Lecture 2.
Basic Camera Models
ECEN 5283 Computer Vision

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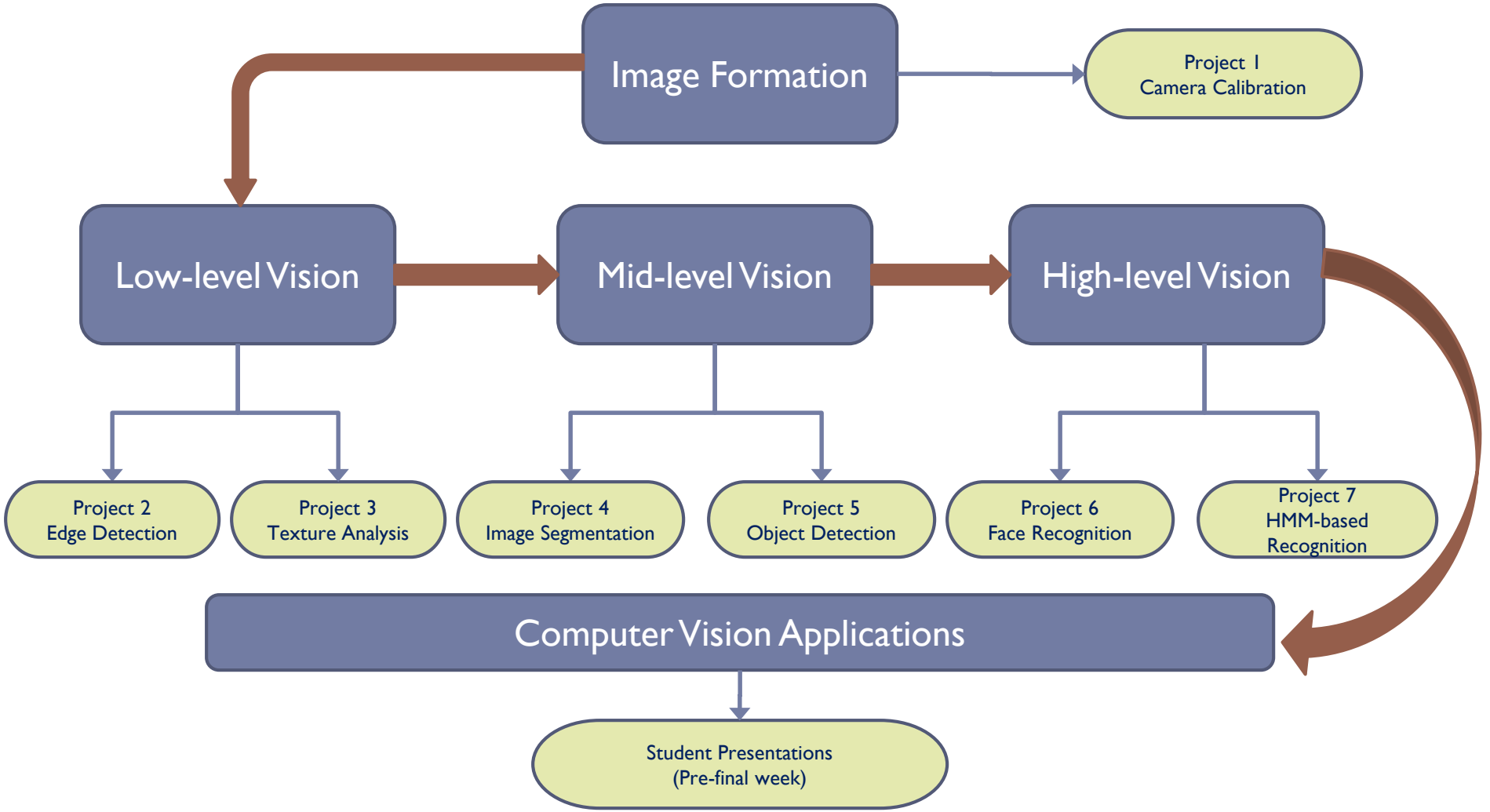
Goals

- To review the class structure.
- To study three basic camera models.
- To apply three different camera models in different situations.

