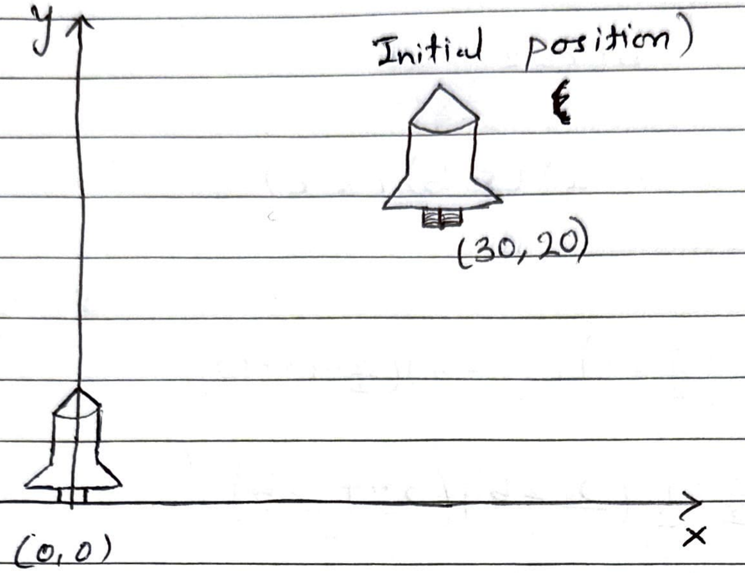
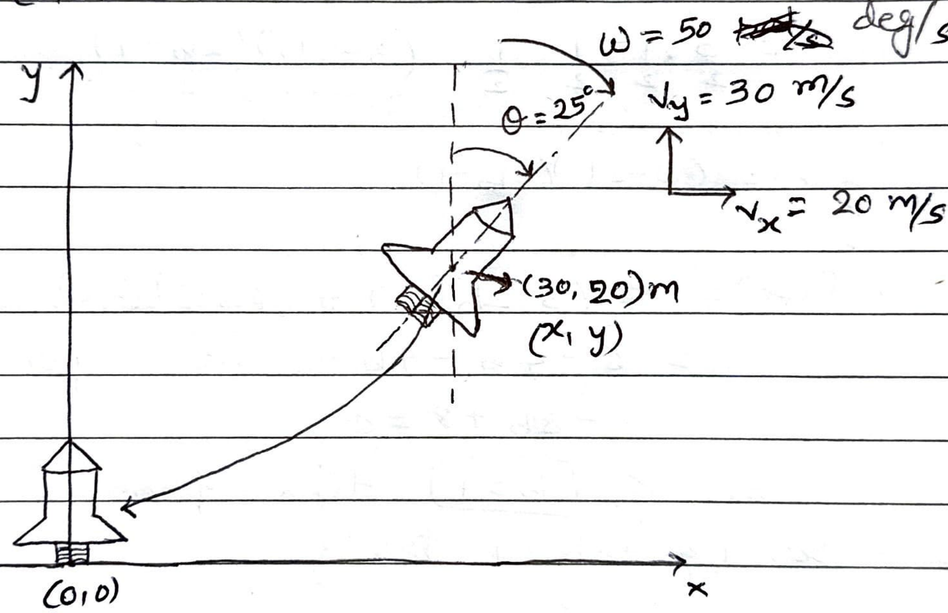
Rumitkumar Patel Design Optimization _/_/_

Project-1





As shown in the figure state space variables are given as $[x, y, V_x, V_y, \theta, \omega]^T = [30, 20, 20, 30, 25, 50]^T$ Now, these variables are at initial position of rocket. which indicates initial condition. Now, we want to bring the rokket to the origin (0,0) where all other parameters should be zero.

