$$\forall i, \quad w_i \begin{bmatrix} u_i \\ v_i \\ 1 \end{bmatrix} = \begin{bmatrix} f_u & 0 & u_c \\ 0 & f_v & v_c \\ 0 & 0 & 1 \end{bmatrix} \sum_{j=1}^{4} \alpha_{ij} \begin{bmatrix} x_j^c \\ y_j^c \\ z_j^c \end{bmatrix}.$$

$$w_i \begin{bmatrix} u_i \\ 1 \end{bmatrix} = A \begin{bmatrix} x_1^c & x_2^c & x_3^c & x_4^c \\ y_1^c & y_2^c & & \\ z_1^c & z_2^c & & \end{bmatrix} \begin{bmatrix} \alpha_{i1} \\ \alpha_{i2} \\ \alpha_{i3} \\ \alpha_{i4} \end{bmatrix}$$

$$w_i \begin{bmatrix} u_i \\ 1 \end{bmatrix} = AC\alpha_i$$

$$e_i = AC\alpha_i - \begin{bmatrix} u_i \\ 1 \end{bmatrix} w_i$$

$$S_i = e_i^T e_i$$

$$E = \sum_i S_i$$

$$\frac{\partial E}{\partial x_i^c} = \frac{\partial e_i^T}{\partial x_i^c} e_i + e_i^T \frac{\partial e_i}{\partial x_i^c}$$

$$\frac{\partial e_i}{\partial x_i^c} = A \frac{\partial C}{\partial x_i^c} \alpha_i - \cancel{\frac{\partial u_i}{\partial x_i^c}}$$

$$\frac{\partial C}{\partial x_1^c} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix} \qquad \frac{\partial C}{\partial y_1^c} = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

$$\frac{\partial C}{\partial x_2} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix} \qquad \text{etc.}$$

$$\frac{\partial C}{\partial x_3} = \begin{bmatrix} 0 & 0 & 1 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix}$$

$$\forall i, \quad w_i \begin{bmatrix} u_i \\ v_i \\ 1 \end{bmatrix} = \begin{bmatrix} f_u & 0 & u_c \\ 0 & f_v & v_c \\ 0 & 0 & 1 \end{bmatrix} \sum_{j=1}^{4} \alpha_{ij} \begin{bmatrix} x_j^c \\ y_j^c \\ z_j^c \end{bmatrix} = \begin{bmatrix} f_u & 0 & u_c \\ 0 & f_v & v_c \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} C \end{bmatrix} \begin{bmatrix} \alpha_i \end{bmatrix} = \begin{bmatrix} f_u & 0 & u_c \\ 0 & f_v & v_c \end{bmatrix} C\alpha_i$$

$$z_1^c \alpha_{i1} + z_2^c \alpha_{i2} + z_3^c \alpha_{i3} + z_4^c \alpha_{i4}$$

$$C = \begin{bmatrix} C_x \\ C_y \\ C_z \end{bmatrix}_{3\times 4}$$

$$\underset{1\times 4}{C_z} \underset{4\times 1}{\alpha_i} [u_i] = A_2 C \alpha_i$$

$$e_i = A_2 C\alpha_i - C_z \alpha_i u_i \qquad S_i = e_i^T e_i$$

$$E = \sum_i e_i^T e_i \qquad \frac{\partial E}{\partial x_j^c} = \sum_i \frac{\partial e_i^T}{\partial x_j^c} e_i + e_i^T \frac{\partial e_i}{\partial x_j^c} \quad \Big| \quad \frac{\partial E}{\partial x_j^c} = 2\sum_i \frac{\partial e_i^T}{\partial x_j^c} e_i$$

$$\frac{\partial E}{\partial y_j^c} = 2\sum_i \frac{\partial e_i^T}{\partial y_j^c} e_i$$

$$\frac{\partial E}{\partial z_j^c} = 2\sum_i \frac{\partial e_i^T}{\partial z_j^c} e_i$$

$$\frac{\partial e_i}{\partial z_1^c} = A_2 \frac{\partial C}{\partial z_1^c} \alpha_i - \frac{\partial C_z}{\partial z_1^c} \alpha_i u_i$$