Camera Models

16-385 Computer Vision (Kris Kitani)

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What's the difference between these two images?

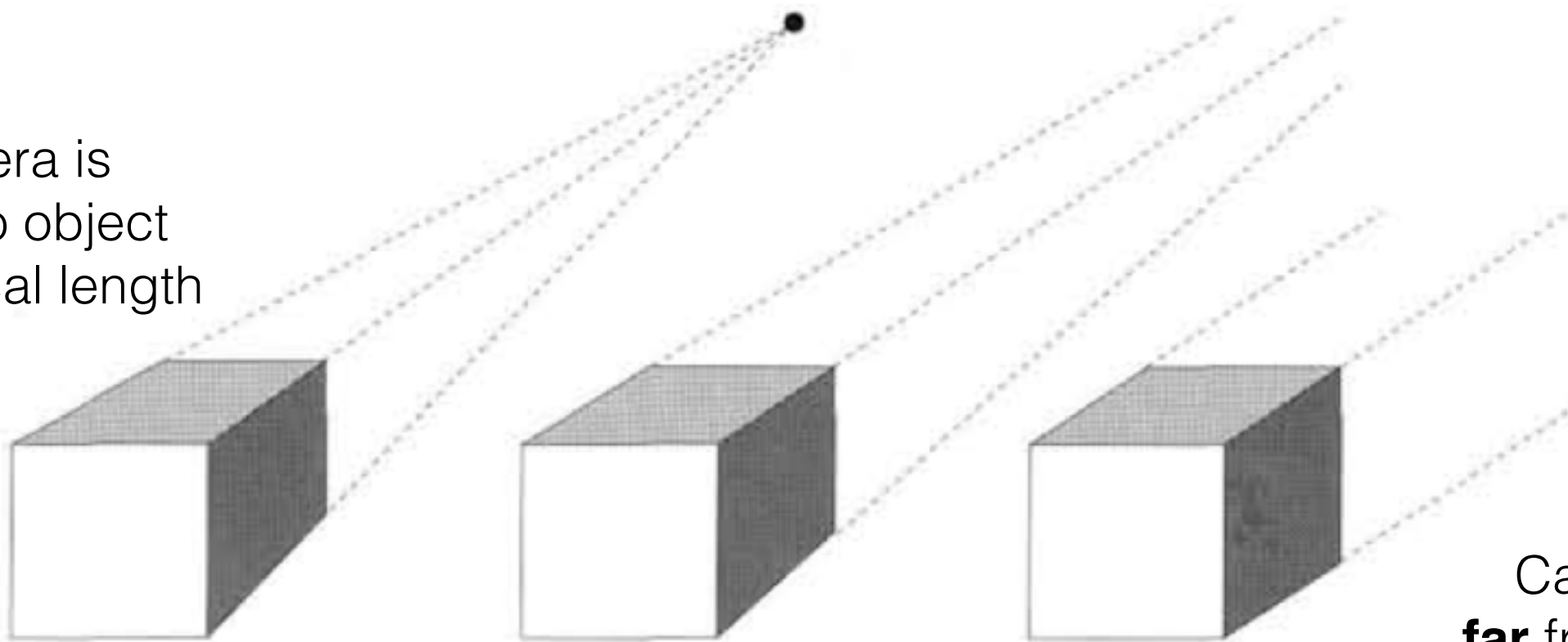*What's the difference between these two images?*

orthographic projection

perspective projection

Different imaging conditions
induce different projections

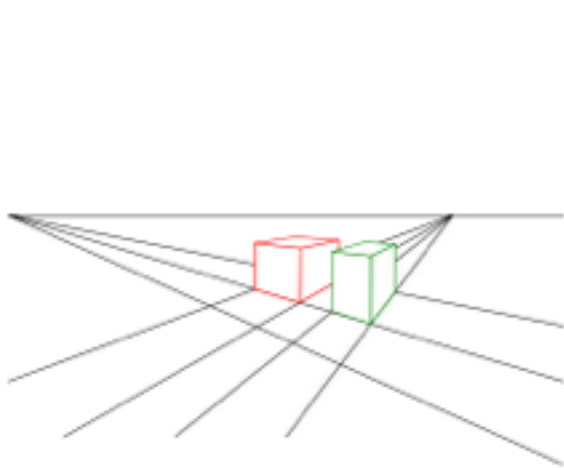Camera is
close to object
small focal length

