## Camera Theory Notes

### Mac Radigan

#### Camera Matrix

#### **Intrinsic Parameters**

The instrinsic camera [1], having focal length f, shear s, sample spacing  $m_x$  and  $m_y$ , and camera center  $x_0$  and  $y_0$ .

$$\begin{bmatrix}
m_x f & s & x_0 \\
0 & m_y f & y_0 \\
0 & 0 & 1
\end{bmatrix}
\begin{bmatrix}
1 & 0 & 0 & 0 \\
0 & 1 & 0 & 0 \\
0 & 0 & 1 & 0
\end{bmatrix}$$
(1)

#### **Extrinsic Parameters**

$$\begin{bmatrix} \mathbf{R} & \mathbf{0}_{3x1} \\ \mathbf{0}_{1x3} & 1 \end{bmatrix} \begin{bmatrix} \mathbf{I}_{3x3} & \mathbf{t} \\ \mathbf{0}_{1x3} & 1 \end{bmatrix}$$
 (2)

#### Representation

$$\mathbf{H} = \mathbf{KPRT} = \begin{bmatrix} m_x f & s & x_0 \\ 0 & m_y f & y_0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} \mathbf{R} & \mathbf{0}_{3x1} \\ \mathbf{0}_{1x3} & 1 \end{bmatrix} \begin{bmatrix} \mathbf{I}_{3x3} & \mathbf{t} \\ \mathbf{0}_{1x3} & 1 \end{bmatrix}$$
(3)

$$\mathbf{t} = \begin{bmatrix} t_x \\ t_y \\ t_z \end{bmatrix} \tag{4}$$

$$\mathbf{R} = \mathbf{R}_{\mathbf{x}} (\theta_{\mathbf{x}}) \, \mathbf{R}_{\mathbf{y}} (\theta_{\mathbf{y}}) \, \mathbf{R}_{\mathbf{z}} (\theta_{\mathbf{z}}) \tag{5}$$

$$= \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos(\theta_x) & -\sin(\theta_x) \\ 0 & \sin(\theta_x) & \cos(\theta_x) \end{bmatrix} \begin{bmatrix} \cos(\theta_y) & 0 & \sin(\theta_y) \\ 0 & 1 & 0 \\ -\sin(\theta_y) & 0 & \cos(\theta_y) \end{bmatrix} \begin{bmatrix} \cos(\theta_z) & -\sin(\theta_z) & 0 \\ \sin(\theta_z) & \cos(\theta_z) & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

# References

[1] R. I. Hartley and A. Zisserman, *Multiple View Geometry in Computer Vision*, 2nd ed. Cambridge University Press, ISBN: 0521540518, 2004.

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