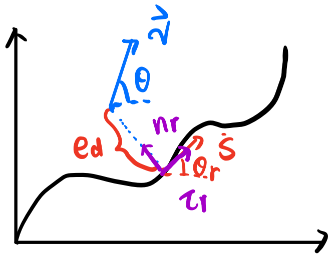
自动驾驶控制算法第七讲

$u = -k e_{rr} + \delta_f$

$K = lqr(A, B, Q, R)$　　A, B 在第三讲，第四讲

或 $dlqr(\bar{A}, \bar{B}, Q, R)$　　K 的计算在第五讲

δ_f 在第六讲



第四讲　　$e_d = (\vec{x} - \vec{x_r}) \cdot \vec{n_r}$

$\dot{e_d} = |\vec{v}| \sin(\theta - \theta_r)$

$e_\varphi = \varphi - \theta_r$

$\dot{e_\varphi} = \dot{\varphi} - k\dot{s}$　　$\dot{\theta_r} = k\dot{s}$ (由曲率的定义式推导而来)

$\vec{x_r} = (x_r, y_r)$　投影点的直角坐标

θ_r　　投影的速度 $\dot{s}$ 与 x 轴的夹角.

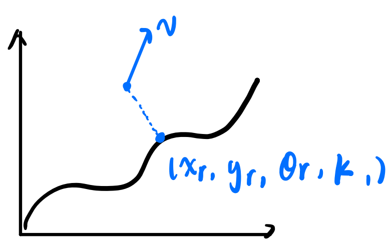
k　　投影的曲率

$\dot{s} = \frac{|\vec{v}| \cos(\theta - \theta_r)}{1 - k e_d}$

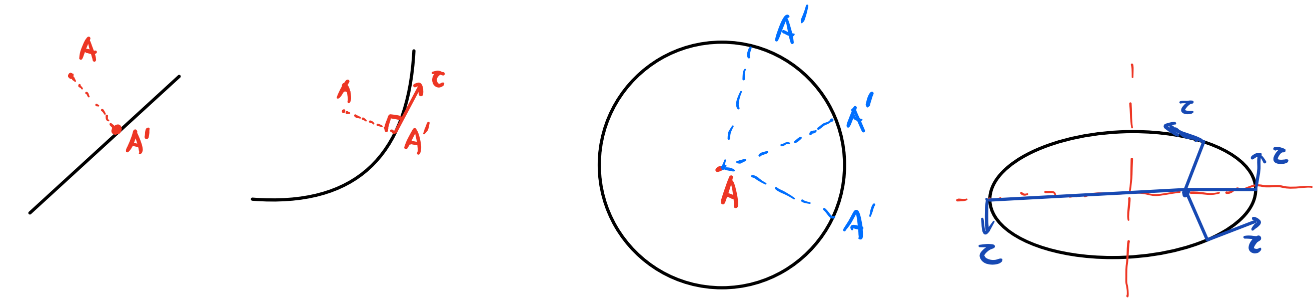
$\vec{x}$, $\vec{v}$, $\dot{\varphi}$

车位置　车速　车横摆角速度，视为已知

只要知道 x_r, y_r, θ_r, k　(s_r)
纵向



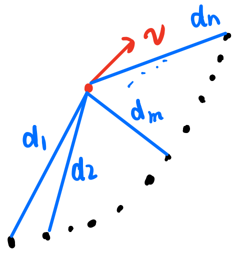
若曲线是连续的，可能会导致投影不唯一



若A与A'的连线与A'的切线垂直，则A'为A的投影

若曲线是连续的，不仅仅求投影麻烦，而且要处理多值问题

离散轨迹点的误差计算



$(x_1, y_1, \theta_1, k_1)$

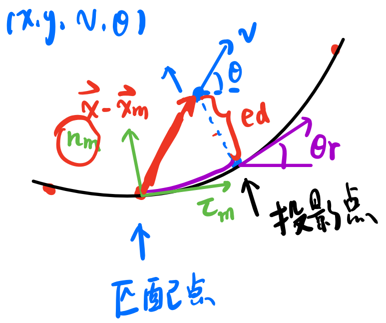
$(x_2, y_2, \theta_2, k_2)$

$\vdots$

$(x_n, y_n, \theta_n, k_n)$

① 找到离散轨迹规划点中与真实位置(x,y)最近的点，在apollo中称为match_point(匹配点)

② 匹配点 = 投影点？ 匹配点≠投影点，但是，可以通过匹配点近似算出投影点



$(x_m, y_m, \theta_m, k_m)$

假设：匹配 → 投影的k不变 ⇒ 匹配 → 投影的轨迹近似用圆弧代替

$\vec{\tau}_m = (\cos\theta_m, \sin\theta_m)$　　$\vec{n}_m = (-\sin\theta_m, \cos\theta_m)$

