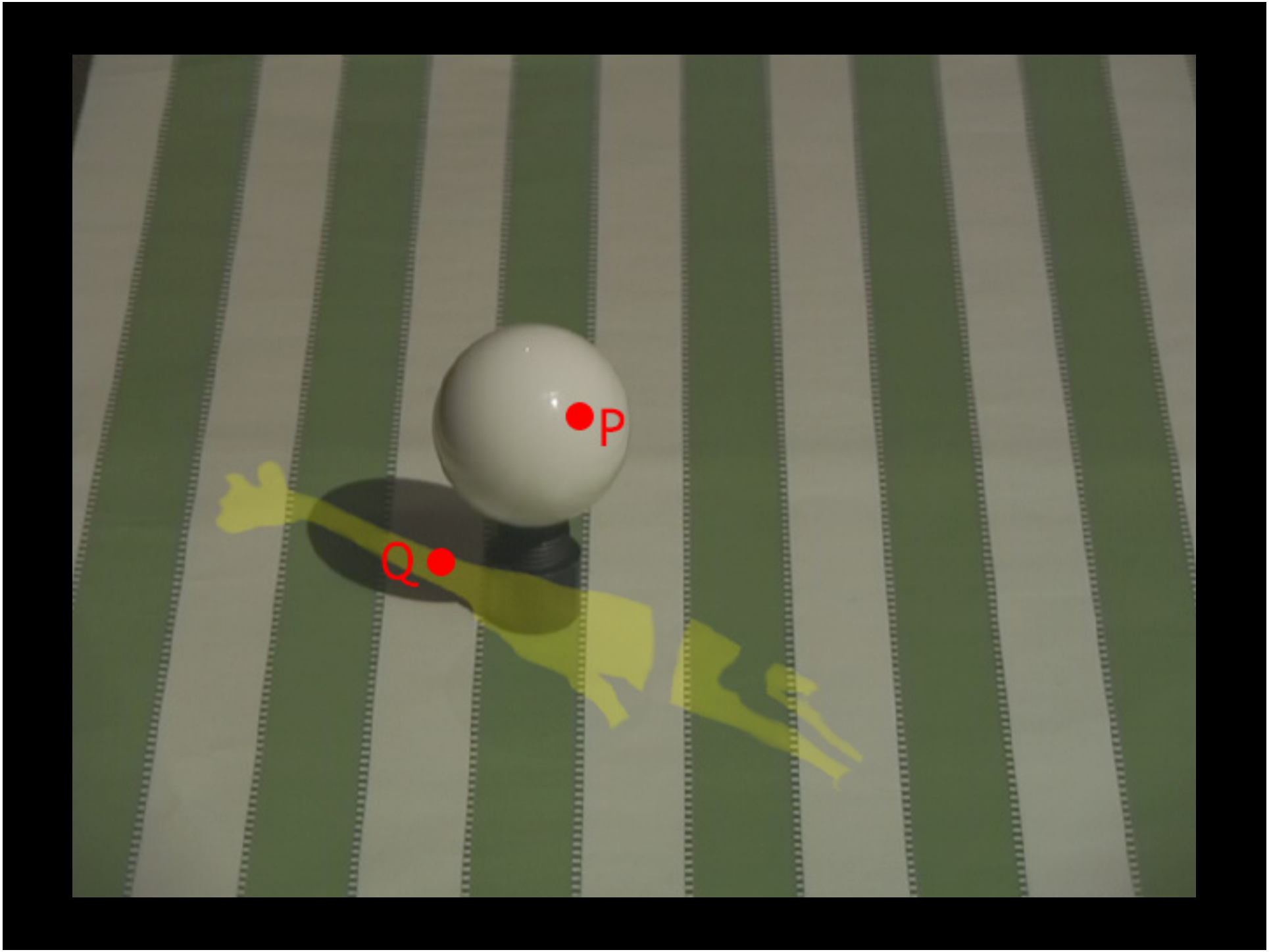

P

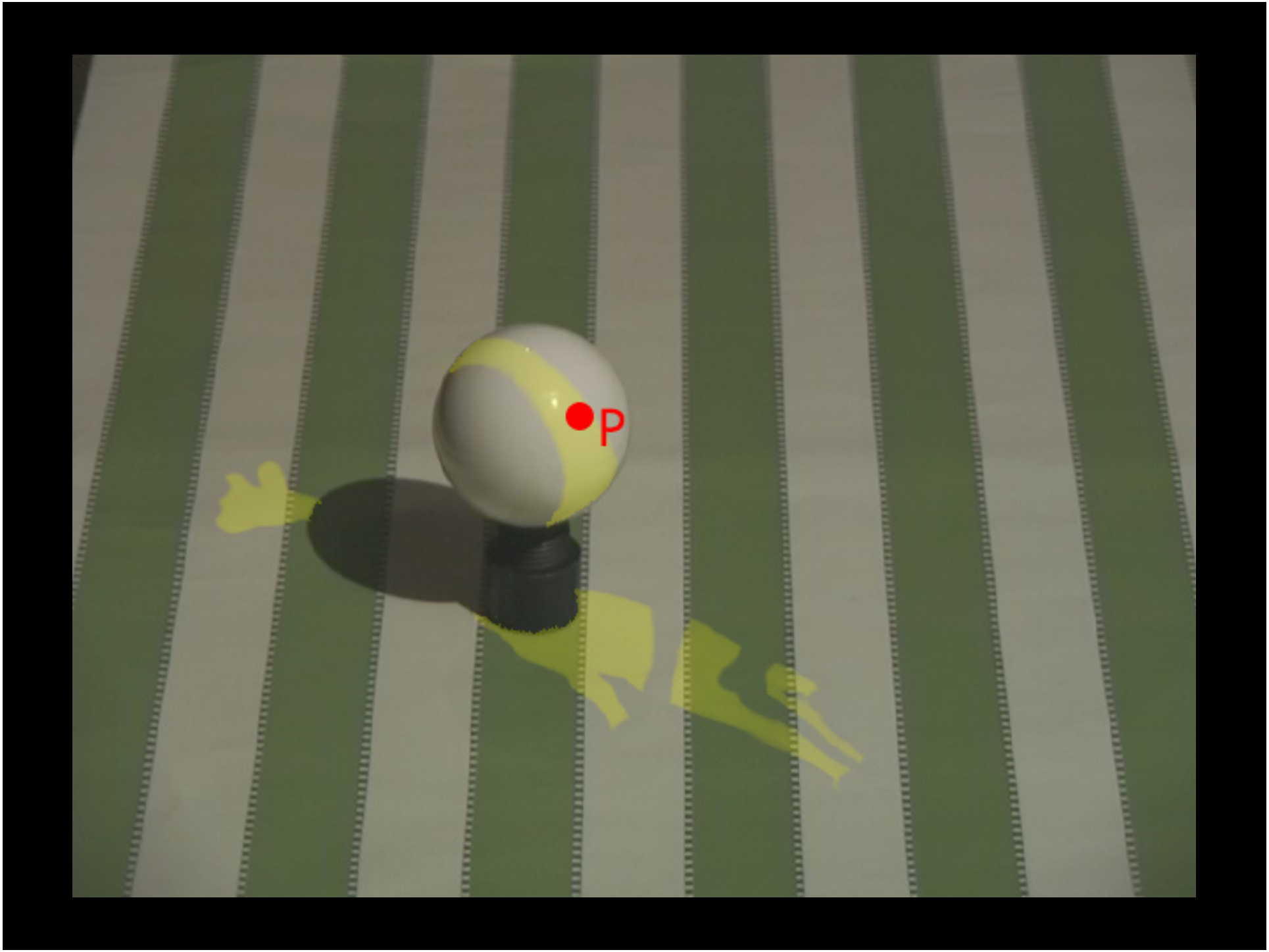

P

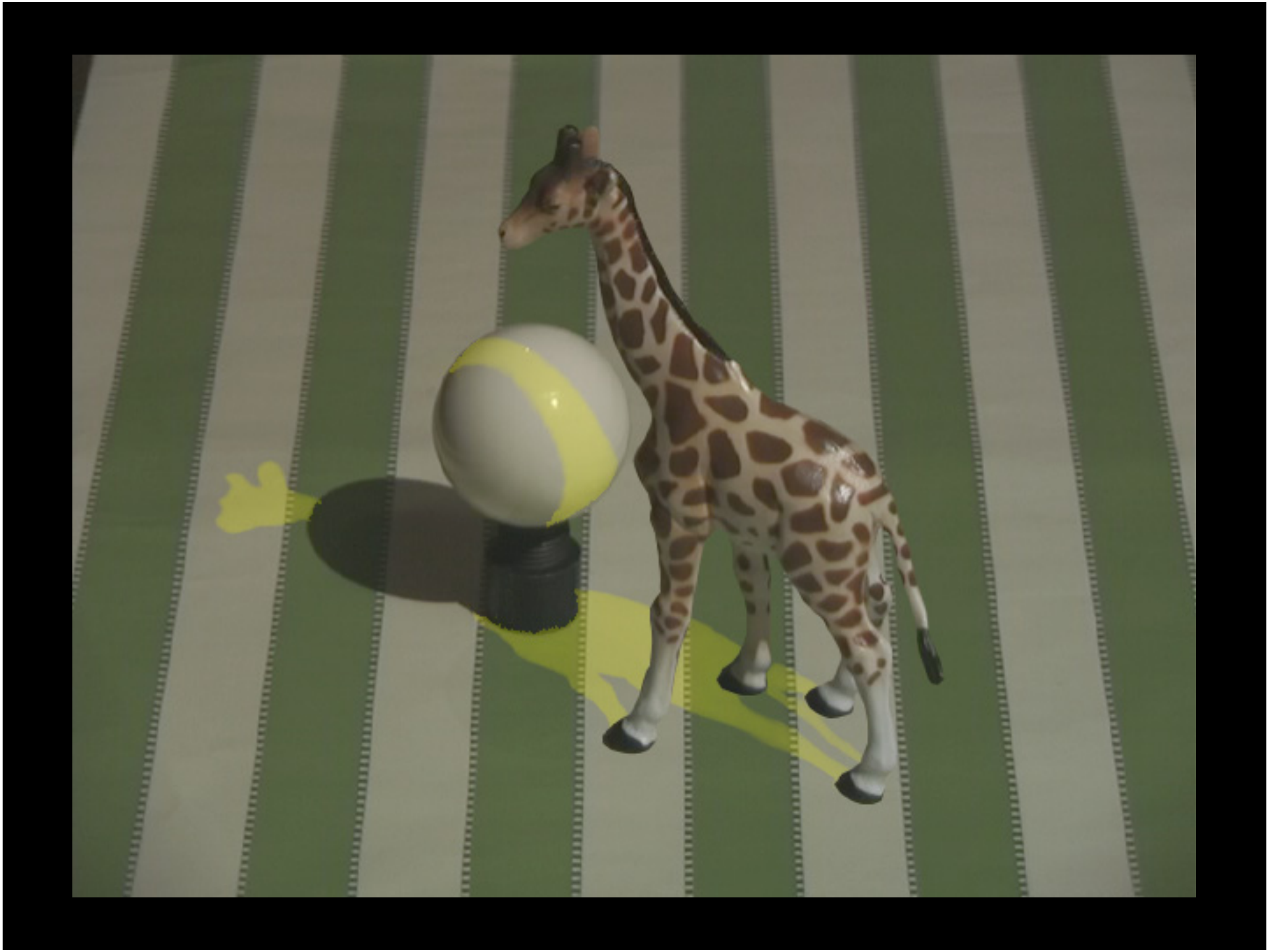

P
Q

