I

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

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

II <u><u>Conventional iLQR</u></u>

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

III <u><u>Conventional DDP</u></u>

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

IV <u><u>mRNEAc DDP</u></u>

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

$$\mathsf{T}_1 = \frac{\partial}{\partial \mathbf{q}} \left[\frac{\partial}{\partial \mathbf{q}} \, \mathrm{mRNEAc}\left(\mathbf{q}, \dot{\mathbf{q}}, \ddot{\mathbf{q}}, \mathbf{a}_g, \boldsymbol{\lambda}, \boldsymbol{\xi_\tau}, \boldsymbol{\pi}\right) \right]$$ $\mathcal{O}(n^2)$

$$\mathsf{T}_2 = \frac{\partial}{\partial \mathbf{q}} \, \mathrm{mRNEAc}\left(\mathbf{q} * 0, \dot{\mathbf{q}} * 0, \frac{\partial \ddot{\mathbf{q}}}{\partial \mathbf{q}}, \mathbf{a}_g * 0, \frac{\partial \boldsymbol{\lambda}}{\partial \mathbf{q}}, \boldsymbol{\xi_\tau}, \boldsymbol{\pi}\right)$$ $\mathcal{O}(n^2)$