Chapitre 2 Camera Calibration

2.1 Introduction
2.2 Linear Camera Model
2.3 Calibrate a Camera
2.4 Simple Stereo
2.5 Project

Chapitre 2 Camera Calibration

2.1 Introduction

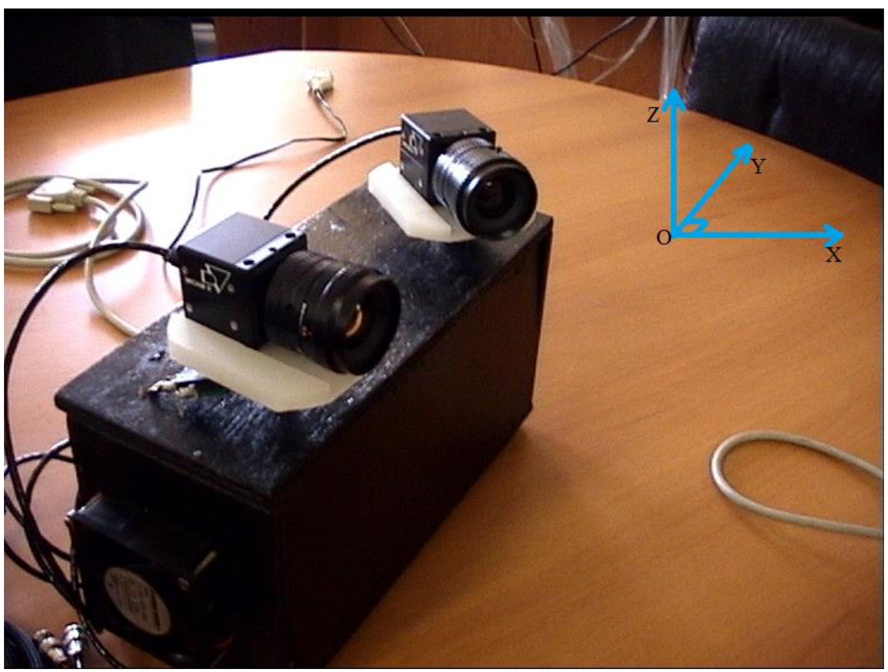
Camera calibration is a method for finding camera's internal and external parameters: How the camera maps the perspective projection points in the world onto its image plane.

- Focal length: f
- Position of impact of optical axis (Ox, Oy)
- Dimensions of the pixel (mm) ex, ey

Chapitre. Camera Calibration

2.1 Introduction

Camera calibration is a method for finding camera's internal and external parameters.



- The position and Orientation of the camera coordinate frame relatively to the world coordinate frame (OXYZ).

Chapitre.   Camera Calibration

2.1 Introduction

Camera calibration is a method for finding camera's internal and external parameters.

We will see in this chapter:
- The linear camera model
- The camera calibration
- Extracting intrinsic and extrinsic matrices
- Example Application: Simple stereo
- A second project