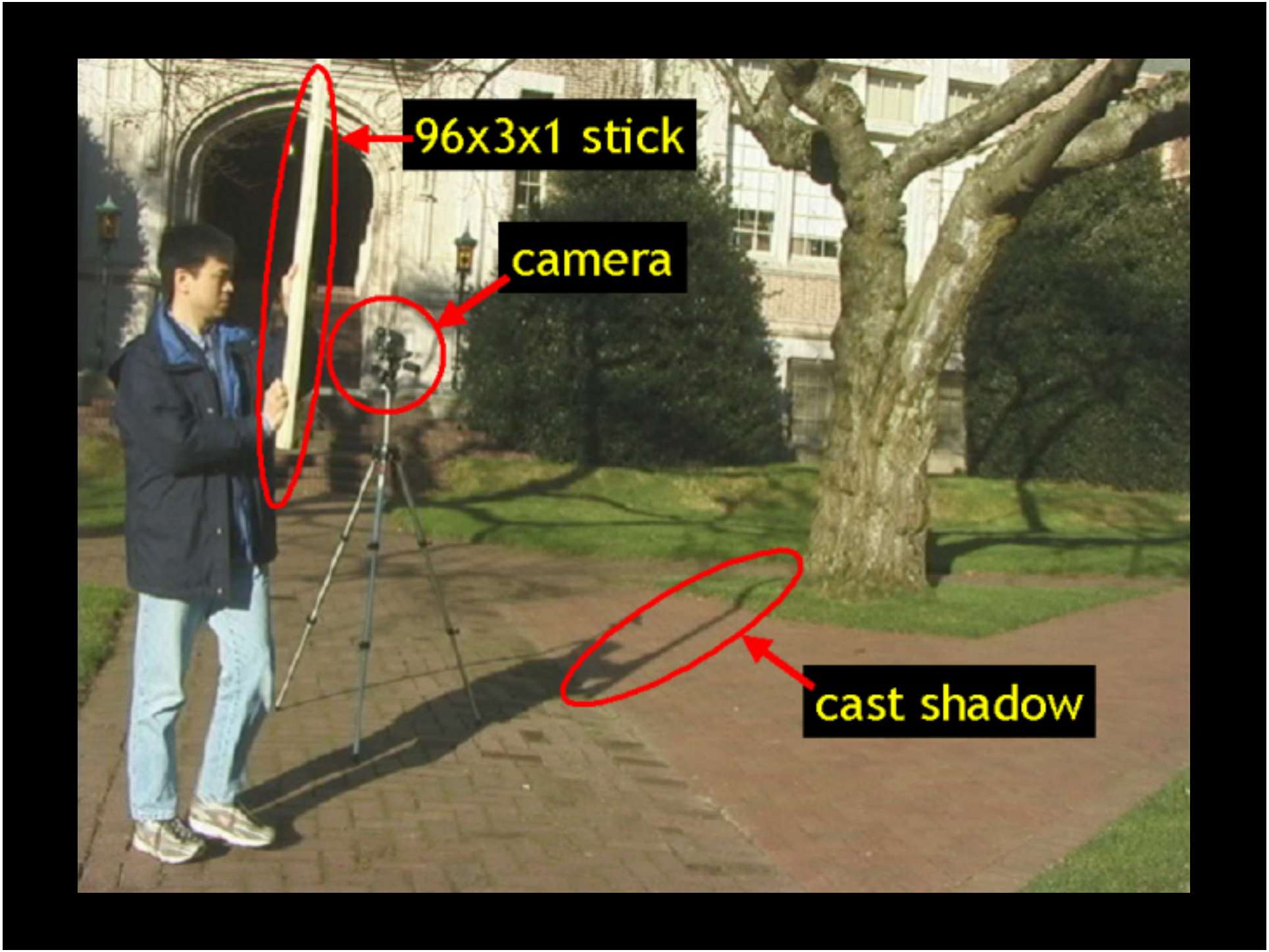

P
Q

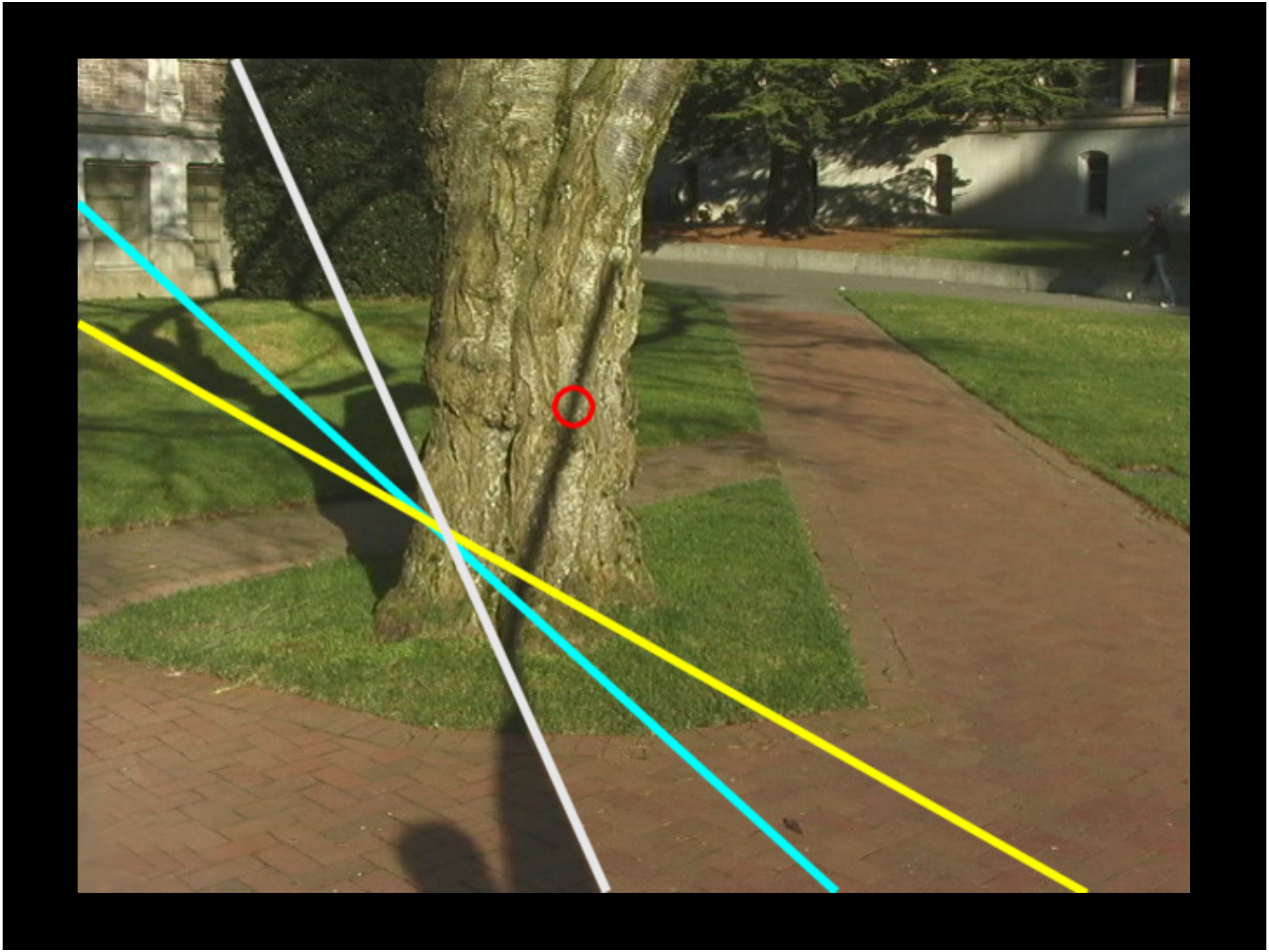

P
Q

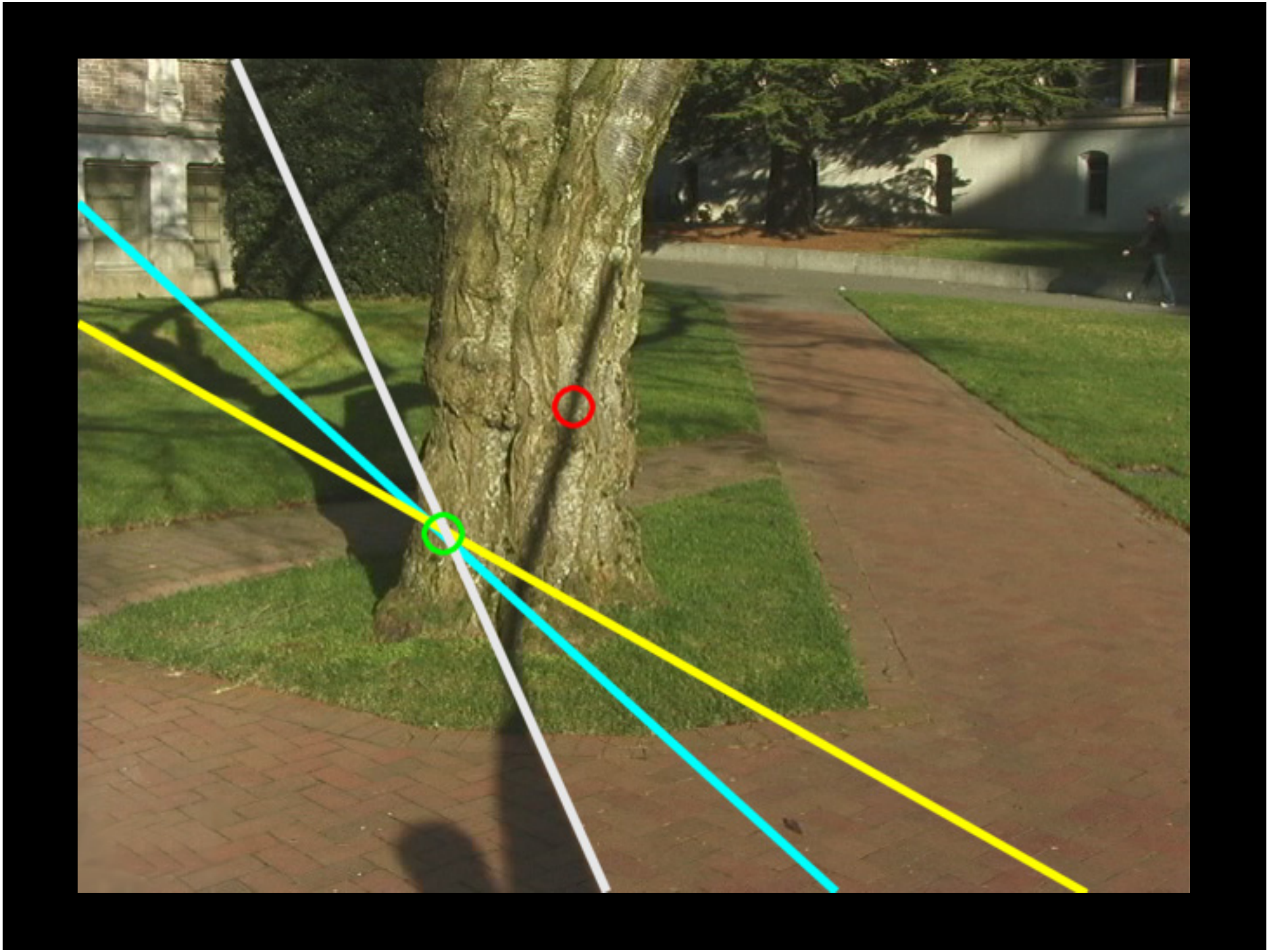

P
Q

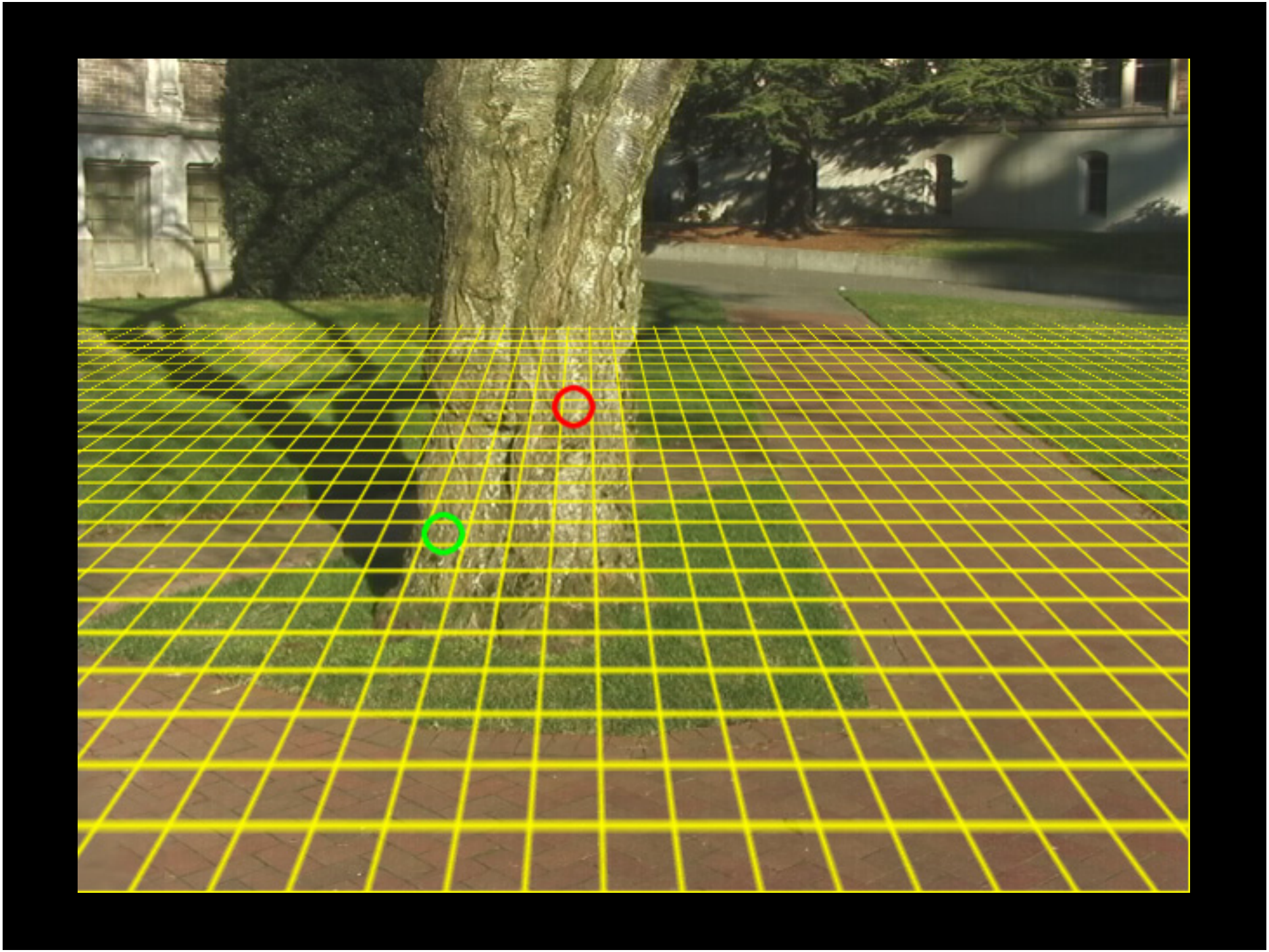

