Assignment - 1.

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(1)

(a)

focal length $f = 10$

$P = (3, 2, 1)$

$$p = K [I / 0] P$$

$$= \begin{bmatrix} 10 & 0 & 0 \\ 0 & 10 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} 3 \\ 2 \\ 1 \\ 1 \end{bmatrix}$$

$$= \begin{bmatrix} 10 & 0 & 0 & 0 \\ 0 & 10 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} 3 \\ 2 \\ 1 \\ 1 \end{bmatrix}$$

$$= \begin{bmatrix} 30 \\ 20 \\ 1 \end{bmatrix}$$

→ Co-ordinates of the ~~image~~ point P when projecting it onto the image is $(30, 20)$.

(b)

→ In pinhole camera model where the image plane is behind the center of projection is better because it gives more accurate image then the pinhole camera model where the image plane is in front of the center of projection.

→ Where image plane is behind the center of projection it will give a better corresponds to physical pinhole camera model.

(c)

→ When the focal length gets bigger projection of an object gets bigger.

→ When the distance to the object gets bigger projection of an object gets smaller.

(d)

→ ~~2D~~ given 2D points are = (1,1)

It's coordinates in homogeneous coordinates (2DH) is = (1, 1, 1).

→ Another 2DH coordinate is $= (tx, ty, t)$
$= (3\times1, 3\times1, 3)$
$= (3, 3, 3)$

(e)

→ 2DH points ~~are~~ is = (1, 1, 2)

Corresponding 2D points = $\left(\frac{1}{2}, \frac{1}{2}\right)$.

(f)

→ given the 2DH point (1, 1, 0), when we will homogeneous them into 2D we will get $\left(\frac{1}{0}, \frac{1}{0}\right)$, which is infinite points.

→ They are called points at infinity. Such points represents direction.

(g)

→ Using Homogeneous coordinates we can write non linear equation as a linear equation. where,

$$\begin{bmatrix} U \\ V \\ W \end{bmatrix} = \begin{bmatrix} f & & \\ & f & \\ & & 1 \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \end{bmatrix}$$

2DH 3D

→ ~~where~~ $U = fX$, $V = fY$, $W = Z$ in this U, V, W coordinates is generated by multiplying matrix with vector. where U, V, W is going to be the weighted sum of coordinate X, Y and Z it is a linear combination and that is why it's a linear equation. where $u = U/W = fX/Z$, $v = V/W = fY/Z$ it is the true perspective projection where U, V is divided by Z.

(h)

$$m = K[I \mid 0]$$

→ dimension of matrix are

$m = 3 \times 4$

$K = 3 \times 3$

$I = 3 \times 3$

$0 = 3 \times 1$

where $K = \begin{bmatrix} f & 0 & 0 \\ 0 & f & 0 \\ 0 & 0 & 1 \end{bmatrix}$

$I = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$, $0 = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}$.

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(i)

$$M = \begin{bmatrix} 1 & 2 & 3 & 4 \\ 5 & 6 & 7 & 8 \\ 1 & 2 & 1 & 2 \end{bmatrix}$$

$$P = \begin{bmatrix} 1 \\ 2 \\ 3 \end{bmatrix}$$

$$P = \begin{bmatrix} 1 & 2 & 3 & 4 \\ 5 & 6 & 7 & 8 \\ 1 & 2 & 1 & 2 \end{bmatrix} \begin{bmatrix} 1 \\ 2 \\ 3 \\ 1 \end{bmatrix}$$

$$= \begin{bmatrix} 18 \\ 46 \\ 10 \end{bmatrix}$$

→ ~~2D coordinate~~

→ 2D point $p = \left(\frac{18}{10}, \frac{46}{10}\right)$.

