CSCE 641 Computer Graphics: Image Mosaicing

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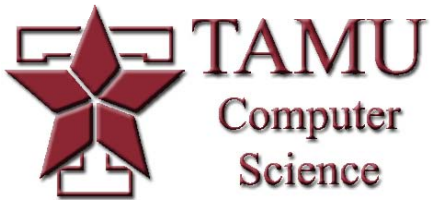


Source:
faculty.cs.tamu.edu/jchai/cpsc641_spring10/lectures/lecture8.ppt

Outline

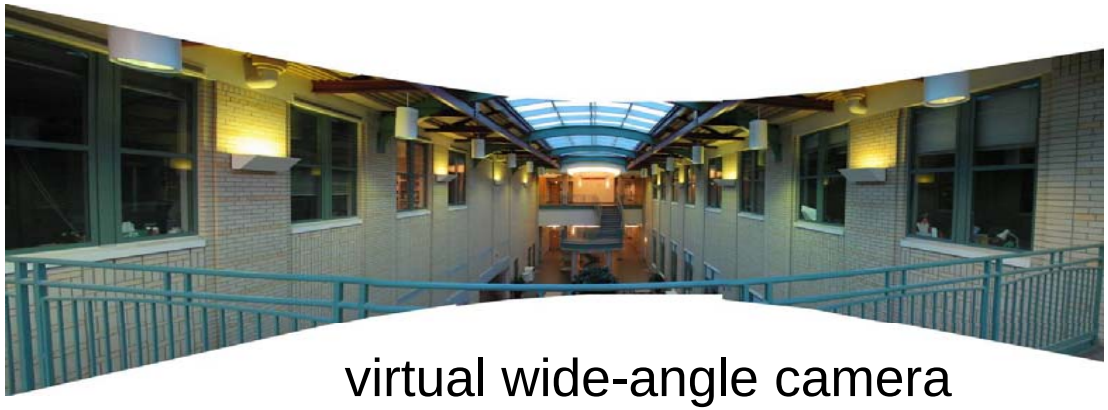
Image registration

- How to break assumptions?

3D-2D registration

Image mosaicing

Mosaics: Stitching Image Together



virtual wide-angle camera

Mosaic Procedure

Basic Procedure

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- Take a sequence of images from the same position
  - Rotate the camera about its optical center

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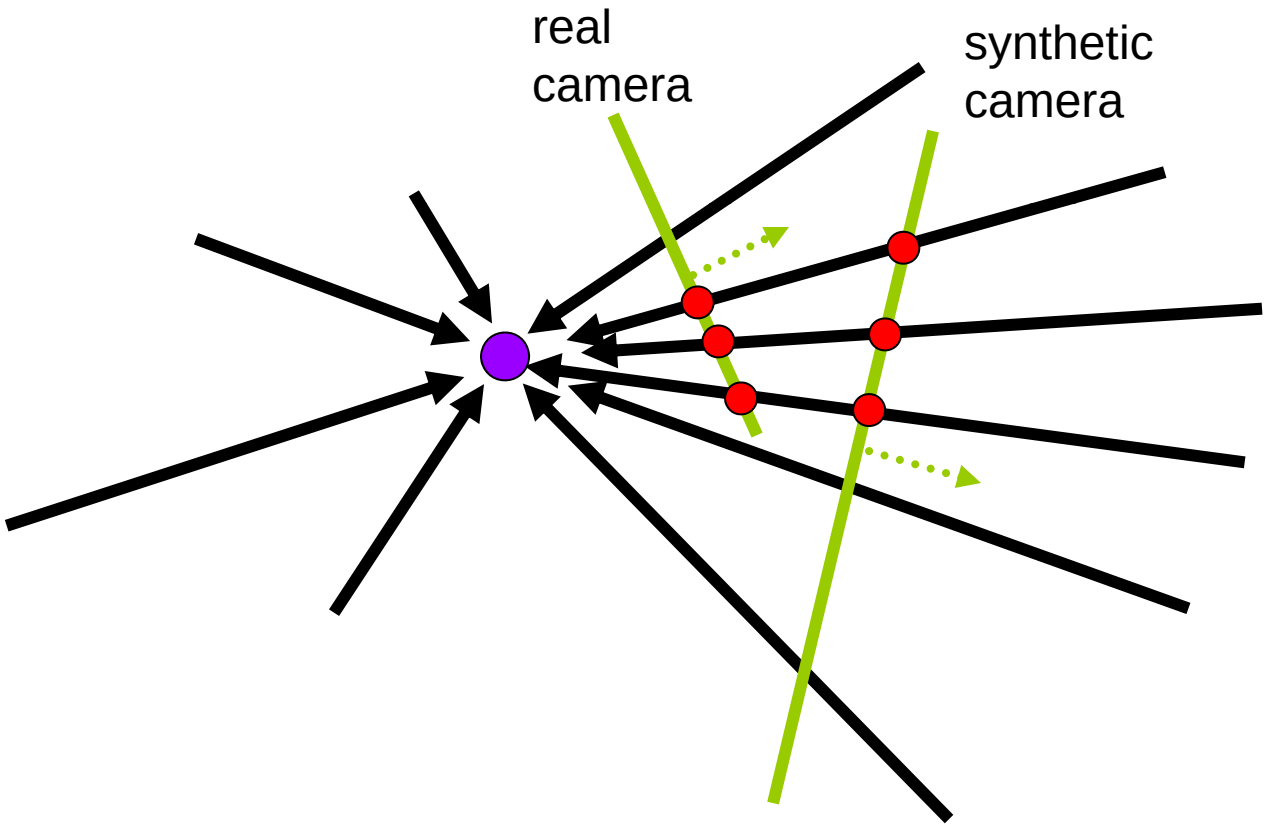
Mosaic Procedure

