Computer Vision I

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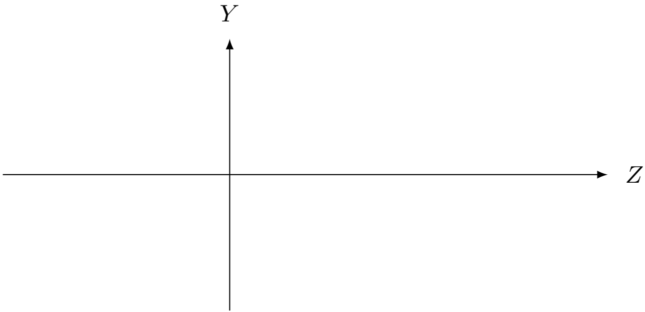
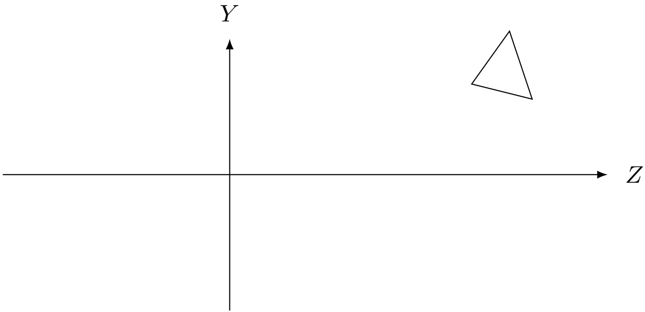
Machine Learning for Computer Vision
TU Dresden

Winter Term 2022/2023

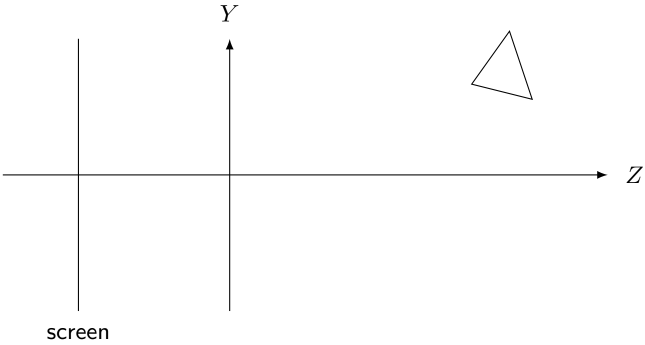
Projective camera



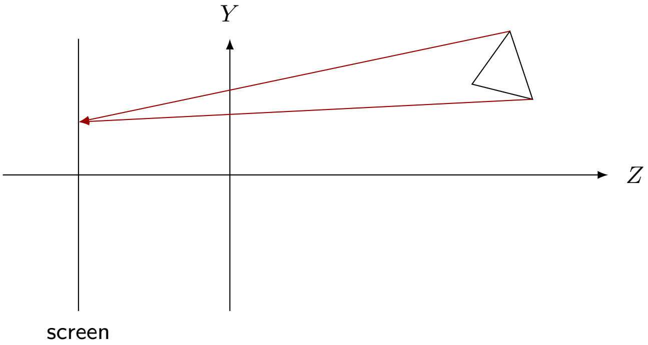
Projective camera



Projective camera



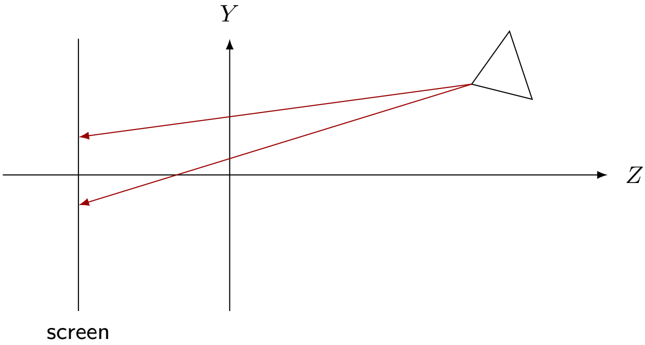
Projective camera



No image formation because

- light incident on one point on the screen originates from different points in the scene

Projective camera



No image formation because

- light incident on one point on the screen originates from different points in the scene
- light emitted from one point in the scene is incident on different points on the screen

