Panoramas

CS 178, Spring 2011

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What is a panorama?

- a wider-angle image than a normal camera can capture
- any image stitched from overlapping photographs
- an extreme aspect ratio on a normal shot

Outline

- capturing panoramas
- stitching together a panorama
- perspective versus cylindrical projection

Panoramic cameras

flatback panoramic camera

swing-lens panoramic camera

Swing-lens panoramic images

San Francisco in ruins, 1906

101 Ranch, Oklahoma, circa 1920

Panoramic cameras

to avoid parallax errors, rotate around center of perspective

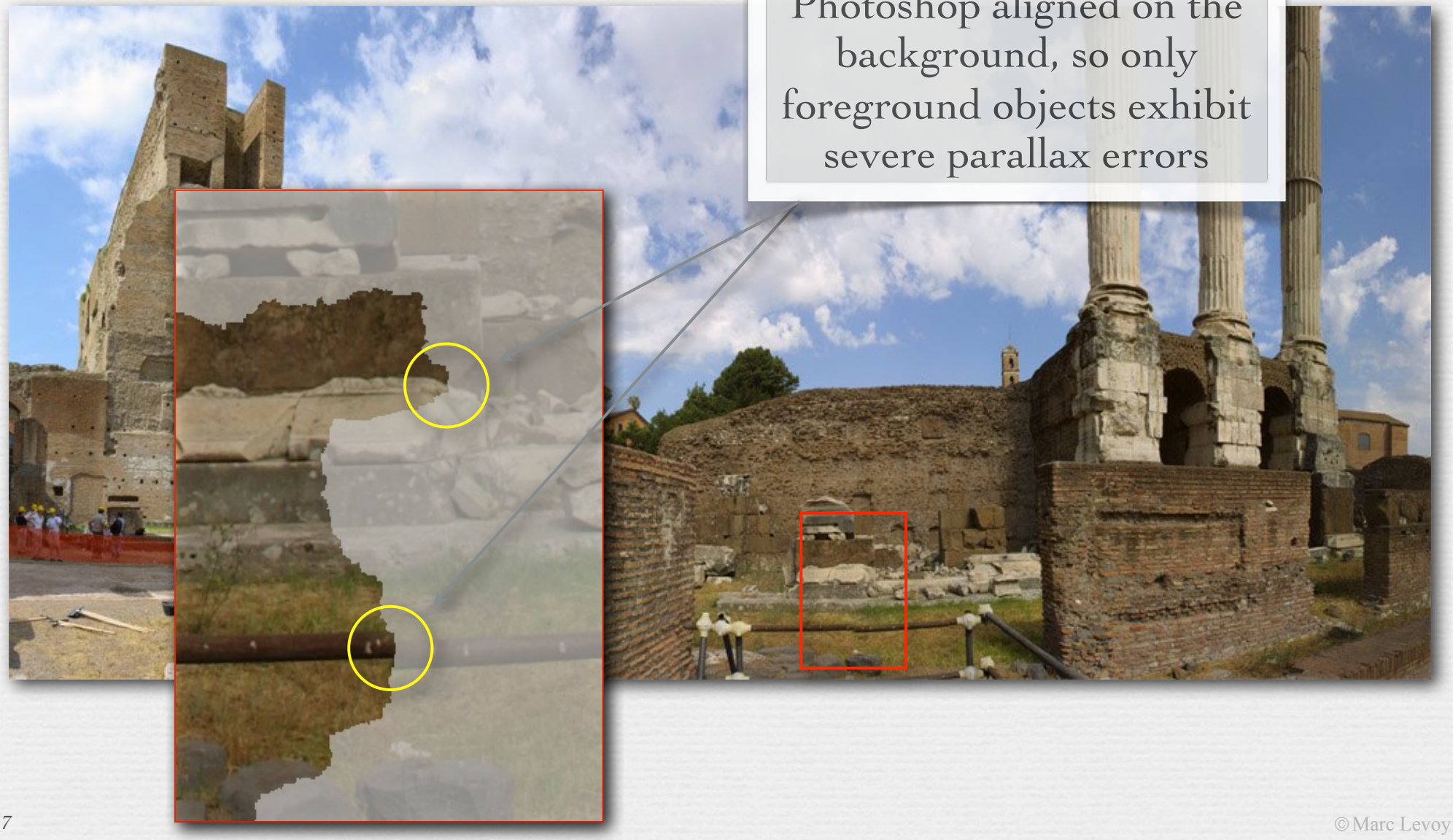
flatback panoramic camera

