



Robotic Perception

Camera Model

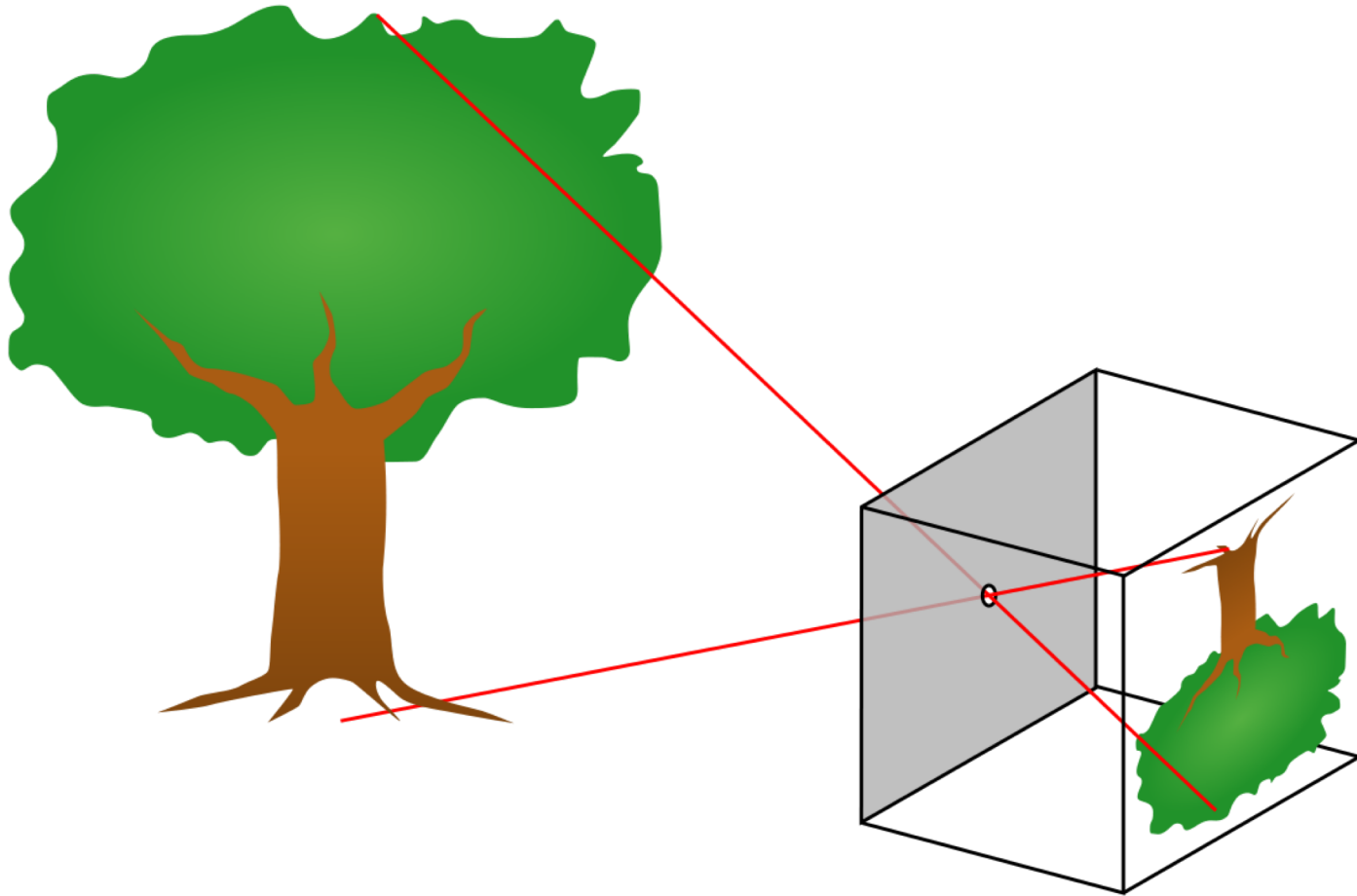
Yezhou Yang, Ph.D.