Class Structure

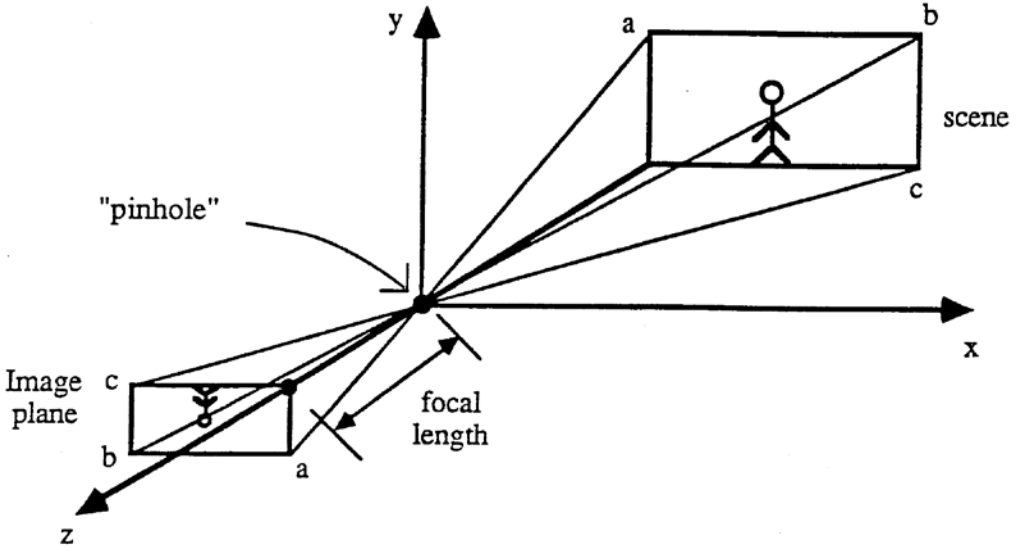


Why do we need a camera model?

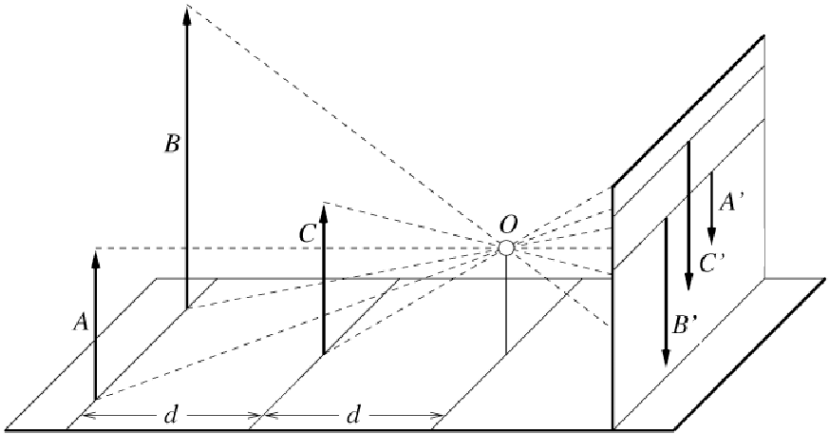
- To build a geometrical mapping relationship between the 3D scene and the 2D image pixels, so that we can infer desired 3D knowledge from 2D image data.

Perspective Projection: Definition

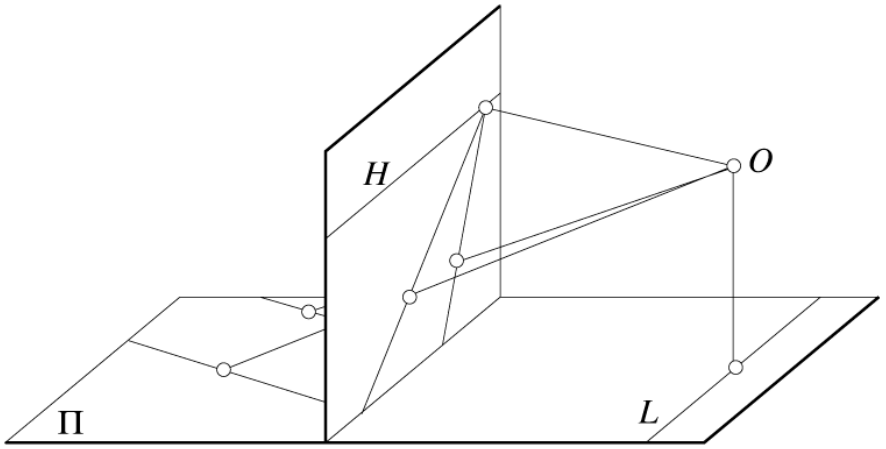
- Approximate the imaging process as a projection of the object through a single point
  - Image is reversed and upside-down.