swing-lens panoramic camera

SLR on panning clamp

motorized pan-tilt head

Parallax errors



Fuji GX 617

Lee Frost, Val D'Orcia, Tuscany, Italy

Lee Frost, Volubilis, Morocco

Lee Frost,
Vertical Panoramas,
Santorini

Matthew Scott, Cuernos del Paine, Chile

gigapan.org, Scanning Electron Micrograph (SEM) of barnacle

gigapan.org, Scanning Electron Micrograph (SEM) of barnacle

Stitching images together to make a mosaic

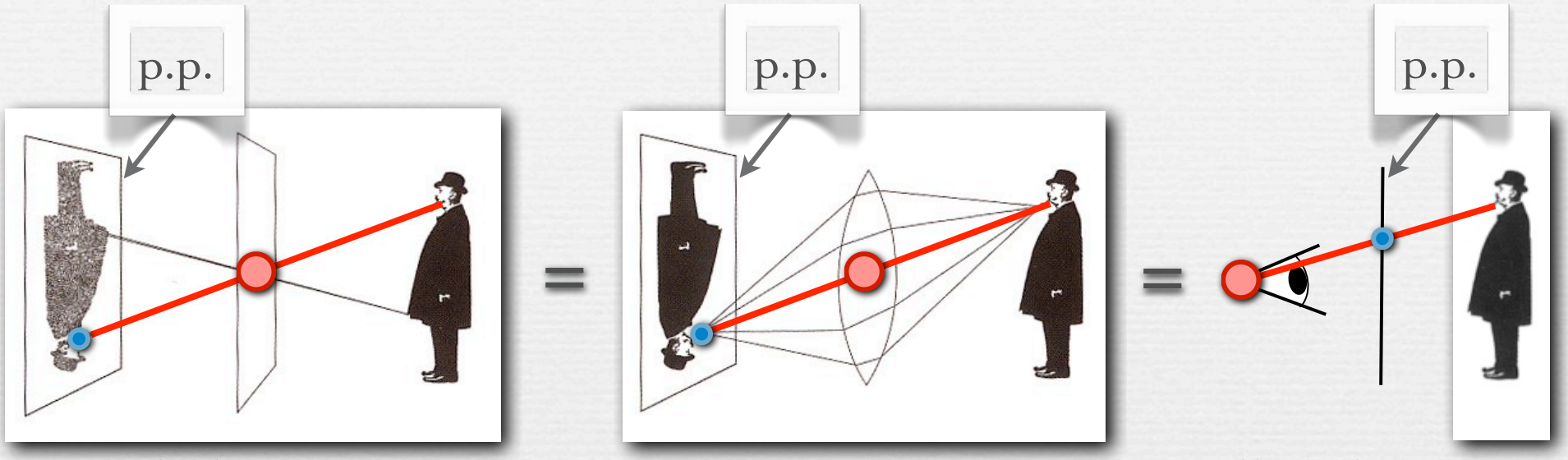
What kind of transformation do we need?

translation?

rotation?

perspective!

Quick review of perspective projection



pinhole camera = photographic camera = Albrecht Dürer's drawing glass

= center of perspective (c.p.)

