CS4670 / 5670: Computer Vision

KavitaBala

Lecture 16: Projection 2 and Panoramas

Reading

- Szeliski Chapter 9

Announcements

- Sign up for PA 2 demo slots
- Cannot fix code up after demo

Focal length

- Can think of as “zoom”

24mm

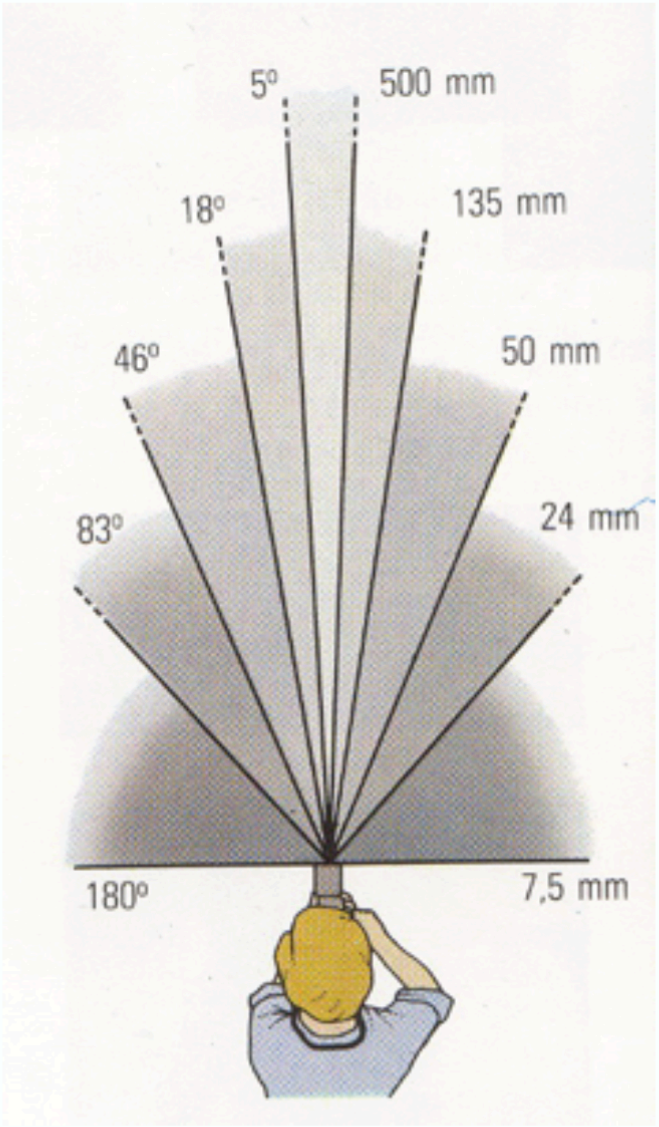
50mm

200mm

800mm

- Related to *field of view*

Focal length in practice



24mm

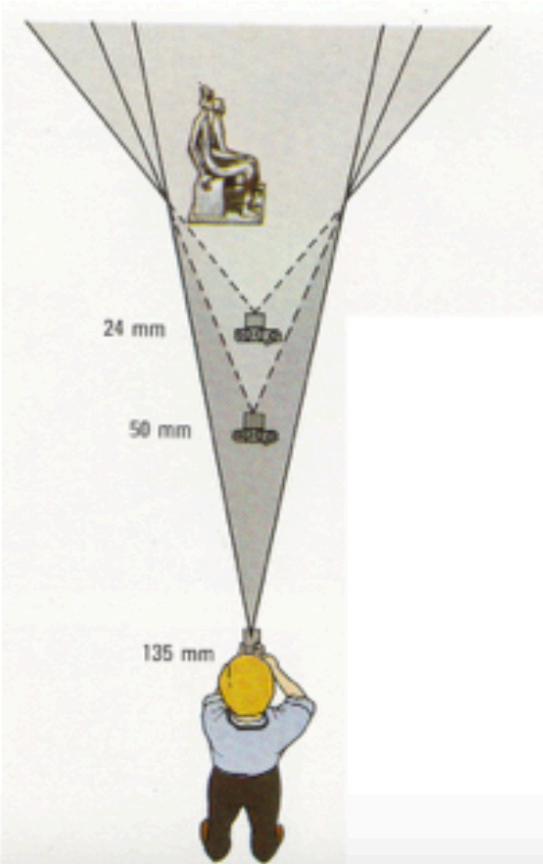
50mm

135mm

Fredo Durand

Focal length vs. viewpoint

- **Telephoto makes it easier to select background (a small change in viewpoint is a big change in background.**



