

Panoramas

CS 178, Spring 2013



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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 from multiple images
- ◆ perspective versus cylindrical projections

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



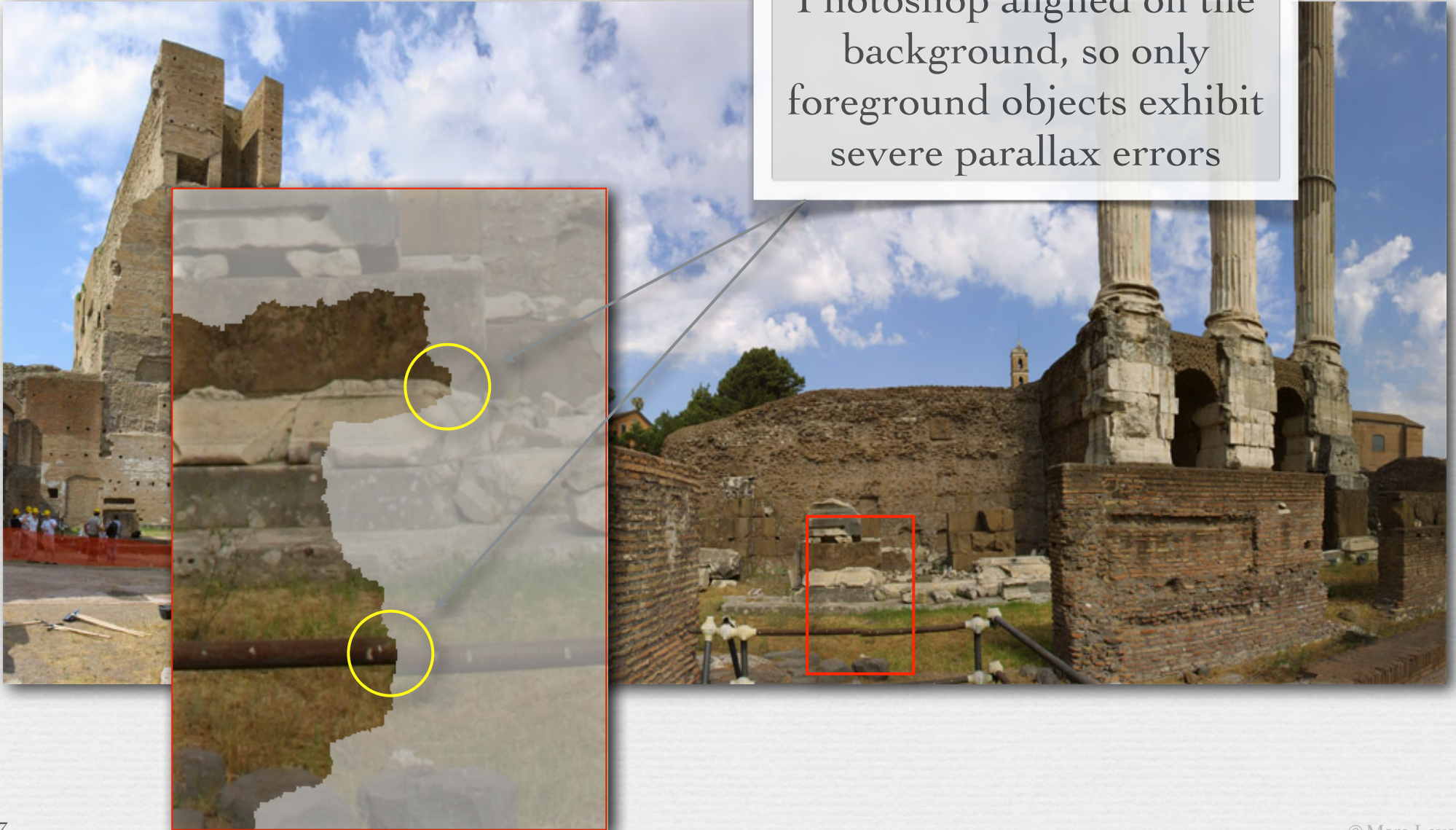
SLR on panning clamp



motorized pan-tilt head © Marc Levoy

Parallax errors

Photoshop aligned on the background, so only foreground objects exhibit severe parallax errors