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

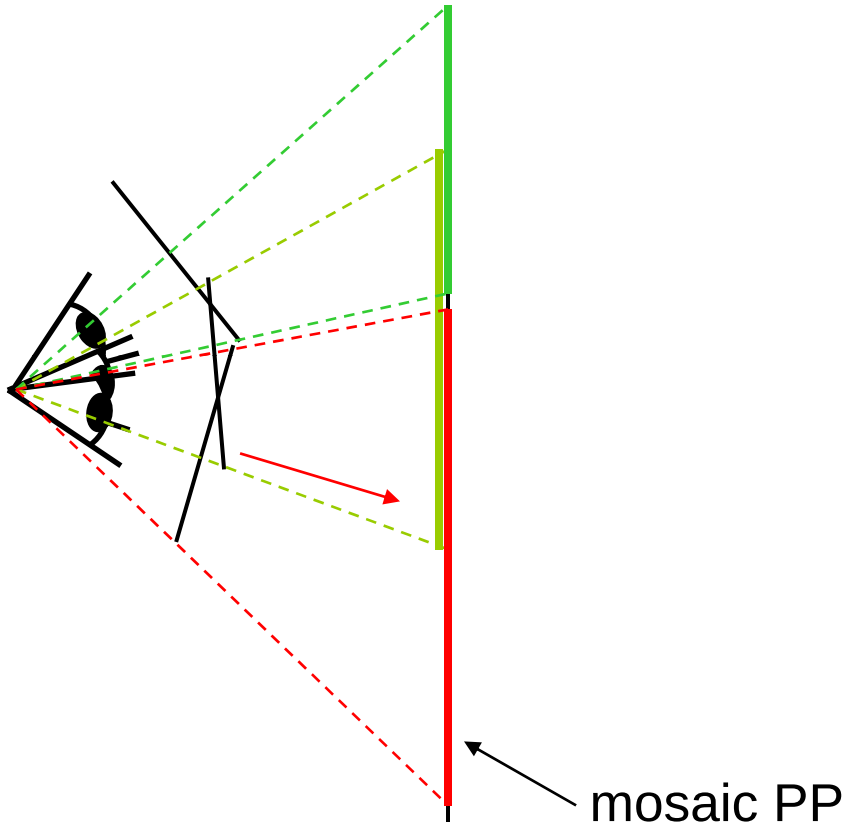
Image Mosaic

Is a pencil of rays contains all views



Can generate any synthetic camera view
as long as it has **the same center of projection**!

Image Re-projection



The mosaic has a natural interpretation in 3D

- The images are reprojected onto a common plane
- The mosaic is formed on this plane
- Mosaic is a *synthetic wide-angle camera*

Issues in Image Mosaic

How to relate two images from the same camera center?

- image registration

How to re-project images to a common plane?