Grand-angulaire 24 mm

Normal 50 mm

Longue focale 135 mm

Fredo Durand

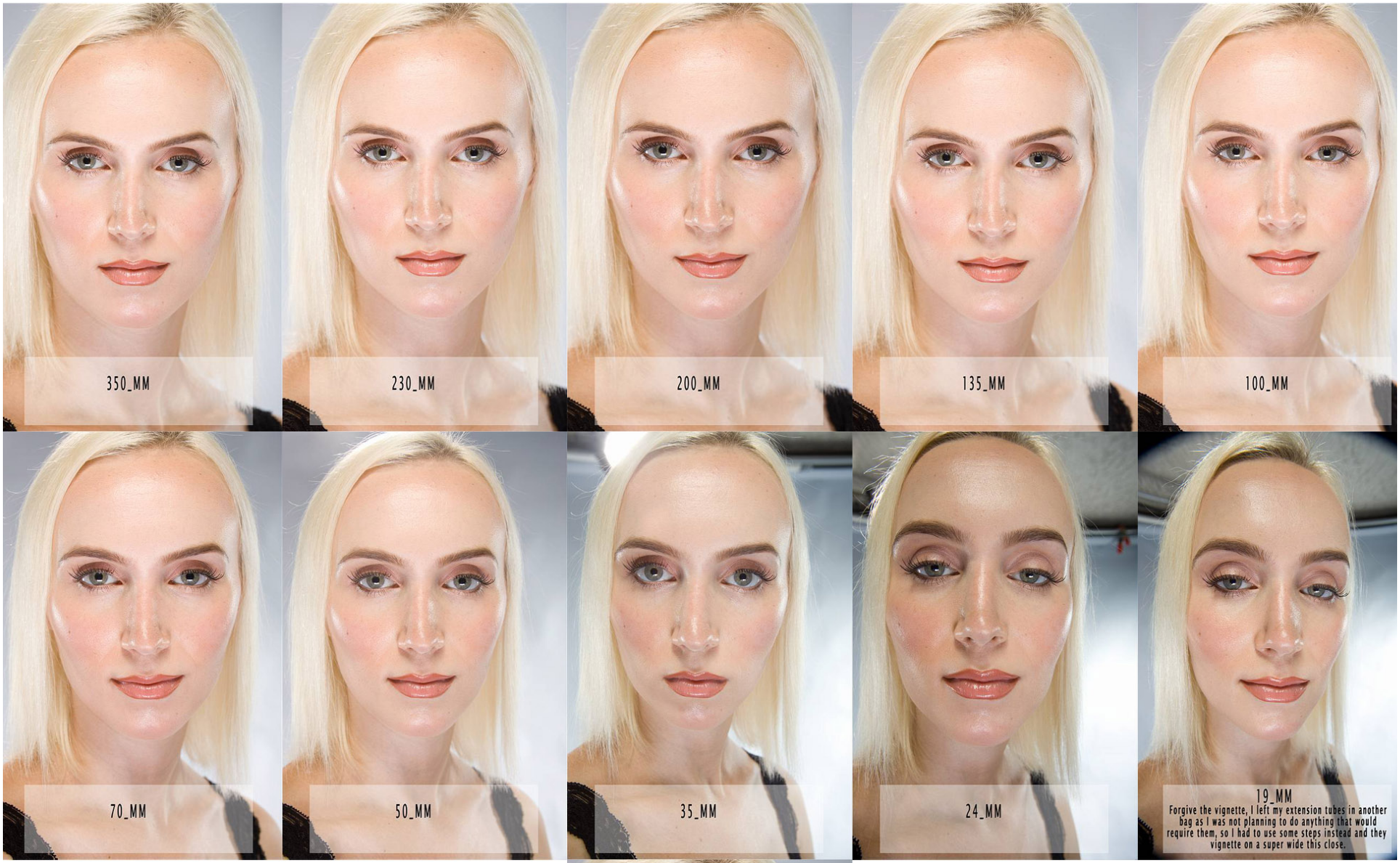
Fredo Durand

Wide angle

Standard

Telephoto

http://petapixel.com/2013/01/11/how-focal-length-affects-your-subjects-apparent-weight-as-seen-with-a-cat/



http://stepheneastwood.com/tutorials/lensdistortion/strippage.htm

Distortion

- 2 types
  - Perspective distortion
  - Lens distortion

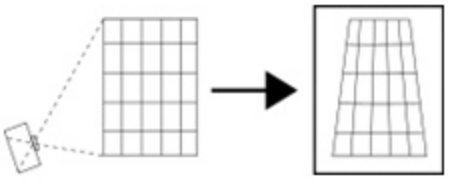
Perspective distortion

- Problem for architectural photography: converging verticals

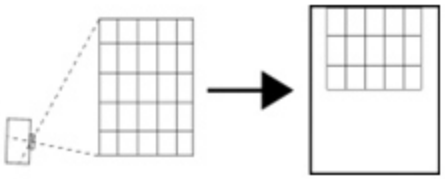
Source: F. Durand

Perspective distortion

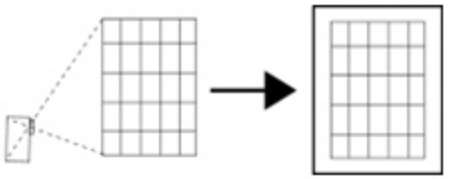
- Problem for architectural photography: converging verticals