= projection of feature in scene onto picture plane (p.p)

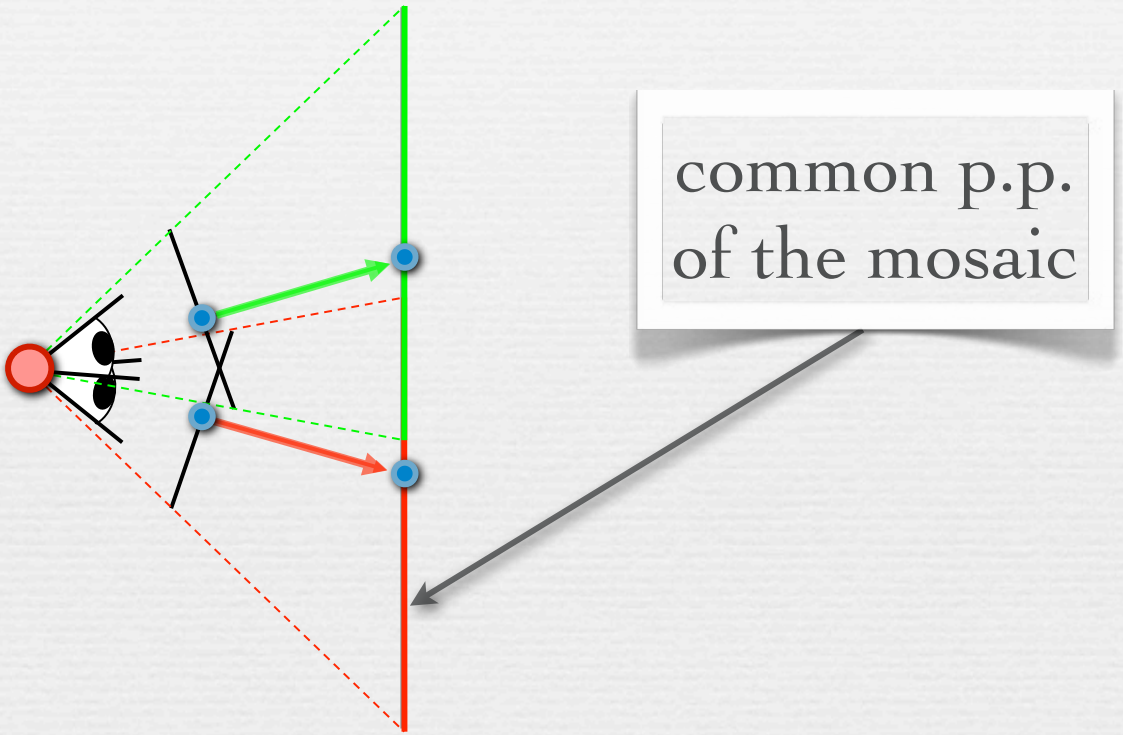
- these three image formation methods will produce the same perspective view on the p.p. (except for the size of the view)
  - all that matters is position of c.p. and orientation of p.p.