- image warping

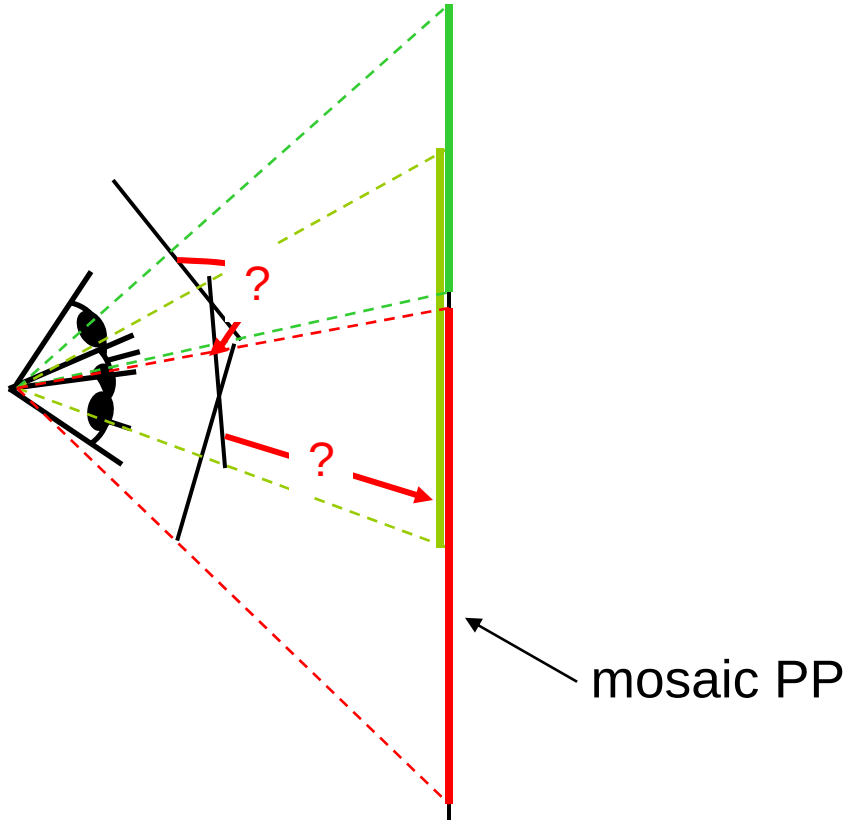


Image Mosaicing

Geometric relationship between images

Image Mosaicing

Geometric relationship between images

– Use 8-parameter projective transformation matrix

$$\begin{pmatrix} x' \\ y' \\ 1 \end{pmatrix} = \begin{vmatrix} a & b & c \\ d & e & f \\ g & h & 1 \end{vmatrix} \begin{pmatrix} x \\ y \\ 1 \end{pmatrix}$$

Image Mosaicing

Geometric relationship between images

– Use 8-parameter projective transformation matrix

$$\begin{pmatrix} x' \\ y' \\ 1 \end{pmatrix} = \begin{vmatrix} a & b & c \\ d & e & f \\ g & h & 1 \end{vmatrix} \begin{pmatrix} x \\ y \\ 1 \end{pmatrix}$$

– Use a 3D rotation model (one R per image)

$$\begin{vmatrix} r_{00} & r_{01} & f_0 r_{02} \\ r_{10} & r_{11} & f_0 r_{12} \\ r_{20}/f_1 & r_{21}/f_1 & f_0 r_{21}/f_1 \end{vmatrix}$$

Derive it by yourself!

Image Mosaicing

Geometric relationship between images

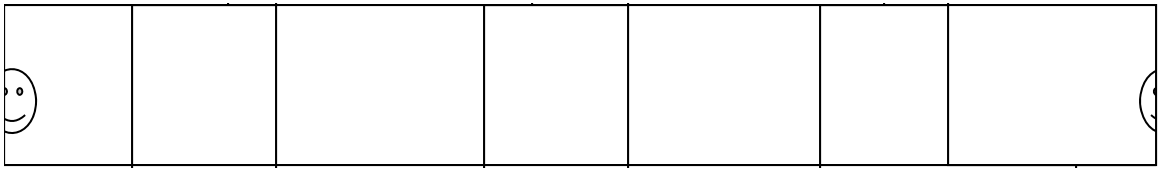
- Use 8-parameter projective transformation matrix
- Use a 3D rotation model (one R per image)