Camera is
far from object
large focal length
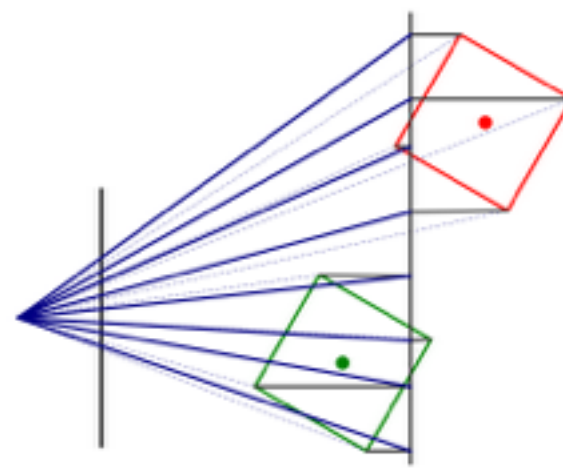
perspective

weak perspective

→ increasing focal length →
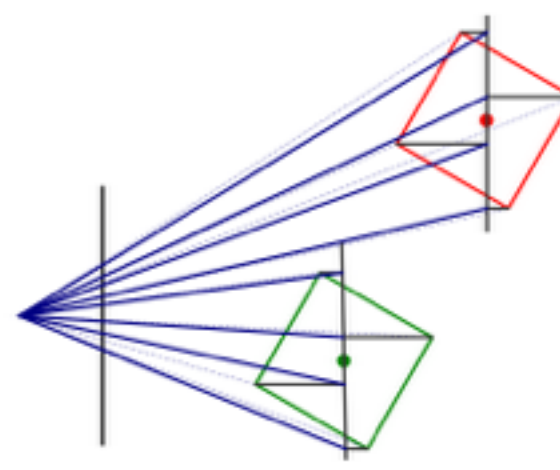
→ increasing distance from camera →

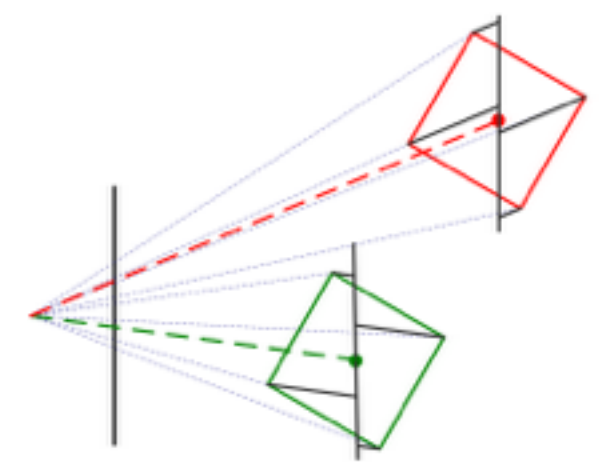# There are many types of camera models (projections)
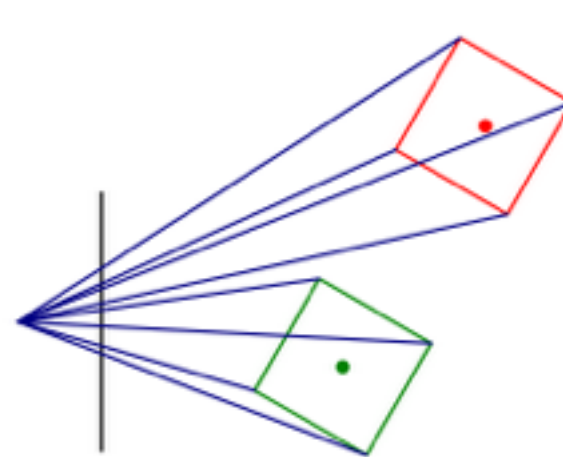