Stanford CityBlock Project (now Google StreetView)

- ◆ capture video while driving
- ◆ extract middle column from each frame
- ◆ stack them to create a panorama



Stanford CityBlock Project



Stanford CityBlock Project





Samsung S4 panorama mode

Fuji GX 617



Lee Frost, Val D'Orcia, Tuscany, Italy



Lee Frost, Volubilis, Morocco

Lee Frost,
Vertical Panoramas,
Santorini

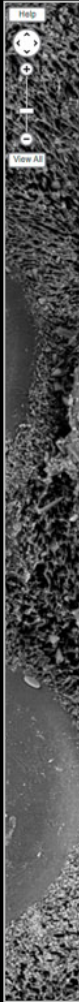




Matthew Scott, Cuernos del Paine, Chile



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?

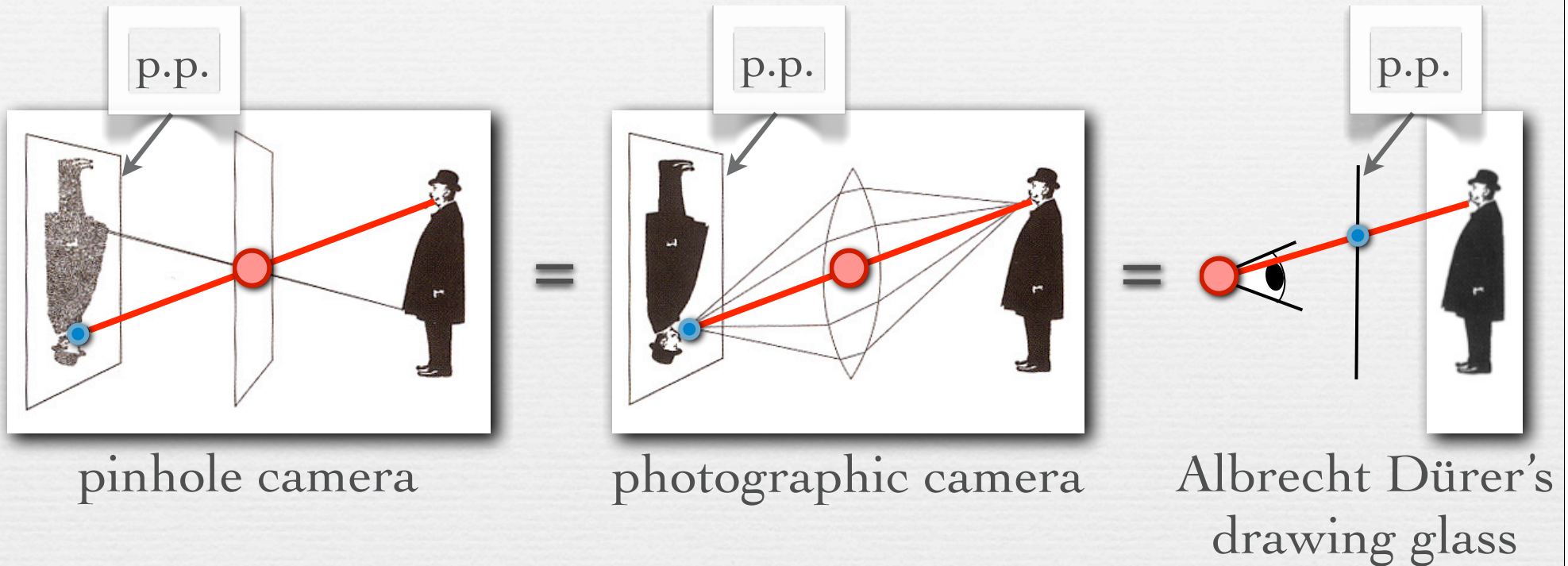


rotation?



perspective!

Quick review of perspective projection



● = center of perspective (c.p.)

