**CSE327 Fall 2023 Homework 8 (10pts)**

**Due Nov 15 2023, 11:59PM, submitted via Brightspace**

**1. Camera Geometry and Coordinate Transformations (6pts)**

Consider an airport hallway that is 20m tall, 20m wide and 100m long. The world coordinate system U-V-W is located at one corner of the hallway, as shown in the figure below. A perspective camera with focal length of 10mm (or 0.01m) is placed at the opposite end of the hall, in the middle of the wall, as shown by camera coordinate system X-Y-Z in the figure. Assume the camera is taking a picture of a person running for a plane, and that the person is currently halfway down the hallway. The person is 2 meters tall (the picture is not drawn to scale). Refer to this scenario to answer the following questions.



Note, you can use either meter or millimeter as the unit of the coordinates of world, camera, and image.

a) Compute the 4x4 matrix specifying the translation that aligns world axes U-V-W with camera axis (X-Y-Z).

b) Compute the 4x4 matrix specifying the rotation that aligns world axes U-V-W with camera axes X-Y-Z.

c) Use the above matrices to compute the location of the world origin (0,0,0) in the camera coordinate system.

d) Compute the 3x4 matrix that specifies the perspective projection of 3D points in X-Y-Z space into 2D image (film) plane coordinates x-y, for a camera with the given focal length (0.01m).

e) Use the above matrices to compute the x-y image location of the world origin (0,0,0).

f) Compute the height in mm of the image of the person by defining two 3D points in (U,V,W) space representing lowermost and uppermost points of the person, projecting those two points into the image, and figuring out the difference in their y coordinates. The lowermost and uppermost points of the person is 2m apart, and assume the vertical centerline of the person lies within the plane W=50m.

**2. Parameter Estimation (4 pts)**

Given a set of points , , we try to fit a general line model

onto the points with the constraint of .

Using the Algebraic distance , we define the error function as

where is the Lagrange multiplier.

Derive the solution to the line parameters

Hint: we solved a similar problem in Lecture 11. Your solution to minimize *E* will be in the format of

(2)

**Show you derivation steps.**

**Explain briefly on how to compute the vector based on Eq.(2)** (Hint: refer to the lectures on Homography matrix computation about SVD and eigen-decomposition.)

**3. Implementation Bonus (Optional, 2 points)**

Given a set of points below

pts = [17 23 35 37 45 57 61 70 80 84;...

81 72 73 58 50 56 36 32 32 19];

where the first row is x and the second row is y.

**Write codes to implement your line fitting in question 2 and compute the (a,b,c).**

**Visualize the points and fitted line.**

**Upload your codes through Brightspace.**