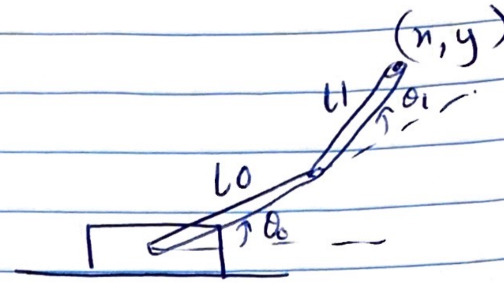
Part 1



A) Forward Model

$l_0 = 0.1 \quad , \quad l_1 = 0.11$

$$x = l_0 \cos(\theta_0) + l_1 \cos(\theta_0 + \theta_1)$$
$$y = l_0 \sin(\theta_0) + l_1 \sin(\theta_0 + \theta_1)$$

} End effector position

B) Jacobian Formula

$$\cancel{J = \frac{\partial\, d(\theta)}{\partial \theta} = \begin{bmatrix} \frac{\partial x}{\partial \theta_1} & \frac{\partial x}{\partial \theta_2} \\ \partial & \end{bmatrix}}$$

$$J = \frac{\partial\, d(\theta)}{\partial \theta} = \begin{bmatrix} \frac{\partial x}{\partial \theta_0} & \frac{\partial x}{\partial \theta_1} \\ \frac{\partial y}{\partial \theta_0} & \frac{\partial y}{\partial \theta_1} \end{bmatrix}$$

$$J(\theta) = \begin{bmatrix} -l_0 \sin(\theta_0) - l_1 \sin(\theta_0+\theta_1) & -l_1 \sin(\theta_0+\theta_1) \\ l_0 \cos(\theta_0) + l_1 \cos(\theta_0+\theta_1) & l_0 \cos(\theta_0+\theta_1) \end{bmatrix}$$

1000, 2

c) Algorithm for Inverse

$$dx = J(\theta)\, d\theta$$

$$\Rightarrow \Delta x = J(\theta)\, \Delta\theta$$

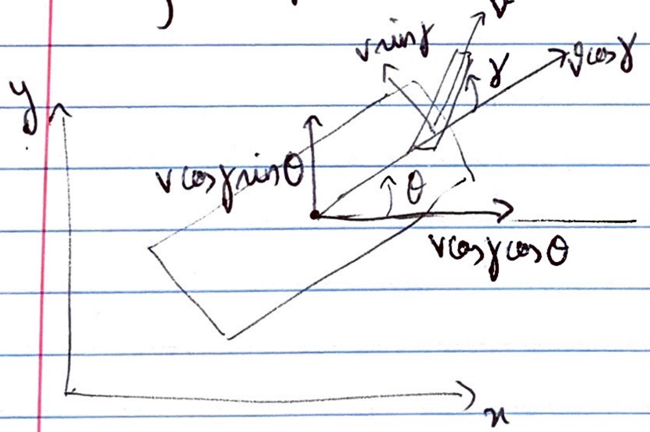
$$\Rightarrow \Delta\theta = J^{-1}(\theta)\, \Delta x$$

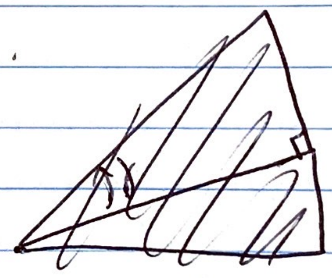
To avoid singularities with $J^{-1}(\theta)$, use pseudoinverse

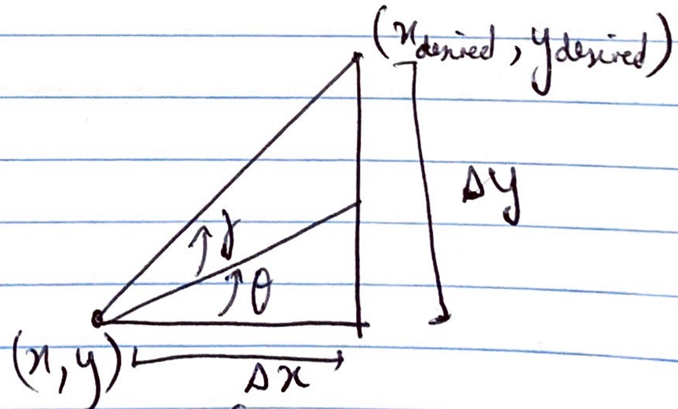
$$\Rightarrow \Delta\theta = J^{+}(\theta)\, \Delta x$$

PART 2

Using bicycle model:







$$\tan(\gamma + \theta) = \frac{\Delta y}{\Delta x}$$