Register *all* pairwise overlapping images

- Feature-based registration
- Pixel-based registration

Chain together inter-frame rotations

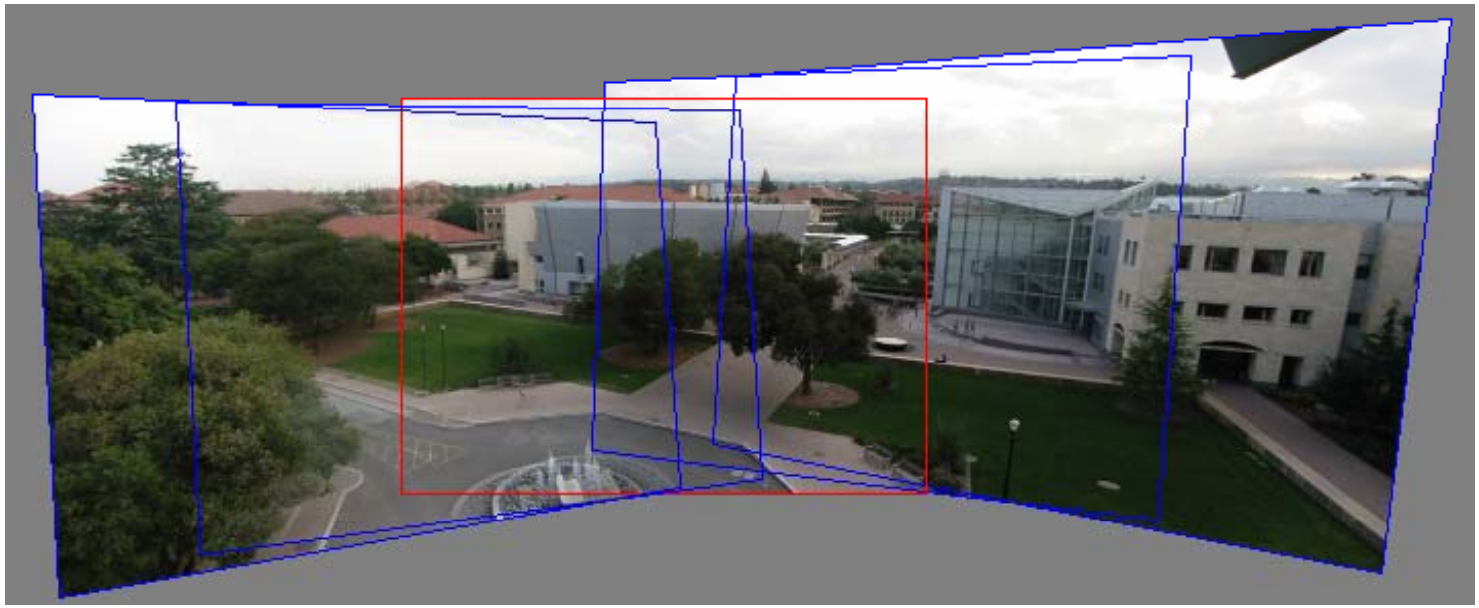
Image Stitching



Stitch pairs together, blend, then crop

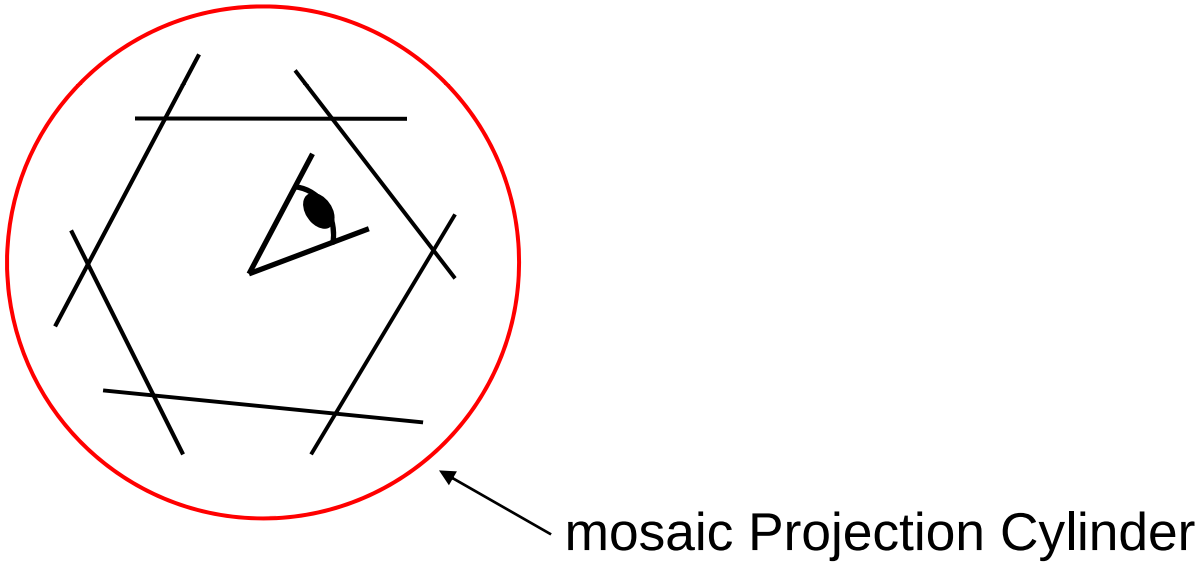
Image Stitching

A big image stitched from 5 small images

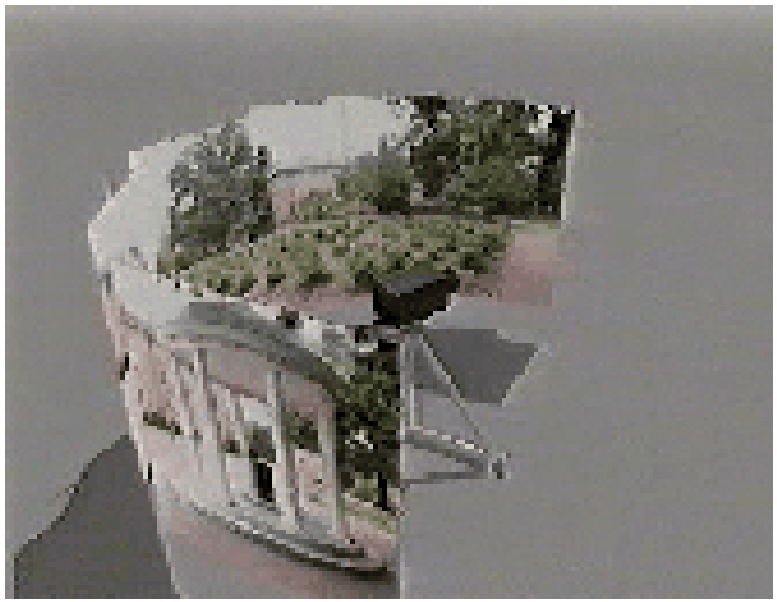


Panoramas

What if you want a 360° field of view?