P

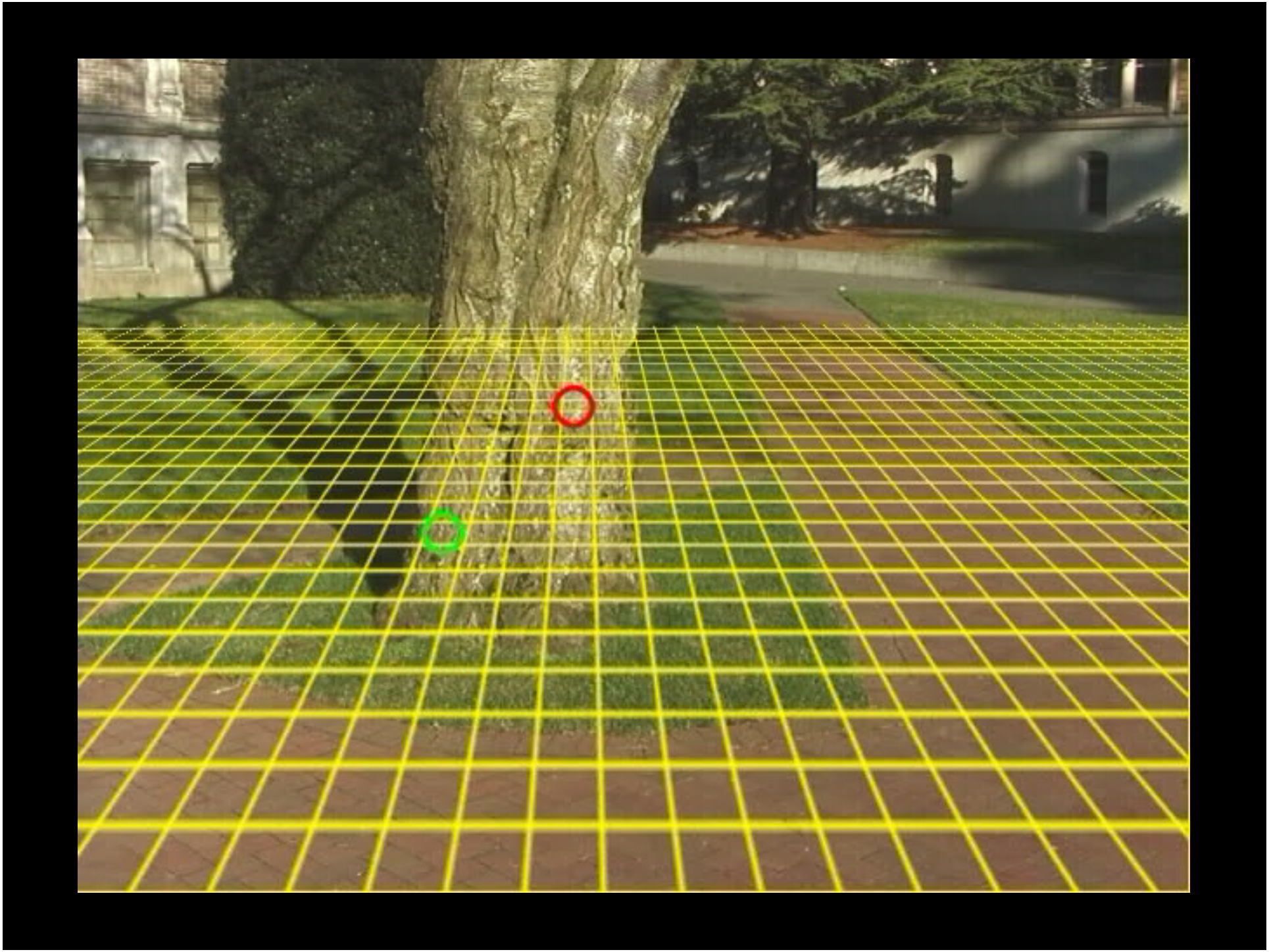


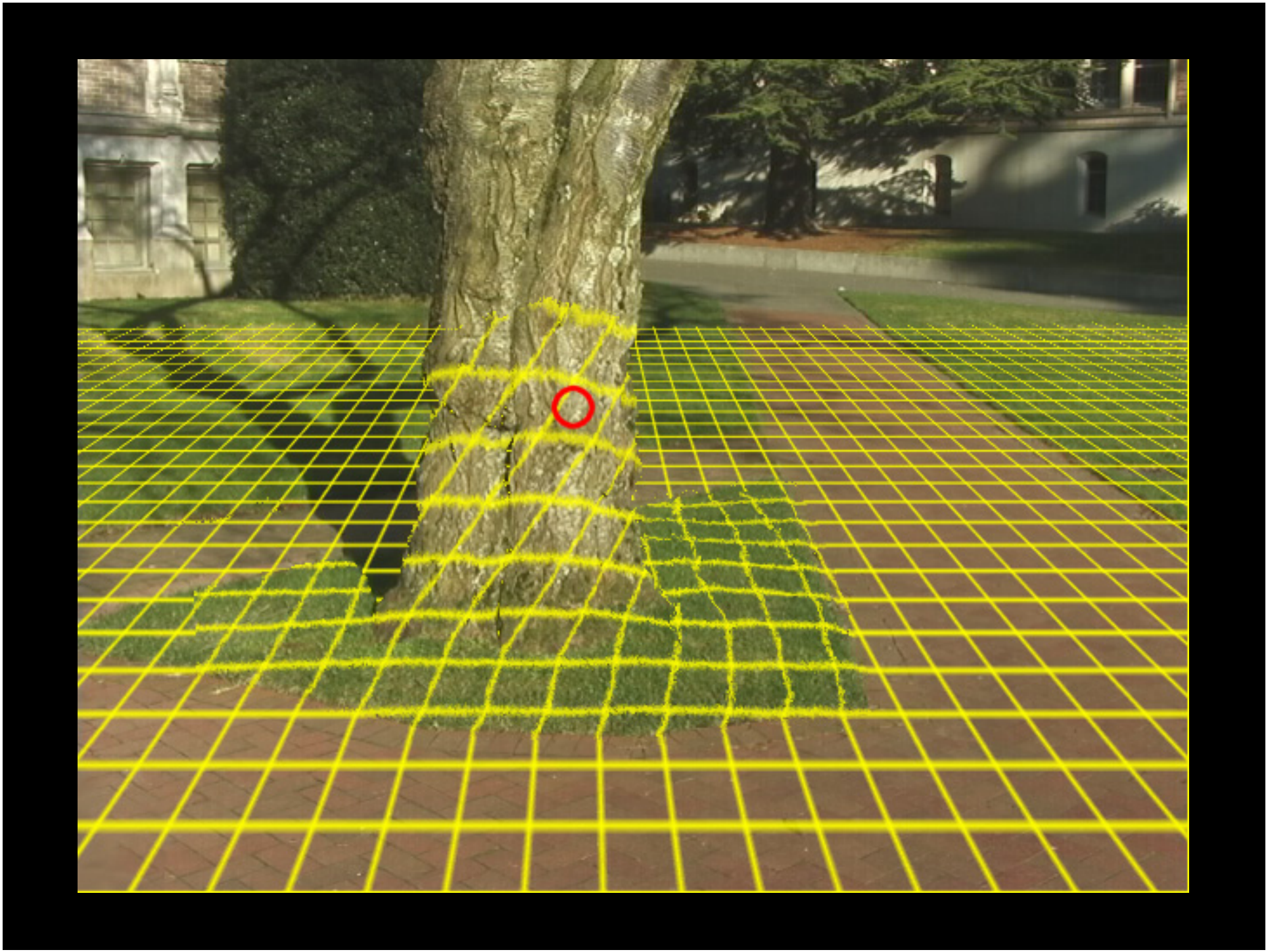

96x3x1 stick
camera
cast shadow

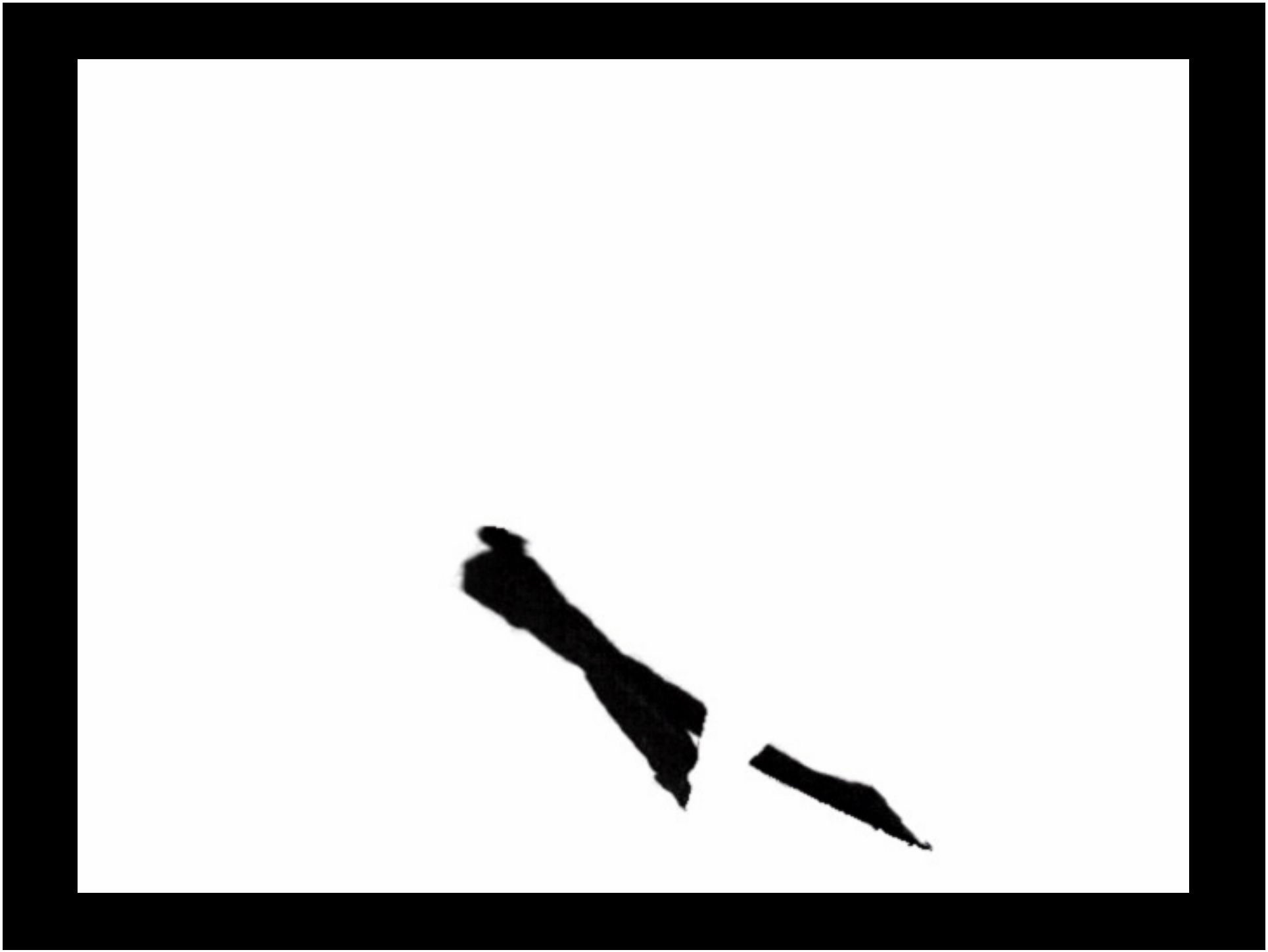