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

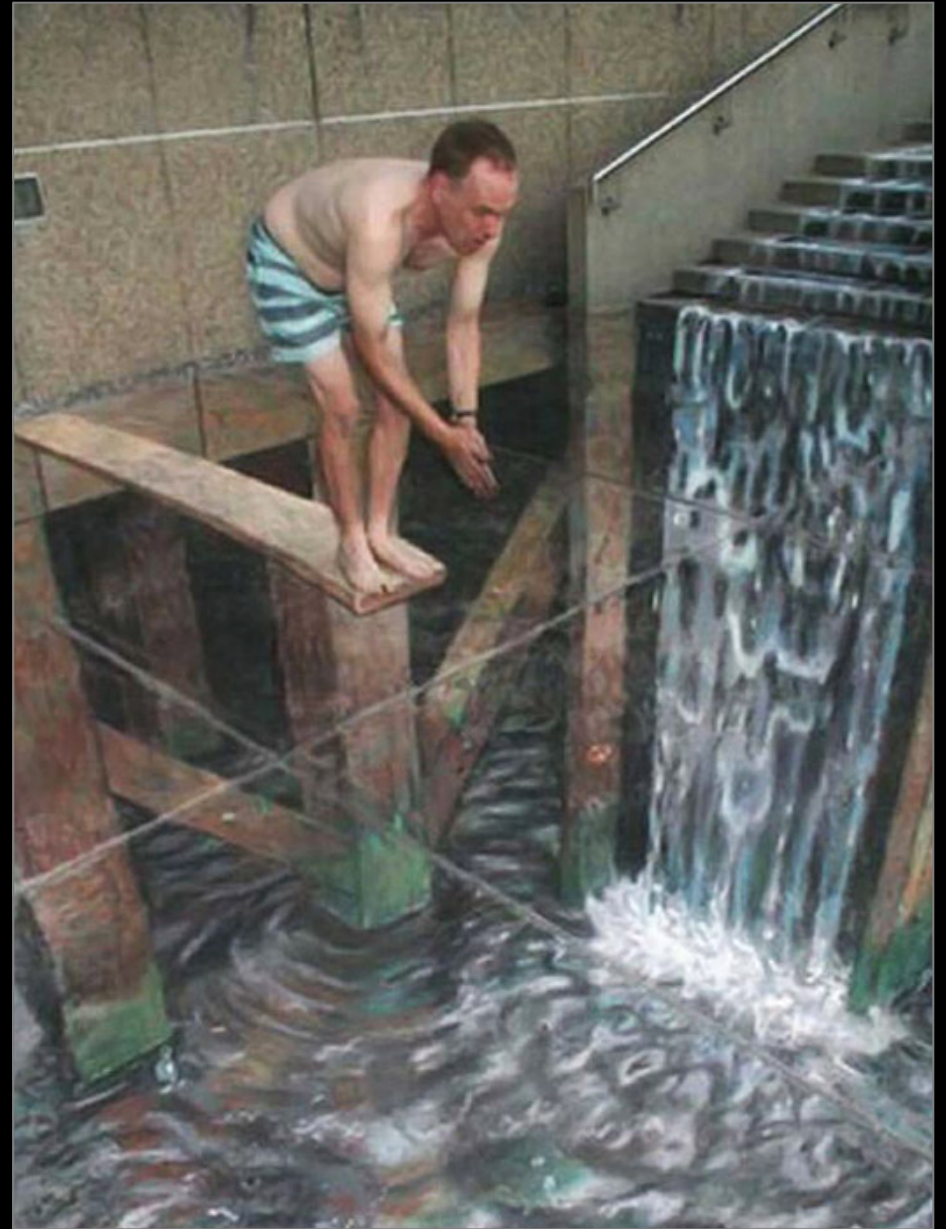
- ◆ these three image formation methods will produce the same perspective view on the p.p. (except for the size of the view)
 - all that matters is position of c.p. and orientation of p.p.

