$$\boldsymbol{x}_{k+1} = \boldsymbol{a}(\boldsymbol{x}_k, \boldsymbol{w}_k) = \boldsymbol{q}_k \otimes \boldsymbol{q}_\triangle + \left[\cos\left(\frac{\|\boldsymbol{w}\|}{2}\right), \boldsymbol{w}^T \sin\left(\frac{\|\boldsymbol{w}\|}{2}\right)\right]^T$$

$$A = \frac{\partial \boldsymbol{a}}{\partial \boldsymbol{x}} = \begin{bmatrix} q_{\triangle w} & -q_{\triangle x} & -q_{\triangle y} & -q_{\triangle z} \\ q_{\triangle x} & q_{\triangle w} & q_{\triangle z} & -q_{\triangle y} \\ q_{\triangle y} & -q_{\triangle z} & q_{\triangle w} & q_{\triangle x} \\ q_{\triangle z} & q_{\triangle y} & -q_{\triangle x} & q_{\triangle w} \end{bmatrix}$$

$$Q = \frac{\partial \boldsymbol{a}}{\partial \boldsymbol{w}} = \begin{bmatrix} \frac{-w_1 \sin\left(\frac{\|\boldsymbol{w}\|}{2}\right)}{2\|\boldsymbol{w}\|} & \frac{-w_2 \sin\left(\frac{\|\boldsymbol{w}\|}{2}\right)}{2\|\boldsymbol{w}\|} & \frac{-w_3 \sin\left(\frac{\|\boldsymbol{w}\|}{2}\right)}{2\|\boldsymbol{w}\|} \\ \sin\left(\frac{\|\boldsymbol{w}\|}{2}\right) + \frac{w_2^2 \cos\left(\frac{\|\boldsymbol{w}\|}{2}\right)}{2\|\boldsymbol{w}\|} & \frac{w_2 w_1 \sin\left(\frac{\|\boldsymbol{w}\|}{2}\right)}{2\|\boldsymbol{w}\|} & \frac{w_3 w_1 \sin\left(\frac{\|\boldsymbol{w}\|}{2}\right)}{2\|\boldsymbol{w}\|} \\ \frac{w_1 w_2 \sin\left(\frac{\|\boldsymbol{w}\|}{2}\right)}{2\|\boldsymbol{w}\|} & \sin\left(\frac{\|\boldsymbol{w}\|}{2}\right) + \frac{w_2^2 \cos\left(\frac{\|\boldsymbol{w}\|}{2}\right)}{2\|\boldsymbol{w}\|} & \frac{w_3 w_2 \sin\left(\frac{\|\boldsymbol{w}\|}{2}\right)}{2\|\boldsymbol{w}\|} \\ \frac{w_1 w_3 \sin\left(\frac{\|\boldsymbol{w}\|}{2}\right)}{2\|\boldsymbol{w}\|} & \frac{w_2 w_3 \sin\left(\frac{\|\boldsymbol{w}\|}{2}\right)}{2\|\boldsymbol{w}\|} & \sin\left(\frac{\|\boldsymbol{w}\|}{2}\right) + \frac{w_3^2 \cos\left(\frac{\|\boldsymbol{w}\|}{2}\right)}{2\|\boldsymbol{w}\|} \end{bmatrix}$$

$$\boldsymbol{z}_k = \boldsymbol{h}(\boldsymbol{x}_k, \boldsymbol{v}_k) = \boldsymbol{q}_k^{-1} \otimes \begin{bmatrix} 0 \\ 0 \\ 0 \\ -g \end{bmatrix} \otimes \boldsymbol{q}_k + \boldsymbol{v}_k$$

$$H = \frac{\partial \boldsymbol{h}}{\partial \boldsymbol{v}} = 2g \begin{bmatrix} q_3 & -q_4 & q_1 & -q_2 \\ -q_2 & -q_1 & q_4 & -q_3 \\ q_1 & q_2 & q_3 & -q_4 \end{bmatrix}$$

$$R = \frac{\partial \boldsymbol{h}}{\partial \boldsymbol{v}} = \boldsymbol{I}$$