Assistant Professor

Zhiyuan Fang, Teaching Assistant

Arizona State University

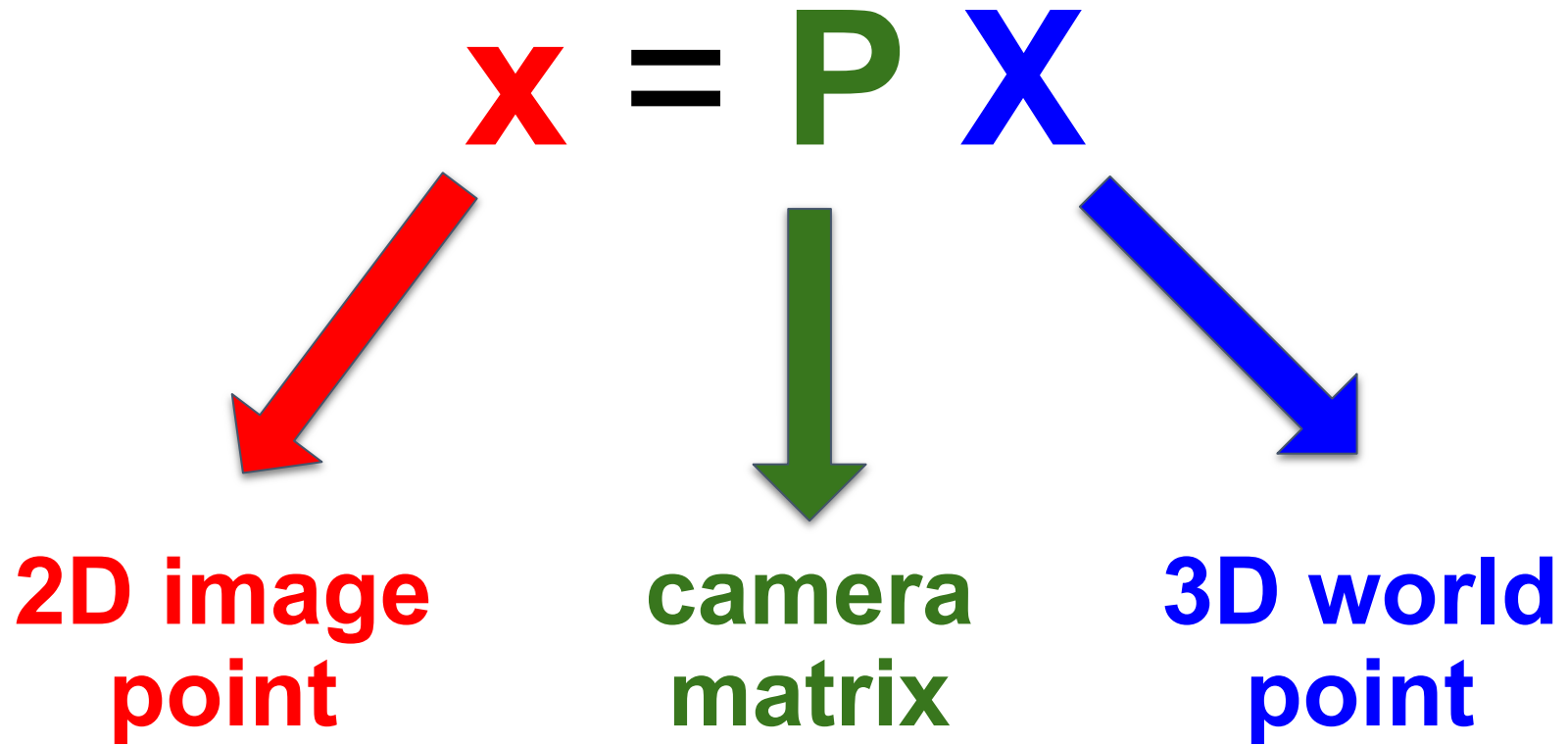
Camera Model



Pinhole Camera Model

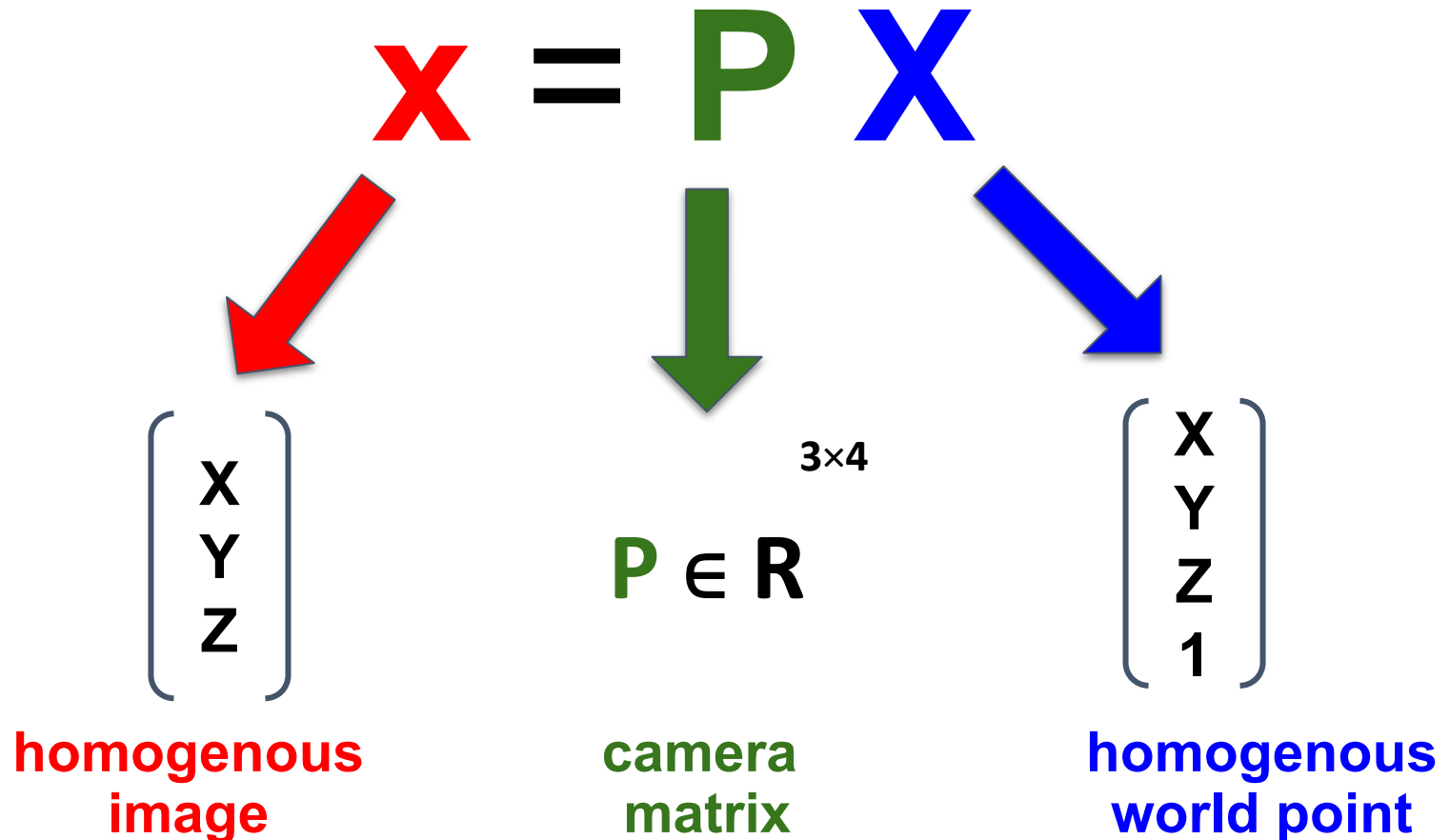
Camera Model

A camera is a mapping between the
3D world and a 2D image

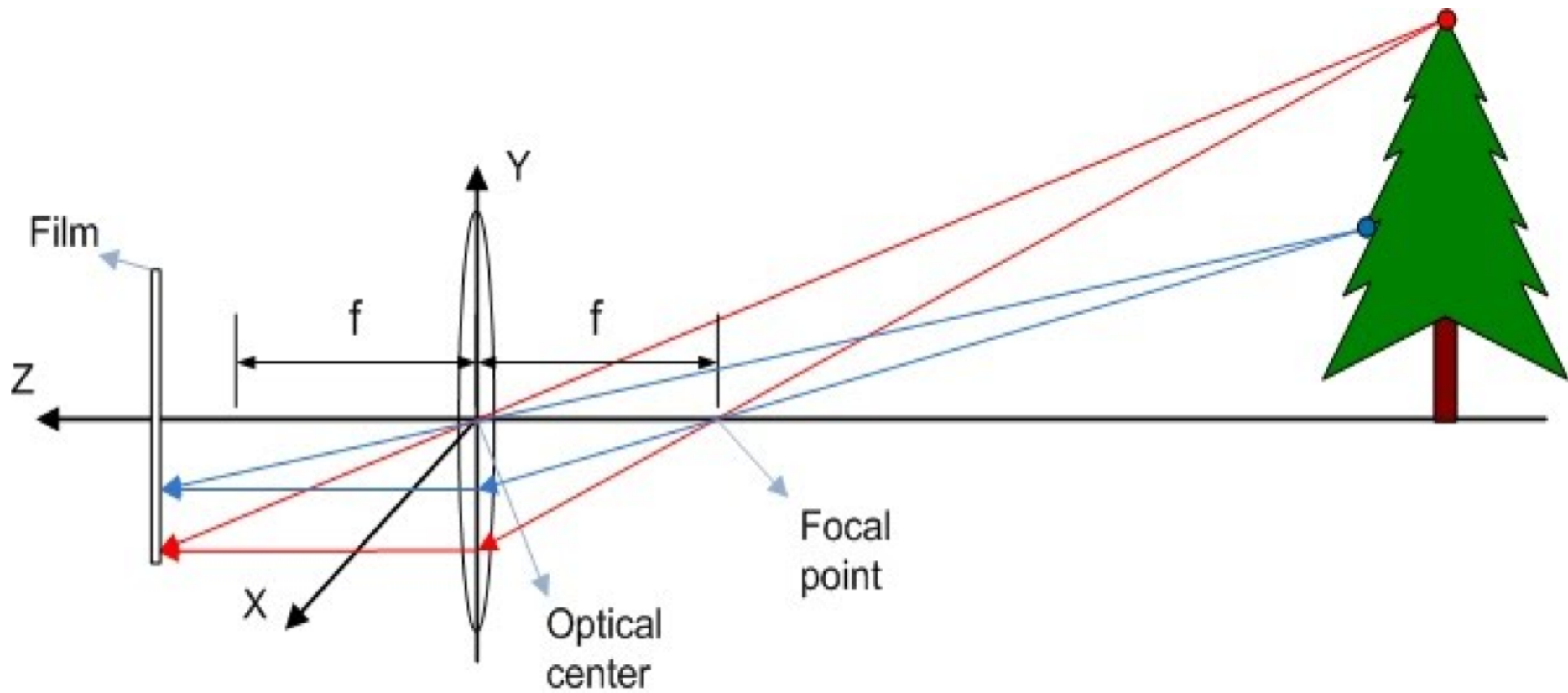


Camera Model

A camera is a mapping between the
3D world and a 2D image



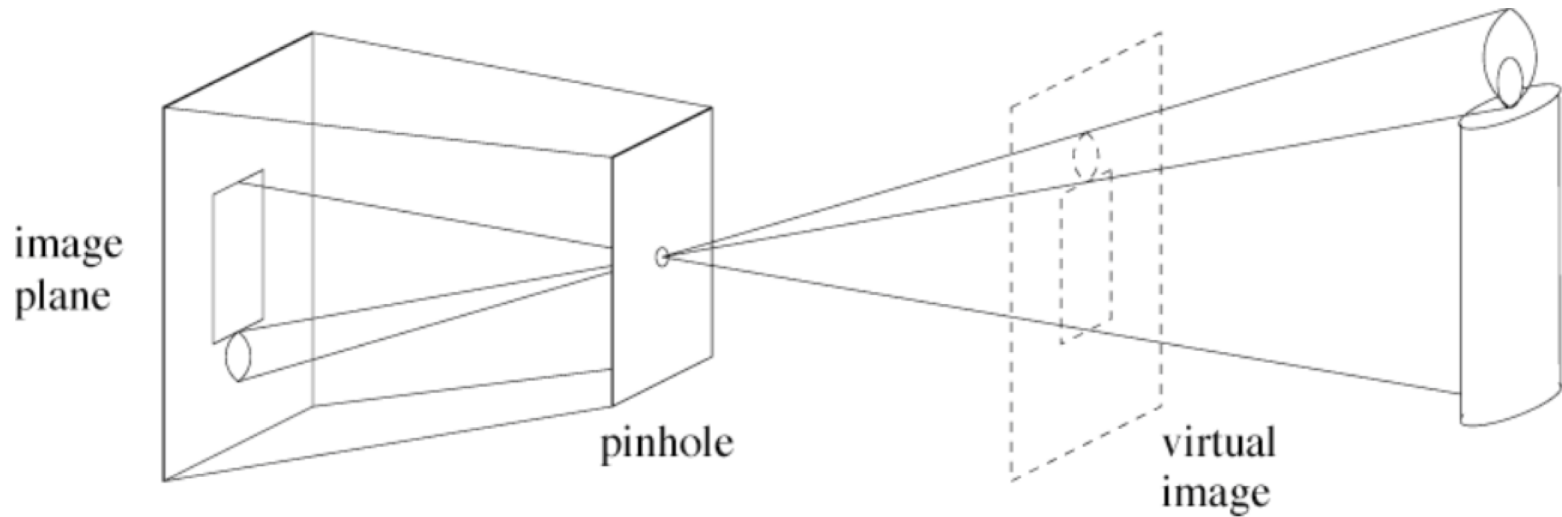
Camera



Pinhole cameras

Pinhole Cameras

- First photograph due to Niepce
- First on record shown in the book - 1822
- Abstract camera model - box with a small hole in it