Reprojecting an image onto a different picture plane



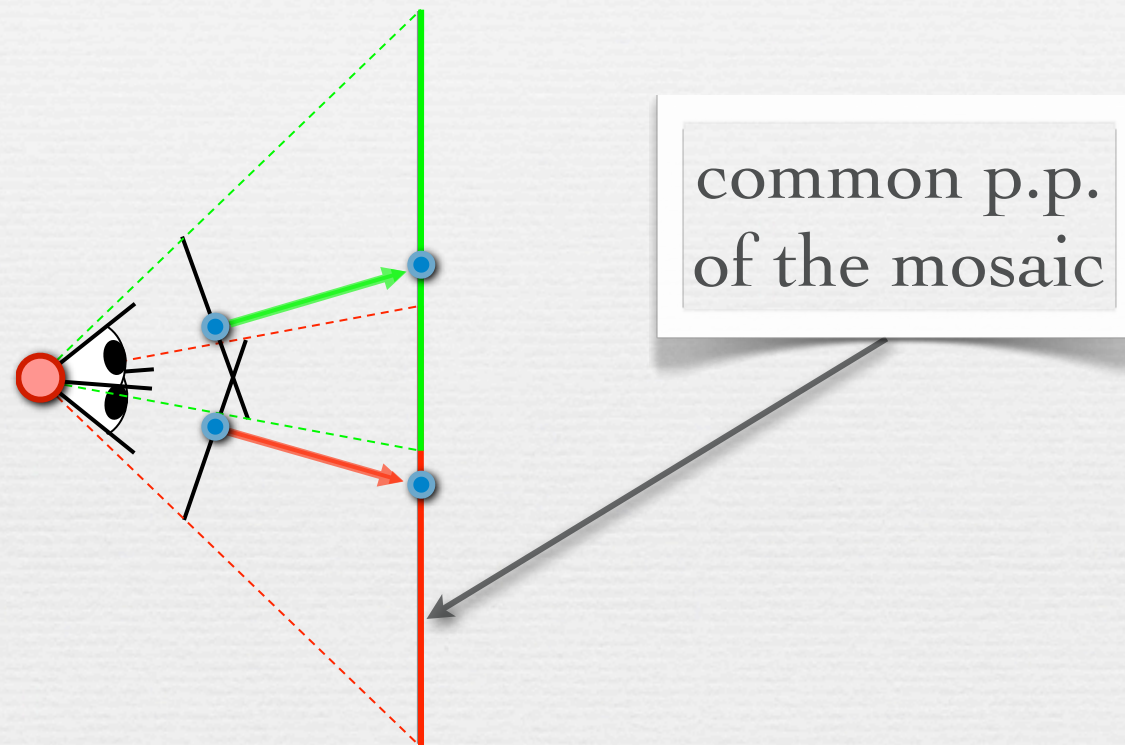
the sidewalk art of Julian Beever

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



Julian Beever

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 with a large flat film plane in the first place

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 231A:
Computer Vision (Win 2014?)



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

Take CS 148:
Introduction to Computer
Graphics (Aut 2013)

Also CS 478:
Computational
Photography (Win 2014)