2.2 Linear Camera Model

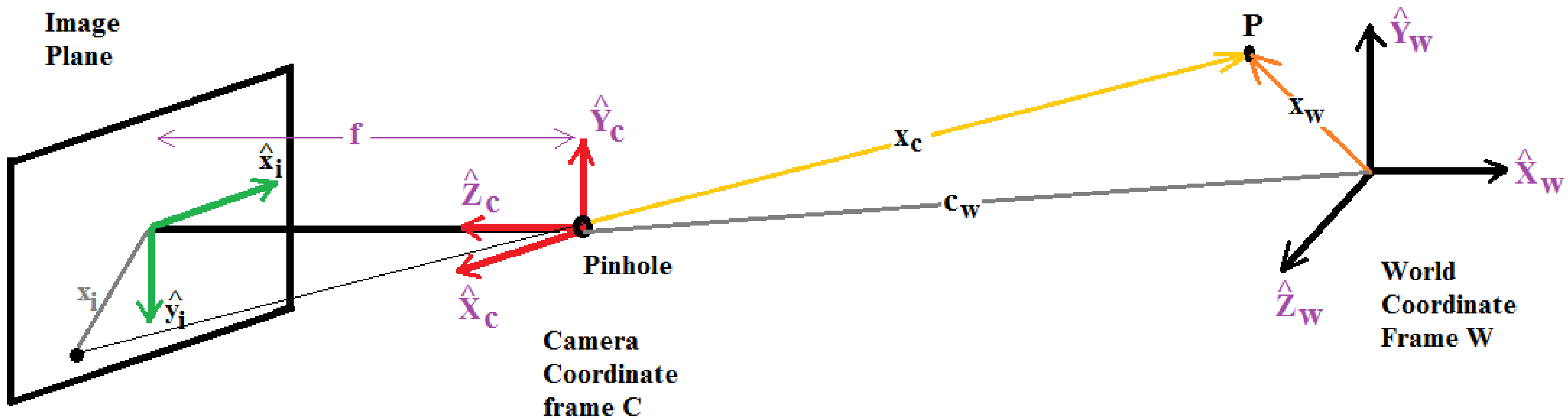


Figure 2. Forward imaging model: 3D to 2D

Coordinates of the point P may be known with respect to the world coordinate W such as P(0,3,4) in figure 3.

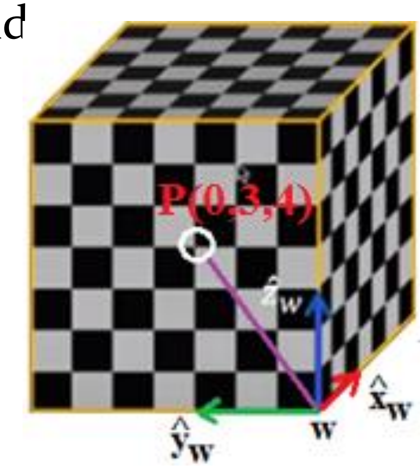


Figure 3. Forward imaging model: 3D to 2D

Chapitre. Camera Calibration

2.2 Linear Camera Model

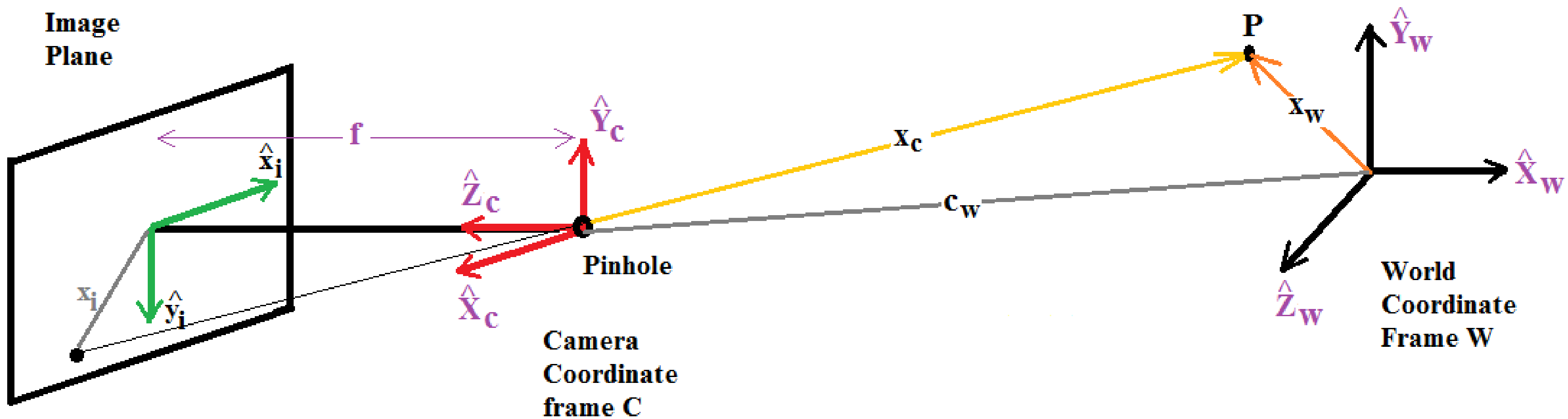


Figure 2. Forward imaging model: 3D to 2D

Coordinates of the point P can't be known with respect to the camera coordinate C because we don't know the position of the projection center C (Pinhole).
We will see in the next that if the coordinates of P with respect to camera coordinate C are known, then we can compute this projection on the image plane