- Pinhole cameras work in practice



Three Coordinate Systems



| Coordinate Systems

- World coordinate frame: 3D coordinates fixed in the real world.
- Camera coordinate frame: 3D coordinates fixed in the camera. Origin of the camera coordinates is at the center of projection of the camera.
- Image coordinate frame: 3-vector $(x, y, 1)$. Origin is in the top-left corner of the image.

Three Coordinate Systems

| World coordinate frame

- 3D coordinates fixed in the real world.

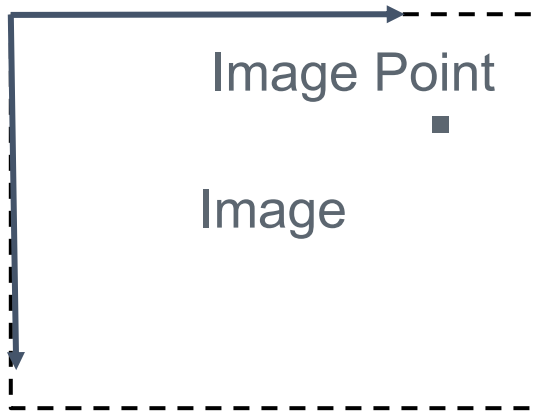
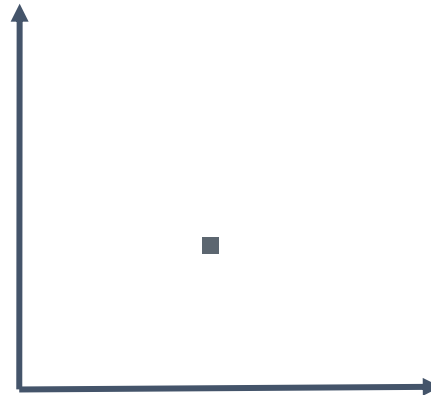