Reprojecting an image onto a different picture plane

the sidewalk art of Julian Beever

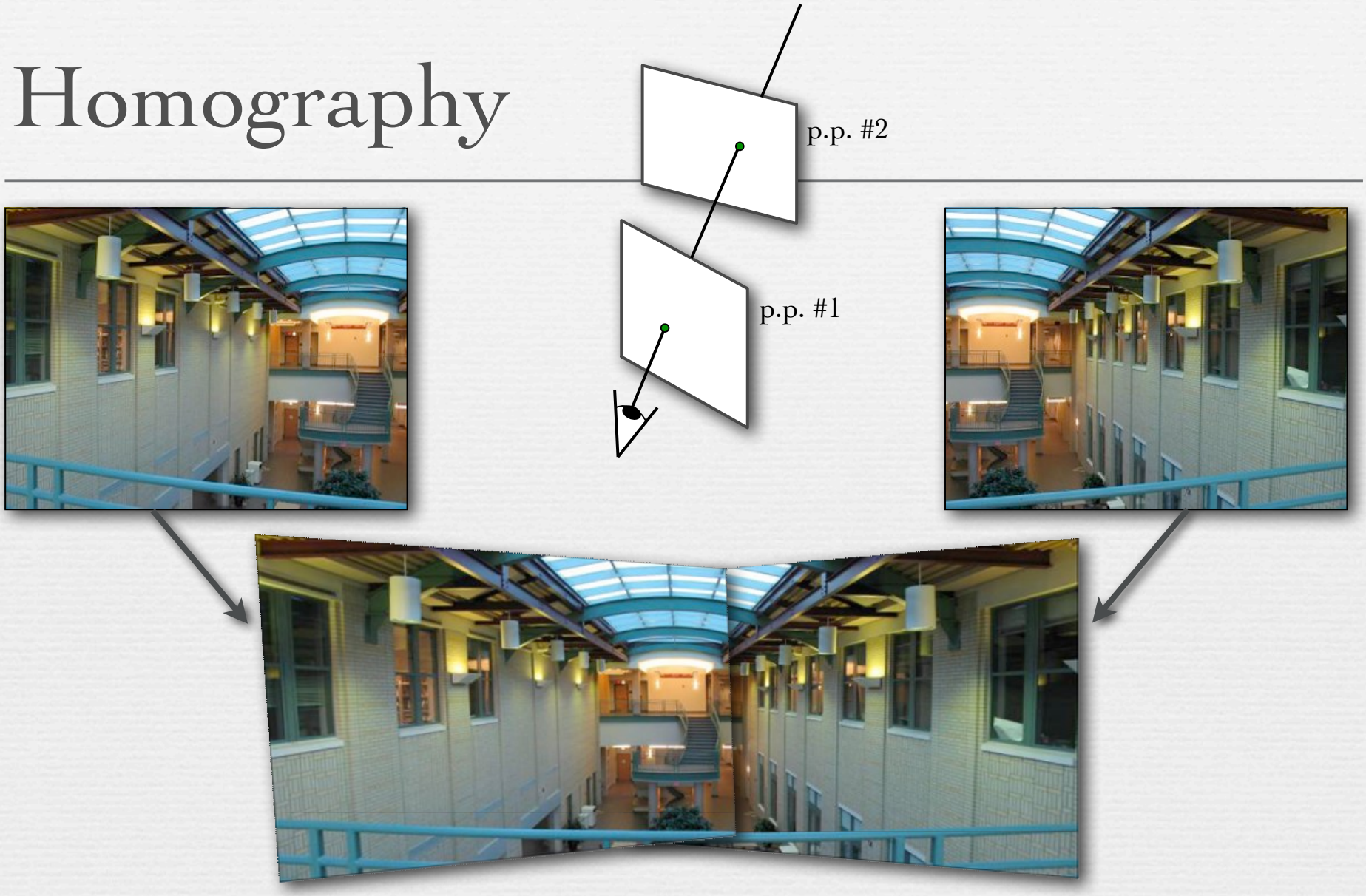
- the view on any picture plane can be projected onto any other plane in 3D without changing its appearance as seen from a common center of projection

Reprojecting panoramic images to a common picture plane



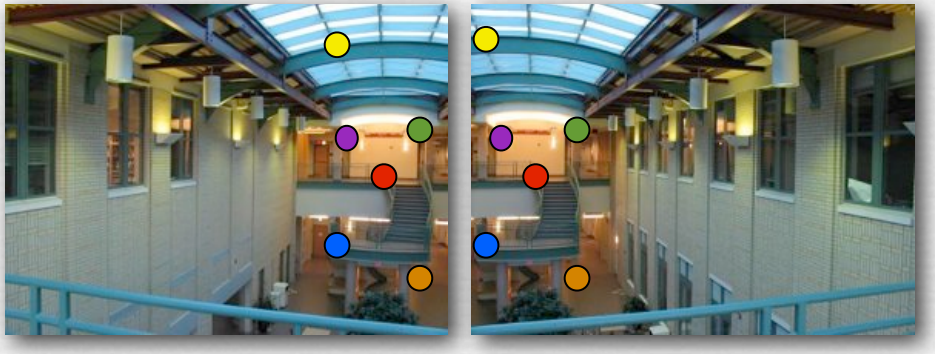
- the common picture plane of the mosaic replaces having had a wide-angle (non-fish-eye) camera in the first place

