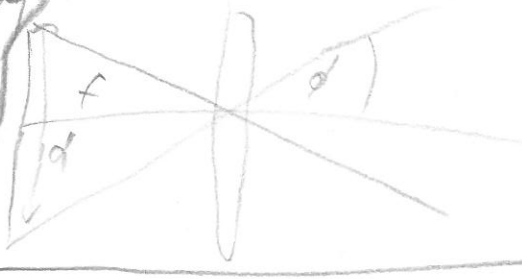
$$\vec{x}_{VS} \cdot \vec{V} = \vec{x}_{VS}^{T}$$

$$\text{dehomogenize}\left(\vec{x}_{PS}\right) = \vec{x}_{PS}$$

$$\vec{x}_{VS} = \begin{pmatrix} xR_{11} + yR_{21} + zR_{31} + t_x \\ xR_{12} + yR_{22} + zR_{32} + t_y \\ xR_{13} + yR_{23} + zR_{33} + t_z \\ 1 \end{pmatrix}^{T}$$

$$FoV_\beta = \tan^{-1}\left(\frac{d}{2f}\right)$$



$$\mathbb{R}^4 \quad \mathbb{R}^{4\times4} \quad \mathbb{R}^4$$

$$\begin{pmatrix} f_{resX} & 0 & 0 & 0 \\ 0 & f_{resY} & 0 & 0 \\ p_{px}r_{esX} & p_{py}r_{esY} & 1 & 0 \\ 0 & 0 & 0 & 0 \end{pmatrix} = \begin{pmatrix} f_{resX}\cdot x_{VS} + p_{px}\cdot r_{esX}\cdot z_{VS} \\ f_{resY}\cdot y_{VS} + p_{py}\cdot r_{esY}\cdot z_{VS} \\ z_{VS} \\ z_{VS} \end{pmatrix}^{T}$$

$$\vec{x}_{VS} \cdot \vec{p} = \vec{x}_{VS}^{T}$$

$z_{VS} \neq 0$ non homogeneous

$$\Rightarrow \begin{pmatrix} \frac{f_{resX}\cdot x_{VS} + p_{px}\cdot r_{esX}\cdot z_{VS}}{z_{VS}} \\ \frac{f_{resY}\cdot y_{VS} + p_{py}\cdot r_{esY}\cdot z_{VS}}{z_{VS}} \end{pmatrix}$$

$$\vec{x}_{PS} = \begin{pmatrix} \frac{f_{resX}\cdot x_{VS} + p_{px}\cdot r_{esX}}{z_{VS}} \\ \frac{f_{resY}\cdot y_{VS} + p_{py}\cdot r_{esY}}{z_{VS}} \end{pmatrix}$$

$$\frac{\partial \vec{x}_{PS}}{\partial \vec{x}_{VS}} = \begin{pmatrix} \frac{\partial \vec{x}_{PS}}{\partial x_{VS}} \\ \frac{\partial \vec{x}_{PS}}{\partial y_{VS}} \\ \frac{\partial \vec{x}_{PS}}{\partial z_{VS}} \end{pmatrix}$$

$$\frac{\partial \vec{x}_{PS}}{\partial x_{VS}} = \begin{pmatrix} \frac{f_{resX}}{z_{VS}} & 0 \end{pmatrix}$$

$$\frac{\partial \vec{x}_{PS}}{\partial y_{VS}} = \begin{pmatrix} 0 & \frac{f_{resY}}{z_{VS}} \end{pmatrix}$$

$$\frac{\partial \vec{x}_{PS}}{\partial z_{VS}} = \begin{pmatrix} -\frac{f_{resX}\cdot x_{VS}}{z_{VS}^2} & -\frac{f_{resY}\cdot y_{VS}}{z_{VS}^2} \end{pmatrix}$$

$$\Rightarrow \frac{\partial \vec{x}_{PS}}{\partial \vec{x}_{VS}} = \begin{pmatrix} \frac{f_{resX}}{z_{VS}} & 0 \\ 0 & \frac{f_{resY}}{z_{VS}} \\ -\frac{f_{resX}\cdot x_{VS}}{z_{VS}^2} & -\frac{f_{resY}\cdot y_{VS}}{z_{VS}^2} \end{pmatrix}$$

$$\frac{\partial (\vec{x}_{WS}^{T}\cdot V)}{\partial x} = (R_{11} \quad R_{12} \quad R_{13} \quad 0)$$

$$\frac{\partial (\vec{x}_{WS}^{T} V)}{\partial y} = (R_{21} \quad R_{22} \quad R_{23} \quad 0)$$

$$\frac{\partial (\vec{x}_{WS}^{T} V)}{\partial z} = (R_{31} \quad R_{32} \quad R_{33} \quad 0)$$

$$\partial \vec{x}_{VS}^{T} = (\partial x \quad \partial y \quad \partial z)^{T} \cdot \begin{pmatrix} R_{11} & R_{12} & R_{13} & 0 \\ R_{21} & R_{22} & R_{23} & 0 \\ R_{31} & R_{32} & R_{33} & 0 \end{pmatrix}$$

$$\frac{\partial \vec{x}_{PS}}{\partial \vec{x}_{WS}} = f \begin{pmatrix} \frac{res_X}{z_{VS}} \\ \frac{res_Y}{z_{VS}} \end{pmatrix} \begin{pmatrix} R_{11} - \frac{x_{VS}\cdot R_{13}}{z_{VS}} & R_{12} - \frac{y_{VS} R_{13}}{z_{VS}} \\ R_{21} - \frac{x_{VS} R_{23}}{z_{VS}} & R_{22} - \frac{y_{VS} R_{23}}{z_{VS}} \\ R_{31} - \frac{x_{VS} R_{33}}{z_{VS}} & R_{32} - \frac{y_{VS} R_{33}}{z_{VS}} \end{pmatrix}$$