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(2)

(a)

→ $(x, y) = (1, 1)$

Translating matrix $= (2, 3)$

$$\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} x \\ y \end{bmatrix} + \begin{bmatrix} 2 \\ 3 \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \end{bmatrix} + \begin{bmatrix} 2 \\ 3 \end{bmatrix} = \begin{bmatrix} 3 \\ 4 \end{bmatrix}$$

→ coordinates after translation is $(3, 4)$

(b)

→ given point $(x, y) = (1, 1)$

Scaling factors $(S_x, S_y) = (2, 2)$

→ Coordinates after scaling $x' = S_x x = 2(1) = 2$

$y' = S_y y = 2(1) = 2$

→ coordinates after scaling is $(2, 2)$

(c)

→ given point $(x, y) = (1, 1)$

$\theta = 45°$

→ Points after rotating $\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix}$

$$= \begin{bmatrix} 1/\sqrt{2} & -1/\sqrt{2} \\ 1/\sqrt{2} & 1/\sqrt{2} \end{bmatrix} \begin{bmatrix} 1 \\ 1 \end{bmatrix}$$

$$= \begin{bmatrix} 0 \\ \sqrt{2} \end{bmatrix}$$

→ coordinates after rotating is $(0, \sqrt{2})$

(d)

→ coordinates $(x, y) = (1+2, 1+2)$
$= (3, 3)$

$$\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} \cos 45° & -\sin 45° \\ \sin 45° & \cos 45° \end{bmatrix} \begin{bmatrix} 3 \\ 3 \end{bmatrix}$$

$$= \begin{bmatrix} 1/\sqrt{2} & -1/\sqrt{2} \\ 1/\sqrt{2} & 1/\sqrt{2} \end{bmatrix}$$

$$= \begin{bmatrix} 0 \\ 3\sqrt{2} \end{bmatrix}$$

(e)

→ Combined matrix P', after rotating first using matrix R and then translate using matrix T is,

$$P' = T R P$$

where T = translating matrix
R = rotating matrix
P = initial co-ordinates.

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(f) $m = \begin{bmatrix} 3 & 0 & 0 \\ 0 & 2 & 0 \\ 0 & 0 & 1 \end{bmatrix}$

when we compare m with, the matrix

$$\begin{bmatrix} S_x & 0 & 0 \\ 0 & S_y & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

so, p will be scaled by (3, 2).

(g) $m = \begin{bmatrix} 1 & 0 & 1 \\ 0 & 1 & 2 \\ 0 & 0 & 1 \end{bmatrix}$

when we compare m with the matrix

$$\begin{bmatrix} 1 & 0 & t_x \\ 0 & 1 & t_y \\ 0 & 0 & 1 \end{bmatrix}$$

so, p will be translate by (1, 2)

(h) $m = \begin{bmatrix} 3 & 0 & 0 \\ 0 & 2 & 0 \\ 0 & 0 & 1 \end{bmatrix}$

Reverse effect is

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

(i)

$$M = R(45)\,T(1,2)$$

$$M^{-1} = T^{-1}(1,2)\,R^{-1}(45)$$

$$M^{-1} = T(-1,-2)\,R^{T}(45)$$

(j)

→ vector which is perpendicular to (1, 3)

$$(1,3)\cdot(x,y)=0$$

$$x+3y=0$$

So, one vector is $(3,-1)$

(k)

$$a = (1, 3)$$
$$b = (2, 5)$$

$$\mathrm{Proj}_b\, a = \left(\frac{a \cdot b}{|b|^2}\right) b$$
$$= \left(\frac{1 \cdot 2 + 3 \cdot 5}{4 + 25}\right)(2, 5)$$
$$= \frac{17}{29}(2, 5)$$
$$= \left(\frac{34}{29}, \frac{85}{29}\right)$$

(3)

(a)

→ general projection matrix is used to relate 3D point in world coordinate system to 2D point in image coordinate.

(b)

→ Camera is rotated by R and translated by T.