Homography



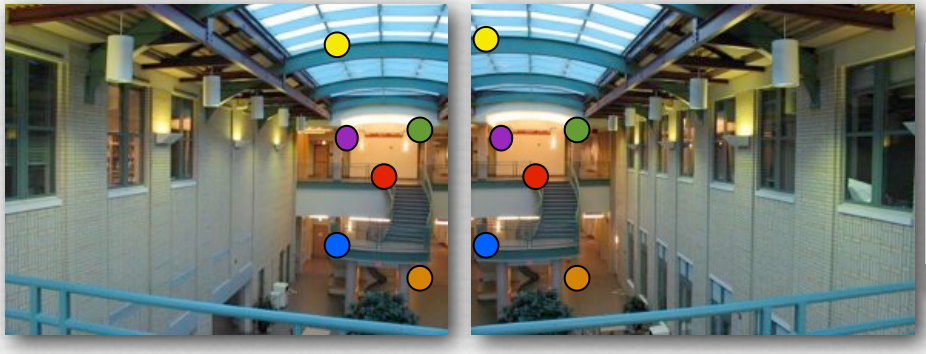
- perspective mapping between two p.p.'s using the same center of projection is called a *homography*
  - input and output x,y positions are related by a 3×3 matrix

Stitching images together to make a mosaic



- step 1: find corresponding features in a pair of image
- step 2: compute perspective from 2nd to 1st image
- step 3: warp 2nd image so it overlays 1st image
- step 4: blend images where they overlap one another
- repeat for 3rd image and mosaic of first two, etc.

Stitching images together to make a mosaic



Take CS 223B:
Computer Vision (Win)

- step 1: find corresponding features in pair of images
- step 2: compute perspective from matched features
- step 3: warp 2nd image so it overlays 1st image
- step 4: blend images where they overlap one another
- repeat for 3rd image and mosaic of first two, etc.

Take CS 148:
Introduction to Computer Graphics (Aut)

Also CS 448A:
Computational Photography (Win)