Example: the Matterhorn

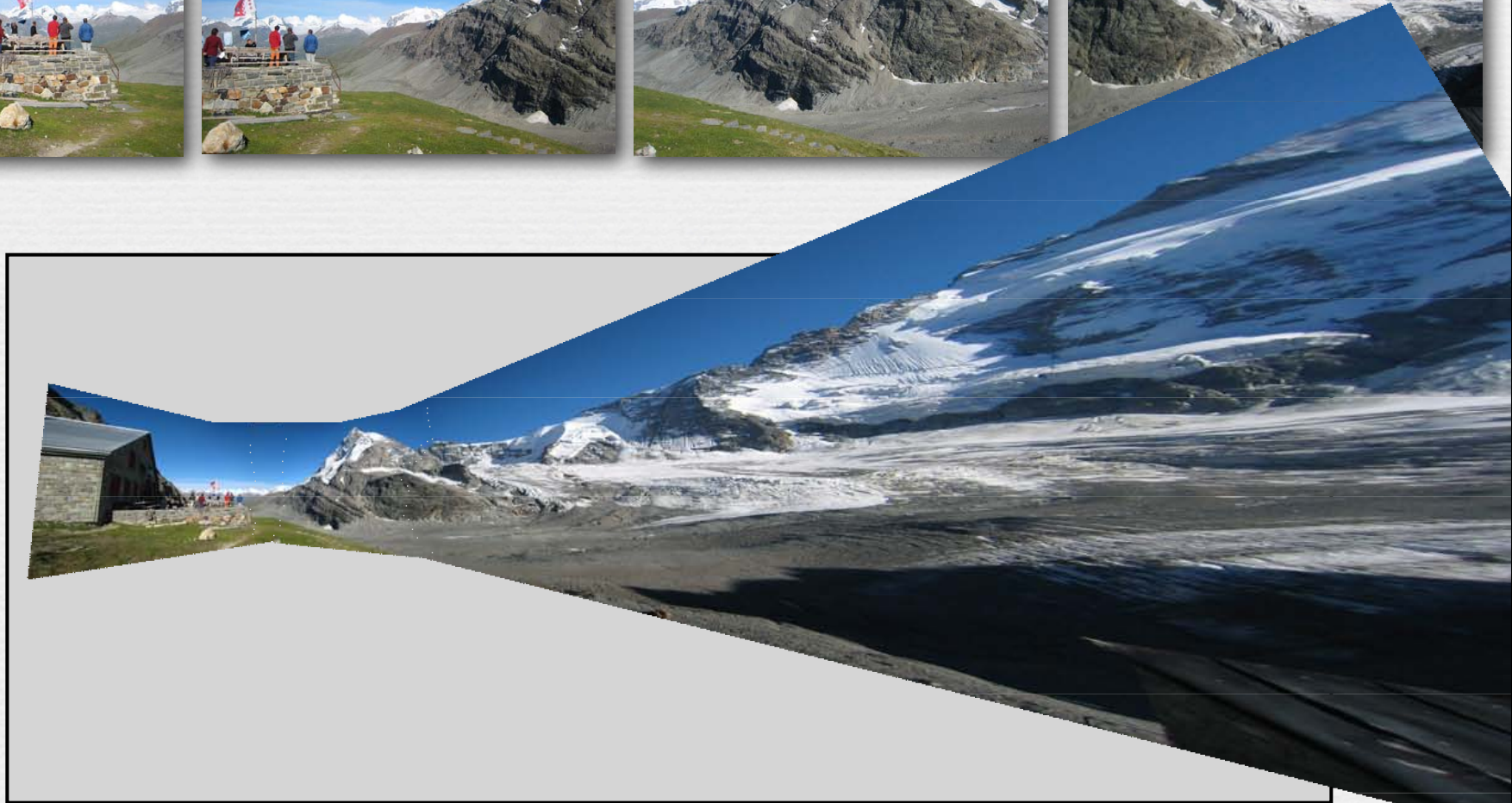


common
picture
plane of
mosaic
image



perspective projection

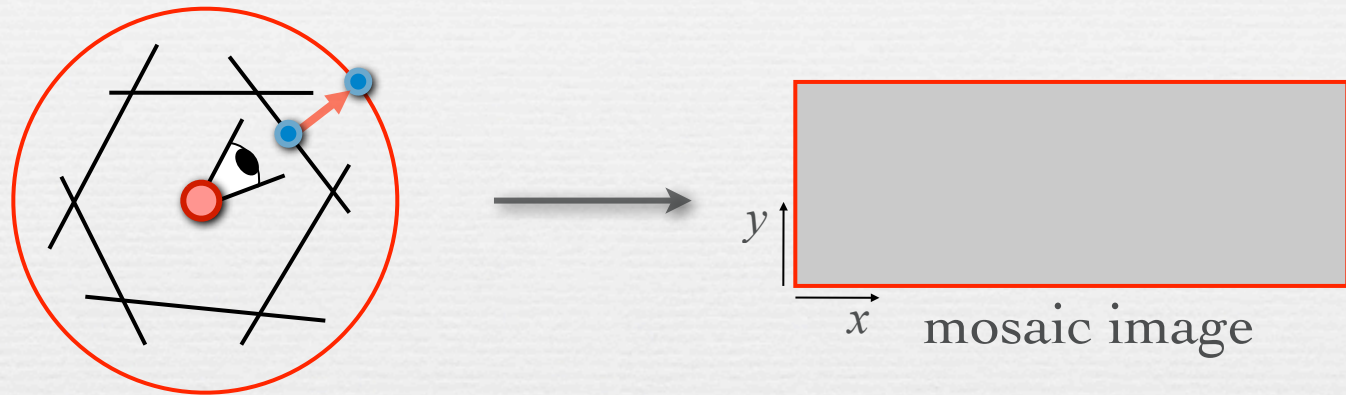
Using 4 shots instead of 3



perspective projection

Cylindrical panoramas

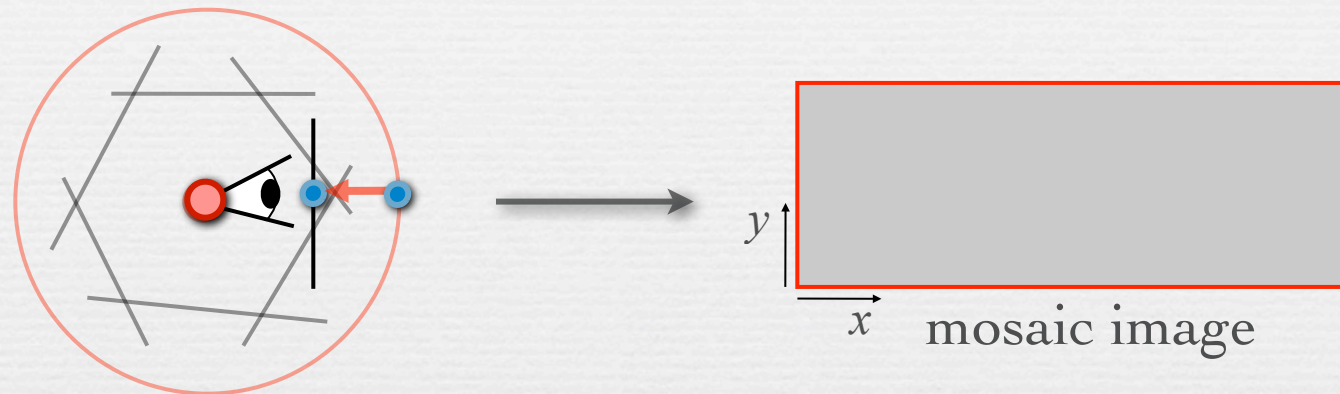
- ◆ even works for 360° panorama



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

