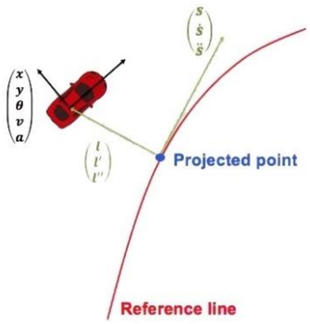
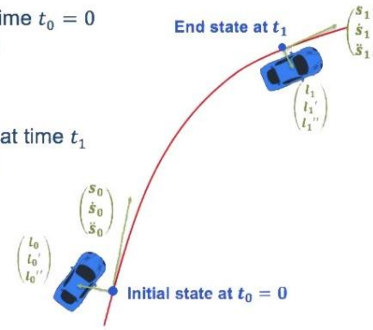
Frenet Coordinates

- Reference line: smooth lane central line.
- Project vehicle position onto the reference line.
- Longitudinal states:
  - s longitudinal distance
  - $\dot{s} = \frac{ds}{dt}$ longitudinal speed
  - $\ddot{s} = \frac{d^2s}{dt^2}$ longitudinal acceleration
- Lateral states:
  - l lateral offset
  - $l' = l'(s) = \frac{dl}{ds}$
  - $l'' = l''(s) = \frac{d^2l}{ds^2}$



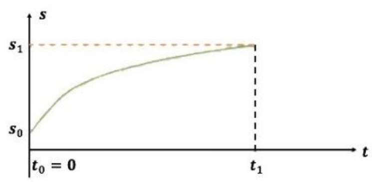
Generate One trajectory (Step 1)

- Given Initial state at time $t_0 = 0$
  $\{(l_0, l_0', l_0''), (s_0, \dot{s}_0, \ddot{s}_0)\}$
- Sample an end state at time t_1
  $\{(l_1, l_1', l_1''), (s_1, \dot{s}_1, \ddot{s}_1)\}$

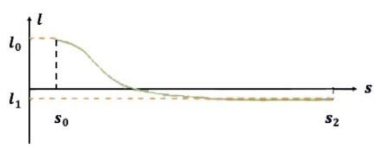


Generate One trajectory (Step 2)

- Quintic polynomial for Longitudinal trajectory $s(t)$
  - $s(t_0) = s_0 \quad s(t_1) = s_1$
  - $\dot{s}(t_0) = \dot{s}_0 \quad \dot{s}(t_1) = \dot{s}_1$
  - $\ddot{s}(t_0) = \ddot{s}_0 \quad \ddot{s}(t_1) = \ddot{s}_1$



- Quintic polynomial for Lateral trajectory $l(s)$
  - $l(s_0) = l_0 \quad l(s_2) = l_1$
  - $l'(s_0) = l_0' \quad l'(s_2) = l_1'$
  - $l''(s_0) = l_0'' \quad l''(s_2) = l_1''$



Generate One trajectory (Step 3)

- For a time point t^* $\rightarrow$ $s^* = s(t^*)$ $\rightarrow$ $l^* = l(s^*)$
- $\hat{p}_{t^*} = \begin{pmatrix} s^* \\ l^* \\ t^* \end{pmatrix}$ $\xrightarrow{\text{Reference Line}}$ $p_{t^*} = \begin{pmatrix} x^* \\ y^* \\ t^* \end{pmatrix}$
- $\{t_0, t_1, \cdots, t_n\}$ $\rightarrow$ $\{p_0, p_1, \cdots, p_n\}$

Combine

- L Lateral polynomials
- S_c Longitudinal polynomials for cruising
- S_s Longitudinal polynomials for stopping
- S_o Longitudinal polynomials for obstacles

$S = S_c \cup S_s \cup S_o$

For l in L :
    For s in S:
        generate trajectory by the Lat-Lon pair (l, s)

Trajectory Cost

- Objective achievement cost
- Lateral offset cost
- Collision cost
- Longitudinal jerk cost
- Lateral acceleration cost
- Centripetal acceleration cost

Total cost = weighted sum of the costs above

The 6 weights are the only parameters of the algorithm