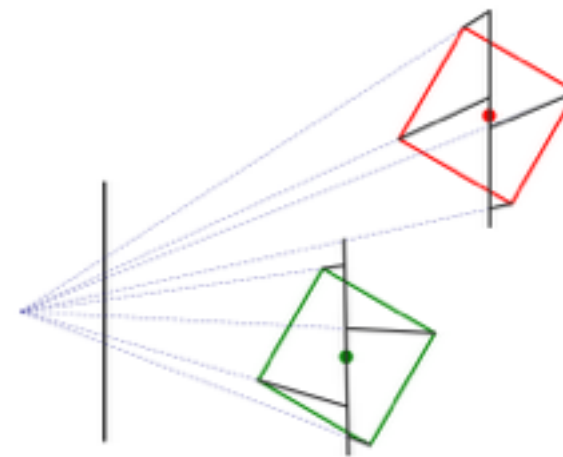(a) 3D view

(b) orthography

(c) scaled orthography

(d) para-perspective

(e) perspective

(f) object-centered

CCD camera

$$\mathbf{P} = \begin{bmatrix} \alpha_x & 0 & p_x \\ 0 & \alpha_y & p_y \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix}$$

(assuming that axes are aligned)

How many degrees of freedom?

CCD camera

$$\mathbf{P} = \begin{bmatrix} \alpha_x & 0 & p_x \\ 0 & \alpha_y & p_y \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix}$$

(assuming that axes are aligned)

How many degrees of freedom?

10 DOF

Finite projective camera

$$\mathbf{P} = \begin{bmatrix} \alpha_x & s & p_x \\ 0 & \alpha_y & p_y \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix}$$

(assuming that axes are aligned)

How many degrees of freedom?

Finite projective camera

$$\mathbf{P} = \begin{bmatrix} \alpha_x & s & p_x \\ 0 & \alpha_y & p_y \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix}$$
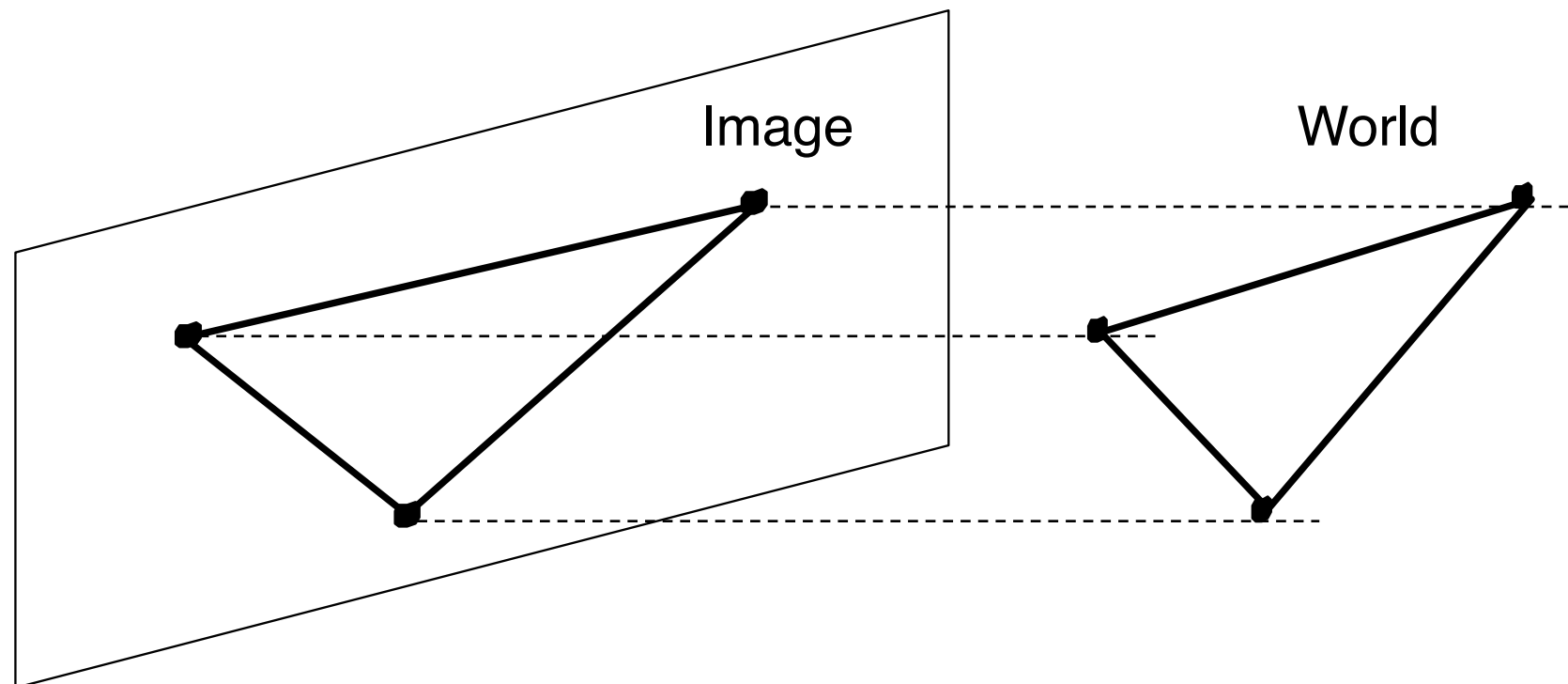
(assuming that axes are aligned)