Projective camera

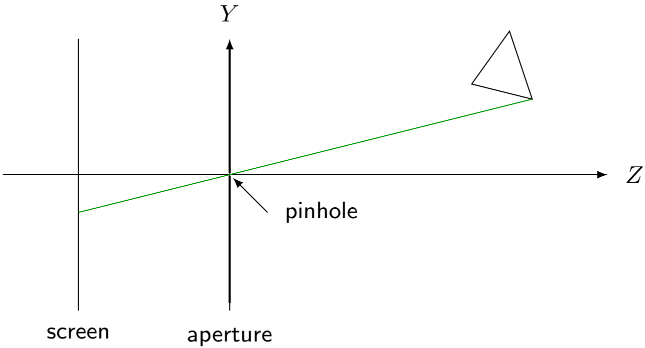


Image formation because

- all light incident on one (any given) point on the screen originates from the same point in the scene
- all light emitted from one (any given) point in the scene is incident on the same point on the screen

Projective camera

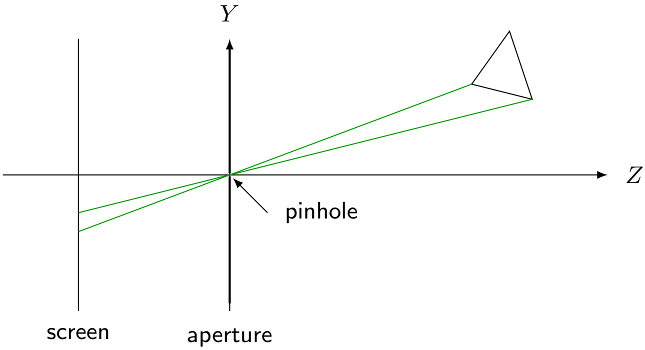


Image formation because

- all light incident on one (any given) point on the screen originates from the same point in the scene
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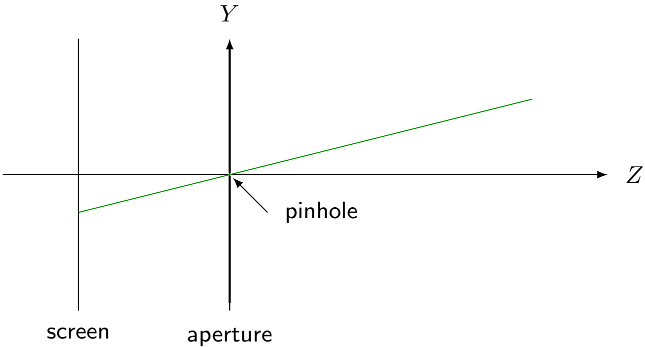
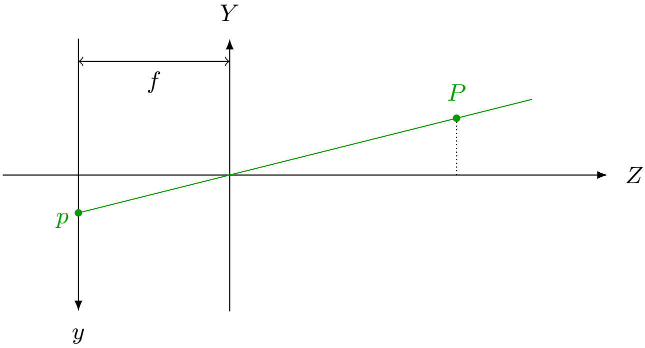
Projective camera



- Limitation: Intensity of light on the screen infinitesimally small
- Remedy: Optics (see e.g. lectures[1] by Prof. Dr. J. Czarske at TU Dresden)
- Here, we use the projective camera as a mathematical model of real optics

[1] https://tu-dresden.de/ing/elektrotechnik/iee/mst/studium/lehrveranstaltungen

Projective camera



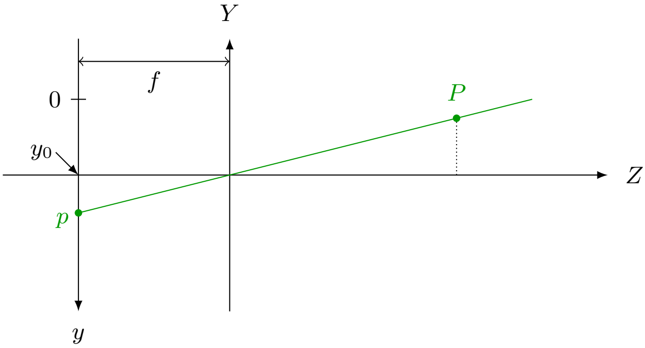
Vector coordinates (by the intersect theorem)

$$\frac{y}{f} = \frac{Y}{Z} \quad \Leftrightarrow \quad y\,Z = f\,Y \quad \Leftrightarrow \quad y = \frac{f\,Y}{Z} \tag{1}$$

