MPC Model

$$x_{t+1} = x_t + v_t \cdot cos(\psi_t) \cdot dt \tag{1}$$
$$y_{t+1} = y_t + v_t \cdot sin(\psi_t) \cdot dt \tag{2}$$
$$\psi_{t+1} = \psi_t + \frac{v_t}{L_f} \cdot \delta_t \cdot dt \tag{3}$$
$$v_{t+1} = v_t + a_t \cdot dt \tag{4}$$
$$cte_{t+1} = f(x_t) - y_t + v_t \cdot sin(e\psi_t) \cdot dt \tag{5}$$
$$e\psi_{t+1} = \psi_t - \psi des_t + \frac{v_t}{L_f} \cdot \delta_t \cdot dt \tag{6}$$

Constraints

$$\delta \in [-25°, +25°] \tag{7}$$
$$a \in [-1.0, +1.0] \tag{8}$$

Cost

$$J = \sum_{t=1}^{N} (cte_t - cte_{ref})^2 + (e\psi_t - e\psi_{ref})^2 + ... \tag{9}$$

MPC state feedback loop:
Pass the current state to the MPC.
Call the optimization solver. The solver uses the state, model, constraints and cost function to return a control vector that minimizes the cost function.