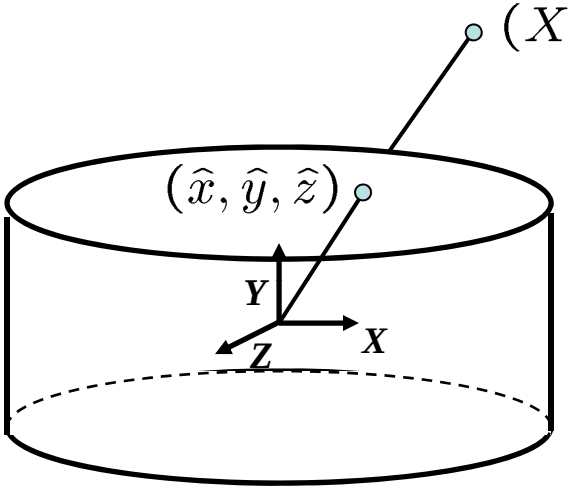
Cylindrical Panoramas



Steps

- Re-project each image onto a cylinder
- Blend
- Output the resulting mosaic

Cylindrical Projection

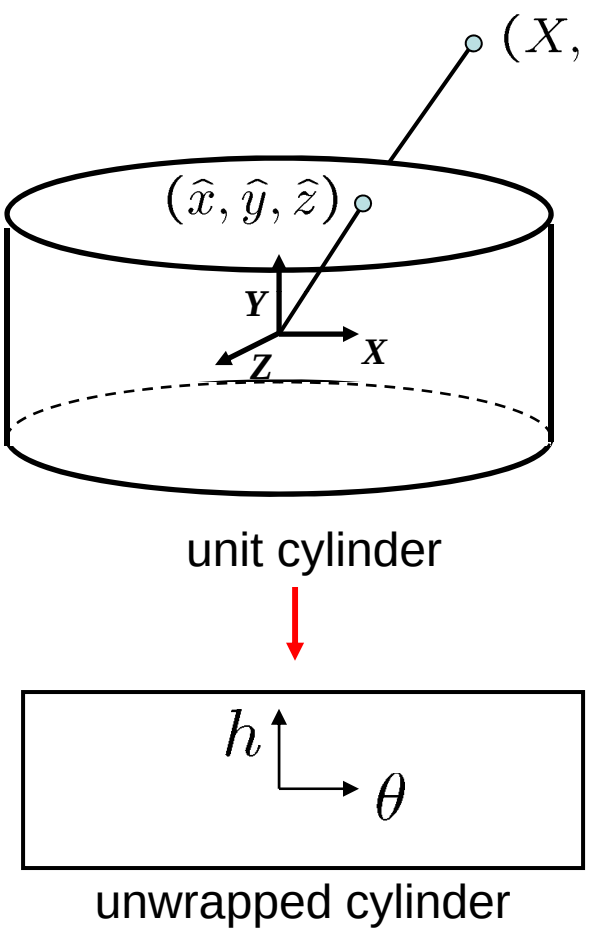


unit cylinder

(X, Y, Z) – Map 3D point (X,Y,Z) onto cylinder

$$(\hat{x}, \hat{y}, \hat{z}) = \frac{1}{\sqrt{X^2+Z^2}}(X, Y, Z)$$

Cylindrical Projection



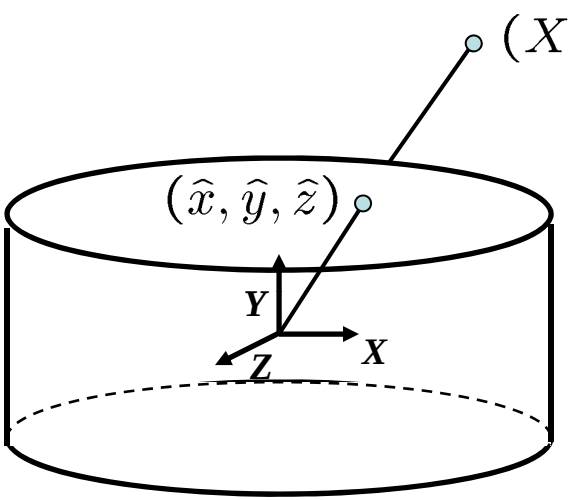
- (X, Y, Z) – Map 3D point (X,Y,Z) onto cylinder

$$(\hat{x}, \hat{y}, \hat{z}) = \frac{1}{\sqrt{X^2+Z^2}}(X, Y, Z)$$

