

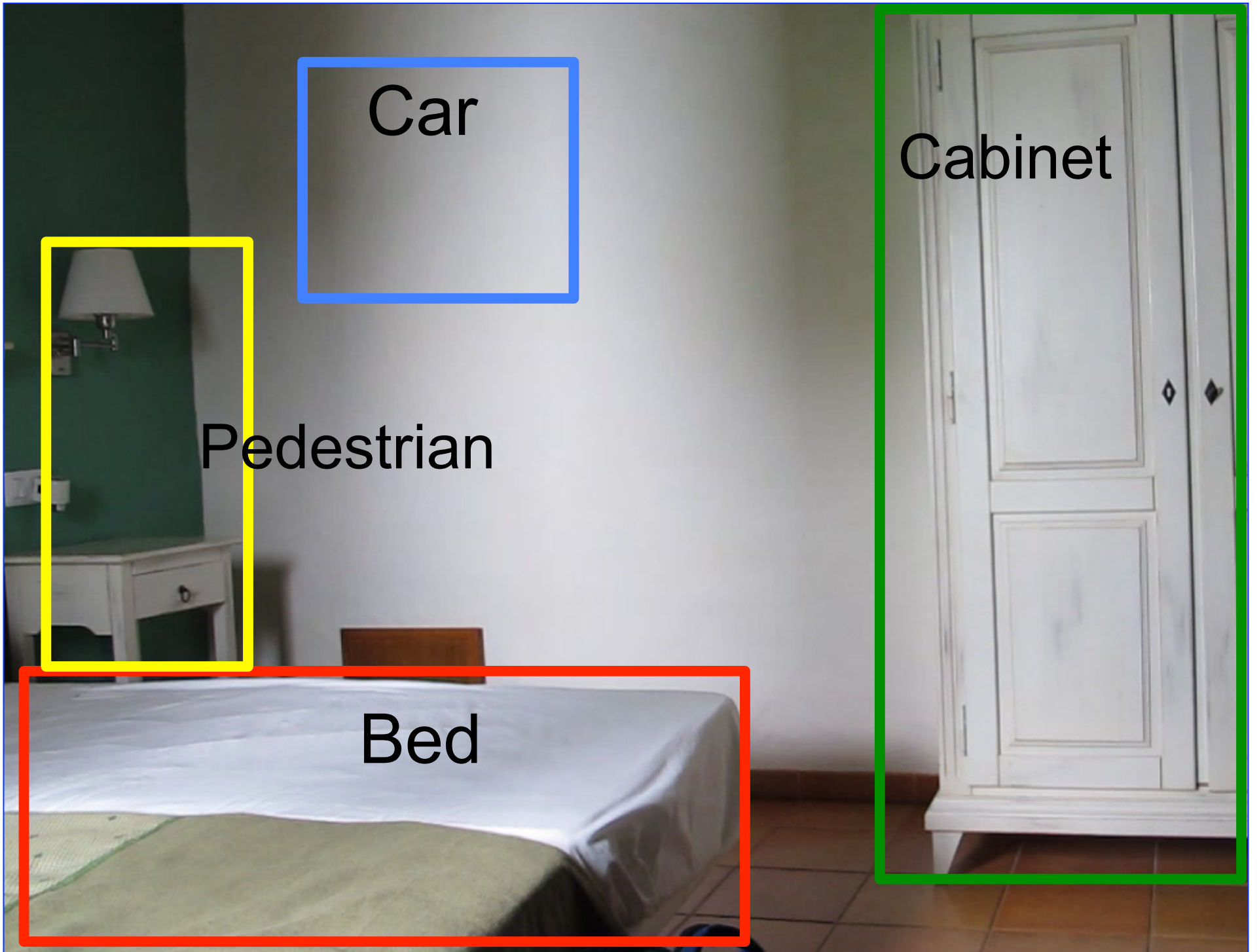
Accidental pinhole and pinspeck cameras: Revealing the scene outside the picture

Antonio Torralba
William T. Freeman



CVPR 2012



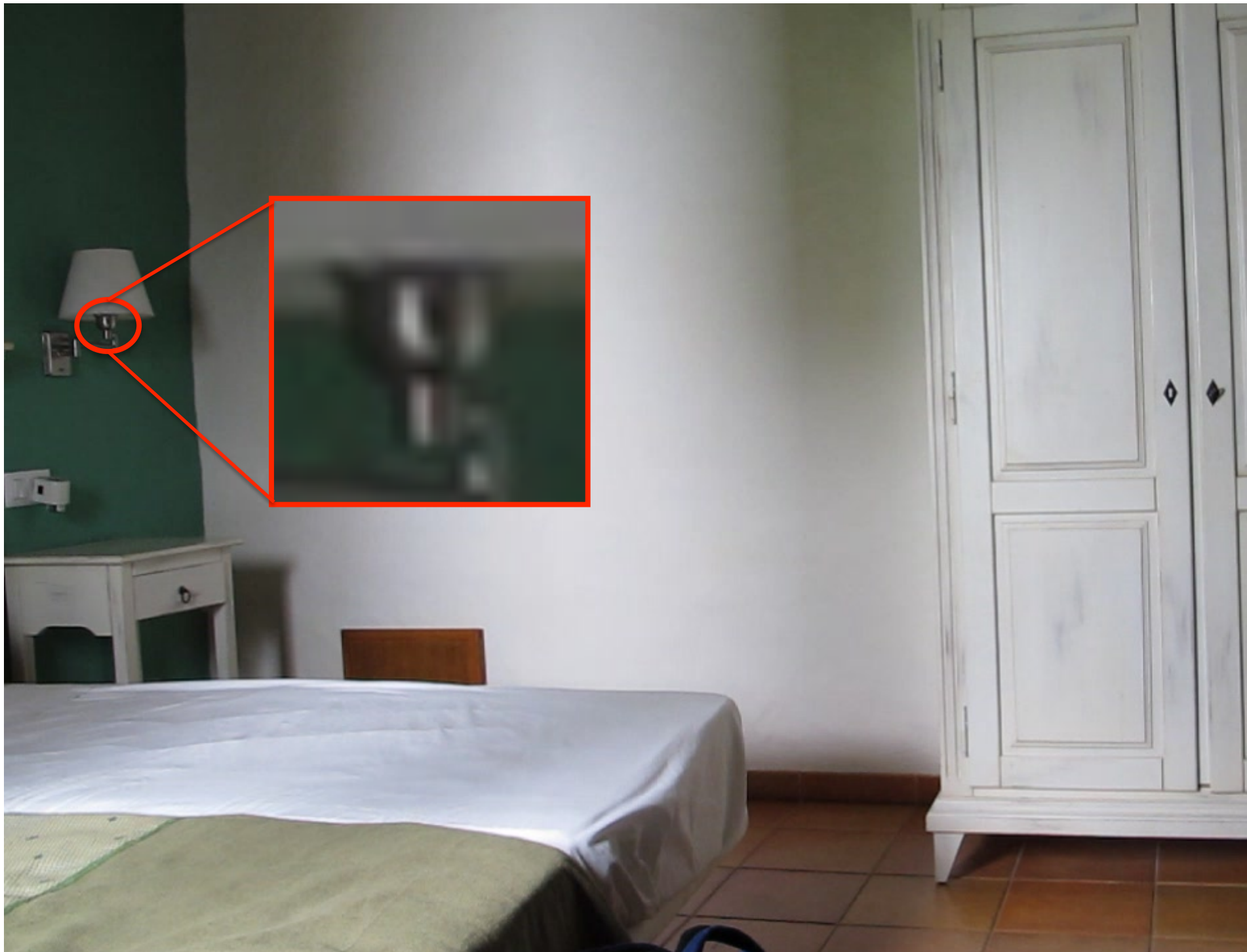


Car

Pedestrian

Bed

Cabinet





Shadows?