Initial states = $[30, 20, 20, 30, 25, 50]^T$

Now, We need to minimize the loss function which is

$$loss = \left[x(T)^2 + y(T)^2 + V_x(T)^2 + V_y(T)^2 + \theta(T)^2 + \omega(T)^2 \right]$$

· We need to $\boxed{\min \; loss}$

Now, the loss function would be function of a_x, a_y and α which we will be getting through the neural network. These variables are also called as action Variables.

all other parameters Can be found from action variables.

$$x(t+1) = x(t) + V_x(t)\,\Delta t$$
$$y(t+1) = y(t) + V_y(t)\,\Delta t$$
$$V_x(t+1) = V_x(t) + a_x(t)\,\Delta t$$
$$V_y(t+1) = V_y(t) + a_y(t)\,\Delta t$$
$$\theta(t+1) = \theta(t) + \omega(t)\,\Delta t$$
$$\omega(t+1) = \omega(t) + \alpha(t)\,\Delta t$$

So, we can say that

$$\min_{a_x, a_y, \alpha} loss.$$

Now, we need to find the input that is given to the rocket.

input in ΔT time

= Force due to gravity + Linear thrust accelaration in x ~~an~~ + linear thrust accelaration in y ~~and~~ + Angular thrust accelaration.

Force due to gravity = Velocity of rocket due to gravity =

$$\begin{bmatrix} 0 \\ 0 \\ 0 \\ -g\Delta T \\ 0 \\ 0 \end{bmatrix}$$

linear ~~thrust~~ in x =

$$\begin{bmatrix} 0 \\ 0 \\ -1 \\ 0 \\ 0 \\ 0 \end{bmatrix} a_x \times \text{thrust accelaration} \times \Delta T$$

linear thrust in $x = \{$ thrust accelaration $\times \Delta T \times \begin{bmatrix} 0 \\ 0 \\ -1 \\ 0 \\ 0 \\ 0 \end{bmatrix} \times a_x$

linear thrust in $y =$ thrust accelaration $\times \Delta T \times \begin{bmatrix} 0 \\ 0 \\ 0 \\ 1 \\ 0 \\ 0 \end{bmatrix} \times a_y$

Angular thrust ~~in~~ = Angular thrust accelaration $\times \Delta T \times \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 1 \end{bmatrix} \times \alpha$

State - space Representation is given by

$$
\underbrace{\begin{bmatrix} x \\ y \\ V_x \\ V_y \\ \theta \\ \omega \end{bmatrix}_{t+1}}_{\text{state}}
=
\underbrace{\begin{bmatrix}
1 & \overset{0}{\cancel{\Delta t}} & \Delta t & 0 & 0 & 0 \\
0 & 1 & 0 & \Delta t & 0 & 0 \\
0 & 0 & 1 & 0 & 0 & 0 \\
0 & 0 & 0 & 1 & 0 & 0 \\
0 & 0 & 0 & 0 & 1 & \Delta t \\
0 & 0 & 0 & 0 & 0 & 1
\end{bmatrix}
\begin{bmatrix} x \\ y \\ V_x \\ V_y \\ \theta \\ \omega \end{bmatrix}_{t}}_{\text{state}}
+
\underbrace{\overbrace{\underset{6\times 3}{\begin{bmatrix}
0 & 0 & 0 \\
0 & 0 & 0 \\
\Delta t & 0 & 0 \\
0 & \Delta t & 0 \\
0 & 0 & 0 \\
0 & 0 & \Delta t
\end{bmatrix}}
\underset{3\times 1}{\begin{bmatrix} a_x \\ a_y \\ \alpha \end{bmatrix}}}^{\text{input}}}_{\overset{6\times 1}{\text{delta\_state}}}
+
\underbrace{\begin{bmatrix} 0 \\ 0 \\ 0 \\ -g\Delta T \\ 0 \\ 0 \end{bmatrix}}_{\text{delta-state-gravity}}
$$

Now, objective is every value of the state space parameters Converge to zero. i.e.

$$
\begin{bmatrix} x \\ y \\ V_x \\ V_y \\ \theta \\ \omega \end{bmatrix}
=
\begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}
$$

after n iteration, which would mean that the rocket is in Stationary Condition.

→ Neural Network Controller.

dim_input = 6 since state-space variables are 6 (state-space dimension is 6).

dim_output = 3 since action-space variables are 3 (a_x, a_y, α).

dim_hidden = 12 latent dimensions.