$$\ddot{y} = -\dot{\psi}\dot{x} + \frac{2C_a}{m}\left(\cos\delta\left(\delta - \frac{\dot{y}+l_f\dot{\psi}}{\dot{x}}\right) - \frac{\dot{y}-l_r\dot{\psi}}{\dot{x}}\right)$$

$$\ddot{x} = \dot{\psi}\dot{y} + \frac{1}{m}(F - fmg)$$

$$\ddot{\psi} = \frac{2l_fC_a}{I_z}\left(\delta - \frac{\dot{y}+l_f\dot{\psi}}{\dot{x}}\right) - \frac{2l_rC_a}{I_z}\left(-\frac{\dot{y}-l_r\dot{\psi}}{\dot{x}}\right)$$

$$S_1 = \begin{bmatrix} y \\ \dot{y} \\ \psi \\ \dot{\psi} \end{bmatrix} \quad \dot{S}_1 = \begin{bmatrix} \dot{y} \\ \ddot{y} \\ \dot{\psi} \\ \ddot{\psi} \end{bmatrix} \qquad S_2 = \begin{bmatrix} x \\ \dot{x} \end{bmatrix} \quad \dot{S}_2 = \begin{bmatrix} \dot{x} \\ \ddot{x} \end{bmatrix}$$

$$\dot{S}_1 = \begin{bmatrix} \dot{y} \\ -\dot{\psi}\dot{x} + \frac{2C_a}{m}\left(\cos\delta\left(\delta - \frac{\dot{y}+l_f\dot{\psi}}{\dot{x}}\right) - \frac{\dot{y}-l_r\dot{\psi}}{\dot{x}}\right) \\ \dot{\psi} \\ \frac{2l_fC_a}{I_z}\left(\delta - \frac{\dot{y}+l_f\dot{\psi}}{\dot{x}}\right) - \frac{2l_rC_a}{I_z}\left(-\frac{\dot{y}-l_r\dot{\psi}}{\dot{x}}\right) \end{bmatrix}$$

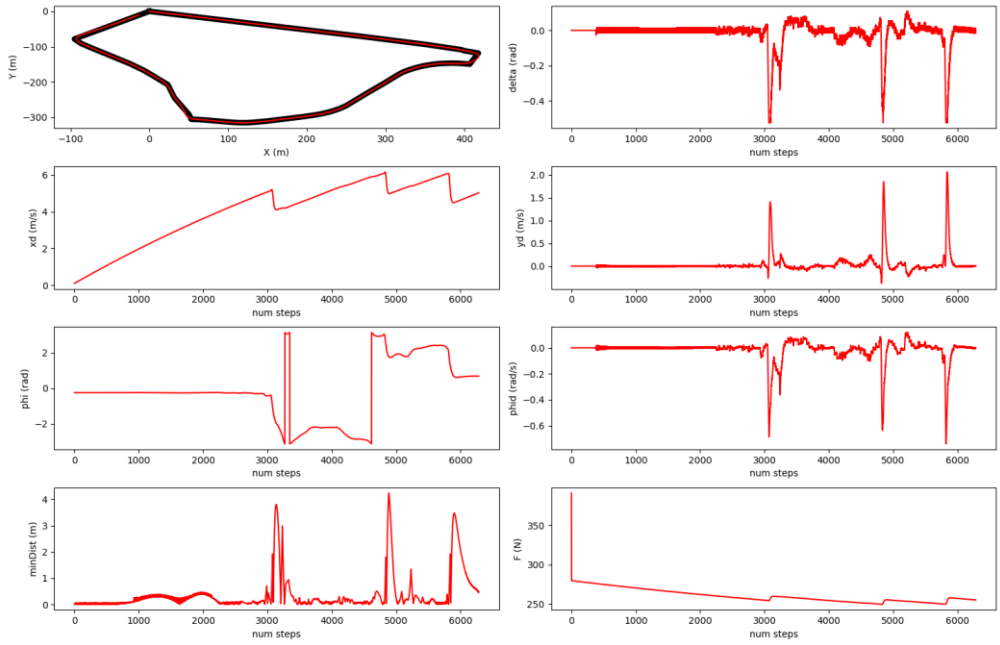
$$\dot{S}_2 = \begin{bmatrix} \dot{x} \\ \dot{\psi}\dot{y} + \frac{1}{m}(F - fmg) \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ 0 & 0 \end{bmatrix} S_2 + \begin{bmatrix} 0 & 0 \\ 0 & \frac{1}{m} \end{bmatrix} \begin{bmatrix} \delta \\ F \end{bmatrix} + \begin{bmatrix} 0 \\ \dot{\psi}\dot{y} - fg \end{bmatrix}$$

$$\ddot{y} = -\frac{2C_a}{m}\left(\cos\delta\frac{1}{\dot{x}} + \frac{1}{\dot{x}}\right)\dot{y} + \left(-\dot{x} + \frac{2C_a}{m}\left(\cos\delta\frac{l_f}{\dot{x}} + \frac{l_r}{\dot{x}}\right)\right)\dot{\psi} + \frac{2C_a}{m}\cos\delta\cdot\delta$$

$$= -\frac{2C_a(\cos\delta+1)}{m\dot{x}}\dot{y} + \left(-\dot{x} - \frac{2C_a}{m\dot{x}}(\cos\delta\, l_f + l_r)\right)\dot{\psi} + 2\frac{C_a}{m}\cos\delta\cdot\delta$$

$$\ddot{\psi} = \left(\frac{2l_fC_a}{I_z}\left(-\frac{1}{\dot{x}}\right) - \frac{2l_rC_a}{I_z}\left(-\frac{1}{\dot{x}}\right)\right)\dot{y} + \left(\frac{2l_fC_a}{I_z}\left(-\frac{l_f}{\dot{x}}\right) - \frac{2l_rC_a}{I_z}\left(\frac{l_r}{\dot{x}}\right)\right)\dot{\psi} + \frac{2l_fC_a}{I_z}\delta$$

$$\dot{S}_1 = \begin{bmatrix} 0 & 1 & 0 & 0 \\ 0 & -\frac{2C_a(\cos\delta+1)}{m\dot{x}} & 0 & -\dot{x} - \frac{2C_a}{m\dot{x}}(\cos\delta\, l_f + l_r) \\ 0 & 0 & 0 & 1 \\ 0 & \frac{2(l_f - l_r)C_a}{I_z\dot{x}} & 0 & -\frac{2(l_f^2 + l_r^2)C_a}{I_z\dot{x}} \end{bmatrix} S_1 + \begin{bmatrix} 0 & 0 \\ \frac{2C_a}{m}\cos\delta & 0 \\ 0 & 0 \\ \frac{2l_fC_a}{I_z} & 0 \end{bmatrix} \begin{bmatrix} \delta \\ F \end{bmatrix}$$


Y (m)
X (m)
delta (rad)
num steps
xd (m/s)
num steps
yd (m/s)
num steps
phi (rad)
num steps
phid (rad/s)
num steps
minDist (m)
num steps
F (N)
num steps