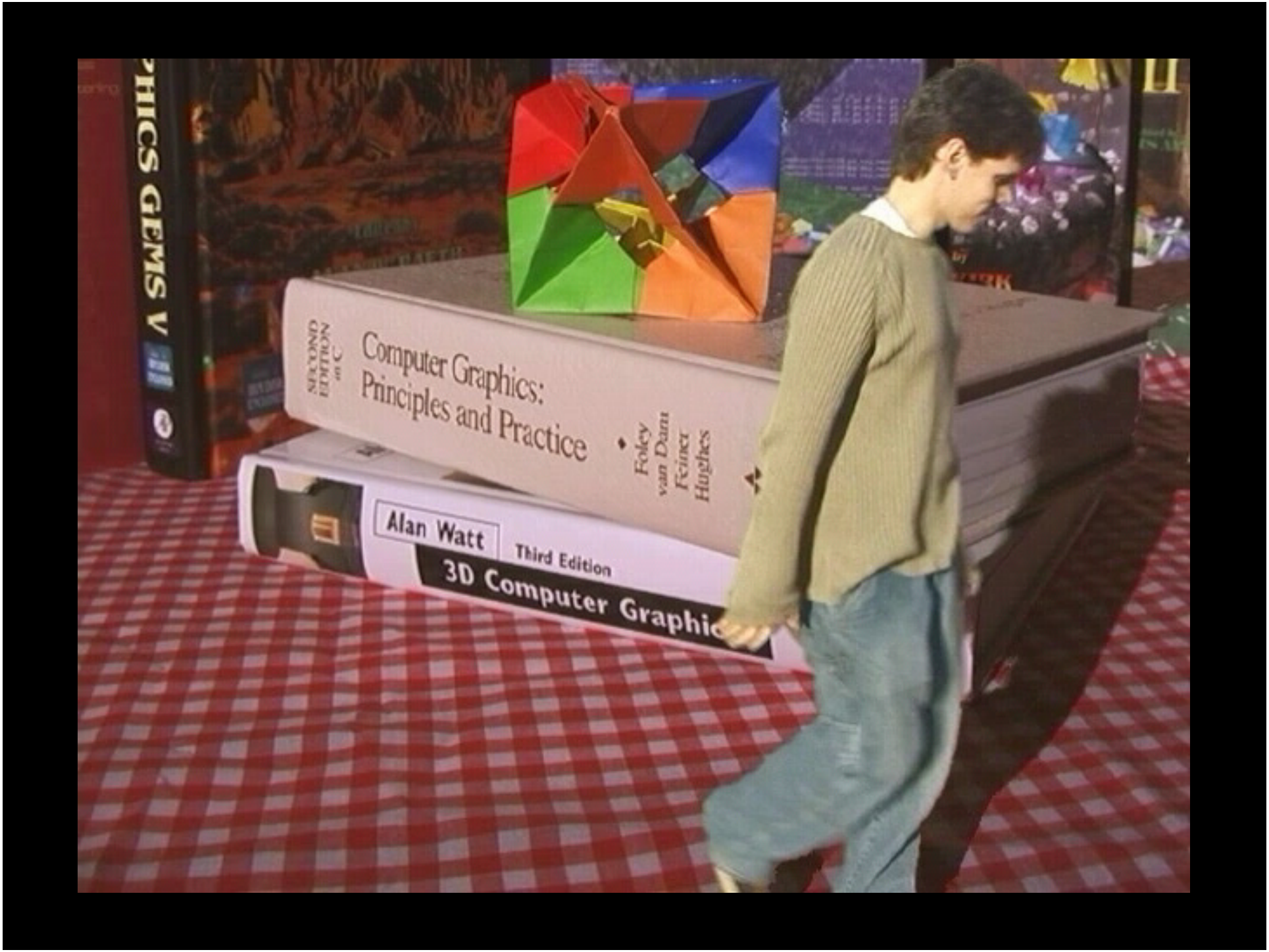









GRAPHICS GEMS V
SECOND EDITION in C
Computer Graphics:
Principles and Practice
Foley
van Dam
Feiner
Hughes
Alan Watt
Third Edition
3D Computer Graphic


GRAPHICS GEMS V
SECOND EDITION in C
Computer Graphics:
Principles and Practice
Foley
van Dam
Feiner
Hughes
Alan Watt
Third Edition
3D Computer Graphic

Reference

- Yung-Yu Chuang, Brian Curless, David Salesin, and Richard Szeliski, A Bayesian Approach to Digital Matting, CVPR 2001, pp264-271.
- Yung-Yu Chuang, Aseem Agarwala, Brian Curless, David H. Salesin, Richard Szeliski, Video Matting of Complex Scenes, SIGGRAPH 2002.
- Yung-Yu Chuang, Dan B. Goldman, Brian Curless, David H. Salesin, Richard Szeliski, Shadow Matting and Compositing, SIGGRAPH 2003.