Name: Nem Zutkovic **COMP 4102:** Assignment 2 March 17, 2020
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1. A pin-hole camera does have an infinite depth of field. This results in perfectly sharp image and everything is in focus regardless of the distance of the objects in the image. The reason this is the case is because of the limited size of the hole. With a very small hole, there is less light coming in, which means the rays are more likely to be organized, generating an image where everything appears in focus.

2. Assuming f is some scalar and both $x = \frac{u}{w} = f\frac{X}{Z}$ and $y = \frac{v}{w} = f\frac{Y}{Z}$ hold true from representing a linear relation, we can compute the scalar projection on to the 3d point through matrix multiplication:

$$\begin{bmatrix} f & 0 & 0 & 0 \\ 0 & f & 0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix} = \begin{bmatrix} u \\ v \\ w \end{bmatrix}$$

Giving us $\begin{bmatrix} fx \\ fy \\ z \end{bmatrix} = \begin{bmatrix} u \\ v \\ w \end{bmatrix}$ such that the following holds true:

$fx = u$ which is equivalent to $x = \frac{u}{f}$.

$fy = v$ which is equivalent to $y = \frac{v}{f}$

and where $z = w$.

Because we know that $x = \frac{u}{w}$ and $y = \frac{v}{w}$ from our assumption so we can compare them to our findings:

$\frac{u}{f} = \frac{u}{w}$ and $\frac{v}{f} = \frac{v}{w}$ where both simplify to $w = f$ and $f = w$ respectively.

Because we see that both the x and y coordinates of the 2d point $p = (x, y)$ are equivalent to the scalar f, we know that each point from the 3d line projects through the same 2d point p.

3A.

$$R = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \quad T = \begin{bmatrix} -70 \\ -95 \\ -120 \end{bmatrix} \quad f = 500 \quad O_x = 320 \quad O_y = 240$$

$$\begin{bmatrix} -500 & 0 & 320 \\ 0 & -500 & 240 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & -70 \\ 0 & 1 & 0 & -95 \\ 0 & 0 & 1 & -120 \end{bmatrix} = \begin{bmatrix} -500 & 0 & 320 & -3400 \\ 0 & -500 & 240 & 18700 \\ 0 & 0 & 1 & -120 \end{bmatrix}$$

3B.

$X_w = [150 \quad 200 \quad 400]^T$

$$\begin{bmatrix} u' \\ v' \\ w' \end{bmatrix} = \begin{bmatrix} -500 & 0 & 320 & -3400 \\ 0 & -500 & 240 & 18700 \\ 0 & 0 & 1 & -120 \end{bmatrix} \begin{bmatrix} 150 \\ 200 \\ 400 \\ 1 \end{bmatrix} = \begin{bmatrix} 49600 \\ 14700 \\ 280 \end{bmatrix}$$

$$u = \frac{u'}{w'} = \frac{49600}{280} = 177.1 \quad \text{and} \quad v = \frac{v'}{w'} = \frac{14700}{280} = 52.5$$

Therefore, the pixel coordinates of X_w are (177, 52).