Perspective Projection: Properties

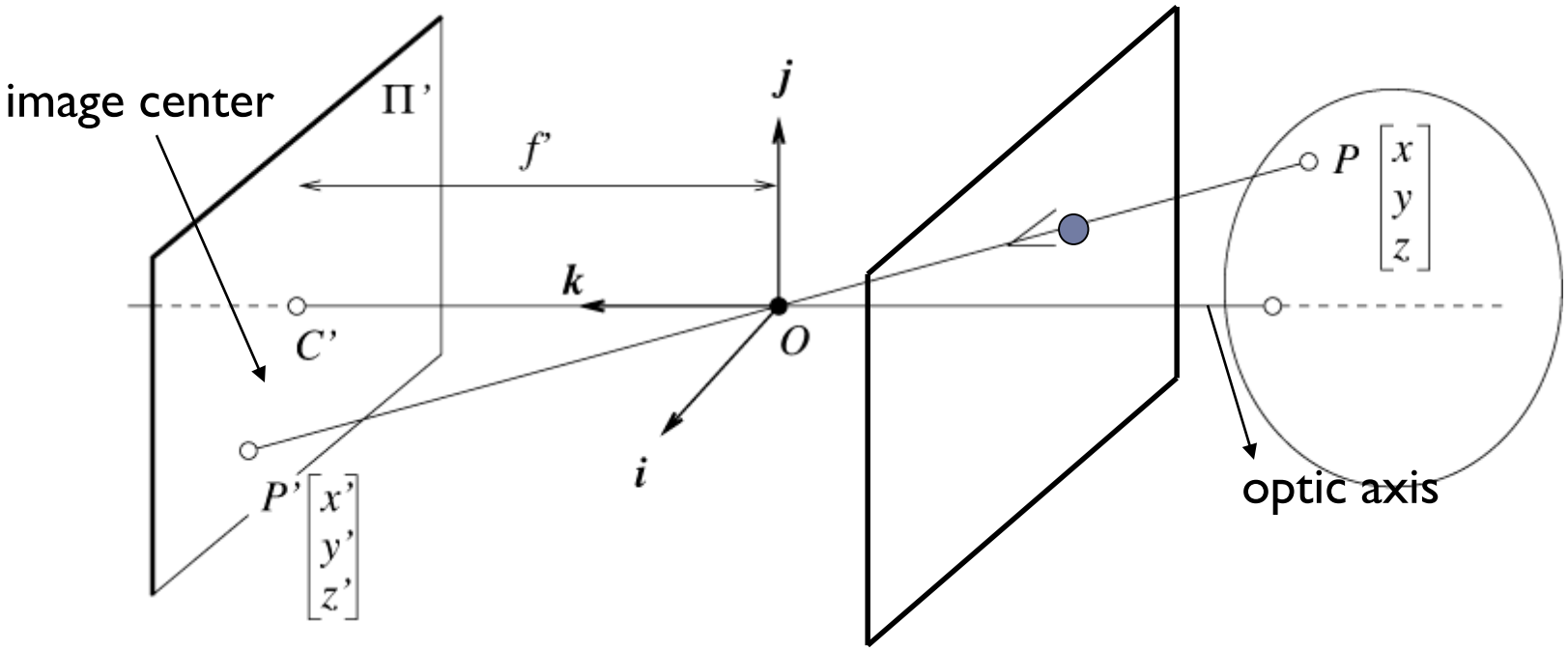


Distant objects are smaller



Parallel lines meet

Perspective Projection: Formulation



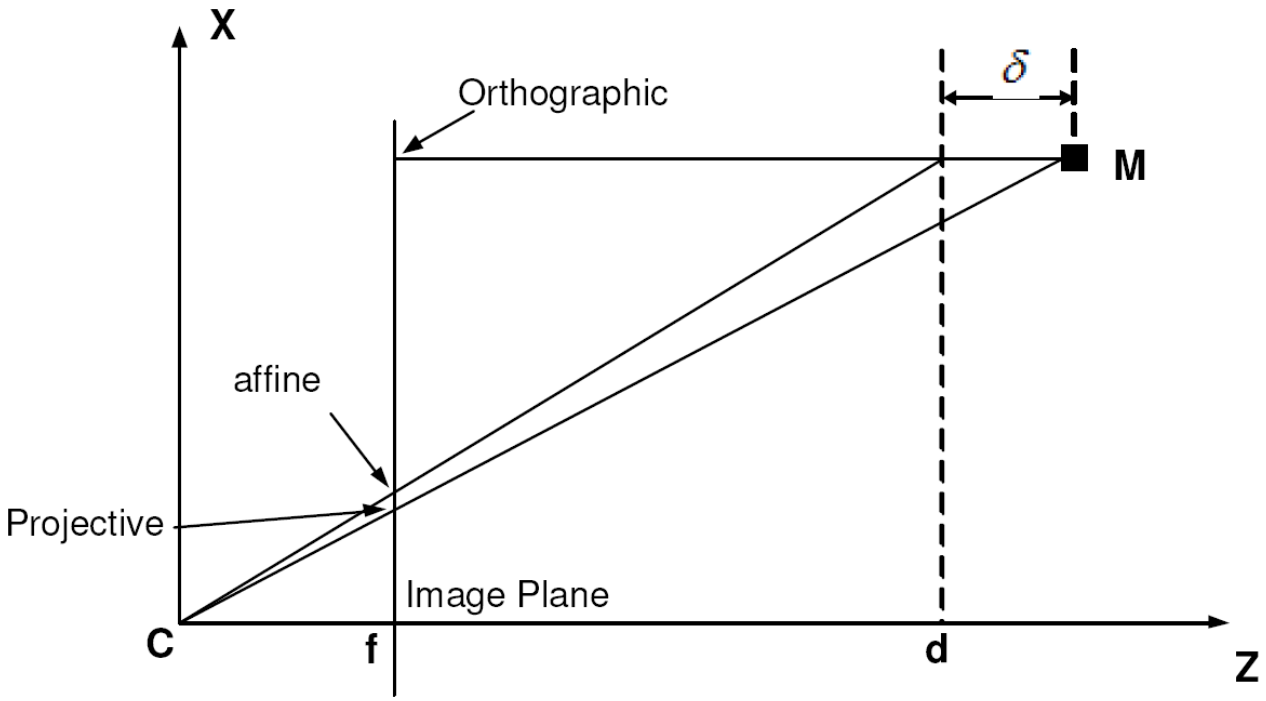
$$\begin{cases} x' = & \lambda x \\ y' = & \lambda y \\ z' = f' = & \lambda z \end{cases} \Leftrightarrow \lambda = \frac{f'}{z} \Rightarrow \begin{cases} x' = & f'\frac{x}{z} \\ y' = & f'\frac{y}{z} \end{cases}$$

What is the sign of λ of this case shown above?

