Dynamics

$$\underbrace{\begin{bmatrix} \mathbf{H} & -\mathbf{J}_c^\top \\ -\mathbf{J}_c & 0 \end{bmatrix}}_{\mathbf{K}} \underbrace{\begin{bmatrix} \ddot{\mathbf{q}} \\ \boldsymbol{\lambda} \end{bmatrix}}_{\boldsymbol{\nu}} = \underbrace{\begin{bmatrix} \mathbf{S}^\top \boldsymbol{\tau} - \mathbf{h} \\ \dot{\mathbf{J}}_c \dot{\mathbf{q}} \end{bmatrix}}_{\Psi}$$

$$\boxed{\boldsymbol{\nu} = \mathbf{K}^{-1} \Psi}$$

Conventional iLQR

AD tools once: $\dfrac{\partial \boldsymbol{\nu}}{\partial \mathbf{q}}$ $\quad \mathcal{O}(n^2)$

Conventional DDP

AD tools twice: $\dfrac{\partial^2 \boldsymbol{\nu}}{\partial^2 \mathbf{q}}$ $\quad \mathcal{O}(n^3)$

mRNEAc DDP

$$\boldsymbol{\gamma}^\top \frac{\partial^2 \boldsymbol{\nu}}{\partial^2 \mathbf{q}} = \mathsf{T}_1 + \mathsf{T}_2 + \mathsf{T}_2^\top$$

$$\mathsf{T}_1 = \frac{\partial^2}{\partial^2 \mathbf{q}} \, \mathrm{mRNEAc}\left(\mathbf{q}, \dot{\mathbf{q}}, \dot{\mathbf{q}}, \mathbf{a}_g, \xi_1, \lambda, \boldsymbol{\rho}, \mathsf{L}\right) \quad \mathcal{O}(n^2)$$

$$\mathsf{T}_2 = \frac{\partial}{\partial \mathbf{q}} \, \mathrm{mRNEAc}\left(\mathbf{q} * 0, \dot{\mathbf{q}} * 0, \frac{\partial \dot{\mathbf{q}}}{\partial \mathbf{q}}, \mathbf{a}_g * 0, \xi_1, \frac{\partial \lambda}{\partial \mathbf{q}}, \boldsymbol{\rho}, \mathsf{L}\right) \quad \mathcal{O}(n^2)$$