Question 3 : Determining Camera Parameter Matrix (Pixel 2XL)

Plan of Action

- Want:
 - $K = \begin{bmatrix} f & 0 & p_x \\ 0 & f & p_y \\ 0 & 0 & 1 \end{bmatrix}$
- Need:
  - f – focal length in pixels
  - p_x, p_y - pixel coordinates of optical center

1. Take calibration image, measure distance from camera to subject (subject must be as wide as picture)

2. Determine optical center (in pixels)
   a) Assume optical center is also the center pixel:
      - $p_x = \frac{1}{2}(image\ pixel\ width)$
      - $p_y = \frac{1}{2}(image\ pixel\ height)$

3. Determine field of view (FOV) angle
   a) Since subject is about as wide as the picture, measure subject width and use trigonometry to determine FOV angle

4. Determine focal length (in pixels)
   a) Use pixel dimensions of image and FOV to determine focal length (in pixels) with trigonometry

5. Combine focal length and optical center into parameter matrix

Calibration Image & Optical Center
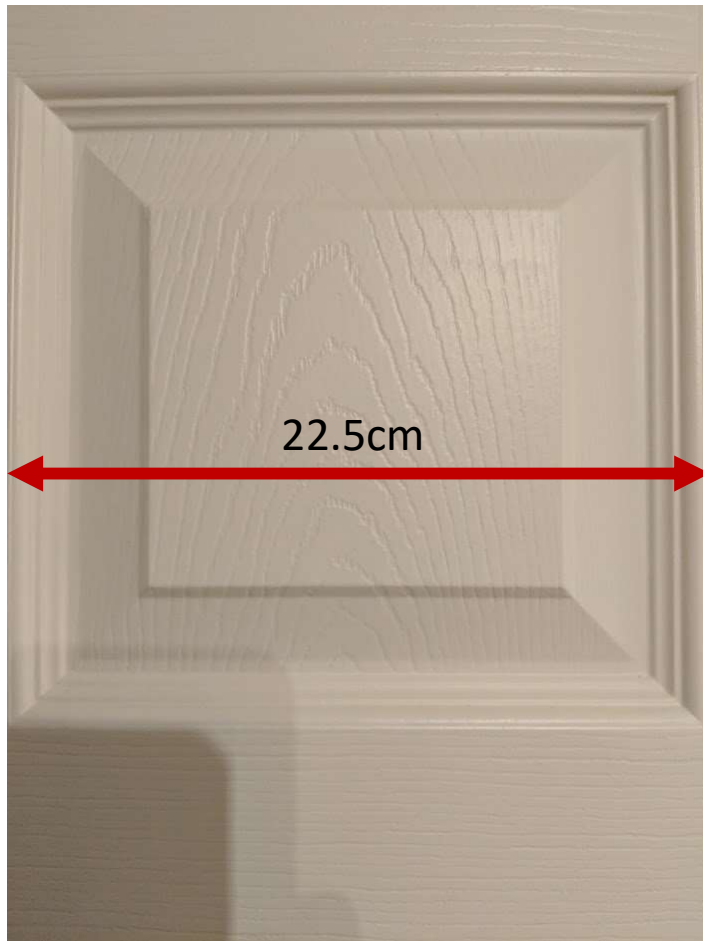
Dimensions
Height: 4032px
Width: 3024px
Camera Distance: 23.5cm

22.5cm
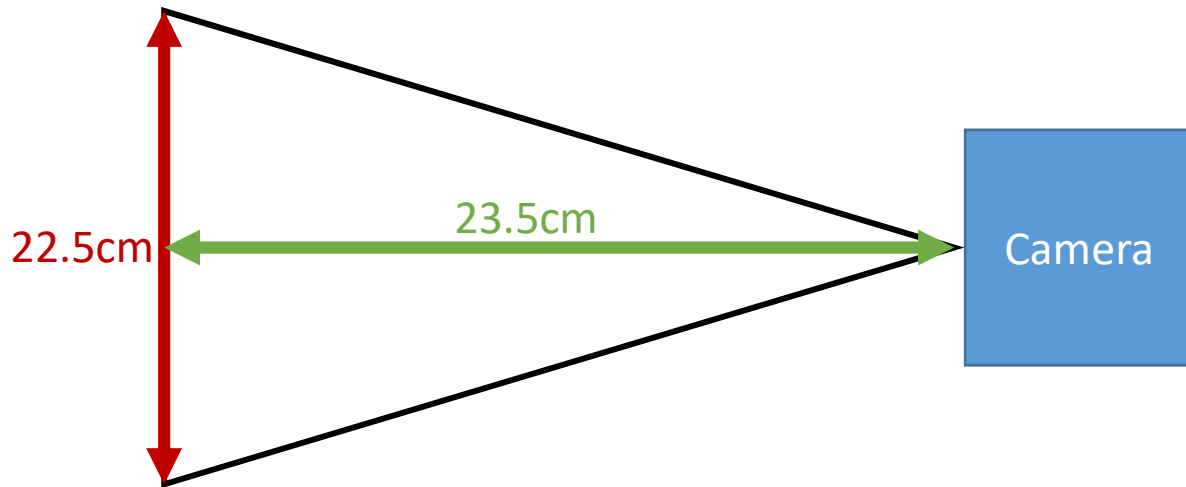
Assume that optical center is also center of image, i.e:

- $p_x = \frac{1}{2}(image\ pixel\ width)$
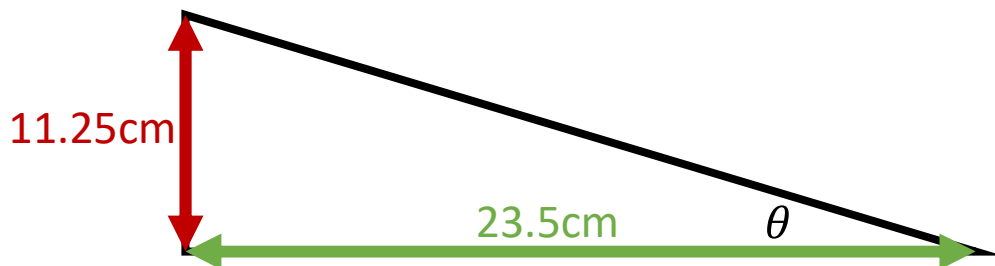- $p_y = \frac{1}{2}(image\ pixel\ height)$

Therefore:

- $p_x = \frac{1}{2}(3024) = 1512$ pixels
- $p_y = \frac{1}{2}(4032) = 2016$ pixels

Determining FOV

Diagram of Calibration Image Setup

Reduction to Right Angle Triangle

Solving for FOV using trigonometry

$$\tan(\theta) = \frac{Opposite}{Adjacent} = \frac{11.25}{23.5}$$
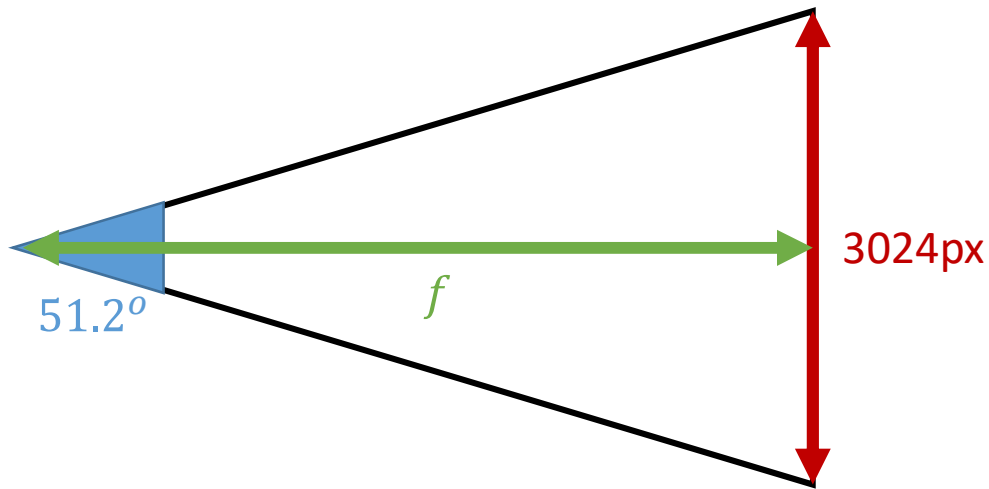
$$\Rightarrow \theta = \arctan\frac{11.25}{23.5}$$

$$\Rightarrow \theta \approx 0.45 rad \approx 25.6^o$$

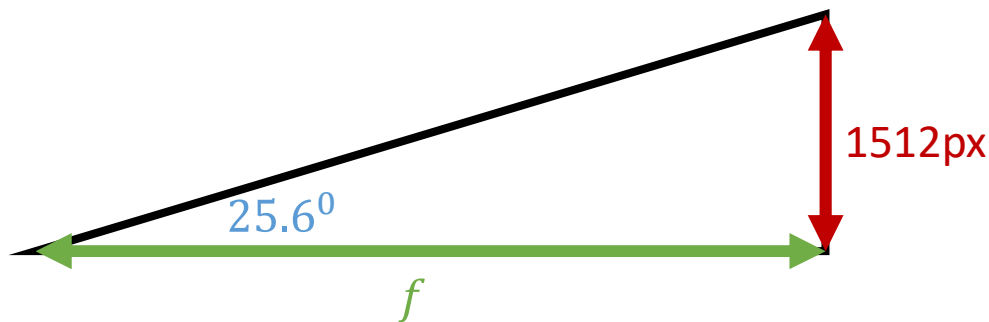Therefore FOV angle is approximately 51.2 degrees.

Determining Focal Length

Diagram of Camera Internals

FOV must also be the same inside the camera on the other side of the lens. However, the cone of light is as wide as the sensor.

51.2°   f   3024px

Reduction to Right Angle Triangle

25.6°   1512px   f

Solving for f using trigonometry

$$\tan(25.6^o) = \frac{1512}{f}$$

$$\Rightarrow f = \frac{1512}{\tan(25.6^o)}$$

$$\Rightarrow f \approx 3155.8px$$

Combining Results into K

- Know:
  - $f = 3155.7$ pixels
  - $p_x = 1512$ pixels
  - $p_y = 2016$ pixels

- Then:

$$K = \begin{bmatrix} f & 0 & p_x \\ 0 & f & p_y \\ 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} 3155.7 & 0 & 1512 \\ 0 & 3155.7 & 2016 \\ 0 & 0 & 1 \end{bmatrix}$$