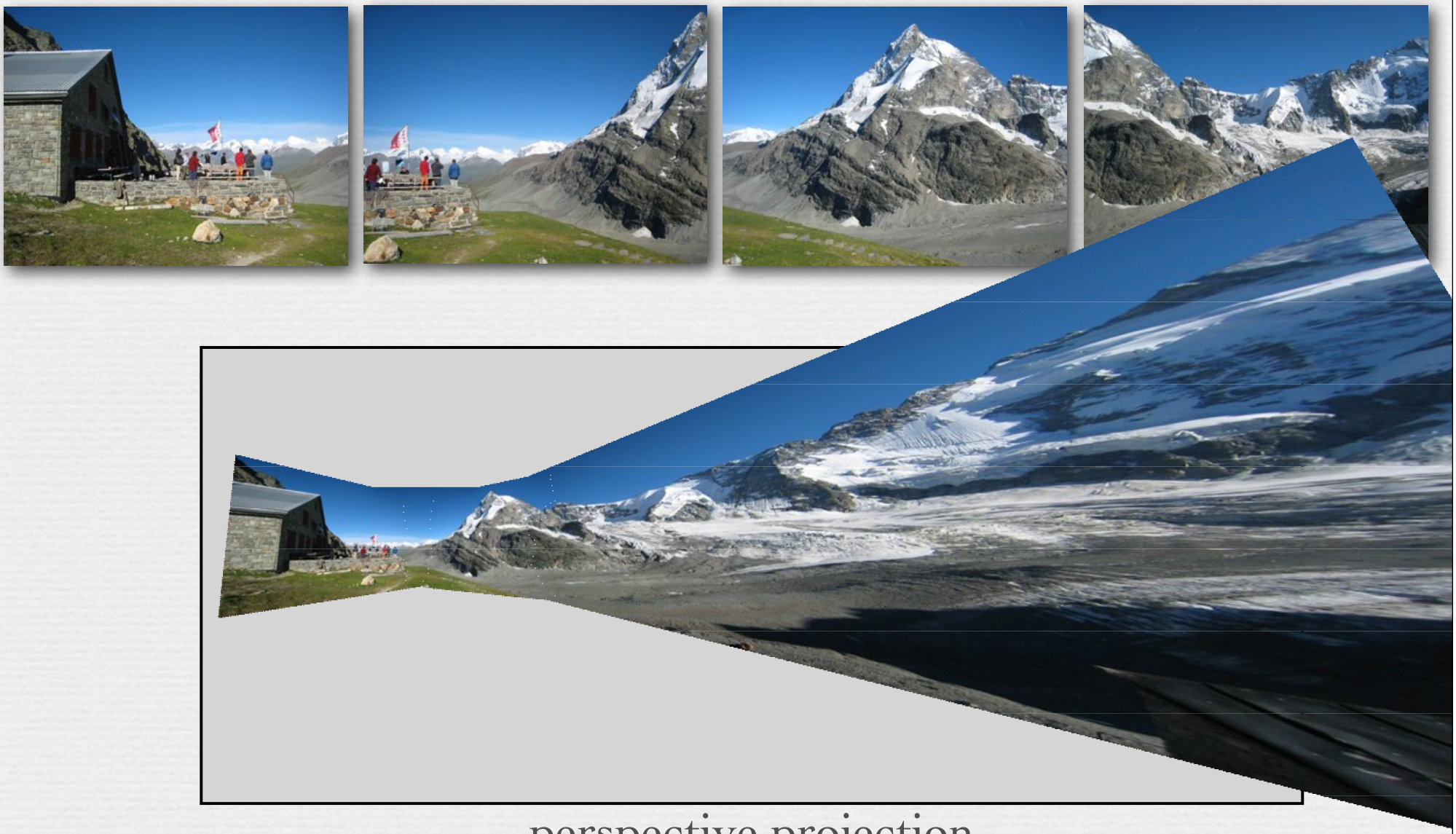
Example: the Matterhorn



common picture plane of mosaic image

perspective projection

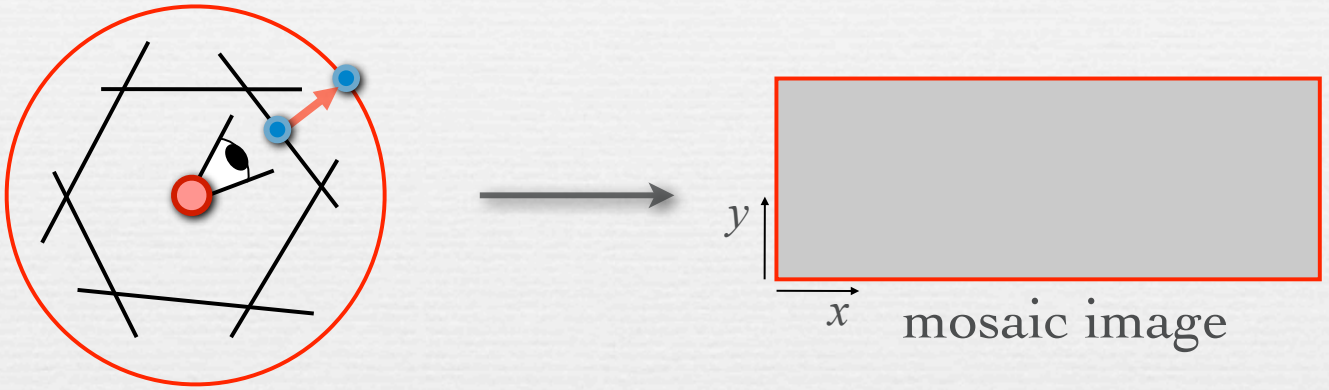
Using 4 shots instead of 3



perspective projection

Cylindrical panoramas

- even works for 360° panorama



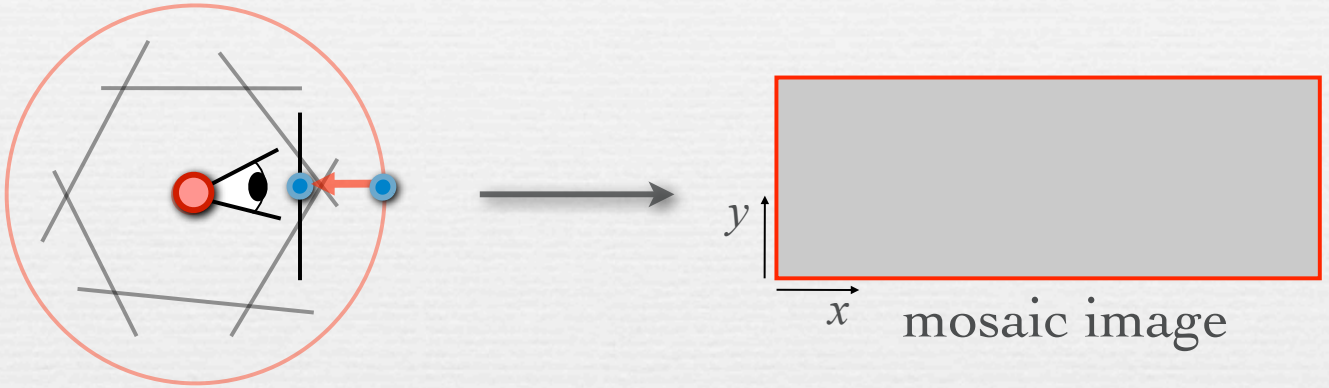
- project each image onto a cylinder
- a cylindrical image can be stored as a rectangular image

Cylindrical panoramas

(FLASH DEMO)

http://graphics.stanford.edu/courses/cs178/applets/projection.html

- even works for 360° panorama



- project each image onto a cylinder
- a cylindrical image can be stored as a rectangular image
- to view without distortion, reproject part of the cylinder onto a picture plane representing the display screen
