EECS 442 Discussion

Arash Ushani

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Announcements

- HW3 due 10/29
- Project Proposals due 10/22
- Thank you for filling out midterm evaluations!
- Jon Beaumont from ETC is here for a Midterm Student Feedback session

Perspective Camera Model

$$\begin{bmatrix} x \\ y \\ 1 \end{bmatrix} = \begin{bmatrix} p_{11} & p_{12} & p_{13} & p_{14} \\ p_{21} & p_{22} & p_{23} & p_{24} \\ p_{31} & p_{32} & p_{33} & p_{34} \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \\ 1 \end{bmatrix}$$

Affine Camera Model

$$\begin{bmatrix} x \\ y \\ 1 \end{bmatrix} = \begin{bmatrix} p_{11} & p_{12} & p_{13} & p_{14} \\ p_{21} & p_{22} & p_{23} & p_{24} \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \\ 1 \end{bmatrix}$$

Affine Camera Model

$$\begin{bmatrix} x \\ y \\ 1 \end{bmatrix} = \begin{bmatrix} p_{11} & p_{12} & p_{13} & p_{14} \\ p_{21} & p_{22} & p_{23} & p_{24} \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \\ 1 \end{bmatrix}$$

- Why do this?

Affine Camera Model

$$\begin{bmatrix} x \\ y \\ 1 \end{bmatrix} = \begin{bmatrix} p_{11} & p_{12} & p_{13} & p_{14} \\ p_{21} & p_{22} & p_{23} & p_{24} \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \\ 1 \end{bmatrix}$$

- Why do this?
- What are the knowns and unknowns?

Affine Camera Model

$$\begin{bmatrix} x \\ y \\ 1 \end{bmatrix} = \begin{bmatrix} p_{11} & p_{12} & p_{13} & p_{14} \\ p_{21} & p_{22} & p_{23} & p_{24} \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \\ 1 \end{bmatrix}$$

- Why do this?
- What are the knowns and unknowns?
- How many unknowns?

Affine Camera Model

$$\begin{bmatrix} x \\ y \\ 1 \end{bmatrix} = \begin{bmatrix} p_{11} & p_{12} & p_{13} & p_{14} \\ p_{21} & p_{22} & p_{23} & p_{24} \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \\ 1 \end{bmatrix}$$

- Why do this?
- What are the knowns and unknowns?
- How many unknowns? 8

Affine Camera Model

$$\begin{bmatrix} x \\ y \\ 1 \end{bmatrix} = \begin{bmatrix} p_{11} & p_{12} & p_{13} & p_{14} \\ p_{21} & p_{22} & p_{23} & p_{24} \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \\ 1 \end{bmatrix}$$

- Why do this?
- What are the knowns and unknowns?
- How many unknowns? 8
- How many constraints per correspondence?

Affine Camera Model

$$\begin{bmatrix} x \\ y \\ 1 \end{bmatrix} = \begin{bmatrix} p_{11} & p_{12} & p_{13} & p_{14} \\ p_{21} & p_{22} & p_{23} & p_{24} \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \\ 1 \end{bmatrix}$$

- Why do this?
- What are the knowns and unknowns?
- How many unknowns? 8
- How many constraints per correspondence? 2

Solving for camera matrix

$$\begin{bmatrix} x \\ y \\ 1 \end{bmatrix} = \begin{bmatrix} p_{11} & p_{12} & p_{13} & p_{14} \\ p_{21} & p_{22} & p_{23} & p_{24} \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \\ 1 \end{bmatrix}$$

- We want to set up a least squares problem to solve for the unknowns.

$$\mathbf{A}p = b$$

Solving for camera matrix

$$\begin{bmatrix} x \\ y \\ 1 \end{bmatrix} = \begin{bmatrix} p_{11} & p_{12} & p_{13} & p_{14} \\ p_{21} & p_{22} & p_{23} & p_{24} \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \\ 1 \end{bmatrix}$$

$$\begin{bmatrix} x \\ y \\ 1 \end{bmatrix} = \begin{bmatrix} Xp_{11} + Yp_{12} + Zp_{13} + p_{14} \\ Xp_{21} + Yp_{22} + Zp_{23} + p_{24} \\ 1 \end{bmatrix}$$