Tilting the camera upwards results in converging verticals

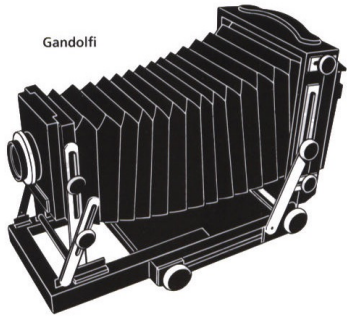


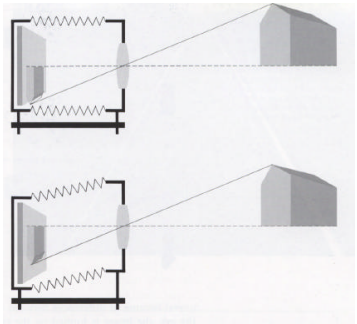
Keeping the camera level, with an ordinary lens, captures only the bottom portion of the building



Shifting the lens upwards results in a picture of the entire subject

- Solution: view camera (lens shifted w.r.t. film)





http://en.wikipedia.org/wiki/Perspective_correction_lens

Source: F. Durand

Perspective distortion

- Problem for architectural photography: converging verticals
- Result:

Source: F. Durand

Perspective distortion

- What does a sphere project to?

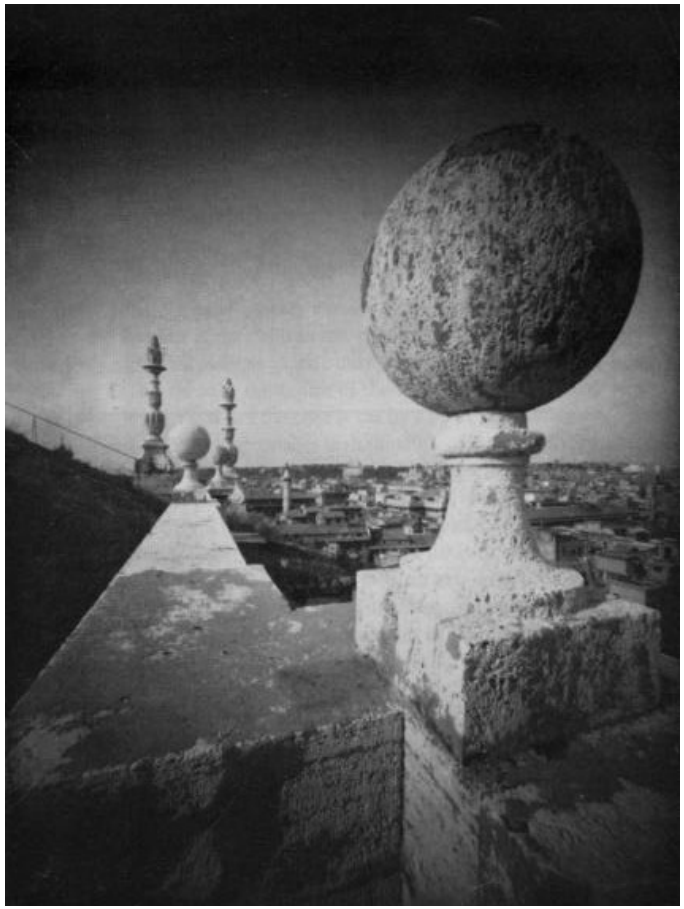
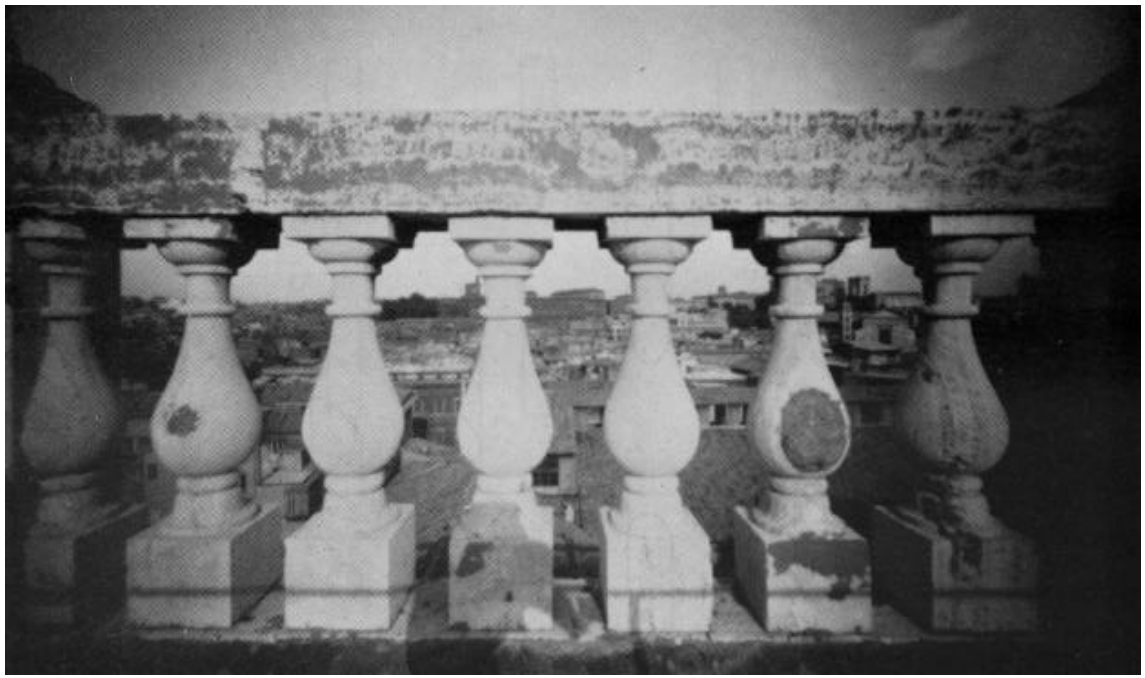
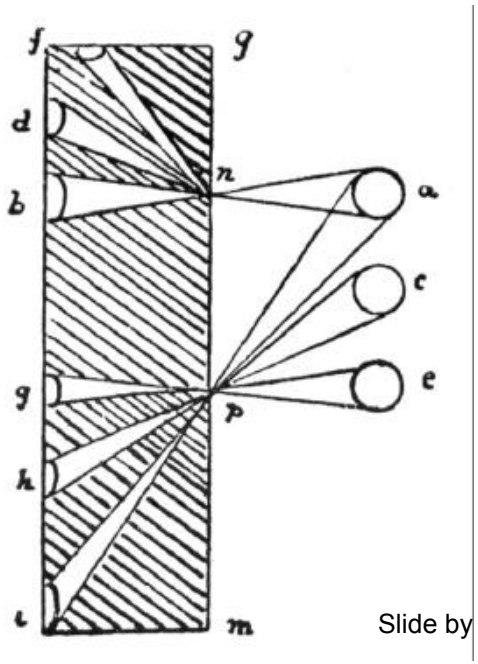