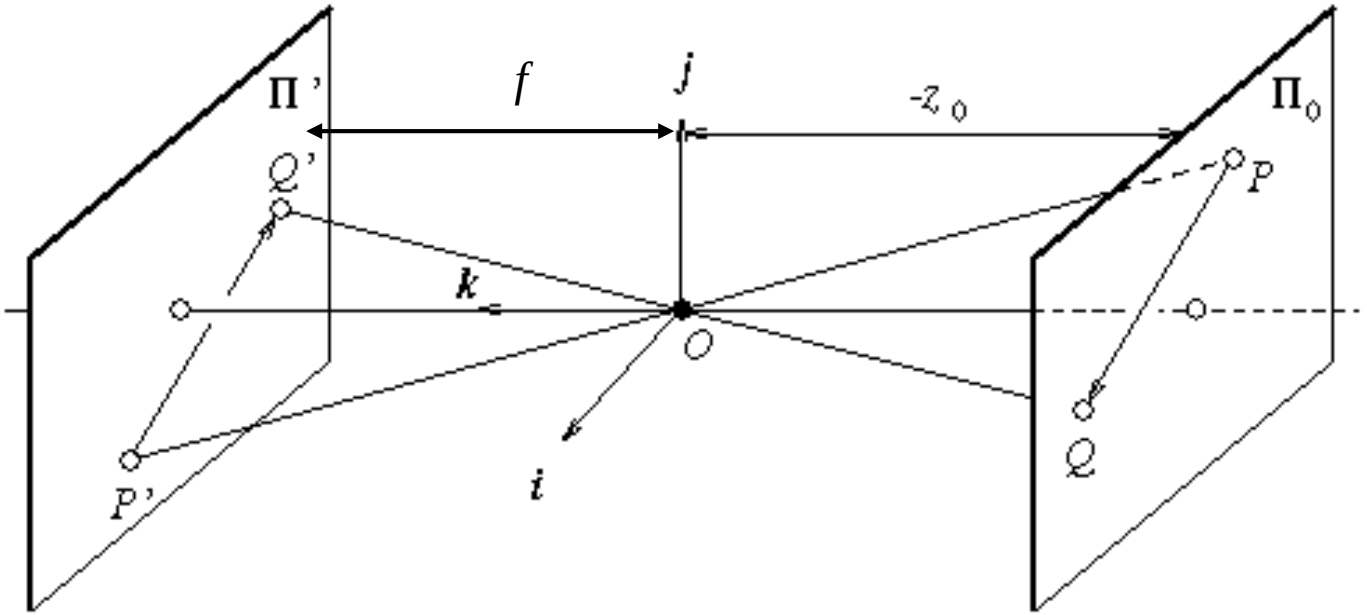
Is this a linear model?

Affine Projection: When?

- Affine projection: when *the scene depth is small relative to the average distance from the camera*, the magnification can be taken to be constant.



Affine Projection



Consider two points *P* and *Q* and their images *P*' and *Q*'.
Obviously, the vector PQ and P'Q' are parallel, and we have

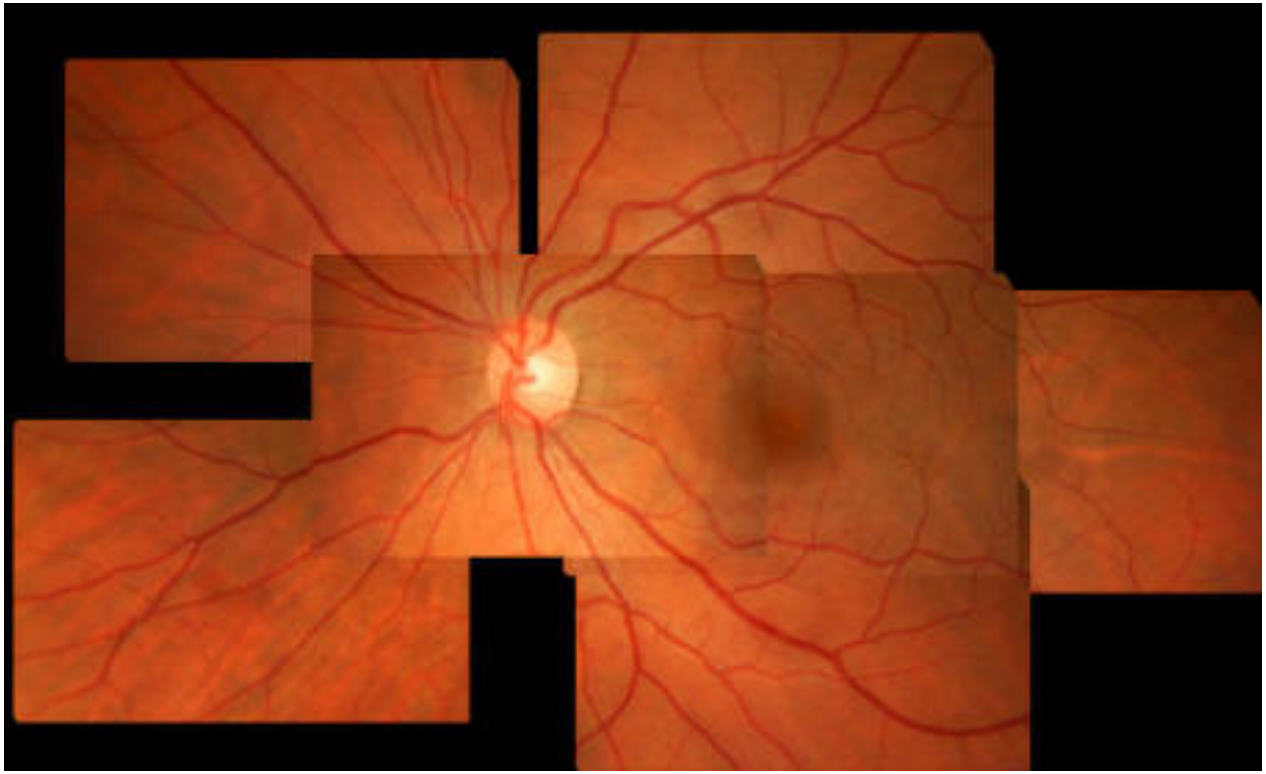
$$|P'Q'| = m|PQ|$$ (Magnification is constant.)