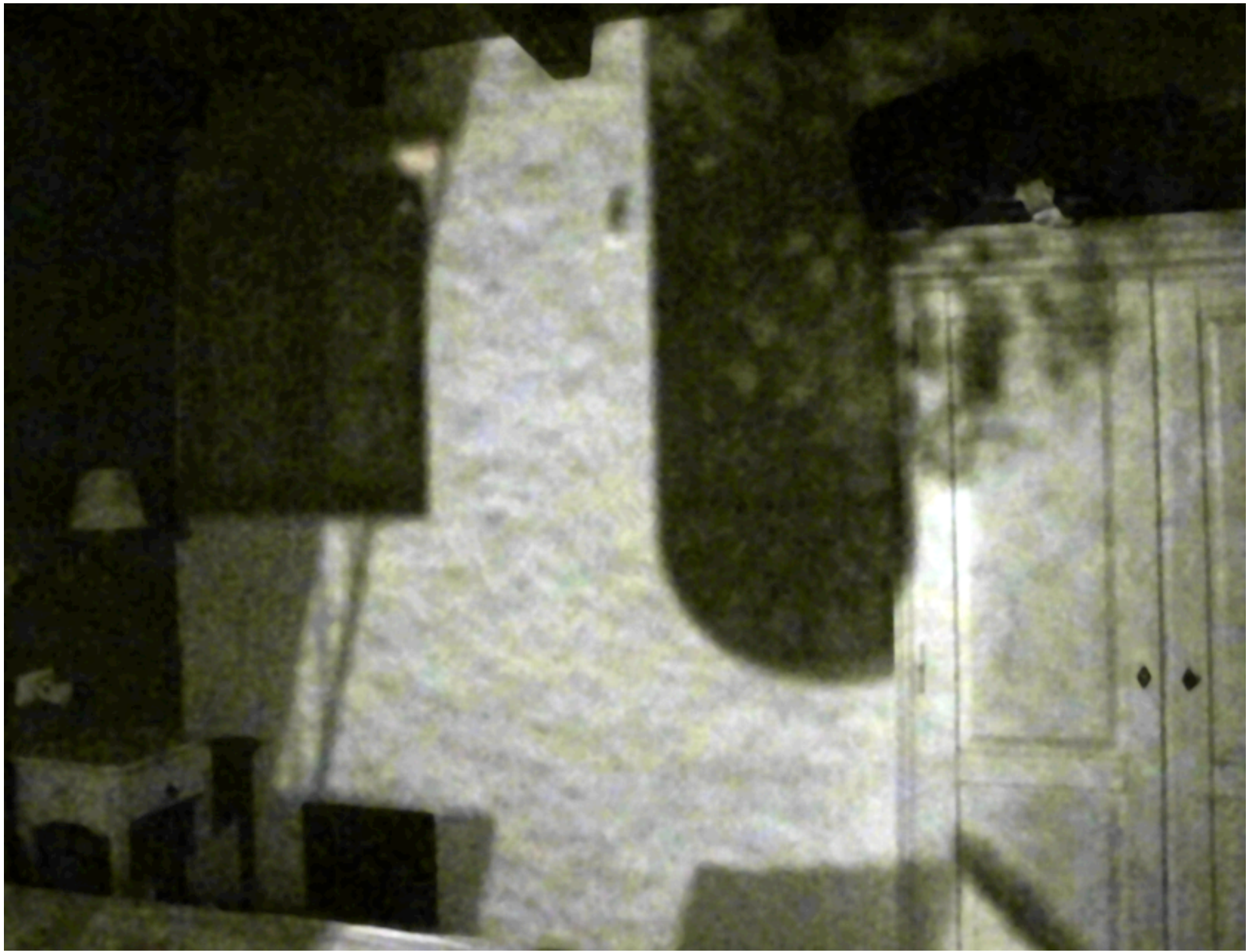




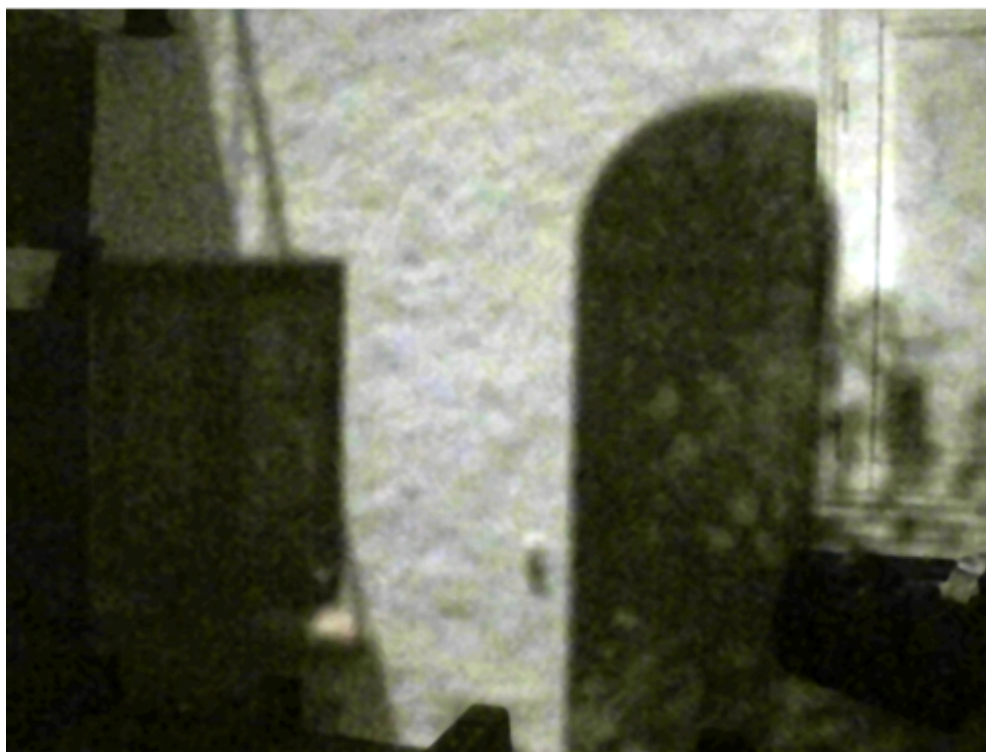
Accidental pinhole camera







Window turned into a pinhole



View outside

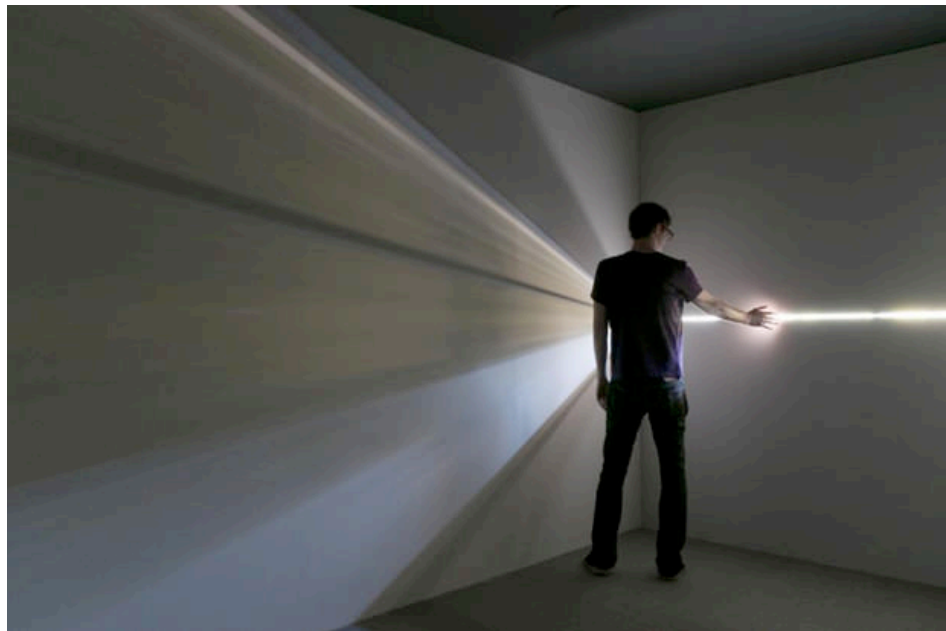




Source: wikipedia



"a camera obscura has been used ... to bring images from the outside into a darkened room"



Chris Fraser

Aberlado Morell





Window open



Window turned into a pinhole



My hotel room,
contrast enhanced.