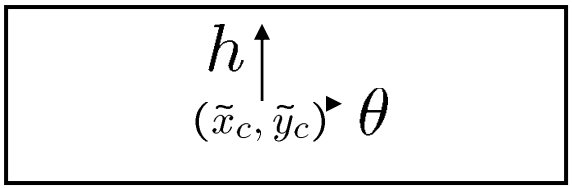
- Convert to cylindrical coordinates

$$(sin\theta, h, cos\theta) = (\hat{x}, \hat{y}, \hat{z})$$

Cylindrical Projection



unit cylinder



unwrapped cylinder

cylindrical image

– Map 3D point (X,Y,Z) onto cylinder

$$(\hat{x}, \hat{y}, \hat{z}) = \frac{1}{\sqrt{X^2+Z^2}}(X, Y, Z)$$

– Convert to cylindrical coordinates

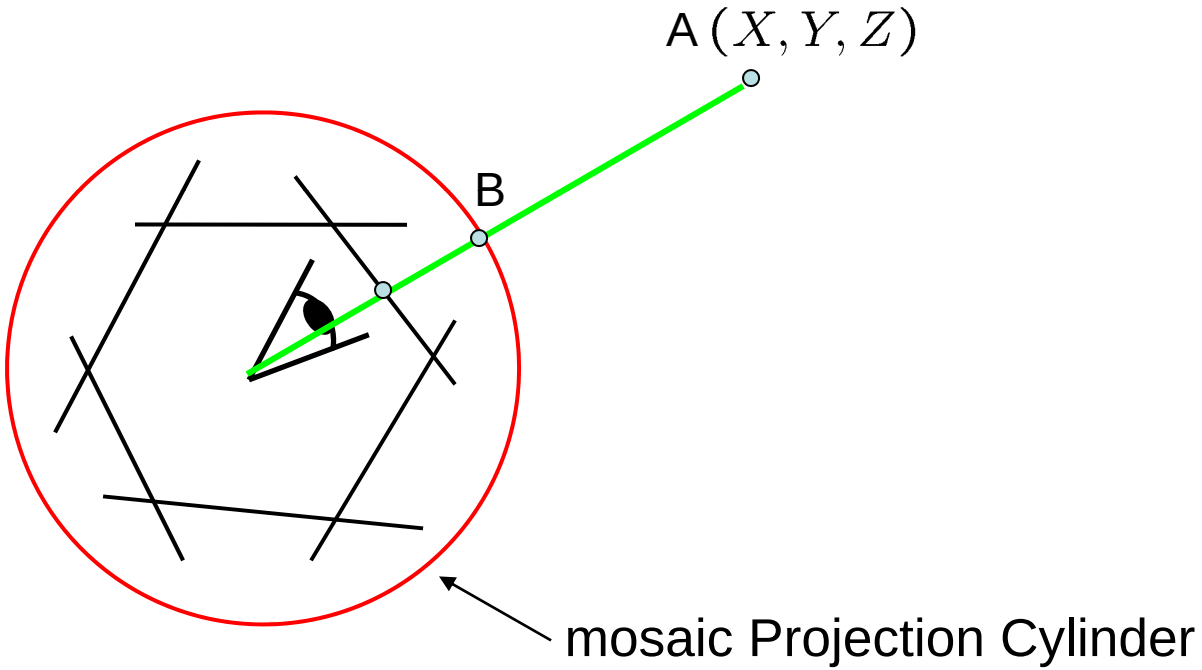
$$(sin\theta, h, cos\theta) = (\hat{x}, \hat{y}, \hat{z})$$