Image source: F. Durand

Perspective distortion

- The exterior columns appear bigger
- The distortion is not due to lens flaws
- Problem pointed out by Da Vinci

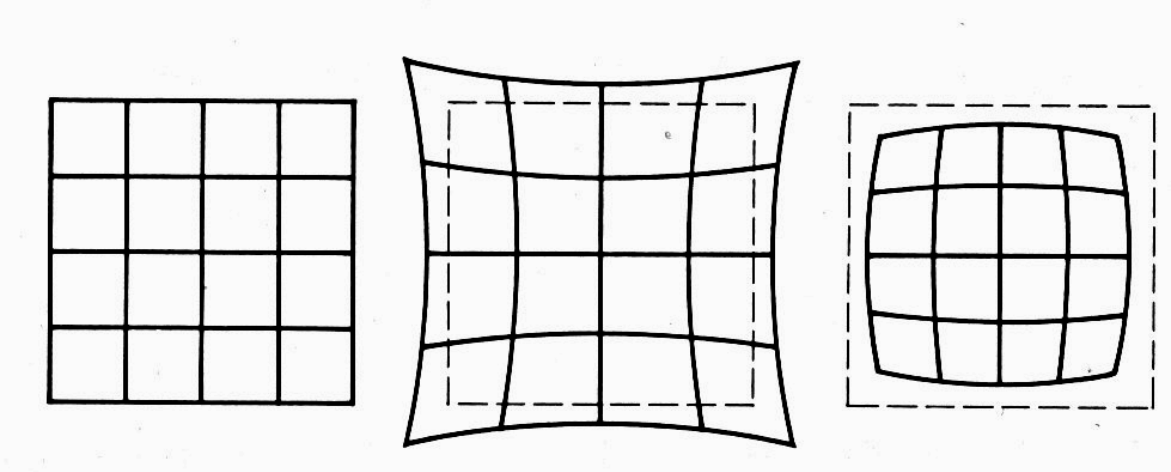




Slide by F. Durand

Perspective distortion: People

Distortion due to lens



- Radial distortion of the image
  - Caused by imperfect lenses
  - Deviations are most noticeable for rays that pass through the edge of the lens


©2004 Vincent Bockaert 123di.com


©2004 Vincent Bockaert 123di.com

Modeling distortion

- Radial distortion model

- Apply after projection, but before camera intrinsic: f and (xc, yc) translation

Project $(\hat{x}, \hat{y}, \hat{z})$ to "normalized" image coordinates

$$x'_n = \hat{x}/\hat{z}$$
$$y'_n = \hat{y}/\hat{z}$$

Modeling distortion

Apply radial distortion

$$
\begin{aligned}
r^2 &= {x'_n}^2 + {y'_n}^2 \\
x'_d &= x'_n(1 + \kappa_1 r^2 + \kappa_2 r^4) \\
y'_d &= y'_n(1 + \kappa_1 r^2 + \kappa_2 r^4)
\end{aligned}
$$