The view from my window



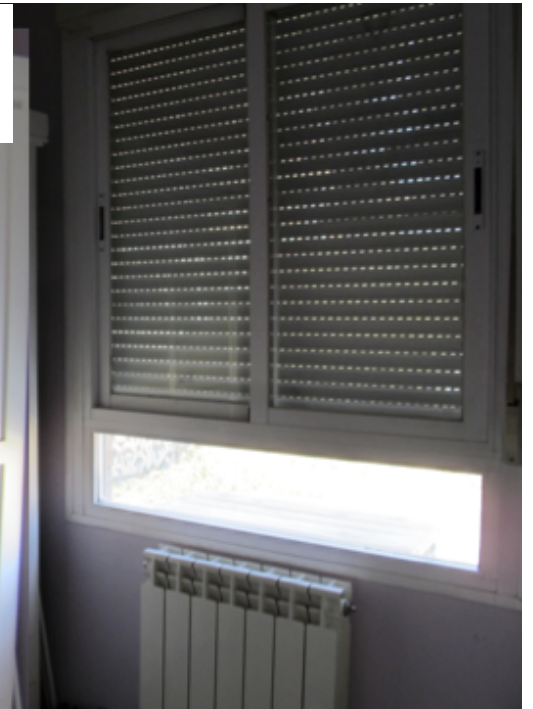
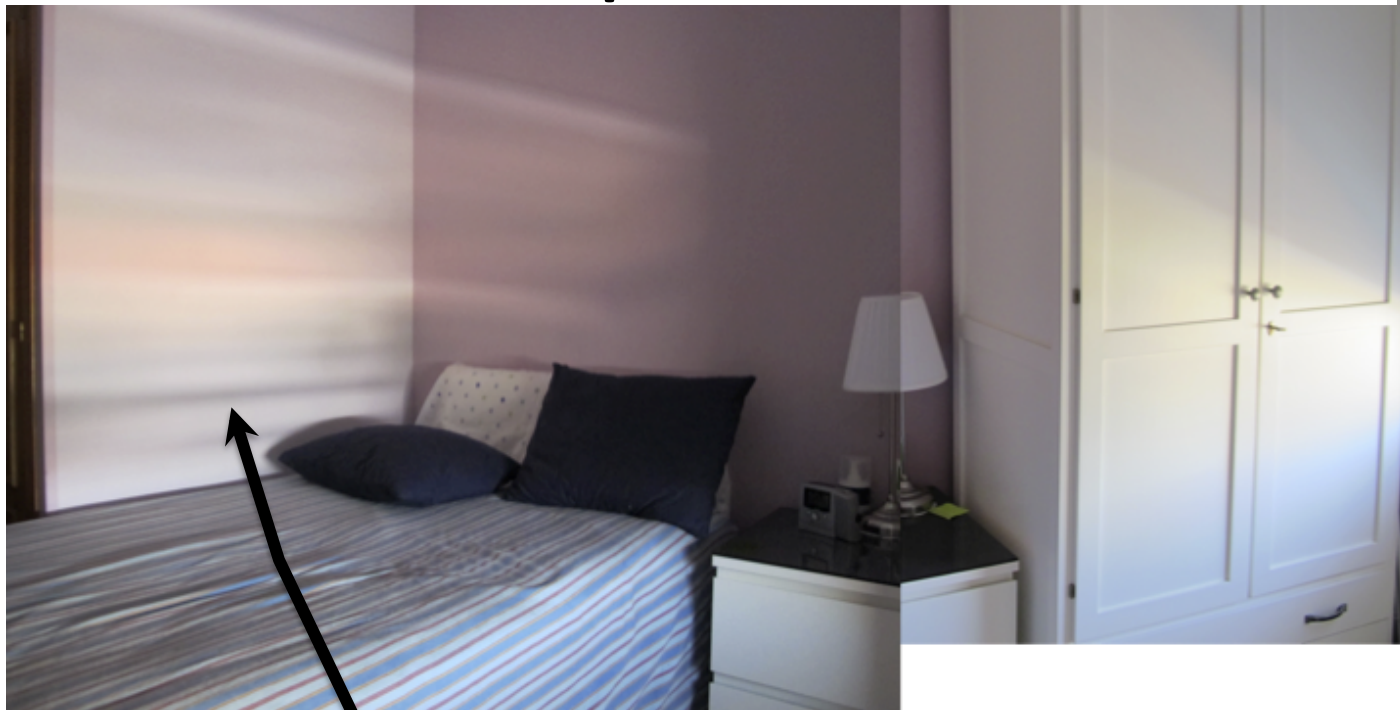
Accidental pinholes produce images that are
unnoticed or misinterpreted as shadows

Accidental pinhole

If the window is big then the images recovered are too blurry



Accidental pinhole camera



Outside scene

*



Aperture

See Zomet, A.; Nayar, S.K. CVPR 2006 for a detailed analysis.