– Convert to cylindrical image coordinates

$$(\tilde{x}, \tilde{y}) = (s\theta, sh) + (\tilde{x}_c, \tilde{y}_c)$$

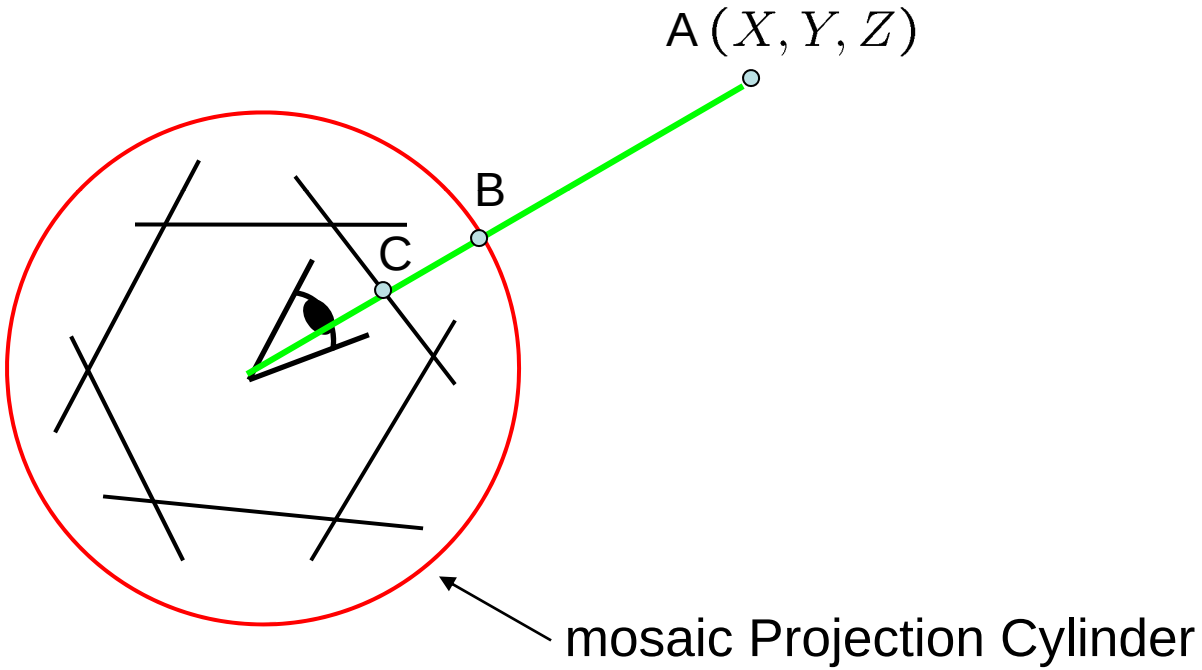
- s defines size of the final image

Cylindrical Panoramas



Cannot map point A to Point B without knowing (X,Y,Z)

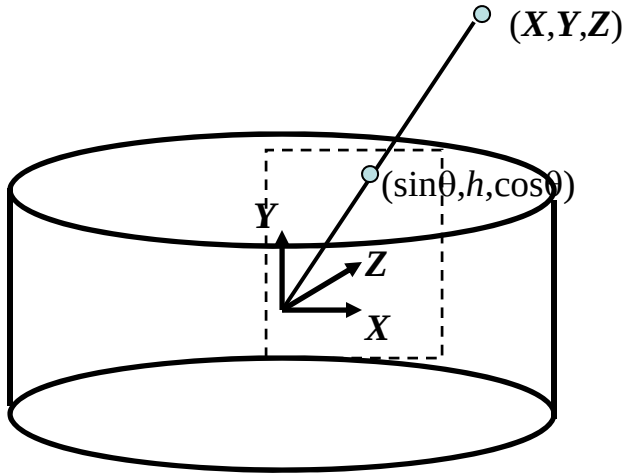
Cylindrical Panoramas



But we can map point C (images) to Point B.

Cylindrical Warping

Given focal length *f* and image center (*xc*,*yc*)



$$
\begin{aligned}
\theta &= (x_{cyl} - x_c)/f \\
h &= (y_{cyl} - y_c)/f \\
\hat{x} &= \sin\theta \\
\hat{y} &= h \\
\hat{z} &= \cos\theta \\
x &= f\hat{x}/\hat{z} + x_c \\
y &= f\hat{y}/\hat{z} + y_c
\end{aligned}
$$