Solving for camera matrix

$$\begin{bmatrix} X & Y & Z & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & X & Y & Z & 1 \end{bmatrix} \begin{bmatrix} p_{11} \\ p_{12} \\ p_{13} \\ p_{14} \\ p_{21} \\ p_{22} \\ p_{23} \\ p_{24} \end{bmatrix} = \begin{bmatrix} x \\ y \end{bmatrix}$$

Solving for camera matrix

$$\underbrace{\begin{bmatrix} X & Y & Z & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & X & Y & Z & 1 \end{bmatrix}}_{\mathbf{A}} \underbrace{\begin{bmatrix} p_{11} \\ p_{12} \\ p_{13} \\ p_{14} \\ p_{21} \\ p_{22} \\ p_{23} \\ p_{24} \end{bmatrix}}_{p} = \underbrace{\begin{bmatrix} x \\ y \end{bmatrix}}_{b}$$

$$\mathbf{A}p = b$$

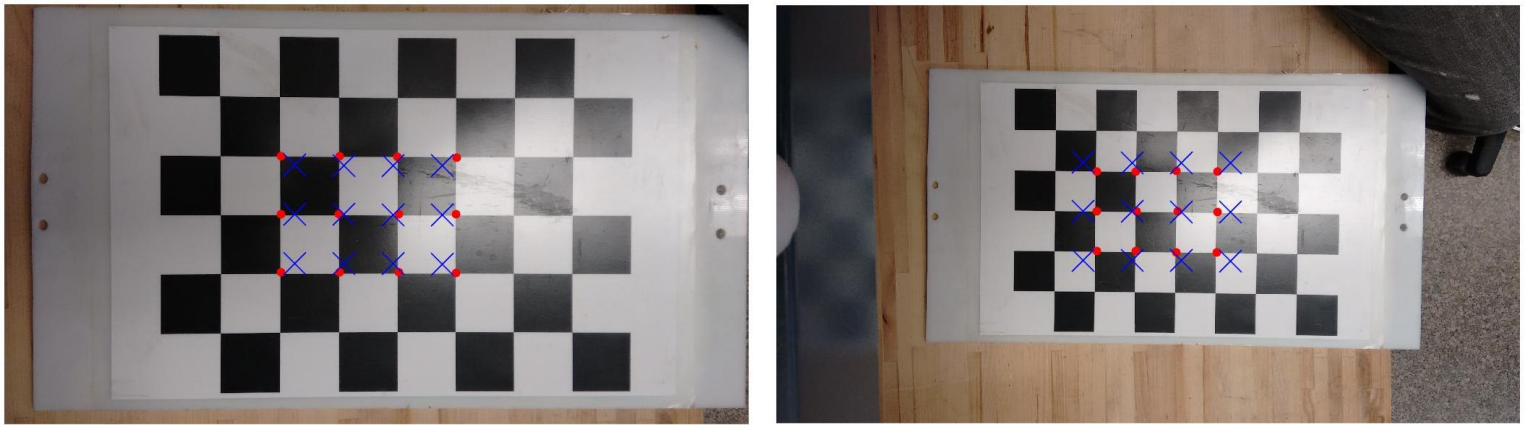
Solving for camera matrix

$$\underbrace{\begin{bmatrix} X & Y & Z & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & X & Y & Z & 1 \end{bmatrix}}_{\mathbf{A}} \underbrace{\begin{bmatrix} p_{11} \\ p_{12} \\ p_{13} \\ p_{14} \\ p_{21} \\ p_{22} \\ p_{23} \\ p_{24} \end{bmatrix}}_{p} = \underbrace{\begin{bmatrix} x \\ y \end{bmatrix}}_{b}$$

$$\mathbf{A}p = b$$

- Stack all constraints from correspondences into **A** and find least squares solution!

MATLAB Exercise



(a) Image 1 (z=45 cm) (b) Image 2 (z=65 cm)

- Go to CTools → Resources → Discussion → 10_21_matlab.zip
- Given a set of correspondences in each image to world frame points, find camera matrix

$$\mathbf{M} = \begin{bmatrix} 48.003 & -0.05515 & 3.6068 & 1112.3 \\ 0.23531 & 47.705 & -0.62871 & 731.86 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$