Anti-pinhole or Pinspeck cameras

Adam L. Cohen, 1982

OPTICA ACTA, 1982, VOL. 29, NO. 1, 63-67

Anti-pinhole imaging

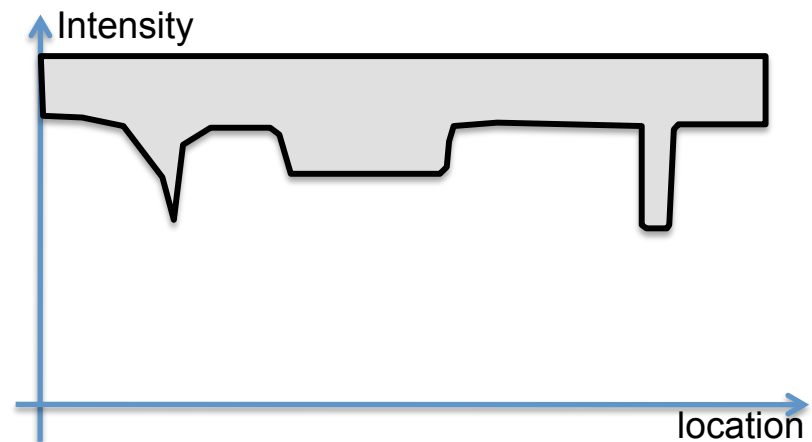
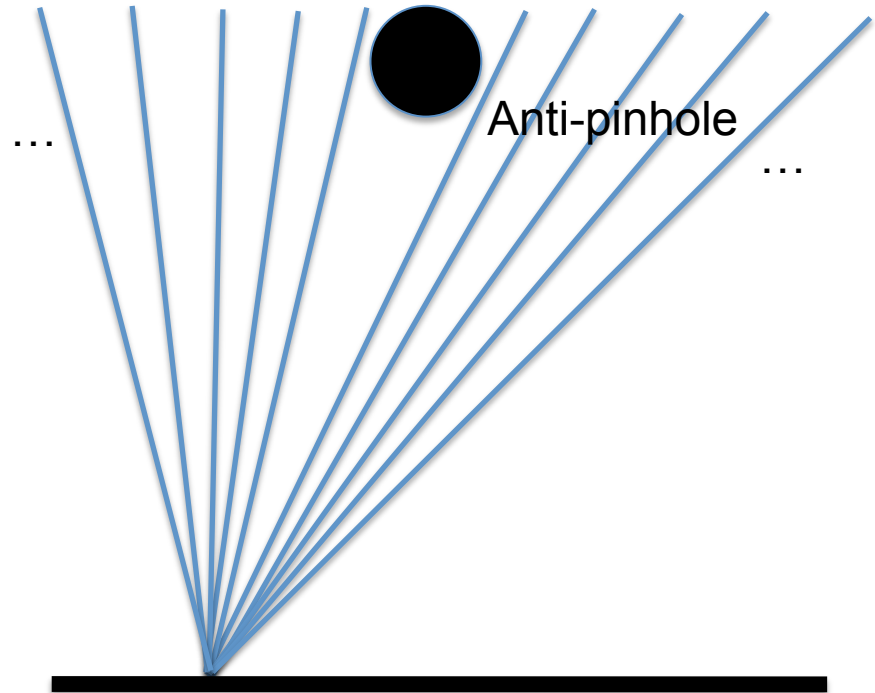
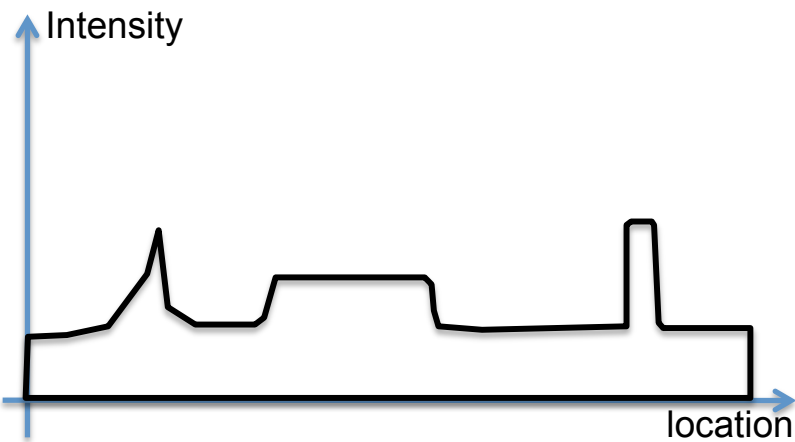
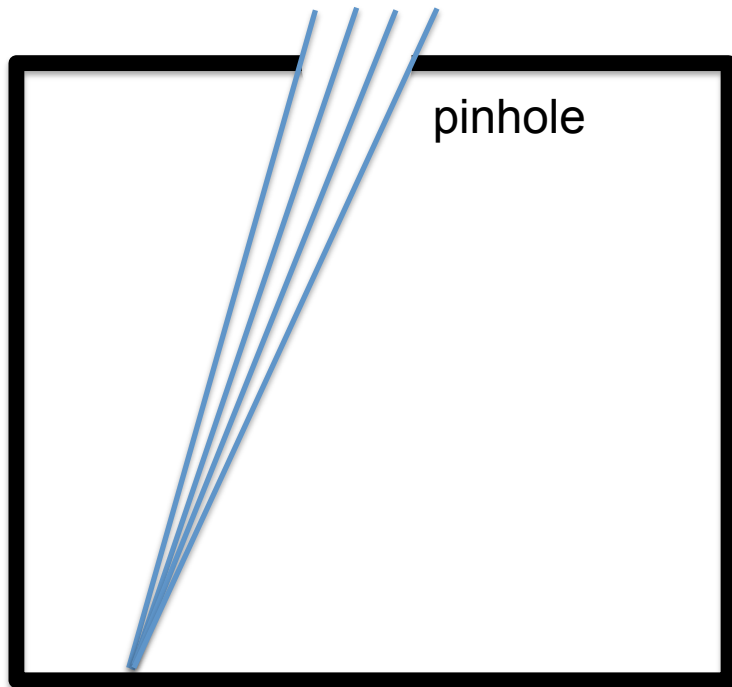
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Chicago, Illinois 60626, U.S.A.

(Received 16 April 1981; revision received 8 July 1981)

Abstract. By complementing a pinhole to produce an isolated opaque spot, the light ordinarily blocked from the pinhole image is transmitted, and the light ordinarily transmitted is blocked. A negative geometrical image is formed, distinct from the familiar 'bright-spot' diffraction image. Anti-pinhole, or 'pinspeck' images are visible during a solar eclipse, when the shadows of objects appear crescent-shaped. Pinspecks demonstrate unlimited depth of field, freedom from distortion and large angular field. Images of different magnification may be formed simultaneously. Contrast is poor, but is improvable by averaging to remove noise and subtraction of a d.c. bias. Pinspecks may have application in X-ray space optics, and might be employed in the eyes of simple organisms.

Pinhole and Anti-pinhole cameras



Natural eyes

Lenses



Pinholes

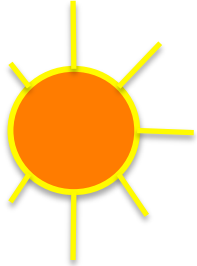


Anti-pinholes



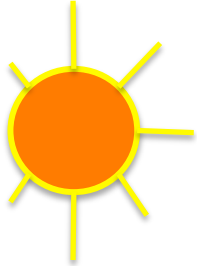
Shadows

Accidental anti-pinhole cameras



Shadows

Accidental anti-pinhole cameras



Background image



Input video



-

= Negative
of the
shadow

Background image



Input video



-

= Negative
of the
shadow

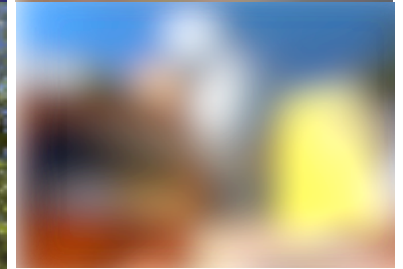
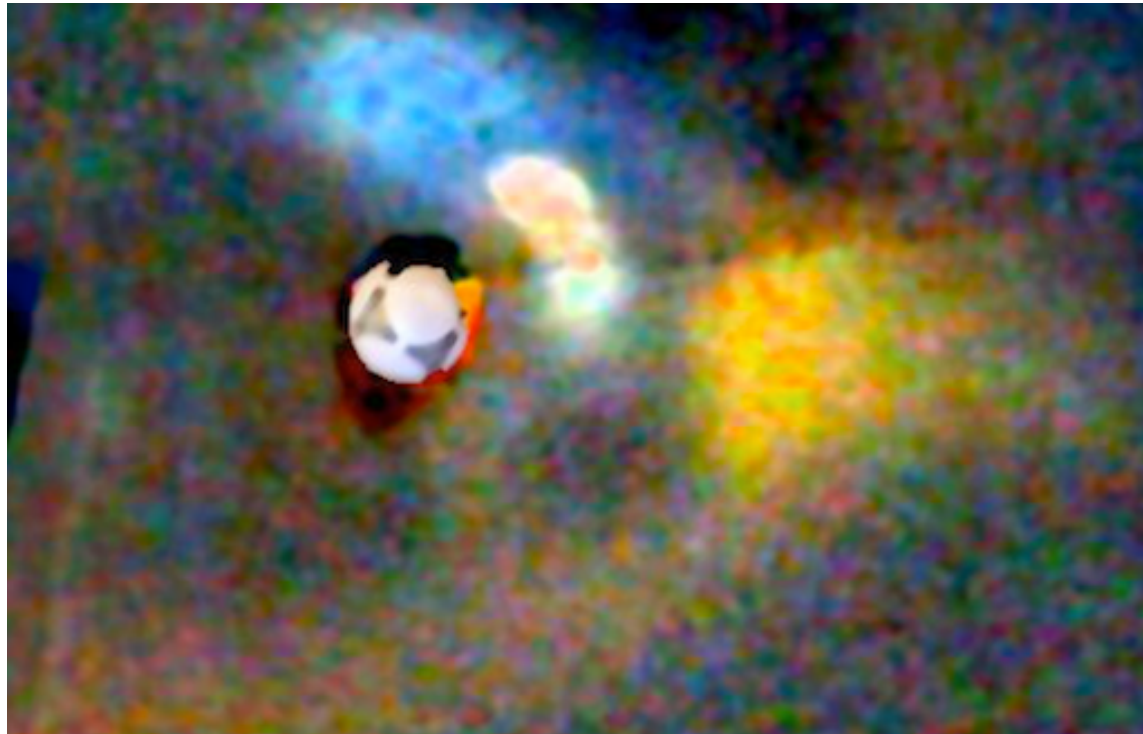




