# CMPEN 497 – Humanoid Robotics

# Week 3 Lab
# Camera Models + Blender

Due on Monday, January 30th, 2022

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## Problem 1

$$Given : M = \begin{bmatrix} r11 & r12 & r13 & tx \\ r21 & r22 & r23 & ty \\ r31 & r32 & r33 & tz \\ 0 & 0 & 0 & 1 \end{bmatrix} \tag{1}$$

$$Given\ M = RC \tag{2}$$

$$R = \begin{bmatrix} cos90° & -sin90° & 0 & 0 \\ sin90° & cos90° & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} 0 & -1 & 0 & 0 \\ 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \tag{3}$$

$$C = \begin{bmatrix} 1 & 0 & 0 & 5 \\ 0 & 1 & 0 & 10 \\ 0 & 0 & 1 & -5 \\ 0 & 0 & 0 & 1 \end{bmatrix} \tag{4}$$

$$M = RC = \begin{bmatrix} 0 & 1 & 0 & 5 \\ -1 & 0 & 0 & 10 \\ 0 & 0 & 1 & -5 \\ 0 & 0 & 0 & 1 \end{bmatrix} \tag{5}$$

## Problem 2

$$Given : M = \begin{bmatrix} 0 & 0 & 1 & 4 \\ 0 & 1 & 0 & -8 \\ -1 & 0 & 1 & 2 \\ 0 & 0 & 0 & 1 \end{bmatrix} \tag{6}$$

$$Given\ R, T\ as\ in \begin{bmatrix} R & \tau \\ 0 & 1 \end{bmatrix} \tag{7}$$

$$Pc \tag{8}$$

$$= R(Pw - C) \tag{9}$$

$$= RPw + \tau \tag{10}$$

$$RPw - RC = Rw + \tau \tag{11}$$

$$RC = -\tau \tag{12}$$

$$C = -R^T \tau \tag{13}$$

$$R = \begin{bmatrix} 0 & 0 & 1 \\ 0 & 1 & 0 \\ -1 & 0 & 0 \end{bmatrix} \tag{14}$$

$$R^-1 = \begin{bmatrix} 0 & 0 & -1 \\ 0 & 1 & 0 \\ 1 & 0 & 0 \end{bmatrix} \tag{15}$$

$$\tau = \begin{bmatrix} 4 \\ -8 \\ 2 \end{bmatrix} \tag{16}$$

$$C = \begin{bmatrix} 2 \\ -8 \\ 4 \end{bmatrix} \tag{17}$$

$$\tag{18}$$

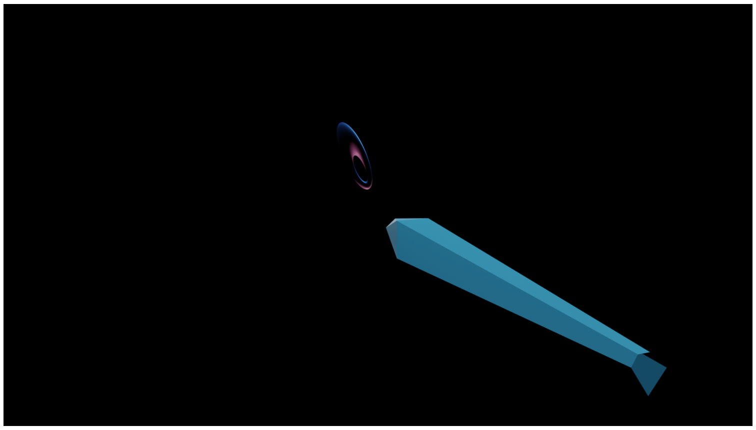
The camera's location in world coordinates is (2,-8,4).

## Problem 3

$$Given : M = \begin{bmatrix} \sqrt(2)/2 & \sqrt(2)/2 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ \sqrt(2)/2 & \sqrt(2)/2 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & -22 \\ 0 & 1 & 0 & 25 \\ 0 & 0 & 1 & -3 \\ 0 & 0 & 0 & 1 \end{bmatrix} \tag{19}$$

Based on the information provided from the M, the left matrix represents the rotation of the camera while the right matrix represents the translation of the camera. It represents the rigid transformation between world and camera coordinate systems and transform the camera's local coordinate system to align with the world coordinate system.
By examining $cos\theta = -\sqrt(2)/2$ and $-sin\theta = -\sqrt(2)/2$ from the left matrix, we can deduce that the it rotates 90 degrees on x-axis and -45 degrees on z-axis . Meanwhile, the right matrix represents a translation of [-22,25,-3].

Figure 1: A rendered example figure for Q3 mm



## Problem 4

(a)
Given f=50mm=0.05m, y=93m.

$$Based\ on\ Lecture\ 3\ slides,\ the\ 3X4\ Perspective\ Projection\ Matrix = \begin{bmatrix} 0.05 & 0 & 0 & 0 \\ 0 & 0.05 & 0 & 0 \\ 0 & 0 & 1 & 1 \end{bmatrix} \tag{20}$$

(b)
Given f=50mm=0.05m, y=93m, y'=24mm=0.024m.

$$\begin{gathered} From\ Lecture\ 3\ notes,\ Perspective\ Projection\ Equation =\ y' = f * (y/z) \\ z = f * (y/y') \\ = 0.05 * (93/0.024) \\ = 0.19375m \end{gathered}$$

The camera will need to be 0.19375m from the structure.