Projective coordinates

$$\begin{bmatrix} y \\ w \end{bmatrix} = \begin{bmatrix} f & 0 & 0 \\ 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} Y \\ Z \\ 1 \end{bmatrix} \tag{2}$$

Projective camera



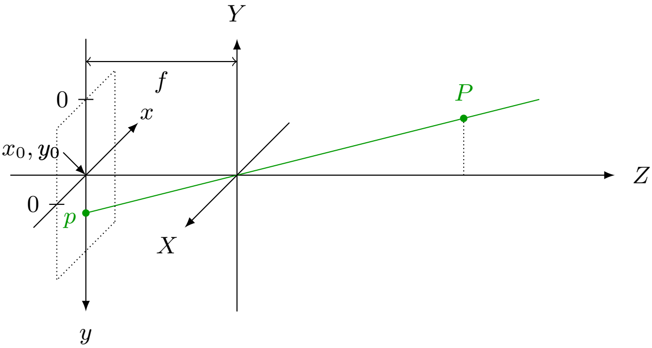
Vector coordinates (by the intersect theorem)

$$\frac{y - y_0}{f} = \frac{Y}{Z} \quad \Leftrightarrow \quad y\,Z = f\,Y + y_0\,Z \quad \Leftrightarrow \quad y = \frac{f\,Y}{Z} + y_0 \tag{1}$$

Projective coordinates

$$\begin{bmatrix} y \\ w \end{bmatrix} = \begin{bmatrix} f & y_0 & 0 \\ 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} Y \\ Z \\ 1 \end{bmatrix} \tag{2}$$

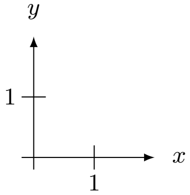
Projective camera



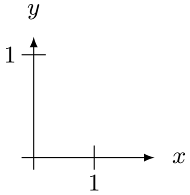
Projective coordinates

$$\begin{bmatrix} x \\ y \\ w \end{bmatrix} = \begin{bmatrix} f & 0 & x_0 & 0 \\ 0 & f & y_0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \\ 1 \end{bmatrix} \tag{1}$$

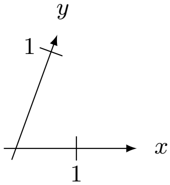
Projective camera



$$\begin{bmatrix} x \\ y \\ w \end{bmatrix} = \begin{bmatrix} f & 0 & x_0 & 0 \\ 0 & f & y_0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \\ 1 \end{bmatrix}$$

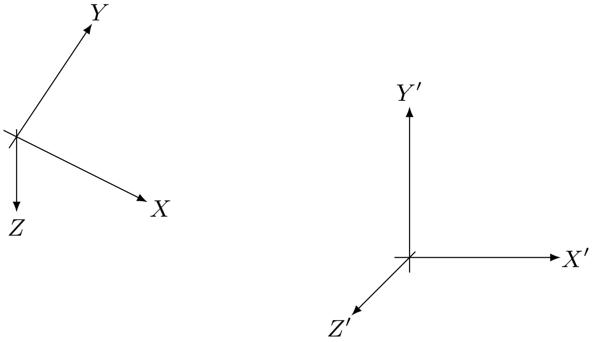


$$\begin{bmatrix} x \\ y \\ w \end{bmatrix} = \begin{bmatrix} f_x & 0 & x_0 & 0 \\ 0 & f_y & y_0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \\ 1 \end{bmatrix}$$



$$\begin{bmatrix} x \\ y \\ w \end{bmatrix} = \begin{bmatrix} f_x & s & x_0 & 0 \\ 0 & f_y & y_0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \\ 1 \end{bmatrix}$$

Projective camera



$$\begin{bmatrix} x \\ y \\ w \end{bmatrix} = \begin{bmatrix} f_x & s & x_0 & 0 \\ 0 & f_y & y_0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} R_{00} & R_{01} & R_{02} & t_0 \\ R_{10} & R_{11} & R_{12} & t_1 \\ R_{20} & R_{21} & R_{22} & t_2 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} X' \\ Y' \\ Z' \\ 1 \end{bmatrix}$$