eiquadprog solves problems of the form

$$\begin{aligned} \min_{x} \quad & \frac{1}{2}x^T Q x + q^T x \\ s.t. \quad & A_{eq}x + b_{eq} = 0 \\ & A_{ineq}x + b_{ineq} \geq 0 \end{aligned} \tag{55}$$

How to write the QP? we can start by writing the contact force as

$$\bar{\lambda} = \underbrace{\lambda_{avg}}_{3.nactive\times 1} - \frac{1}{\delta t} \underbrace{D}_{3.nactive\times 6.nactive} \underbrace{\int_0^{\delta t} e^{\tau A} d\tau}_{6.nactive\times 6.nactive} \underbrace{\begin{bmatrix} \frac{\delta t}{2} I \\ I \end{bmatrix}}_{6.nactive\times 3.nactive} \underbrace{\dot{\bar{p}}_0}_{3.nactive\times 1}$$

$$\bar{\lambda} = \underbrace{\lambda_{avg}}_{3.nactive\times 1} - \underbrace{\bar{A}}_{3.nactive\times 3.nactive} \underbrace{\dot{\bar{p}}_0}_{3.nactive\times 1}$$

where λ_{avg} is defined as

$$\lambda_{avg} = \frac{1}{\delta t} D \int_0^{\delta t} x(\tau)\, d\tau + K p_0 \tag{56}$$

To approximate the friction cone by an inner 4-sided pyramid, let $\tilde{\mu} = \mu/\sqrt{2}$ where μ is the coefficient of friction, then the constraints can be written as

$$\bar{\lambda}_i.\hat{n}_i \geq 0 \tag{57}$$

$$-\tilde{\mu}\left(\bar{\lambda}_i.\hat{n}_i\right) \leq \bar{\lambda}_i.\hat{t}_{ai} \leq \tilde{\mu}\left(\bar{\lambda}_i.\hat{n}_i\right) \tag{58}$$

$$-\tilde{\mu}\left(\bar{\lambda}_i.\hat{n}_i\right) \leq \bar{\lambda}_i.\hat{t}_{bi} \leq \tilde{\mu}\left(\bar{\lambda}_i.\hat{n}_i\right) \tag{59}$$

let $\hat{n}$ is matrix containing all the normal vectors to all the active contacts and written as

$$\hat{n}^T = \underbrace{\begin{bmatrix} \hat{n}_1^T & 0 & 0 \\ 0 & \ddots & 0 \\ 0 & 0 & \hat{n}_{nactive}^T \end{bmatrix}}_{nactive\times 3.nactive} \tag{60}$$

Similarly define the matrices $\hat{t}_a^T$ and $\hat{t}_b^T$. Then, rewrite the inequalities to match the solver notation

$$\hat{n}^T\bar{\lambda} \geq 0 \tag{61}$$
$$\tilde{t}_a^T\bar{\lambda} + \tilde{\mu}\hat{n}^T\bar{\lambda} \geq 0 \tag{62}$$
$$-\tilde{t}_a^T\bar{\lambda} + \tilde{\mu}\hat{n}^T\bar{\lambda} \geq 0 \tag{63}$$
$$\tilde{t}_b^T\bar{\lambda} + \tilde{\mu}\hat{n}^T\bar{\lambda} \geq 0 \tag{64}$$
$$-\tilde{t}_b^T\bar{\lambda} + \tilde{\mu}\hat{n}^T\bar{\lambda} \geq 0 \tag{65}$$

We have to write the constraints in terms of $\dot{\bar{p}}_0$. Expand and regroup the constraints above to get

$$-\hat{n}^T\bar{A}\dot{\bar{p}}_0 + \hat{n}^T\lambda_{avg} \geq 0 \tag{66}$$
$$-\left(\tilde{\mu}\hat{n}^T + \hat{t}_a^T\right)\bar{A}\dot{\bar{p}}_0 + \left(\tilde{\mu}\hat{n}^T + \hat{t}_a^T\right)\lambda_{avg} \geq 0 \tag{67}$$
$$-\left(\tilde{\mu}\hat{n}^T - \hat{t}_a^T\right)\bar{A}\dot{\bar{p}}_0 + \left(\tilde{\mu}\hat{n}^T - \hat{t}_a^T\right)\lambda_{avg} \geq 0 \tag{68}$$
$$-\left(\tilde{\mu}\hat{n}^T + \hat{t}_b^T\right)\bar{A}\dot{\bar{p}}_0 + \left(\tilde{\mu}\hat{n}^T + \hat{t}_b^T\right)\lambda_{avg} \geq 0 \tag{69}$$
$$-\left(\tilde{\mu}\hat{n}^T - \hat{t}_b^T\right)\bar{A}\dot{\bar{p}}_0 + \left(\tilde{\mu}\hat{n}^T - \hat{t}_b^T\right)\lambda_{avg} \geq 0 \tag{70}$$

then we can construct the inequality matrix and vector A_{ineq} and b_{ineq} as follows

$$A_{ineq} = \begin{bmatrix} -\hat{n}^T \\ -\left(\tilde{\mu}\hat{n}^T + \hat{t}_a^T\right) \\ -\left(\tilde{\mu}\hat{n}^T - \hat{t}_a^T\right) \\ -\left(\tilde{\mu}\hat{n}^T + \hat{t}_b^T\right) \\ -\left(\tilde{\mu}\hat{n}^T - \hat{t}_b^T\right) \end{bmatrix} \bar{A} \tag{71}$$

$$b_{ineq} = \begin{bmatrix} \hat{n}^T \\ \left(\tilde{\mu}\hat{n}^T + \hat{t}_a^T\right) \\ \left(\tilde{\mu}\hat{n}^T - \hat{t}_a^T\right) \\ \left(\tilde{\mu}\hat{n}^T + \hat{t}_b^T\right) \\ \left(\tilde{\mu}\hat{n}^T - \hat{t}_b^T\right) \end{bmatrix} \lambda_{avg} \tag{72}$$