Chapitre. Camera Calibration

2.2 Linear Camera Model

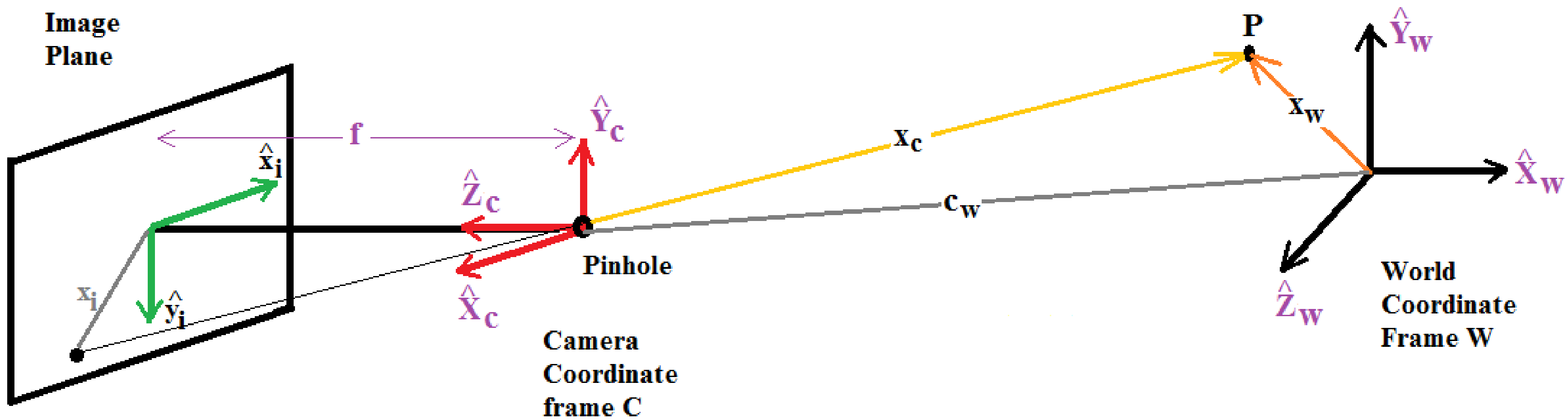


Figure 2. Forward imaging model: 3D to 2D

Consequently, we need to write the coordinate of P (known with respect to World coordinate W) with respect to camera coordinate: make a Transformation