Input
video



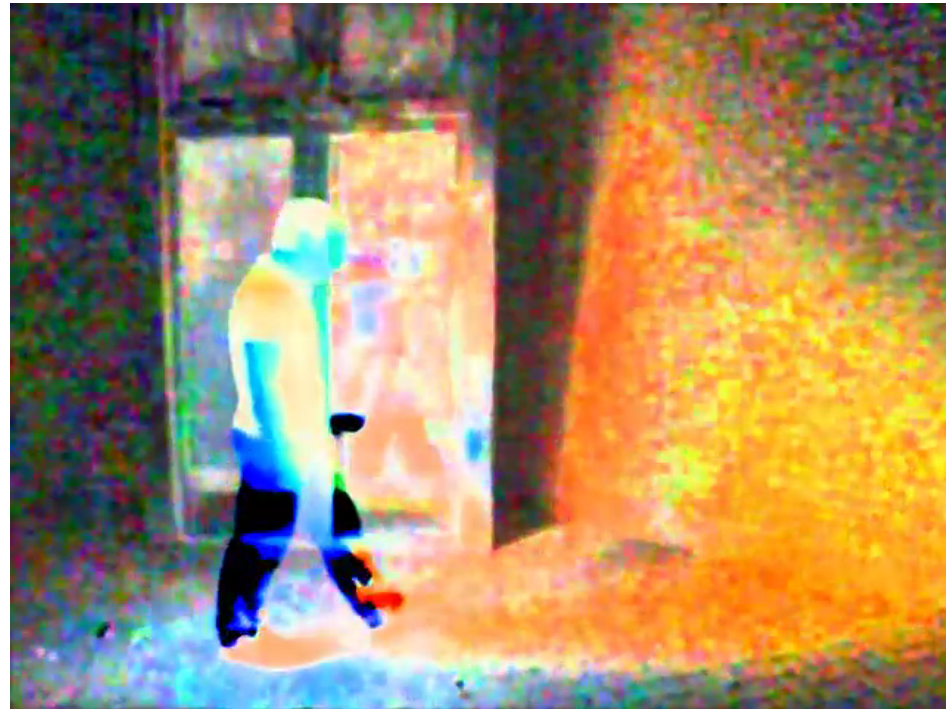
Negative
of the
shadow



The importance
of the size of
the occluder



Input
video

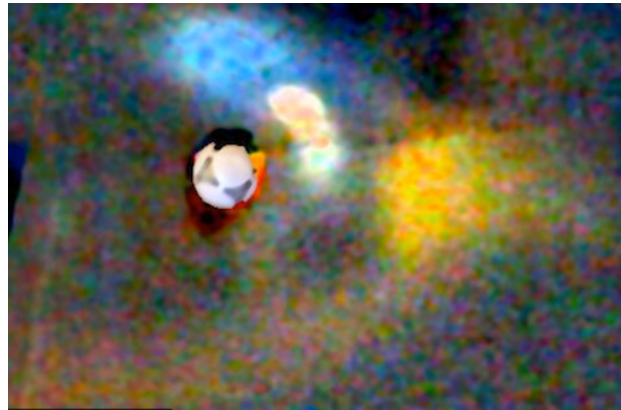
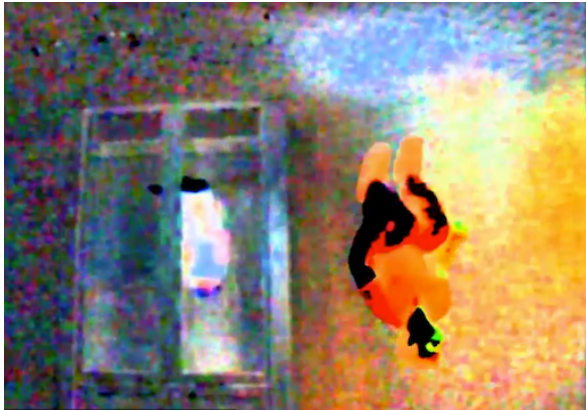