(c)
Given f=50mm,x=13m,x'=100m.

$$\begin{gathered} x' = f * (x/z) \\ z = f * (x/x') \\ = 0.05 * (13/100) \\ = 6.5mm \end{gathered}$$

The length of the arm on the film plane is 6.5mm.

## Problem 5

Based on the side note 2 on field of view (FOV), smaller focal length will yield a wider fields of view in both horizontal and vertically and vice versa for longer focal length.
From Lecture Week 3 Camera Model pg 40,

$$Fovx = 2atan(W/2f) \tag{21}$$
$$Fovy = 2atan(H/2f) \tag{22}$$

Meanwhile, the render results in Blender also suggested that a smaller focal length will provide a better view of the entire room with a wider view as an increase in focal length will provide a smaller scope of view that focus on certain objects with sharper details under enlarged visual on further objects.

Figure 2: An example figure for f=35mm

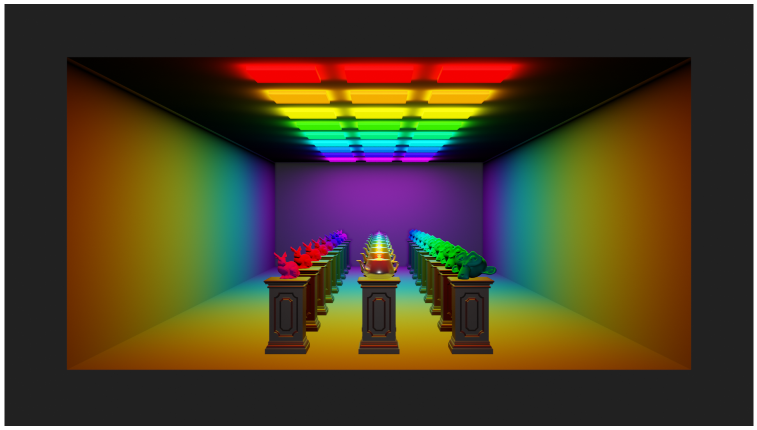


Figure 3: An example figure for f=85mm

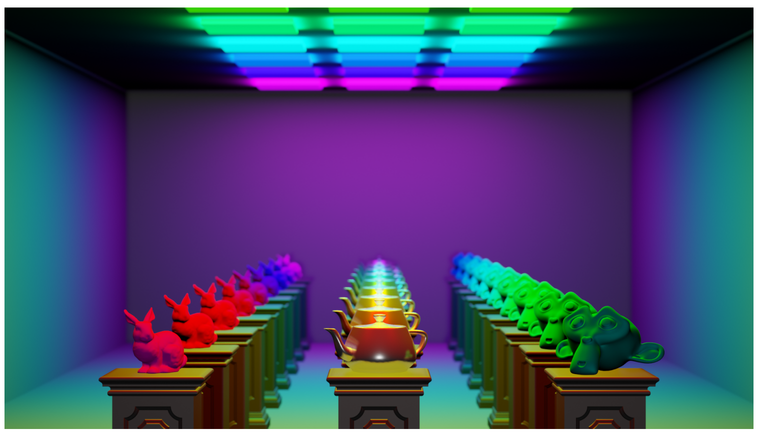
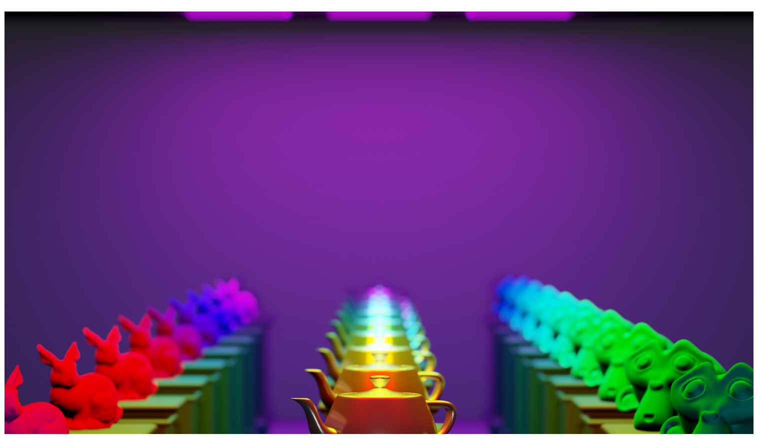


Figure 4: An example figure for f=135mm



# References

[1] "Collins,Robert. (2022, January). Page 19 , Lecture-Week3-CameraModel.pdf. CMPN 497. State College. "

[2] "Collins,Robert. (2022, January). Page 30 , Lecture-Week3-CameraModel.pdf. CMPN 497. State College. "