* Dynamic model

- $M\ddot{q} + b = \tau$

* sliding variable

- $s = \lambda^2 e + 2\lambda\dot{e}$
- $\dot{s} = 2\lambda\dot{\lambda}e + \lambda^2\dot{e} + 2\dot{\lambda}\dot{e} + 2\lambda\ddot{e}$

* PD control signal

- $u = M(s) + b$

* SMC control signal

- $u = M(s + \tanh(s)) + b$

* Cost function

- $J = \underbrace{\frac{\gamma}{2}s^2}_{\text{reduce } \Delta\ddot{q}} + \underbrace{\frac{(1-\gamma)}{2}\dot{s}^2}_{\text{reduce } \Delta\dddot{q}}$

* Gradient descent

- $$\frac{\partial J}{\partial \lambda} = \frac{\partial J}{\partial s}\cdot\frac{\partial s}{\partial q}\cdot\frac{\partial q}{\partial u}\cdot\frac{\partial u}{\partial \lambda} + \frac{\partial J}{\partial \dot{s}}\cdot\frac{\partial \dot{s}}{\partial q}\cdot\frac{\partial q}{\partial u}\cdot\frac{\partial u}{\partial \lambda}$$

* $\frac{\partial u}{\partial \lambda}$ for PD control signal

- $\frac{\partial u}{\partial \lambda} = M.[2\lambda e + 2\dot{e}]$

* $\frac{\partial u}{\partial \lambda}$ for SM control signal

- $\frac{\partial u}{\partial \lambda} = M.(2-\tanh^2(s)).(2\lambda e + 2\dot{e})$

* $\frac{\partial s}{\partial q} = -\lambda^2$

* $\frac{\partial \dot{s}}{\partial q} = -2\lambda\dot{\lambda}$

* $\frac{\partial J}{\partial s} = \gamma s$

* $\frac{\partial J}{\partial \dot{s}} = (1-\gamma)\dot{s}$

* $\lambda(k+1) = \lambda(k) - \alpha\frac{\partial J}{\partial \lambda}$

* $\frac{\lambda(k+1) - \lambda(k)}{\Delta t} = \frac{-\alpha}{\partial t}\cdot\frac{\partial J}{\partial \lambda}$

* $\dot{\lambda} = \frac{-\alpha}{\partial t}\cdot\widehat{\frac{\partial J}{\partial \lambda}}$

Scanned with CamScanner