Apply focal length
translate image center

$$
\begin{aligned}
x' &= f x'_d + x_c \\
y' &= f y'_d + y_c
\end{aligned}
$$

- To model lens distortion
  - Use above projection operation instead of standard projection matrix multiplication

Correcting radial distortion

from Helmut Dersch

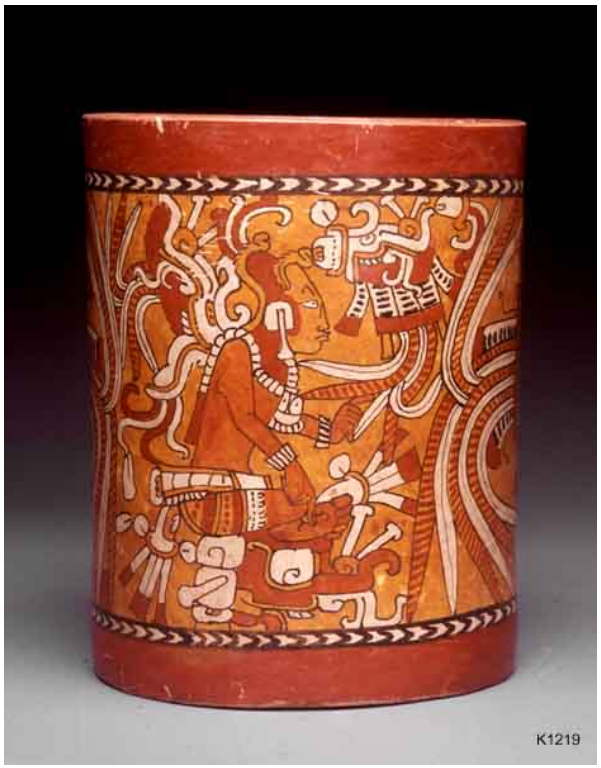
Other types of projection

- Lots of intriguing variants…
- (I'll just mention a few fun ones)

360 degree field of view…

- Basic approach
  - Take a photo of a parabolic mirror with an orthographic lens (Nayar)
  - Or buy one a lens from a variety of omnicam manufacturers…
    - See http://www.cis.upenn.edu/~kostas/omni.html

Rotating sensor (or object)



Rollout Photographs © Justin Kerr

http://research.famsi.org/kerrmaya.html

Also known as “cyclographs”, “peripheral images”

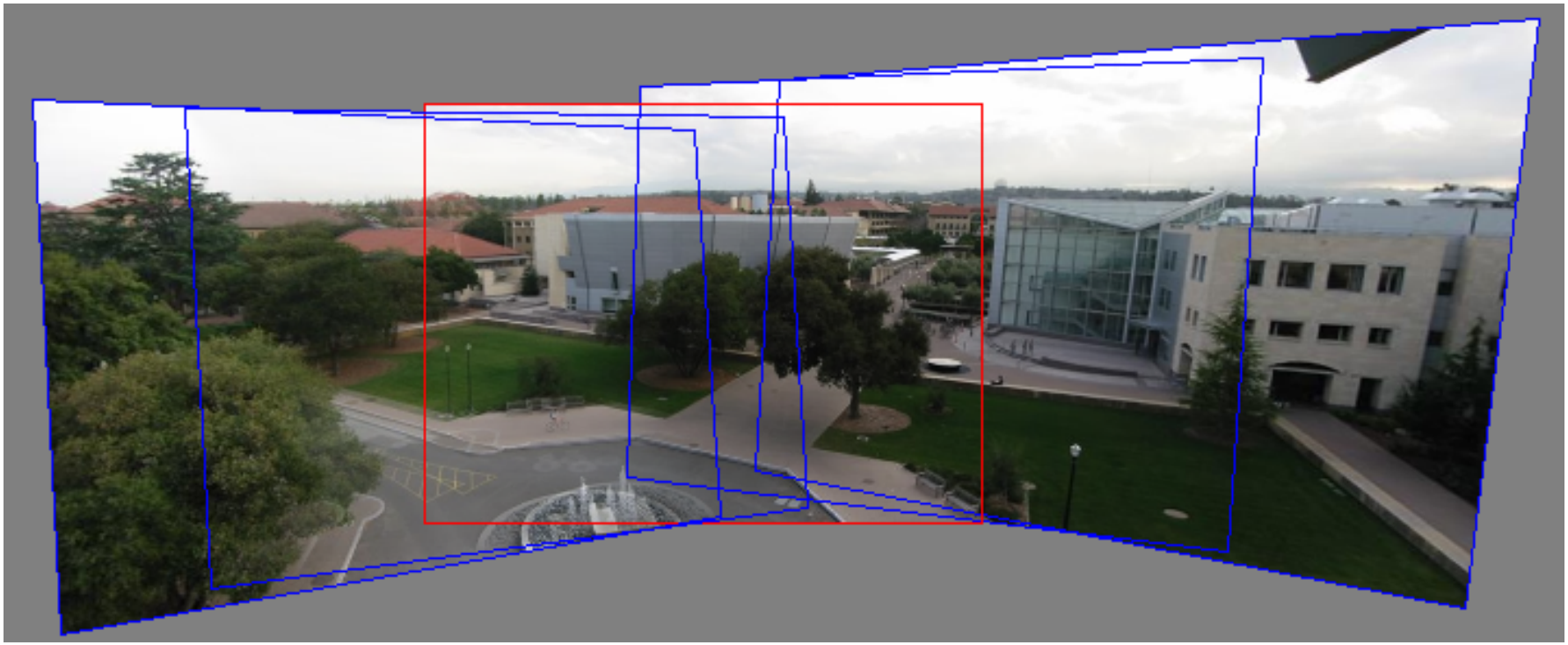
Back to mosaics

- How do we align the images?