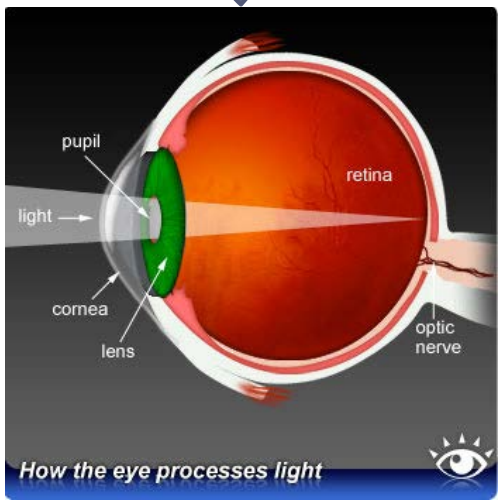
where $m = \left|\frac{f}{z_0}\right|$

$$\begin{cases} x' = & -mx \\ y' = & -my \end{cases}$$

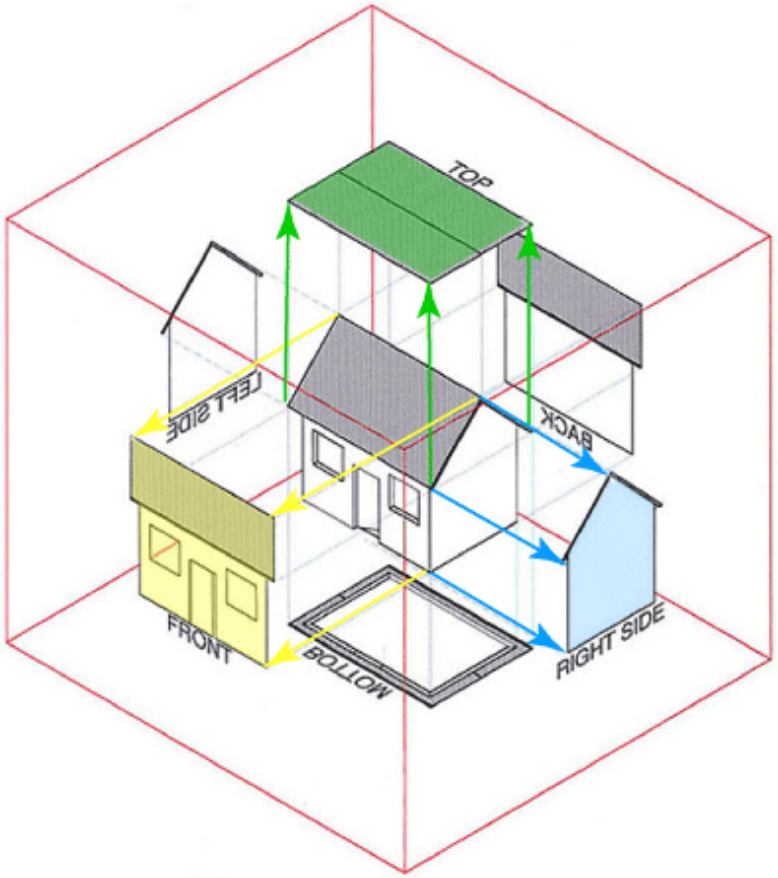
Advantages:
- It is a linear model.
- Easy for optimization.