How many degrees of freedom?

11 DOF

Orthographic camera
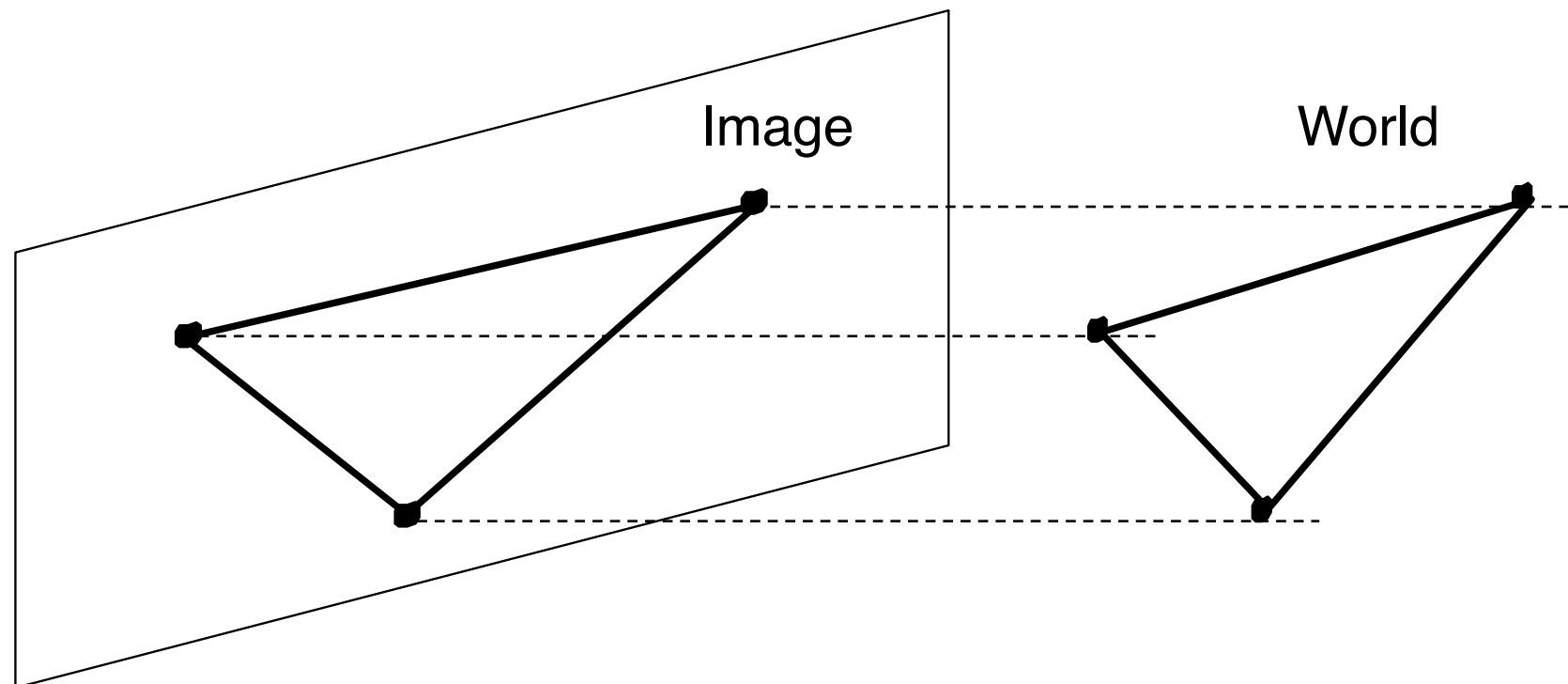
(parallel projection)