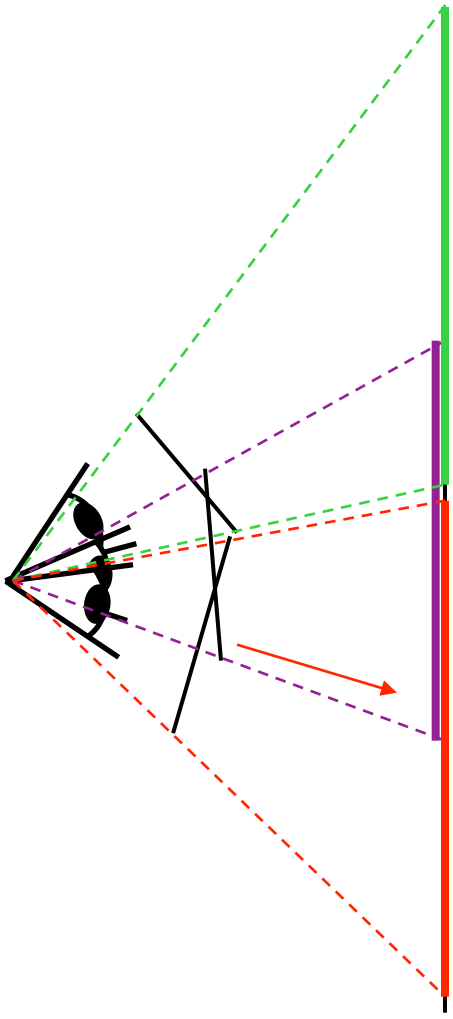
Creating a panorama

- Basic Procedure
  - Take a sequence of images from the same position
    - Rotate the camera about its optical center
  - Compute transformation between second image and first
  - Transform the second image to overlap with the first
  - Blend the two together to create a mosaic
  - If there are more images, repeat

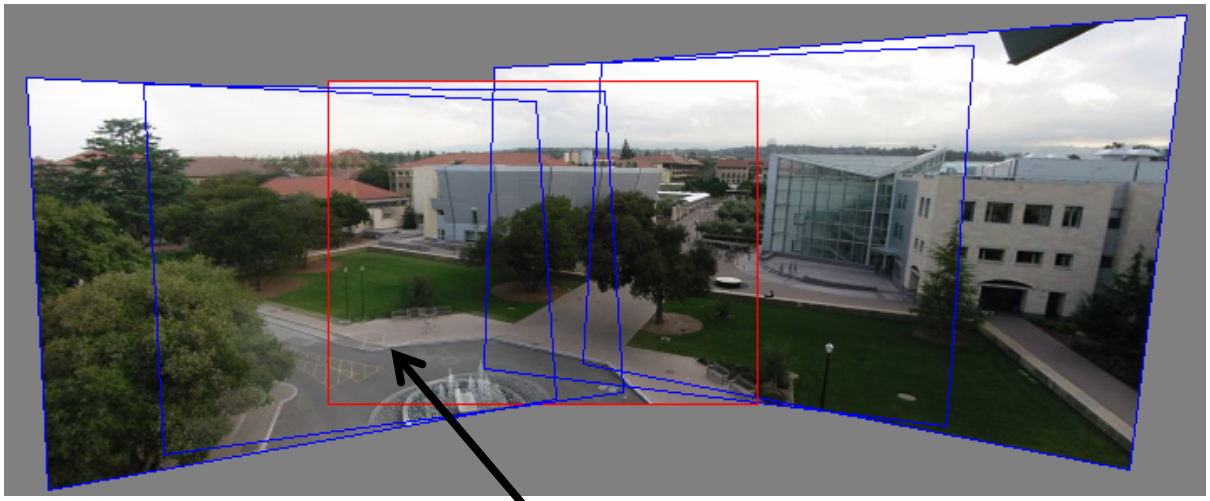
Can we use homography to create a 360 panorama?