Negative
of the
shadow

Size of the occluder

Me

Ball



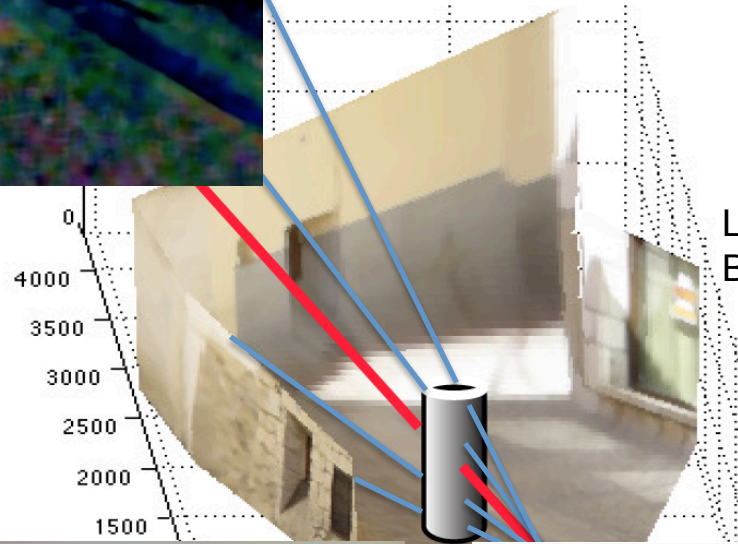
Input video



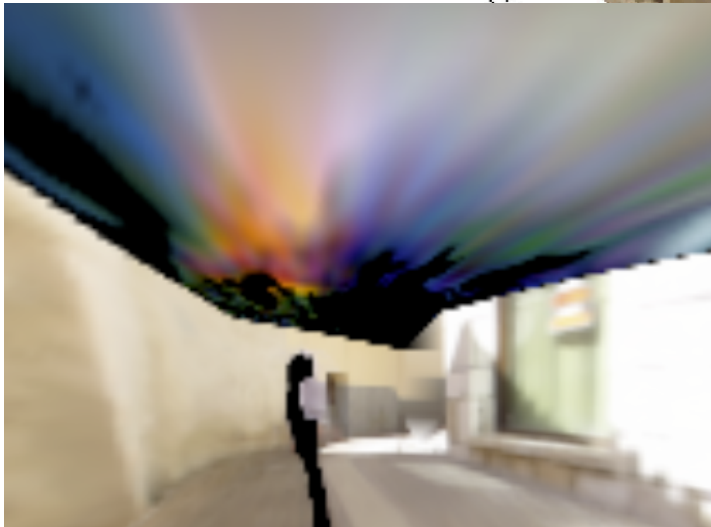
Negative of the shadow



Using some single view metrology. A. Criminisi, I. Reid, and A. Zisserman 1999



Labelme 3D toolbox.
B. Russell, A. Torralba. CVPR 2009



Mixed accidental pinhole and anti-pinhole cameras

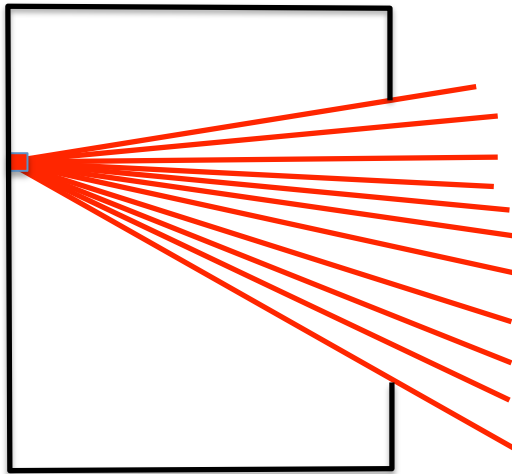


Mixed accidental pinhole and anti-pinhole cameras

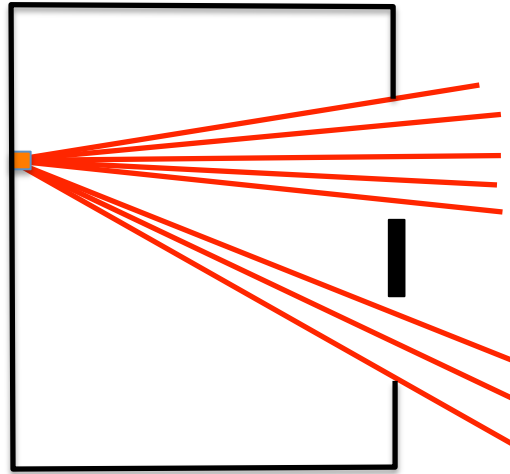


Mixed accidental pinhole and anti-pinhole cameras

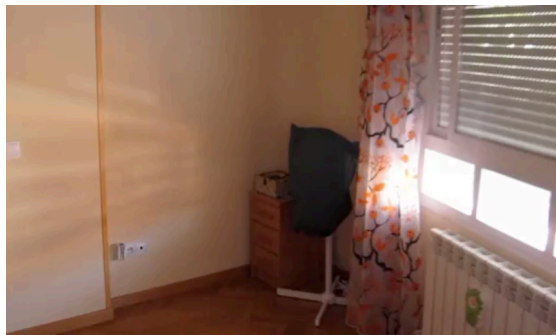
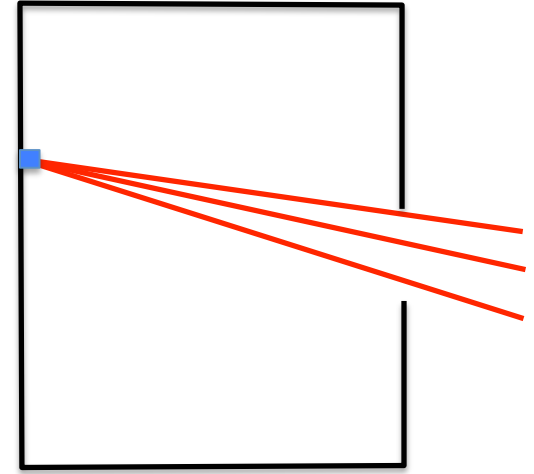
Room with a window



Person in front of the window

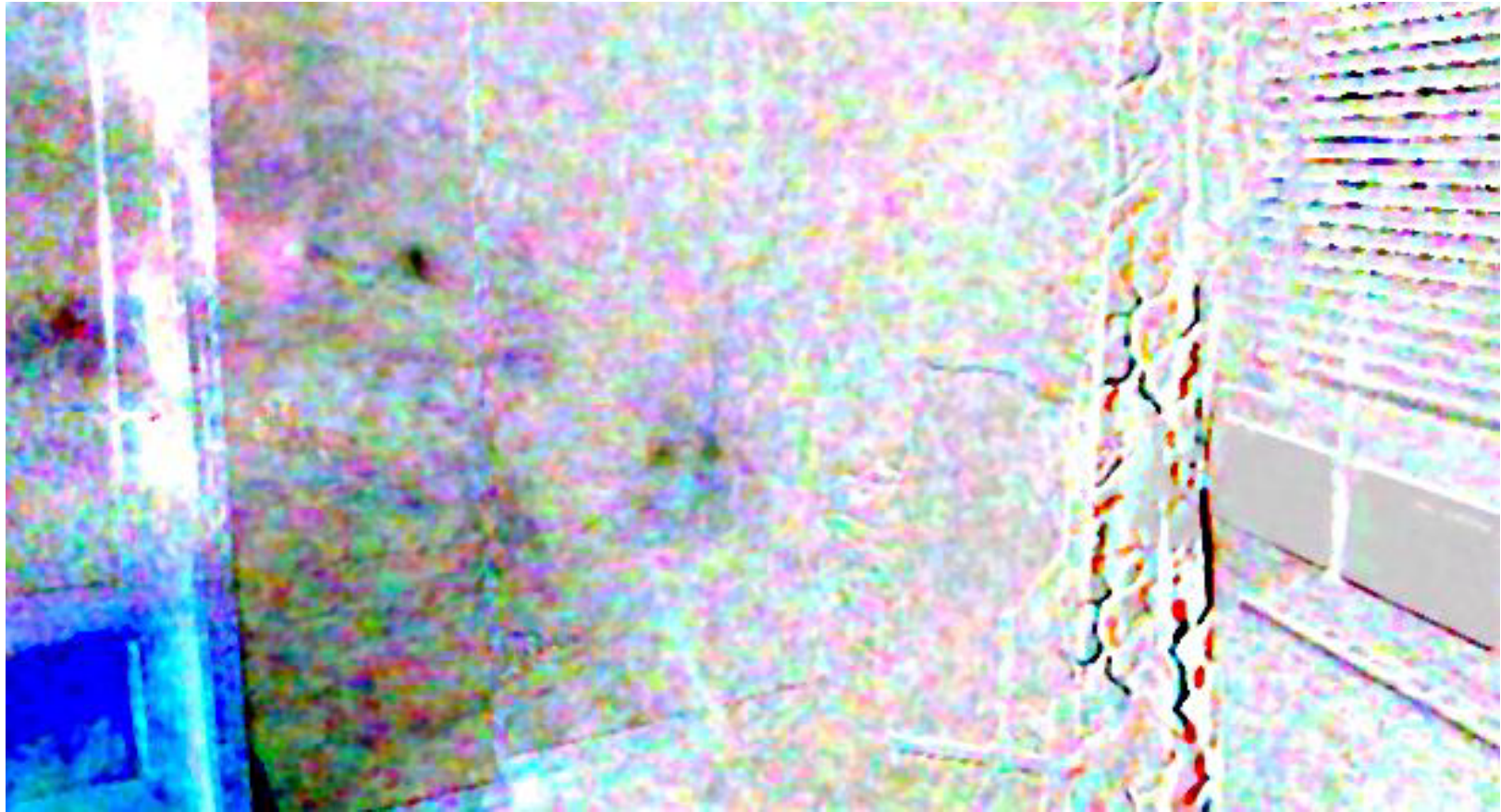


Difference image



= ?