Cylindrical panoramas

- ◆ 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

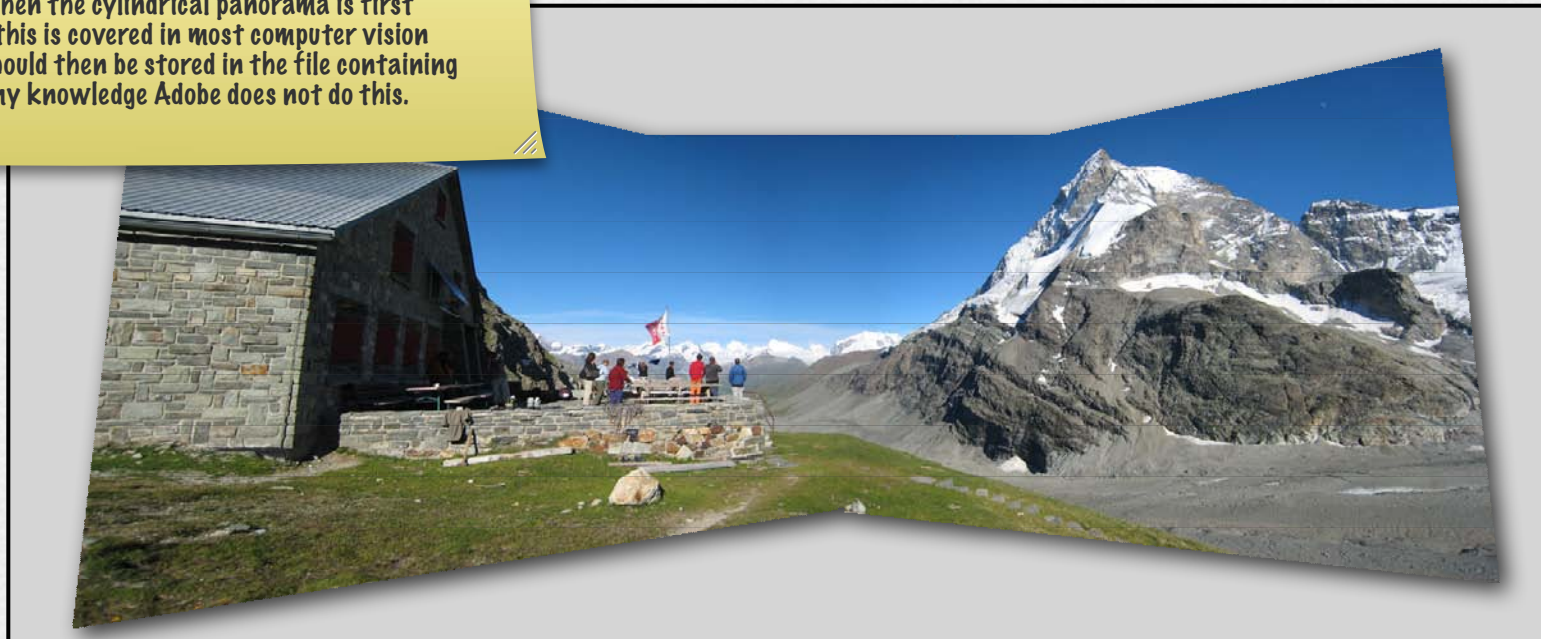
blended

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).



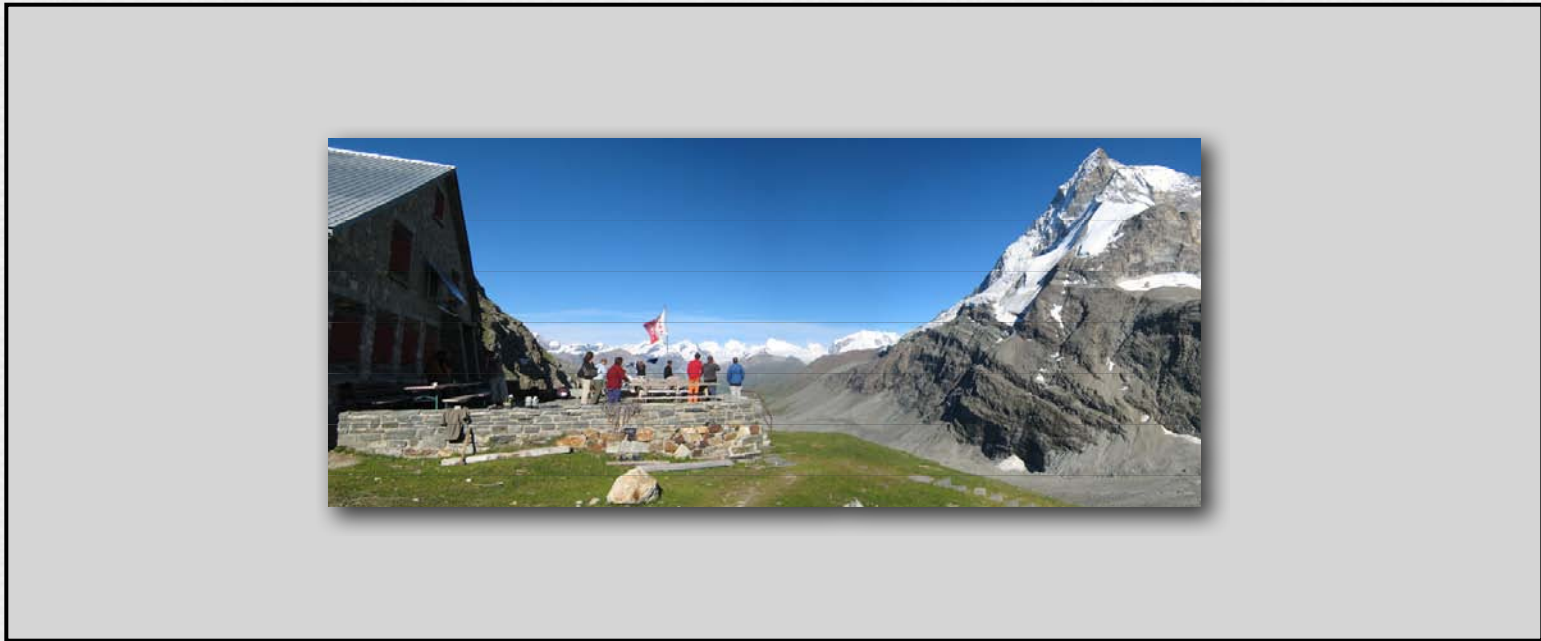
Also, as a student in class astutely observed, you need to know the field of view (FOV) of the panorama in order to perform this reprojection, i.e. how wide an angular extent does it cover? 90 degrees? a complete 360-degree circle? The FOV can be estimated when the cylindrical panorama is first created; how to do this is covered in most computer vision courses. The FOV should then be stored in the file containing the panorama. To my knowledge Adobe does not do this.