Idea: projecting images onto a common plane

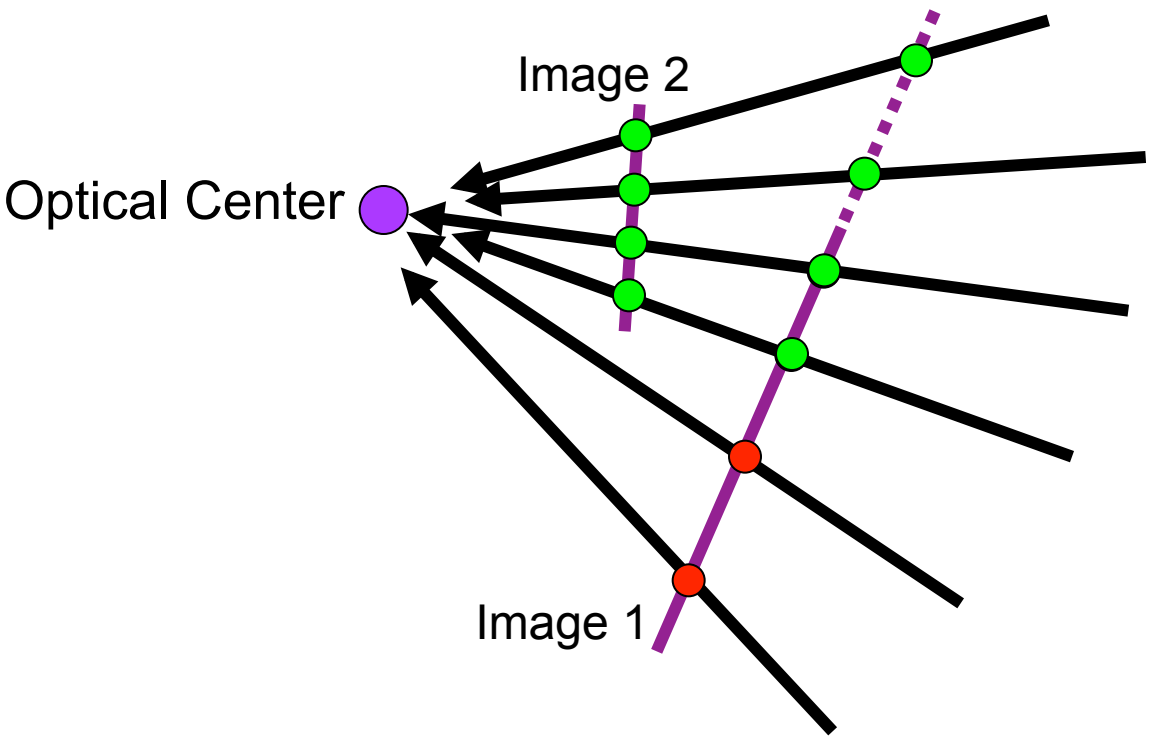


mosaic PP



each image is warped with a homography $\mathbf{H}$

Geometric Interpretation of Mosaics

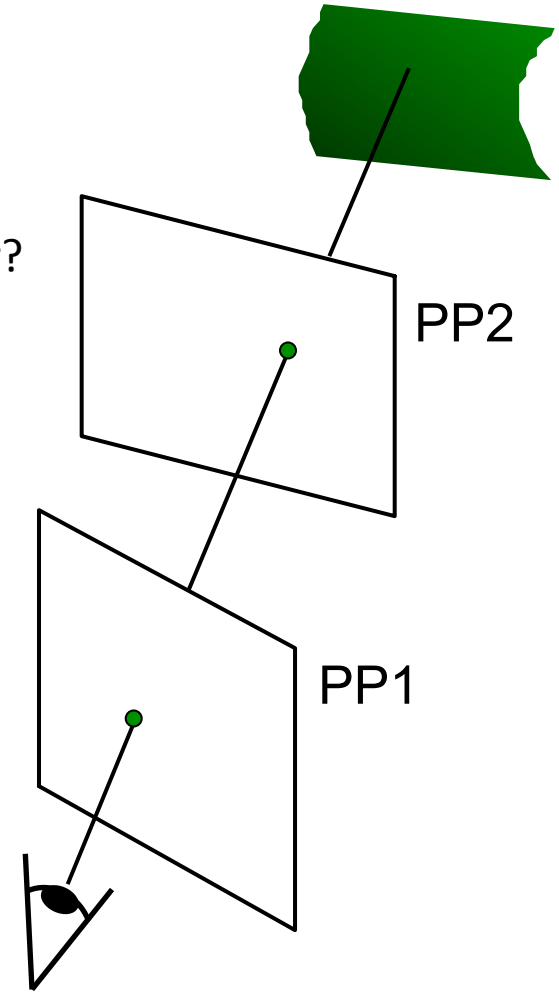


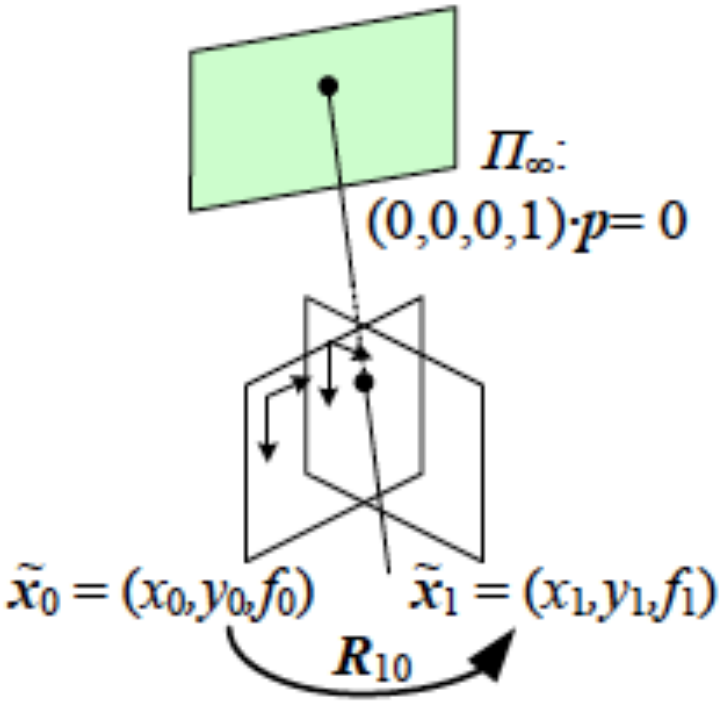
- If we capture all 360º of rays, we can create a 360º panorama
- The basic operation is *projecting* an image from one plane to another
- The projective transformation is scene-INDEPENDENT
  - This depends on all the images having the same optical center

Image reprojection

- Basic question