$$\mathbf{P} = \mathbf{K} \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

(assuming that axes are aligned)
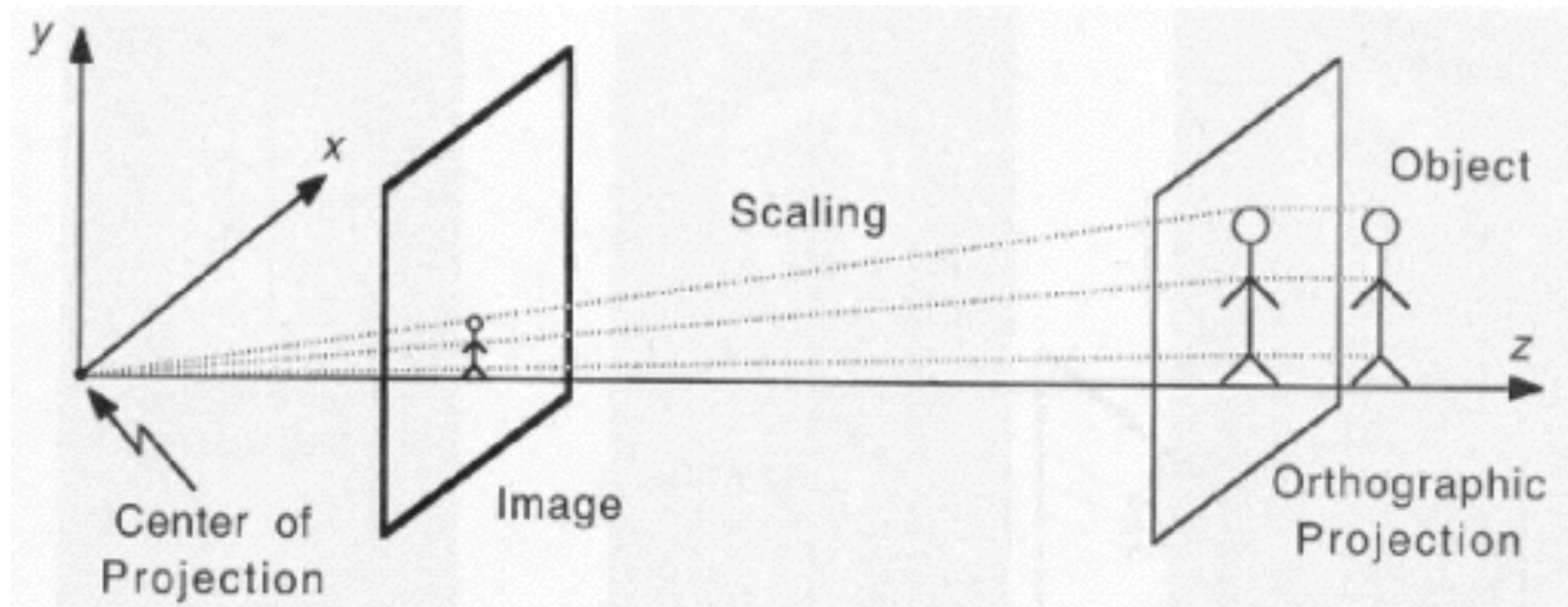
Orthographic camera