  - if your FOV is narrow, this view won't be too distorted

Back to the Matterhorn



surface of cylinder

cylindrical projection

Back to the Matterhorn



surface of cylinder

blended

Example

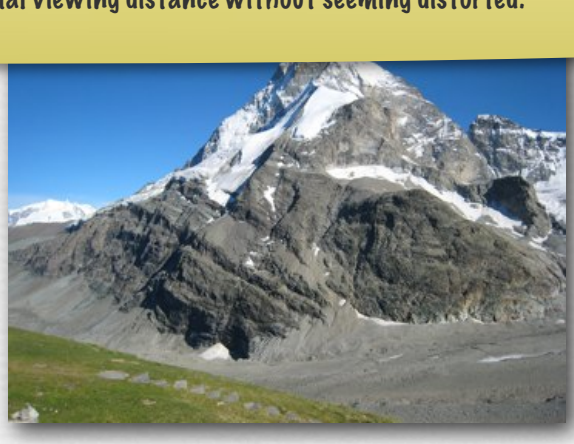
As mentioned in class, Photoshop does not perform the perspective reprojection shown here. Instead, it leaves you with the raw cylindrical image shown in the previous slide. On this image, straight lines are not straight, and the edges of the original photographs appear as curves. This is not a correct linear perspective. However, some panorama viewing software does perform this perspective reprojection, e.g. Microsoft's HDView (Google for it).



