

CMPEN 497 – Humanoid Robotics

Week 3 Lab

Camera Models + Blender

Released on Monday, January 23, 2023

Due on Monday, January 30, 2023

Spring 2023

Dr. Yanxi Liu

Dr. Robert Collins

Addison Petro

amp6809@psu.edu

Important Notice

Academic Integrity policies will be **strictly enforced** (see our course syllabus on CANVAS). The work must be your own. Write up the answers **in your own words**, explain all of the steps of your reasoning, and be neat! In addition, **cite/acknowledge any external references** you use (other than the textbook) to come up with your answers.

Labs must be submitted to Canvas **before the due date!** There are **no late days** for lab assignments. Any submission after the due date will be subject to penalties as described in the syllabus.

Submit your solutions as **PDF files**. All homework **submissions must be typed!** We highly recommend you use L^AT_EX to type up your homework solutions. If you plan to submit handwritten figures, please make sure that your handwriting is **clear** and that the scanned images can be **easily read**.

Introduction

In this lab, you will be required to create a write-up to the questions we ask regarding camera models. Some of these questions involve performing manipulations to Blender scenes (provided) and including the resulting renderings in your writeup. Be sure to read all instructions carefully and double check your work.

Instructions

- (A) Take a camera that is initially aligned with the world coordinate system. If it is rotated 90° about its z-axis and placed at the location (5, 10, -5) in world coordinates, what is its resulting extrinsic parameter matrix M ?

$$M = \begin{bmatrix} r_{11} & r_{12} & r_{13} & t_x \\ r_{21} & r_{22} & r_{23} & t_y \\ r_{31} & r_{32} & r_{33} & t_z \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Express your answer as a product of two matrices and evaluate the multiplication – for example, your answer should have the form $M = RC$ where M , R , and C are all 4×4 homogeneous matrices.

- (B) You are given a camera's extrinsic parameters as the following matrix M : $M = \begin{bmatrix} 0 & 0 & 1 & 4 \\ 0 & 1 & 0 & -8 \\ -1 & 0 & 0 & 2 \\ 0 & 0 & 0 & 1 \end{bmatrix}$

What is this camera's location in world coordinates? Be sure to show your work.

- (C) We provide a Blender file “W3LabQ3.blend” which contains multiple objects and a camera that is aligned with world coordinates as shown in lecture. That is, the camera's “look-at” vector (+Z) is aligned with the world's +Z, its “up” vector (+Y) is aligned with the world's +Y, and its “left” vector (+X) is aligned with the world's +X. Set up the camera object such that it has extrinsic parameter matrix M .

$$M = \begin{bmatrix} \frac{-\sqrt{2}}{2} & \frac{-\sqrt{2}}{2} & 0 & 0 \\ 0 & 0 & 1 & 0 \\ \frac{-\sqrt{2}}{2} & \frac{\sqrt{2}}{2} & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & -22 \\ 0 & 1 & 0 & 25 \\ 0 & 0 & 1 & -3 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Describe your process for transforming the camera, render the resulting scene, and include the output image in your lab document.

-
- (D) Imagine you are trying to take a picture of the Statue of Liberty which is 93 meters in height from the very base to the top. Unfortunately, you don't have a wide-angle lens for architecture, just a standard lens that has a 50mm focal length. Be sure to show your work for the following questions.
- (a) What is the 3×4 perspective projection matrix for your camera?
 - (b) If you would like the Statue of Liberty to appear 24mm tall on the film plane, how far away from the structure will your camera need to be?
 - (c) The length of one arm is approximately 13m in length. Assuming your camera is 100m away from the statue, what will be the length of the arm on the film plane?
- (E) We provide a Blender file “W3LabQ5.blend” which contains a scene and a camera. You will need to make multiple renderings of the scene with different camera focal lengths and include them all in your writeup. Additionally, you must describe how different focal lengths affect the resulting images. The focal lengths you need to use are:
- 35mm
 - 85mm
 - 135mm

Note: If you are unfamiliar with how to change the focal length of the camera in Blender, access the camera settings tab on the right-hand navigation menu (where material, rendering, and world property tabs are located). There should be an option for camera focal length options. See Figure 1 for an example of where the camera settings are located.

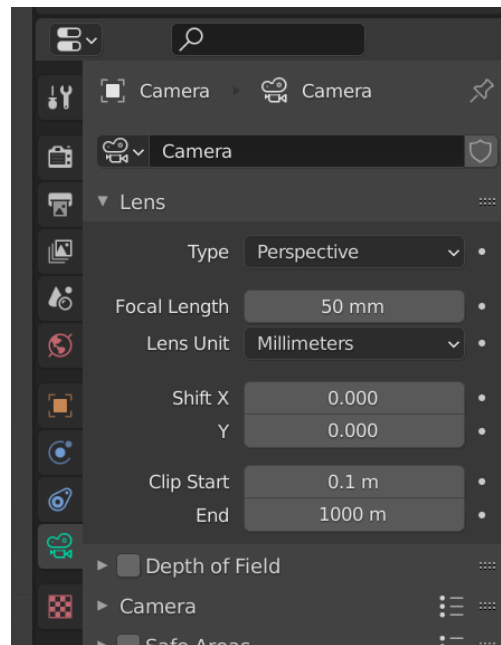


Figure 1: Camera settings tab location