Cylindrical Panoramas

Map image to cylindrical or spherical coordinates

- need *known* focal length

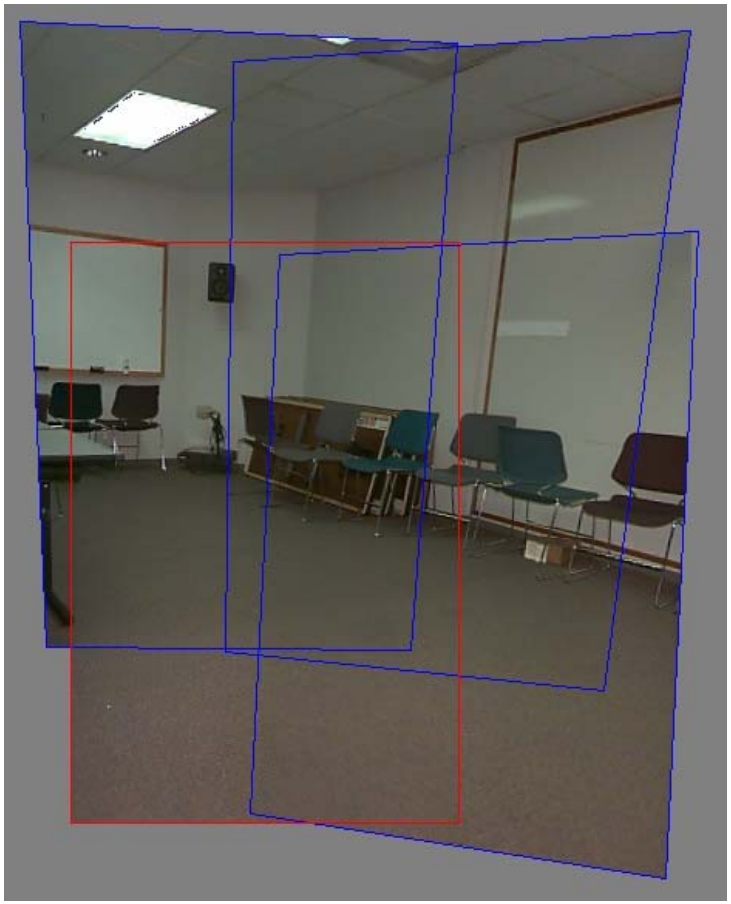
Image 384x300

f = 180 (pixels)

f = 280

f = 380

Cylindrical Panorama



3D rotation registration of four images taken with a handheld camera.

Cylindrical Panorama

Recognizing panoramas

- A fully automatic 2D image stitcher system

Input Images

Output panorama #1

Recognizing panoramas

- A fully automatic 2D image stitcher system

Input Images

Output panorama #2

Recognizing panoramas

- A fully automatic 2D image stitcher system

Input Images

Output panorama #3

Recognizing panoramas

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Input Images

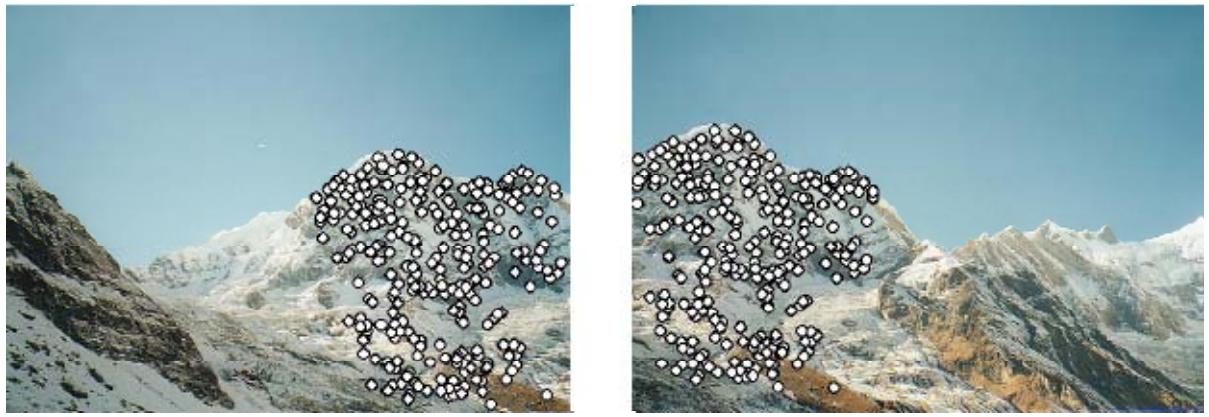
- How to recognize which images can be used for panoramas?
- How to stitch them automatically?

Recognizing panoramas

- A fully automatic 2D image stitcher system


Recognizing panoramas

- A fully automatic 2D image stitcher system



- Image matching with SIFT features
- For every image, find the M best images with RANSAC
- Form a graph and find connected component in the graph
- Stitching and blending.

Outline

Image registration

- How to break assumptions? (cont.)

3D-2D registration

Image mosaicing