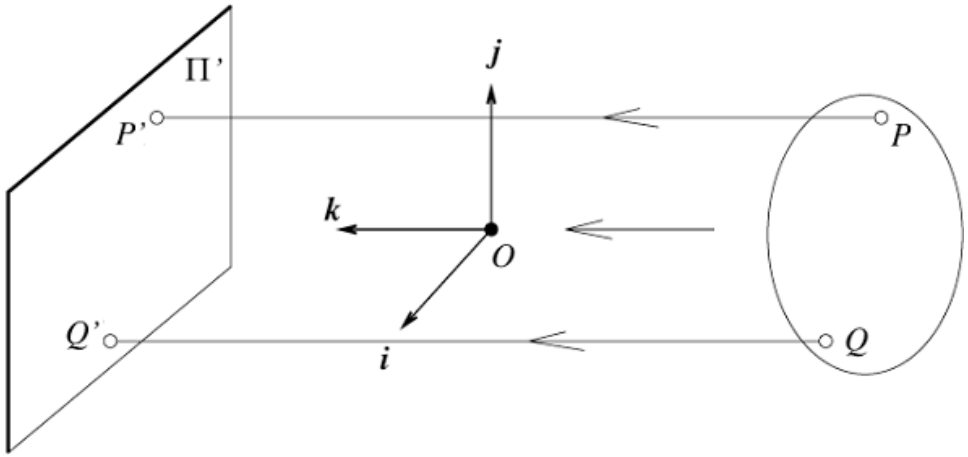
Affine Projection





Orthographic Projection: What?

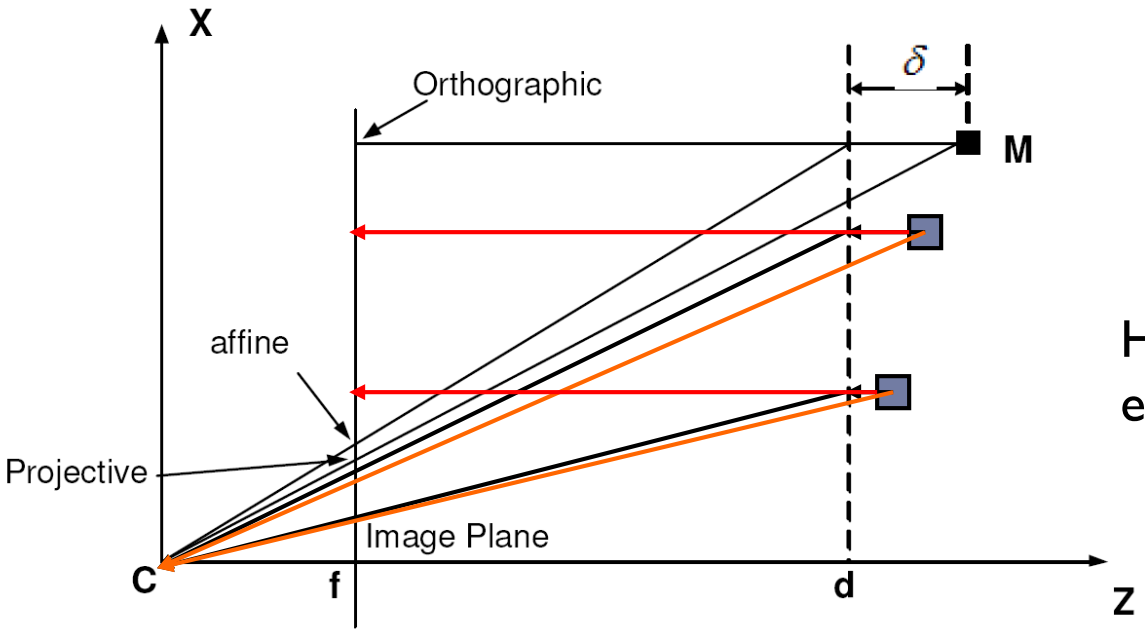




All light rays parallel to the ***k*** axis and orthogonal to the image plane Π'. Therefore, the metric is well preserved in the image.

Orthographic Projection: When?