  - How to relate two images from the same camera center?
    - how to map a pixel from PP1 to PP2

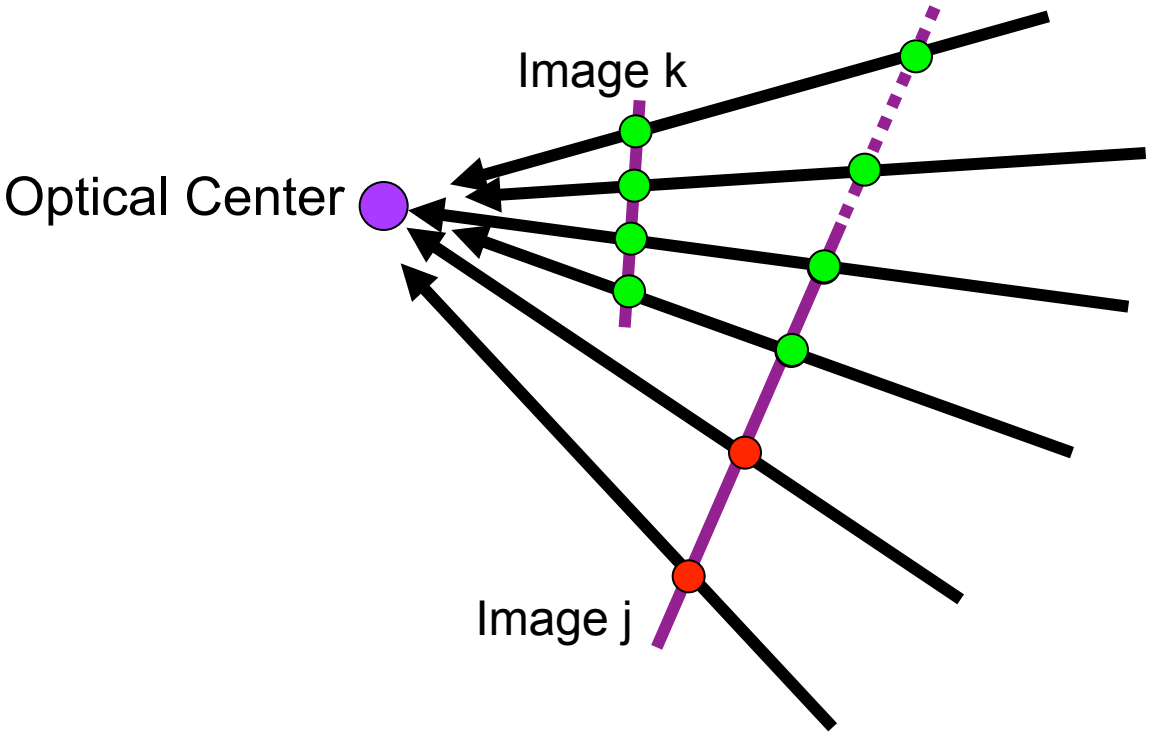
  Answer
    - Cast a ray through each pixel in PP1
    - Draw the pixel where that ray intersects PP2





$$\tilde{H}_{10} = K_1 R_1 R_0^{-1} K_0^{-1} = K_1 R_{10} K_0^{-1},$$

What is the transformation?



$$\tilde{\boldsymbol{x}}_{ik} \sim \tilde{\boldsymbol{H}}_{kj}\tilde{\boldsymbol{x}}_{ij} = \boldsymbol{K}_k\boldsymbol{R}_k\boldsymbol{R}_j^{-1}\boldsymbol{K}_j^{-1}\tilde{\boldsymbol{x}}_{ij}.$$

- Next time
  - Cylindrical and spherical projection