Revised Point for Today’s Lecture

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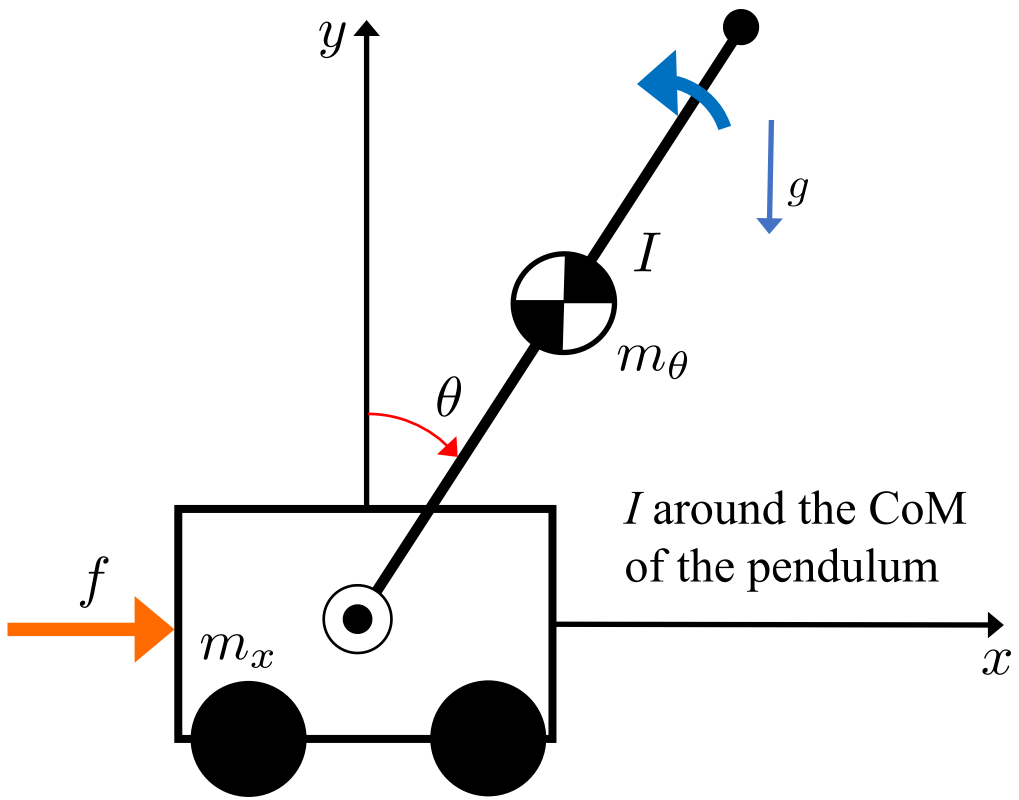
The Problem: Definition of Pendulum Angle

$$\dot{\theta} < 0$$



I around the CoM of the pendulum

If we input a positive force, the CoM of pendulum moves the negative rotational direction of the angle

For stabilize the system, we put the following input

$$f = -\{K_p(r - \theta) - K_v\dot{\theta}\}$$

$$F(s) = -\{K_p(R(s) - \Theta(s)) - sK_v\dot{\Theta}(s)\}$$

$$= -K_p(R(s) - \Theta(s)) + sK_v\dot{\Theta}(s)$$

Why Is Python Correct?

Revised version of the python code

```python
def Control(p):
    x, dx, theta, dtheta = p

    out = - K_p*(theta_d-theta) - K_v*(dtheta_d-dtheta)

    return out
```

```python
def InvertedPendulum(p, t):
    x, dx, theta, dtheta = p

    if theta > math.pi:
        theta = -math.pi
    elif theta < -math.pi:
        theta = math.pi

    M_11 = m_x + m_th
    M_12 = m_th*l_g*math.cos(theta)
    M_21 = m_th*l_g*math.cos(theta)
    M_22 = I + m_th*l_g*l_g

    #define matrix
    M = np.matrix([[M_11, M_12],[M_21, M_22]])
    N = np.matrix([[-m_th*l_g*math.sin(theta)*dtheta*dtheta],[0]])
    G = np.matrix([[0],[-m_th*g*l_g*math.sin(theta)]])
    F = np.matrix([[Control(p)],[0]])

    IM = np.linalg.inv(M) # calc Inverse matrix
    A = (-1)*IM.dot(N+G-F) # F is right hand side of equations

    ddx, ddtheta = A

    return [dx, ddx, dtheta, ddtheta]
```

$$f = \boxed{-}\{K_p(r-\theta) - K_v\dot{\theta}\}$$

$$\begin{aligned} F(s) &= -\{K_p(R(s)-\Theta(s)) - sK_v\dot{\Theta}(s)\} \\ &= -K_p(R(s)-\Theta(s)) + sK_v\dot{\Theta}(s) \end{aligned}$$

$$\boldsymbol{F} = [f, 0]^T, \boldsymbol{\theta} = [x, \theta]^T$$

$$\boldsymbol{F} = \boldsymbol{M}(\boldsymbol{\theta})\ddot{\boldsymbol{\theta}} + \boldsymbol{h}(\boldsymbol{\theta}, \dot{\boldsymbol{\theta}}) + \boldsymbol{g}(\boldsymbol{\theta})$$

$$\ddot{\boldsymbol{\theta}} = -\boldsymbol{M}(\boldsymbol{\theta})^{-1}\{\boldsymbol{h}(\boldsymbol{\theta}, \dot{\boldsymbol{\theta}}) + \boldsymbol{g}(\boldsymbol{\theta}) \boxed{-} \boldsymbol{F}\}$$

I will upload the Stability Analysis for IP soon!!!