HW 1 Solution

1. Geometric image formation
a: P = (30, 20)

b: behind model projects an inverted image; front model projects an upright image.
The behind model corresponds better to physical pinhole. The other model has same equation except image inversion.

c: focal length gets bigger, the projection becomes bigger; distance gets bigger, the projection becomes smaller.

d: (1,1,1); another: k*(1,1,1)

e: (1/2, 1/2)

f: infinity point which represents a direction

g: In homogeneous coordinates:

$\begin{bmatrix} U \\ V \\ W \end{bmatrix} = \begin{bmatrix} f & 0 & 0 \\ 0 & f & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \end{bmatrix}$ which is a linear equation, and u = U/W, v = V/W.

h: dimension of M is 3x4, K is 3x3, I is 3x3, O is 3x1.

i: p = (1.8, 4.6)

2. Modeling transformations
a: (3,4)

b: (2,2)

c: (0, $\sqrt{2}$)

d: (2, 2- $\sqrt{2}$)

e: TR

f: p is scaled by (3, 2)

g: p is translated by (1, 2)

h: $\begin{bmatrix} 1/3 & 0 & 0 \\ 0 & 1/2 & 0 \\ 0 & 0 & 1 \end{bmatrix}$

i: T(-1,-2)R(-45)

j: find (x,y) where x + 3y = 0

k: (34/29, 85/29)

3. General camera model

a: The general projection matrix can help transform objects from different coordinate systems in different situations.

b: $\begin{bmatrix} R^T & -R^T T \\ 0 & 1 \end{bmatrix}$

c: R = [$\hat{x}$, $\hat{y}$, $\hat{z}$]

d: R* and T* are the rotation and translation of world with respect to camera.

e: $\begin{bmatrix} k0 & 0 & 512 \\ 0 & kv & 512 \\ 0 & 0 & 0 \end{bmatrix}$

f: K* contains intrinsic parameters, [R*|T*] contains extrinsic parameters.

g: To make the camera model more accurate

h: The location of the original pixel changed in a non-linear way. The camera model more scale away from center.

i: Weak-perspective camera: M∞ is approximation to perspective camera's matrix M where the last raw is [0,0,0,1]. The parallel line of object appears to parallel each other.

Affine camera: A special case of projective camera. and is obtained by constraining the matrix such that the elements in the last row of the matrix are all zeros except the last one.

4. Color and photometric image formation

a: The surface radiance is the power of light per surface area reflected from the surface. The image irradiance is the power of light per surface area that are received at each pixel.

b: E(p) = L(p) $\frac{\pi}{4}(\frac{d}{f})\cos\alpha^4$

c: Defined as the ratio of irradiance reflected to the irradiance received by a surface

d: That's how human perceive colors

e: gray

f: Mapping can be done using CIE conversion.

g: Y represents the relative luminance of the color as perceived by human eye.
I.e. perceived relative brightness.

h: Lab color is approximate to human vision. Colorimetric distances between the individual colors correspond to perceived color differences.