Chapitre. Camera Calibration

2.2 Linear Camera Model

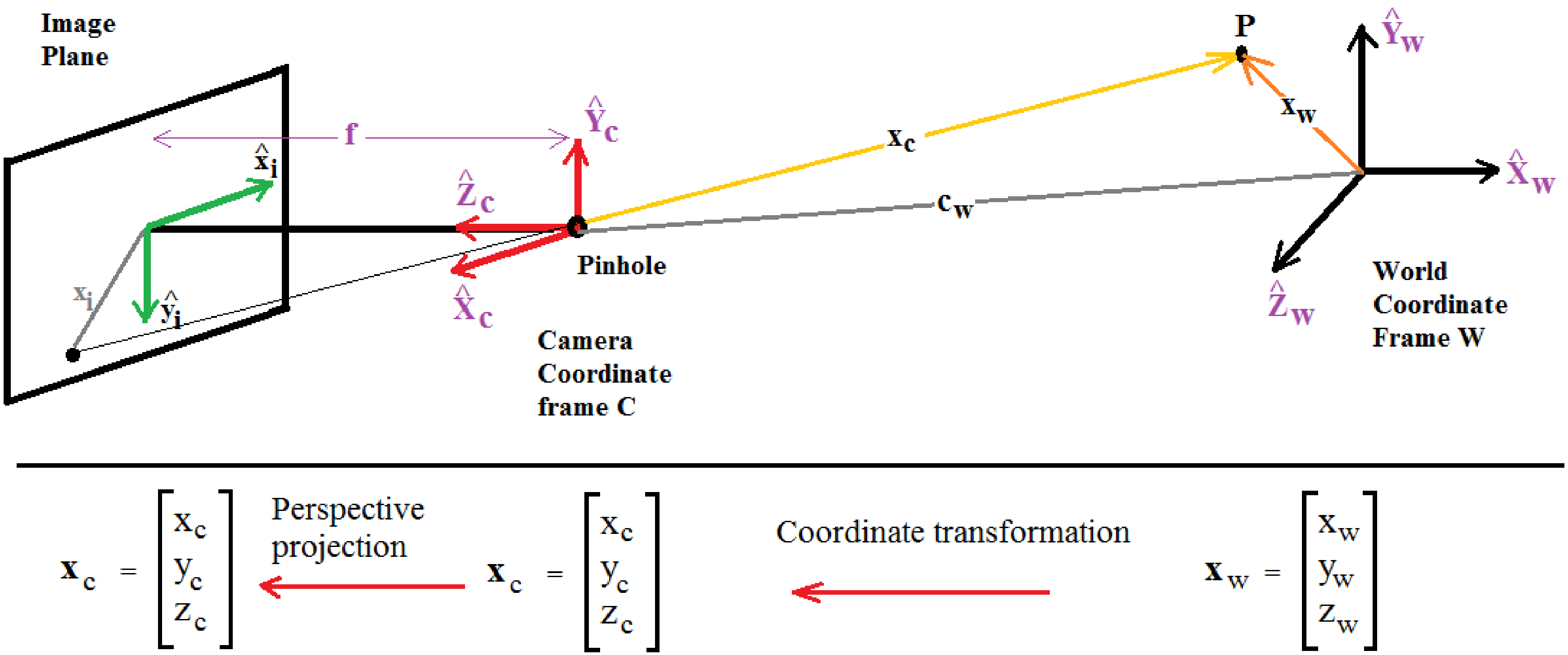
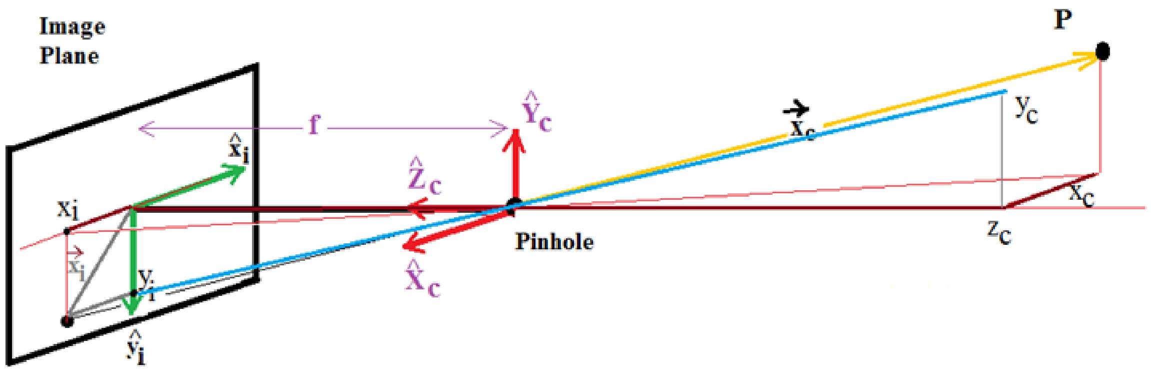