perspective reprojection onto a plane

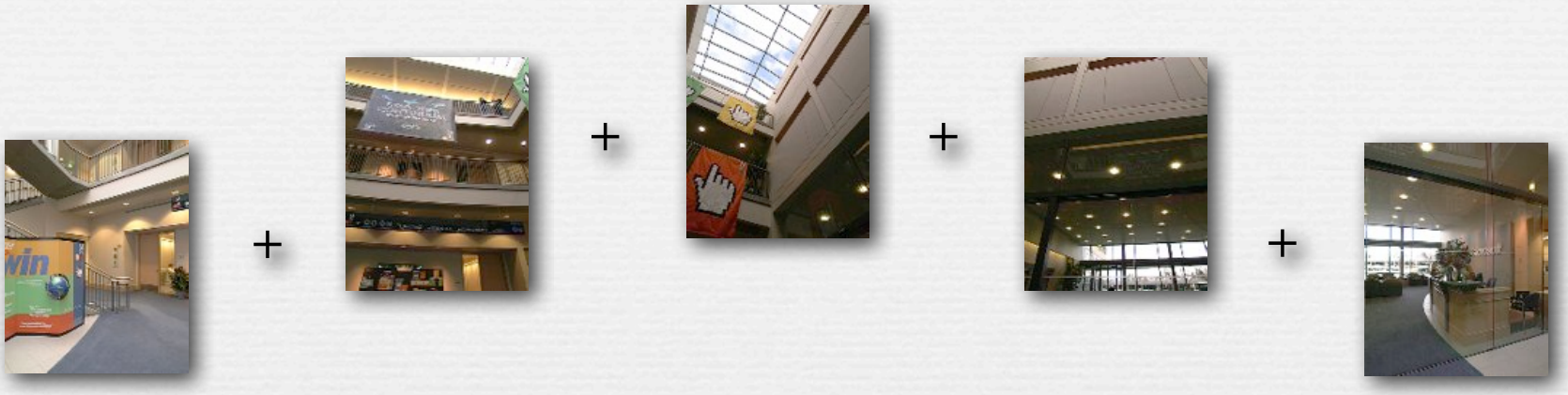
Example

As I mentioned in class, the sequence of (1) projecting one or more images to a cylindrical surface, and (2) reprojecting that cylindrical image back to a planar surface, produces an image with no distortion, i.e. it is a correct linear perspective. However, it might be rather wide-angle, as shown in the previous slide. Unless you view this image with your face close to the display, which would be the correct viewpoint for such a wide-angle perspective, it will seem distorted. We covered this issue in the first lecture of the course. To reduce the requirement that you must place yourself so close to the display, you should crop the reprojected panorama, as is done in this slide. The resulting image is not so wide-angle, and can be viewed from a normal viewing distance without seeming distorted.



cropped to avoid distortion

Spherical panoramas



- projections are to a sphere instead of a cylinder
- can't store as rectangular image without distortion

Recap

- panoramas can be captured by a camera with a wide planar back, a cylindrical back and a moving slit, or a rotating camera
  - rotate around the center of perspective to avoid *parallax errors*
- to assemble panoramas from a rotating camera, use corresponding features to compute a *perspective warp* that projects the images to a *common picture plane*, then blend them together
- for very wide angle or 360° panoramas, project the images to a *common cylindrical surface*, which can be stored as an ordinary (wide) rectangular image
  - reproject them to a picture plane for display
- spherical panoramas are possible, but cannot be stored as rectangular images without distortion

Questions?

Slide credits

- Fredo Durand
- Alyosha Efros
- Steve Seitz
- Rick Szeliski

- Frost, Lee, *Panoramic Photography,* F+W Publications, 2005.

Calvin and Hobbes

by Watterson