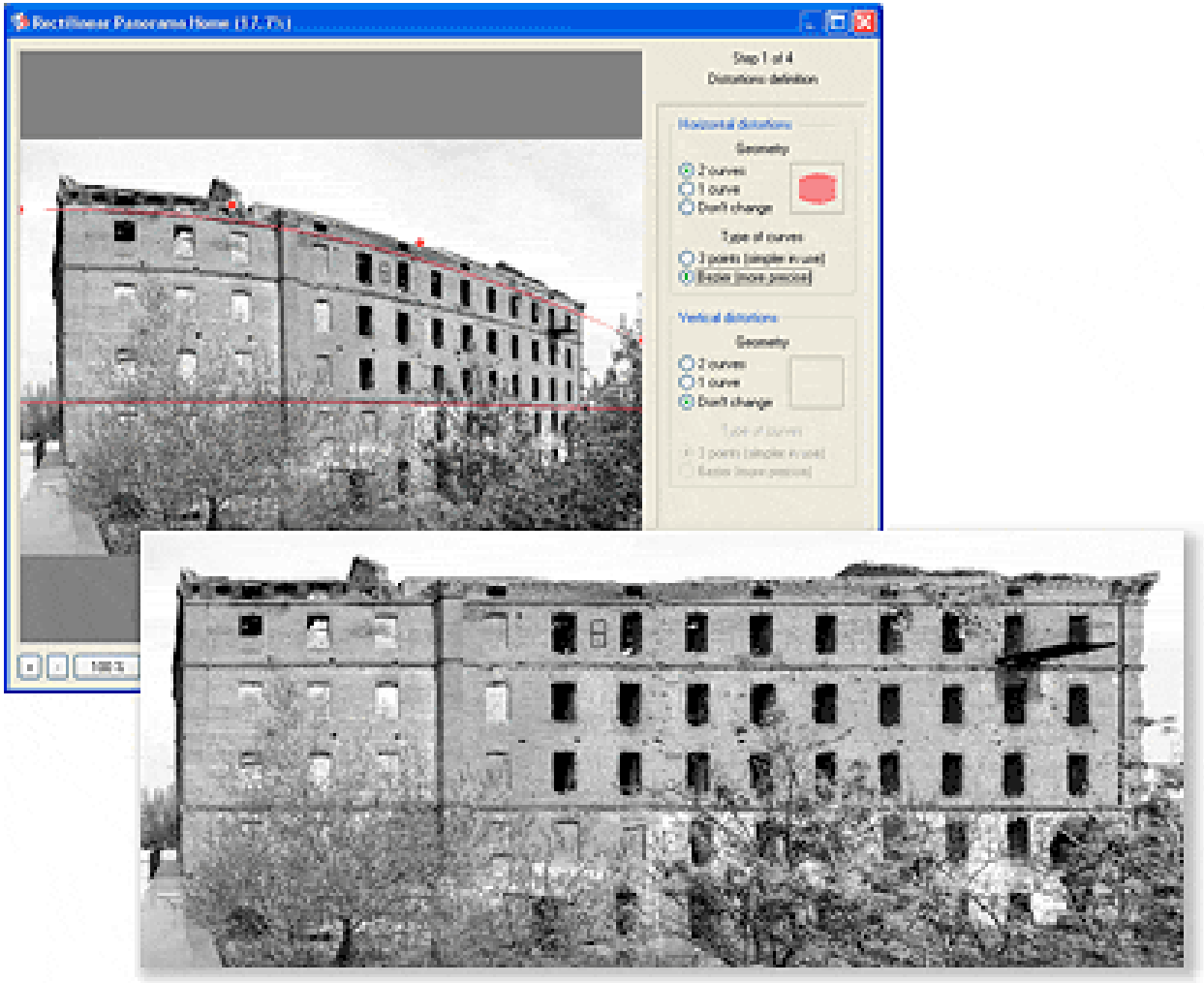
- Orthographic projection: When *it is a prior known that the camera always remains at a roughly constant distance from the scene*, we can go further and normalize the image coordinates.



How about the effective focal length?

Orthographic Projection: Why

Orthocorrection



Summary

- Perspective projection is a standard camera model for image formation.
- Affine projection is a simplified camera model that has good linearity and low complexity when there is no much depth variation in the scene.
- Orthographic projection is an idealized camera model with the infinite focal length. It is useful when the metric information must be preserved in the image, and it can done via orthocorrection.