perspective reprojection onto a plane

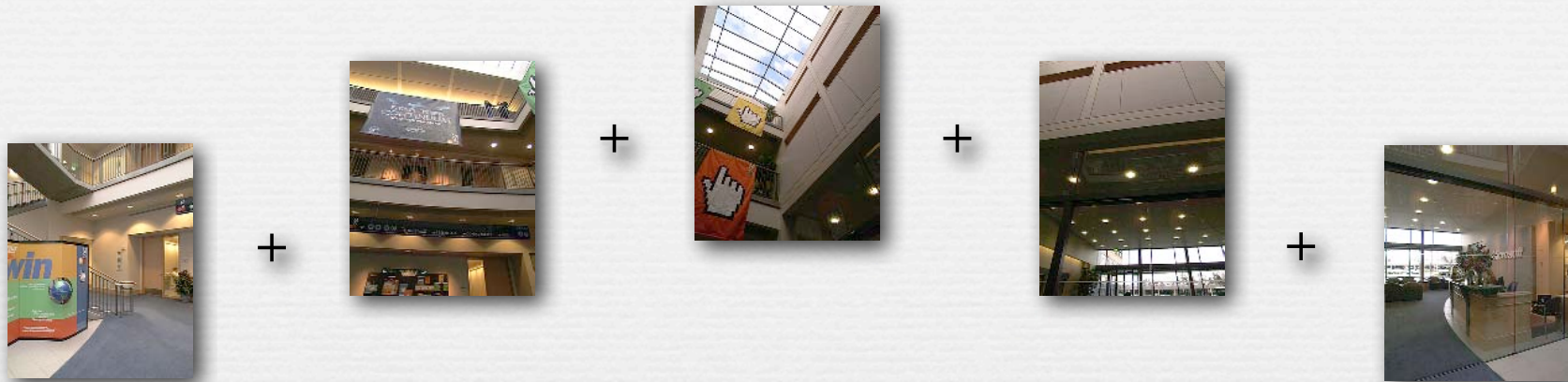
Example

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 hide distorted portions

Spherical panoramas



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

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
 - optionally reproject them to a picture plane for display (not done by Photoshop)
- ◆ spherical panoramas are possible, but cannot be stored as rectangular images without extreme stretching of the image

Questions?

Slide credits

- ◆ Fredo Durand
 - ◆ Alyosha Efros
 - ◆ Steve Seitz
 - ◆ Rick Szeliski
-
- ◆ Frost, Lee, *Panoramic Photography*, F+W Publications, 2005.

calvin and HOBBS

by WATTERSON