Mixed accidental pinhole and anti-pinhole cameras



Mixed accidental pinhole and anti-pinhole cameras

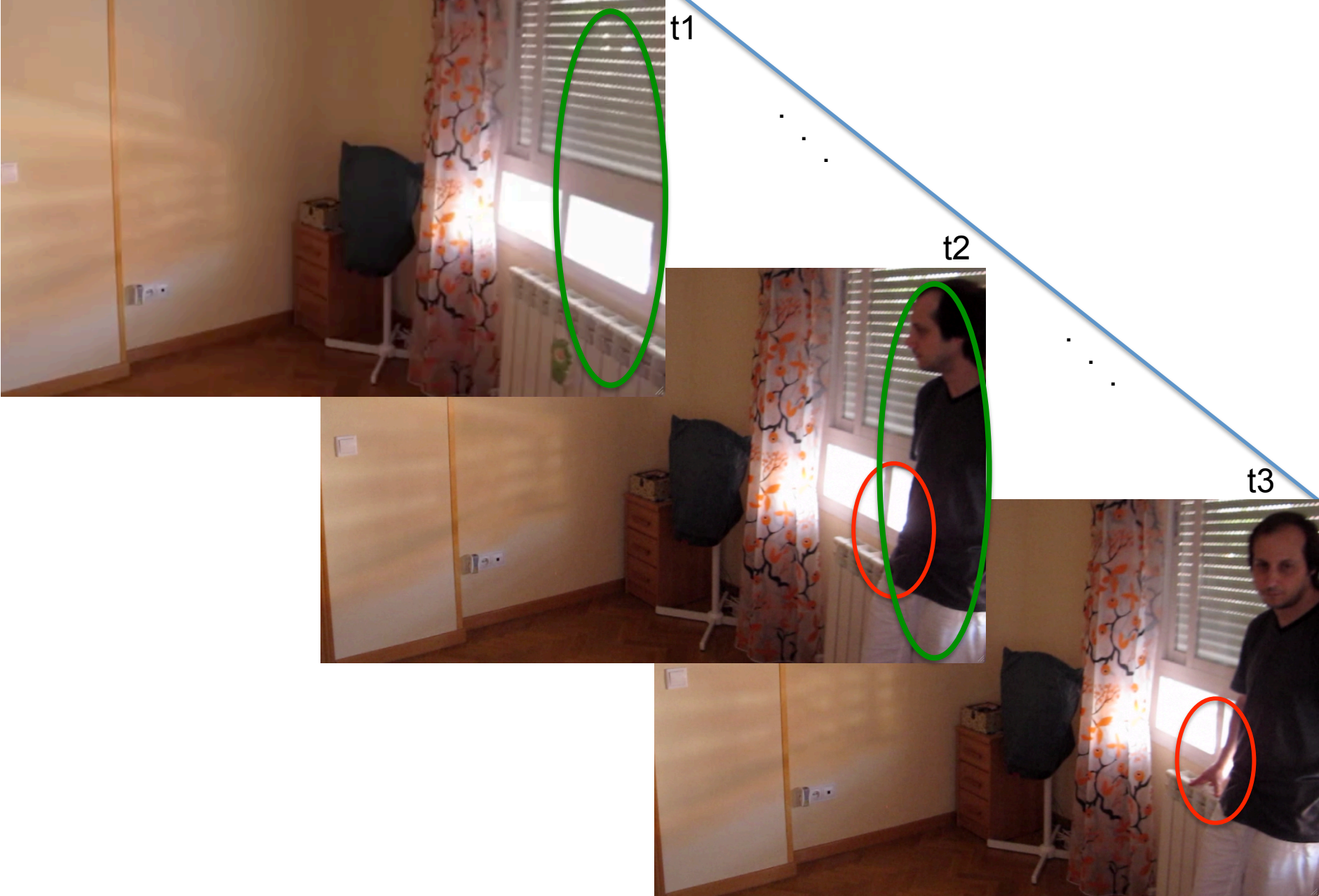
Body as the occluder



View outside the window



Looking for a small accidental occluder



Reference



Video



-

=



Looking for a small accidental occluder

Body as the occluder



Hand as the occluder



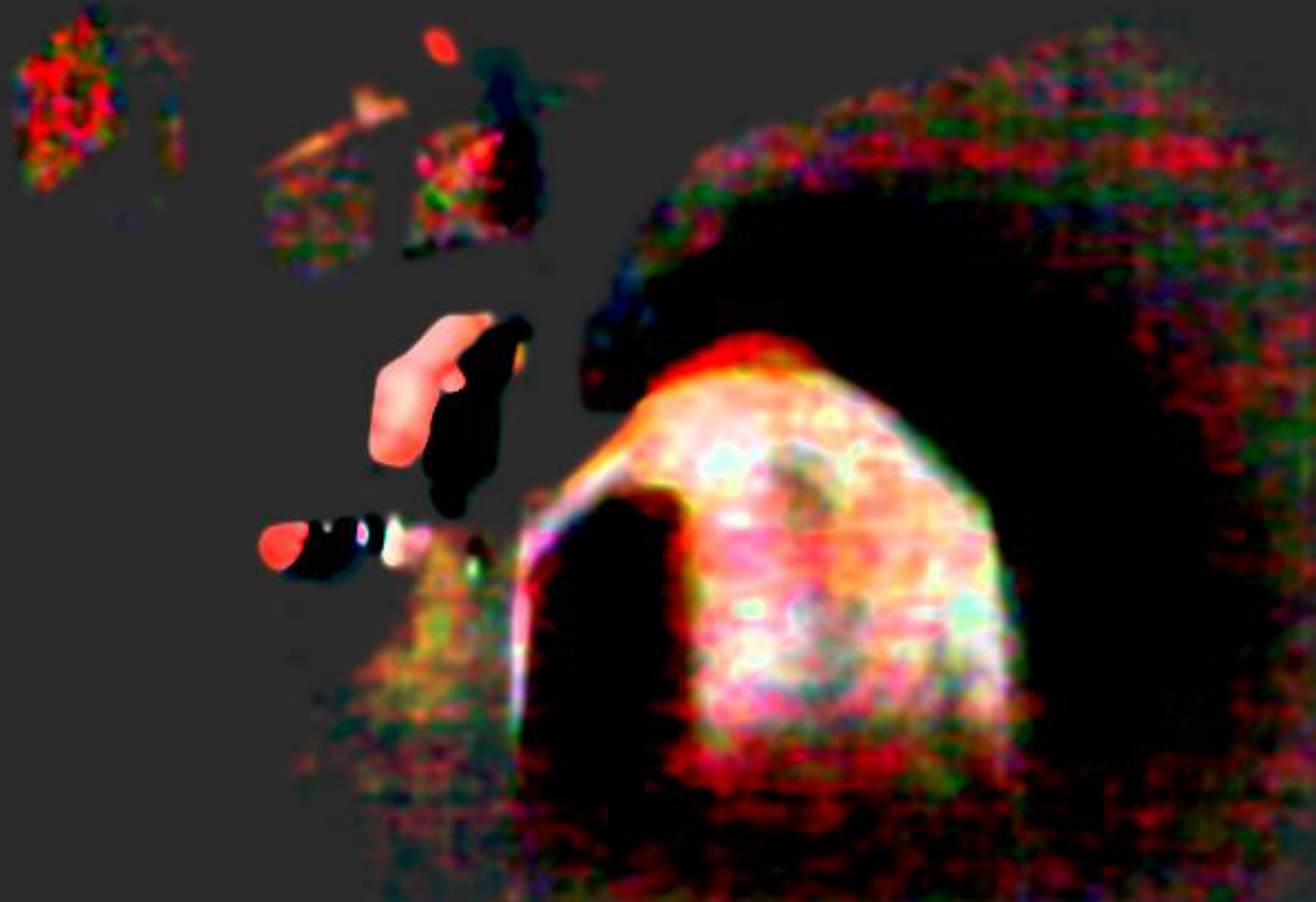
View outside the window



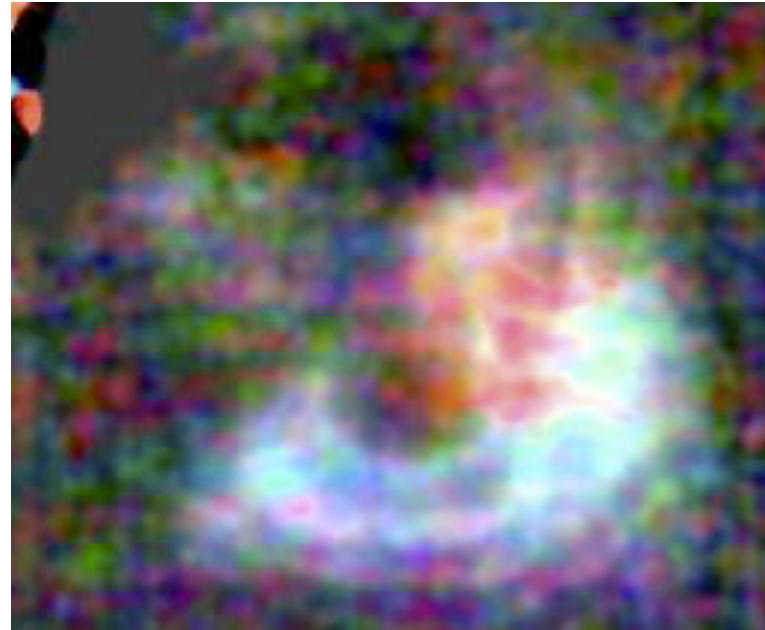




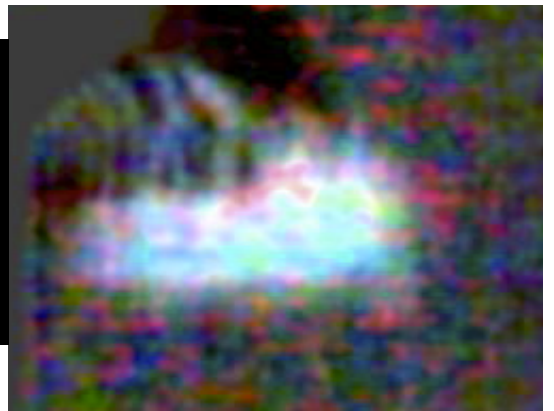
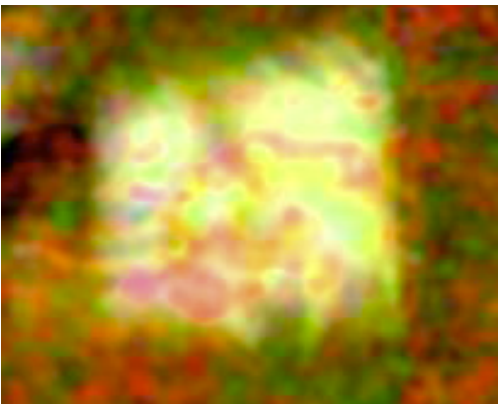
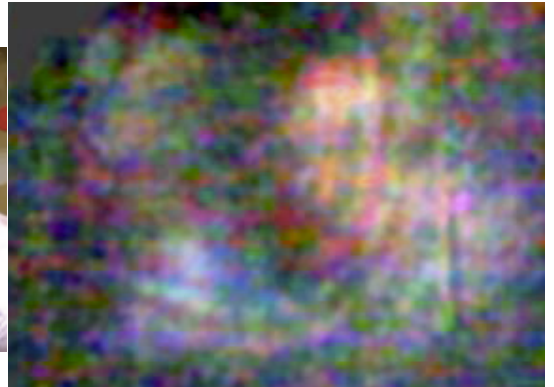
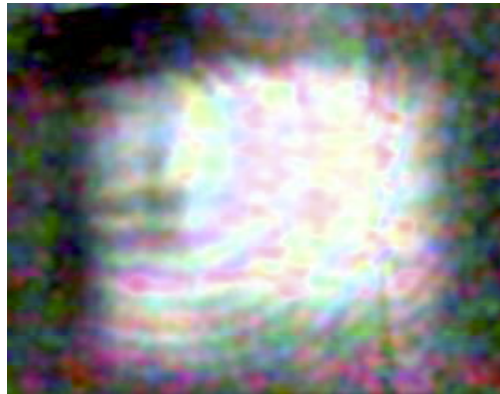
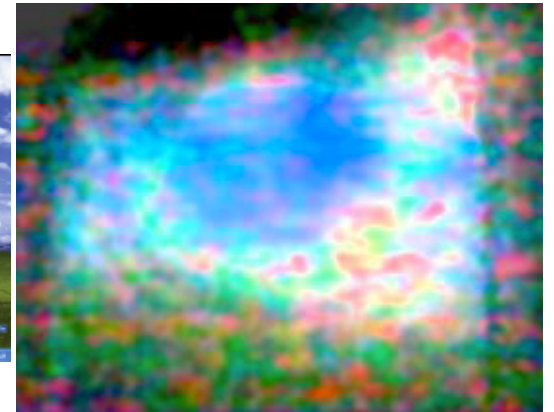
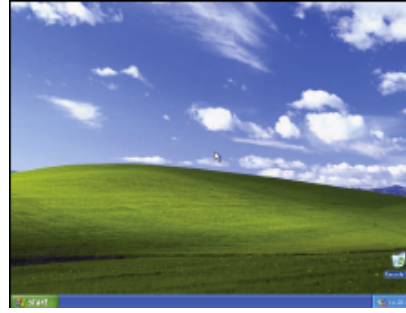
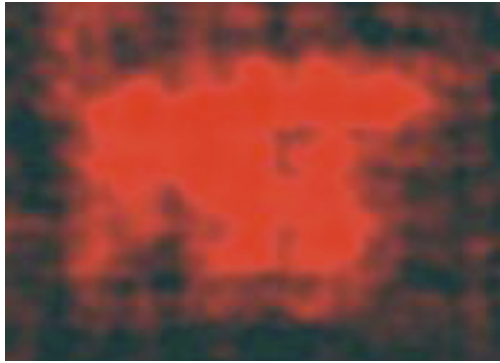