→ P is a point in world coordinate system and ~~...~~ $\hat{x}_c$, $\hat{y}_c$ and $\hat{z}_c$ is unit vector in camera coordinate.

$$\begin{bmatrix} x' \\ y' \\ z' \end{bmatrix} = \begin{bmatrix} \hat{x}_c^T \\ \hat{y}_c^T \\ \hat{z}_c^T \end{bmatrix} (P-T)$$

$$= R^T(P-T)$$

(c)

→ given unit vectors $\hat{x}, \hat{y}, \hat{z}$, the rotation matrix describing rotation of the camera with respect to the world is $= \begin{bmatrix} \hat{x} \\ \hat{y} \\ \hat{z} \end{bmatrix}$

(d)

→ Transformation ~~...~~ matrix between world and camera coordinates

$$M = \begin{bmatrix} R^* & T^* \\ 0 & 1 \end{bmatrix}$$

→ In this matrix R^* is a rotation of world with respect to camera.

→ T^* is translation with respect to camera.

(e).

→ There are k_u pixels per mm in the x direction, k_v pixels per mm in the y direction and the optical center of the camera is translated by $(u_0, v_0) = (512, 512)$ pixels.

→ Transformation matrix that will convert camera coordinates to image coordinates is

$$M_{i \leftarrow c} = \begin{bmatrix} k_u & 0 & u_0 \\ 0 & k_v & v_0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$M_{i \leftarrow c} = \begin{bmatrix} k_u & 0 & 512 \\ 0 & k_v & 512 \\ 0 & 0 & 1 \end{bmatrix}$$

(f)

→ Projection matrix $M = K^*[R^* | T^*]$

→ Here, R^* is a rotation of world with respect to camera. and T^* is the translation with respect to camera.

→ Here, in the projection matrix K^* is intrinsic parameter. The value of this parameter will change when you change the position of the camera.

→ $R^*|T^*$ is a extrinsic parameter. ~~This parameters~~. Value of this parameter will change when you change the position of the camera.

(g)

→ 2D skew parameter increases the accuracy of the model.

→ If you want your model to be accurate then 2D skew parameter is necessary and sometime in some model we can ignore it.

(h)

→ When we taking into account radial lens distortion then it complicates the projection in camera model.

→ Here, λ depends on the distance from the center. When the center is at zero. then there will be no scale.

→ when you move from the center it makes projection of image more difficult.

(i)

→ perspective means distance object looks smaller. A week perspective is correct when smaller compared to distance from camera.

In week perspective images looks as it is because there is not much perspective.

→ In Affine camera is used to make the projection model more easy. The affine camera preserves parallelism.

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(4)

(a).

→ The difference between surface radiance and the image radiance is that the surface radiance is a light that will be reflected on the surface and the image radiance is a light that is received at the image.

(b).

→ Radiosity equations relating surface radiance and image radiance is,

$$E(p) = L(p) \frac{\pi}{4} \left(\frac{d}{f}\right)^2 (\cos \alpha)^4$$

where, $E(p)$ = image radiance
$L(p)$ = surface radiance
d = diameter.
f = focal length.

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(c)

→ Albedo of a surface is a reflection coefficient.

→ It gives us the idea that how good was the surface reflection.

→ The value of ~~Add~~ Albedo is between 0 and 1.

→ When the value of albedo is 0 then it means that surface did not reflect light.

→ When the value of albedo is 1 then it means that surface reflected excellent light.

(d)

→ RGB color model is used because our human eye work on this model. It detects the light and send it to brain.

(e)

→ Given the RGB color cube, the line that connects (0,0,0) and (1,1,1) contains all the grayscale color.

(f)

→ We can map the RGB color to real world colors by doing experiments. when we change the different value of R.G.B and compare it to the real world color. then after doing the few variation with them we select the value.

(g)

→ Use of the luminance component Y in the CIE RGB color model. is to convert the colored image to greyscale (black & white) image.

(h)

→ LAB color space. is close resemblance to human perception. It has wide color gamut. It treats black and white as their own opponent channel.

→ Also, we can boost the color in LAB color space.