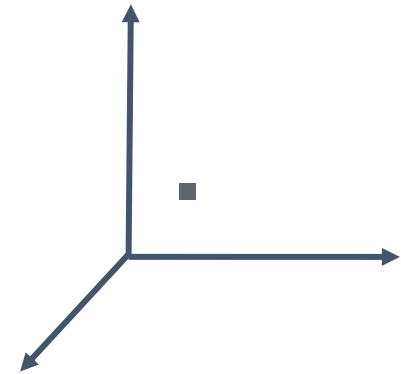


Image Coordinate



Camera Coordinate



World Coordinate

Properties of Projection



- | 3D coordinates fixed in the real world.
- | Lines project to lines
- | Planes project to the whole image or part of the image
- | Angles are not preserved
- | Degenerate cases – Line through focal point projects to a point.
- | Plane through focal point projects to line
- | Plane perpendicular to image plane projects to part of the image (with horizon).

Basic Transformations

Translation	$y = x + t$	$\begin{pmatrix} I & \mathbf{t} \\ 000 & 1 \end{pmatrix}$
Rotation	$y = Rx$	$\begin{pmatrix} \mathbf{R} & \mathbf{0} \\ 000 & 1 \end{pmatrix}$
Rigid	$y = Rx + t$	$\begin{pmatrix} \mathbf{R} & \mathbf{t} \\ 000 & 1 \end{pmatrix}$
Affine	$y = Ax + t$	$\begin{pmatrix} \mathbf{A} & \mathbf{t} \\ 000 & 1 \end{pmatrix}$
Projective		4×4 matrix \mathbf{M}

Related Materials



- | **Camera Projection Lecture 12, CSE486, Penn State, Robert Collins**
- | **The perspective camera model, Thomas Opsahl**
- | **Camera Models, CSC418, Allan Jepson**
- | **Camera Matrix, Kris Kitani**
- | **CS231A Course Notes 1: Camera Models Kenji Hata and Silvio Savarese**