$\vec{x} - \vec{x}_m = (x - x_m, y - y_m)$

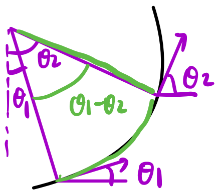
③ $e_d \approx (\vec{x} - \vec{x}_m) \cdot \vec{n}_m$　　(有正负，左为正，右为负)

④ $e_s \approx (\vec{x} - \vec{x}_m) \cdot \vec{\tau}_m$　　e_s为匹配点与投影点的弧长(有正负)

正代表投影在匹配点的前面　负 ------ 后 --

⑤ $\theta_r = \theta_m$ (apollo)

$\theta_r = \theta_m + k_m \cdot e_s$ (我)



$\theta_1 - \theta_2 = \frac{S}{R} = kS$

⑥ $e_d = (\vec{x} - \vec{x}_m) \cdot \vec{n}_m$

$e_s = (x - \vec{x}_m) \cdot \vec{\tau}_m$

$\theta_r = \theta_m + k_m \cdot e_s$

$k_r = k_m$

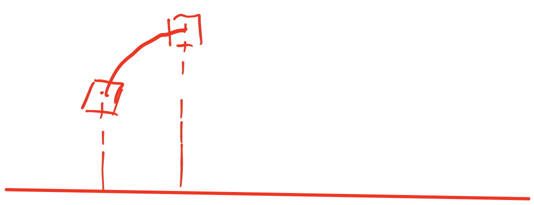
$\dot{s} = \frac{\vec{v}\cos(\theta - \theta_r)}{1 - k_r e_d}$

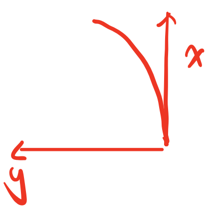
$e_\varphi = \varphi - \theta_r$

$\dot{e}_\varphi = \dot{\varphi} - \dot{\theta}_r = \varphi - k_r \cdot \dot{s}$

$\dot{e}_d = |\vec{v}| \sin(\theta - \theta_r)$

$u = -K e_r + \delta_f$





$v\,dt = S$

$S = \int \sqrt{1 + y'^2}\,dx$

$\frac{ds}{d\theta}\ d\theta$

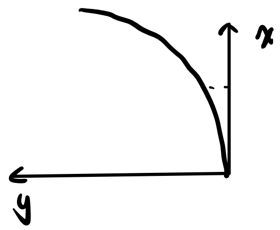
$\frac{ds}{d\theta}$ (?)

$ds \cos d\theta$

$\frac{ds}{d\theta} \cdot \frac{1}{2} d\theta^2$

$\dot{s}(t_1) = v_1$

$\frac{ds\ d\theta}{2}$



$$s = v_0 + a_0 t$$

$$\theta = \theta_0 + a_1 t$$

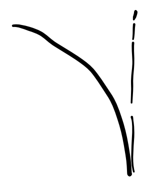
$$\dot{s} = \dot{x}\cos$$

$$y' = \tan\theta$$

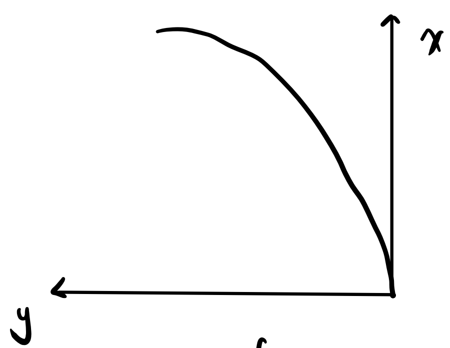
$$s = \int_0^x \sqrt{1 + \tan(\theta_0 + a_1 t)^2}\ dx$$

$$s = \sqrt{1 + y'^2}\ dx$$

$$s = s_0 + \frac{\partial s}{\partial x}(x - x_0) + \frac{\partial^2 s}{\partial x^2}(x - x_0)^2 + \frac{\partial^3 s}{\partial x^3}$$



$$s = \int_0^x \sqrt{1 + y'^2}\ dx$$



assume $s = s_0 + v_0 t + \frac{1}{2} a t^2$

$$\theta = \theta_0 + \dot{\theta}_0 t + \frac{1}{2}\beta t^2$$

$\because$ $s = \int \sqrt{1 + y'^2}\ dx$ $\therefore$ $\frac{ds}{dt} = \frac{ds}{dx} \cdot \frac{dx}{dt}$, $\Rightarrow$ $v_0 + at = \sqrt{1 + y'^2}\ \dot{x}$

$$\Rightarrow \quad \dot{x} = \frac{v_0 + at}{[1 + \tan^2(\theta_0 + \dot{\theta}_0 t + \frac{1}{2}\beta t^2)]^{\frac{1}{2}}}$$

$$x = \int_{t_0}^{t} \frac{v_0 + at}{[1 + \tan^2(\theta_0 + \dot{\theta}_0 t + \frac{1}{2}\beta t^2)]^{\frac{1}{2}}}\ dt$$