CSCI 497P/597P: Computer Vision

Lecture 18
Pinhole Camera Model
360 (Spherical) Panoramas
Announcements

• Deadline to pair up for P2 is Wednesday night.
  • Include your github usernames in your email.

• Reminder/597 update: Letter grade surveys
  • 497: opt in for letter grade by June 5
  • 597 opt in for P/NP by May 22
Goals

- Understand where images come from (under the pinhole camera model)
- Be able to derive the 3x4 pinhole projection matrix
- Understand the interpretation of planar panorama stitching in terms of using homographies to map images onto a common plane.
- Know how to create 360 degree panoramas by mapping images onto a spherical surface instead.
Can we make 360 panoramas?

To answer this, we need to know how these images came to be. Why can we even make any panoramas with homographies?
Where do images come from?

497Cam, Mk I
Sensor → Pinhole

497Cam, Mk II
Camera Obscura (pinhole camera)
The Effect of Pinhole Size
Aside: What about Lenses?
The Pinhole Camera Model

• 497Cam, Mk II:
• 497Cam, Mk IIM:
Projection in a Pinhole Camera

- Ms. Collins' geometric (10th grade) way:
\[ \frac{y'}{y} = \left( \frac{f}{z} \right) y \]

These are 3D (non-homogeneous) coordinates.

In the image, the coordinates will be:

\[ \begin{bmatrix} x' \\ y' \\ z' \end{bmatrix} = \begin{bmatrix} -fx \\ fy \\ z \end{bmatrix} \\]

because if we divide out the f, all entries would have f=1.
Projection in a Pinhole Camera

- Dr. Swenton's (15th grade) way:

\[
\begin{bmatrix}
-x \\
-fx \\
fy \\
2
\end{bmatrix}
\Rightarrow
\begin{bmatrix}
-x \\
-fx \\
fy \\
2
\end{bmatrix}
\Rightarrow
\begin{bmatrix}
x \\
y \\
-z \\
2
\end{bmatrix}
= \begin{bmatrix}
1 & 0 & 0 & 0 & 0 \\
0 & 1 & 0 & 0 & 0 \\
0 & 0 & 1 & -f & 0 \\
0 & 0 & 0 & 0 & 1
\end{bmatrix}
\begin{bmatrix}
x \\
y \\
z \\
2
\end{bmatrix}
\]

Pinhole projection matrix

What we want to end up with:

Get rid of division

Put all weirdness in one place

3D homography
Scene coords
Reinterpreting Homographies

A 3x3 linear transformation, applied to a projection plane.
Reinterpreting Homography-aligned Panoramas

- Several image planes are warped (projected) onto a common image plane.
I'll ask it again:
Can we make 360 panoramas?
Spherical Panoramas

Idea: project images onto a sphere instead of a plane.

What motion model do we use?