(parallel projection)

$$\mathbf{P} = \mathbf{K} \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Affine camera

(assuming that axes are aligned)

Weak Perspective Camera

$$\mathbf{P} = \mathbf{K} \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & \bar{Z} \end{bmatrix}$$

(assuming that axes are aligned)

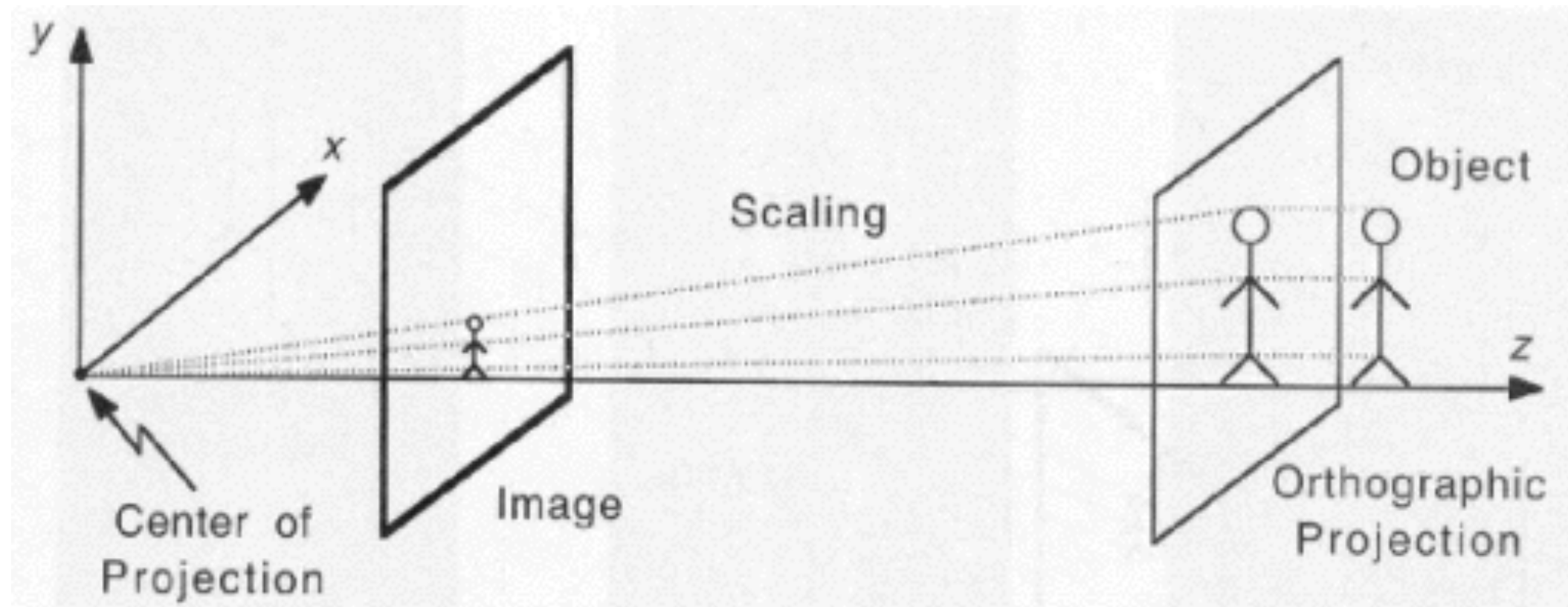# When can you assume a weak perspective camera model?

When can you assume a weak perspective camera model?

all the mountains are roughly 'far away'

Weak Perspective Camera

$$\mathbf{P} = \mathbf{K} \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & \bar{Z} \end{bmatrix}$$

Affine camera

(assuming that axes are aligned)

Perspective vs Weak Perspective Projection