Figure 2. Forward imaging model: 3D to 2D

Chapitre. Camera Calibration

2.2 Linear Camera Model



We apply Thales's Theorem and we obtain:

$\frac{x_i}{f} = \frac{x_c}{z_c}$ and $\frac{y_i}{f} = \frac{y_c}{z_c}$

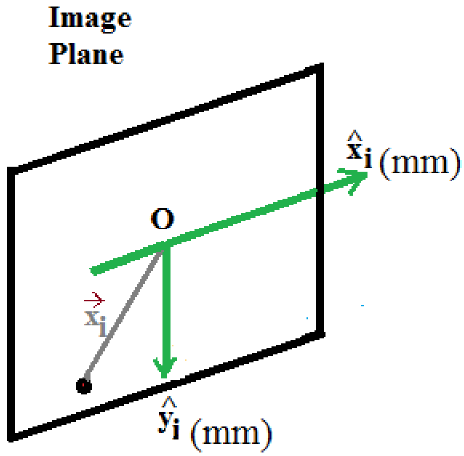
Therefore: $x_i = f\,\frac{x_c}{z_c}$, $y_i = f\,\frac{y_c}{z_c}$

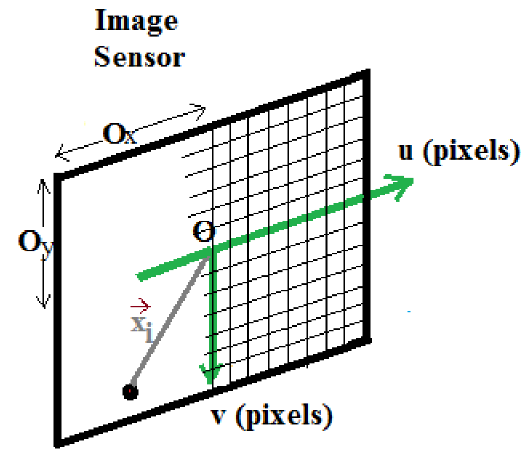
Chapitre. Camera Calibration

2.2 Linear Camera Model

$$x_i = f\,\frac{x_c}{z_c}\,,\; y_i = f\,\frac{y_c}{z_c}$$

If we assume that m_x, m_y are the pixel densities (pixels/mm) in x and y directions, the coordinates of the pixel are (u, v) where:





Chapitre. Camera Calibration

2.2 Linear Camera Model

We obtain: $\frac{x_i}{f} = \frac{x_c}{z_c}$ and $\frac{y_i}{f} = \frac{y_c}{z_c}$

therefore: $x_i = f\frac{x_c}{z_c}$ and $y_i = f\frac{y_c}{z_c}$

If we assume that m_x, m_y are the pixel densities (pixels/mm) in x and y directions, the coordinates of the pixel are (u, v) where:

$$u = m_x x_i = m_x f\frac{x_c}{z_c} \qquad v = m_y y_i = m_y f\frac{y_c}{z_c}$$

Let (O_x, O_y) be the coordinates of the principle point with respect to the top left corner of image plane. We can the write:

$$u = m_x x_i = m_x f\frac{x_c}{z_c} + O_x \qquad v = m_y y_i = m_y f\frac{y_c}{z_c} + O_y$$

Chapitre. Camera Calibration

2.2 Linear Camera Model

Let (f_x, f_y) be the focal lengths in pixels in x and y directions. We can then write the non linear equations for perspective projection:

$$u = f_x \frac{x_c}{z_c} + O_x \qquad v = f_y \frac{y_c}{z_c} + O_y$$

The intrinsic parameters of the camera are: (f_x, O_x, f_y, O_y)

$$u = \boxed{f_x} \frac{x_c}{z_c} + \boxed{O_x} \qquad v = \boxed{f_y} \frac{y_c}{z_c} + \boxed{O_y}$$

It is convenient to express these equations linearly.