$$I(t) - I(t - 2\text{seconds}) =$$



This video is upside down



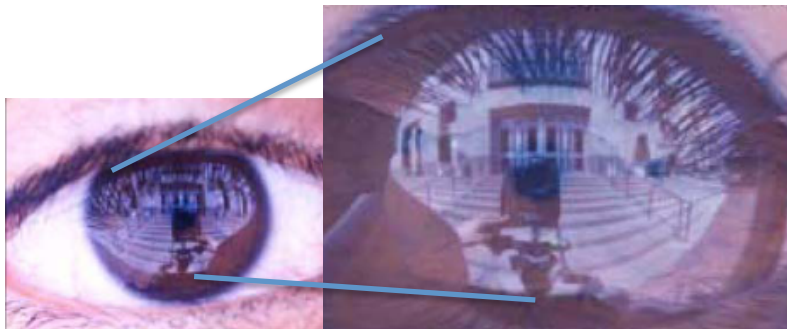
Thanks to Tomasz for suggesting this application



Thanks to Tomasz for suggesting this application

Accidental cameras reveal parts of the scene not directly visible

Mirrors

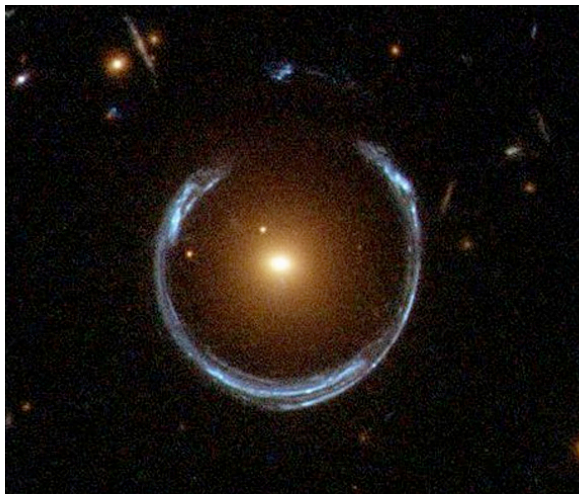


Nishino and Nayar, IJCV 2006

Pinholes



Lenses



Gravitational lensing

Anti-pinholes



Conclusion

Shadows and apertures produce accidental images that are unnoticed most of the time. Accidental cameras can reveal the scene outside the picture.

Applications:

- Image forensics (J. O'Brian & H. Farid, 2012)
- Computer graphics providing better light models



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