Smoothing Module
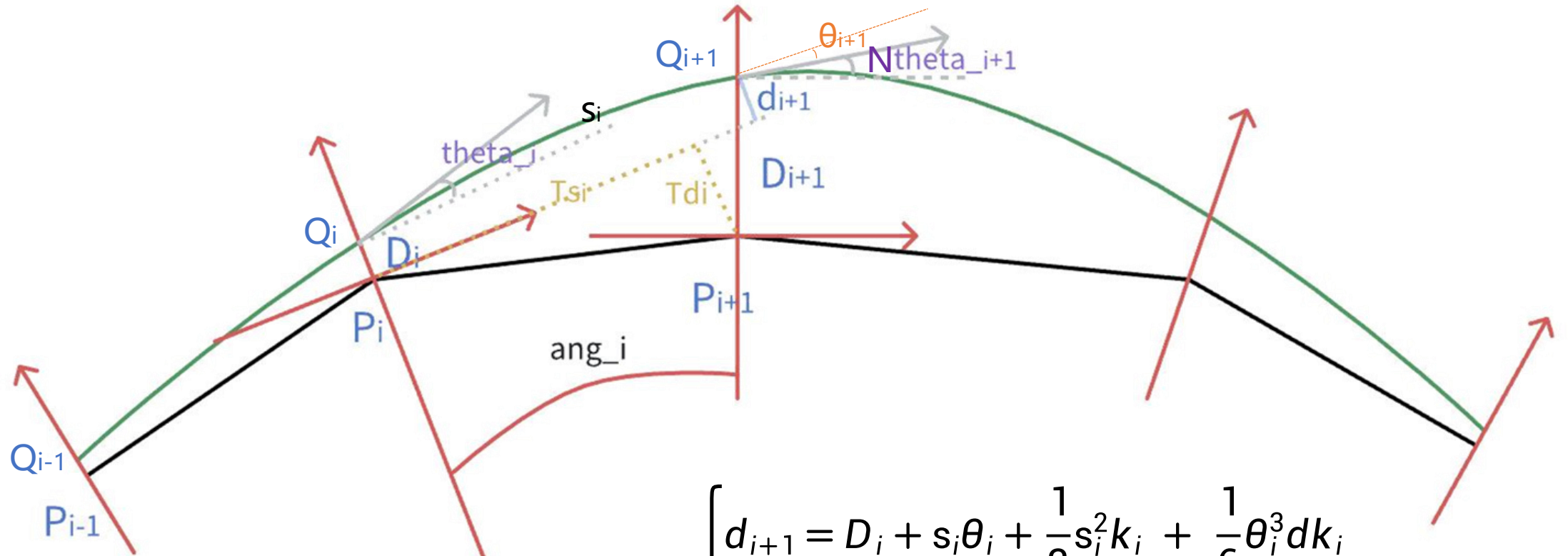
Xiaoming Chen

2023.9.20

Model

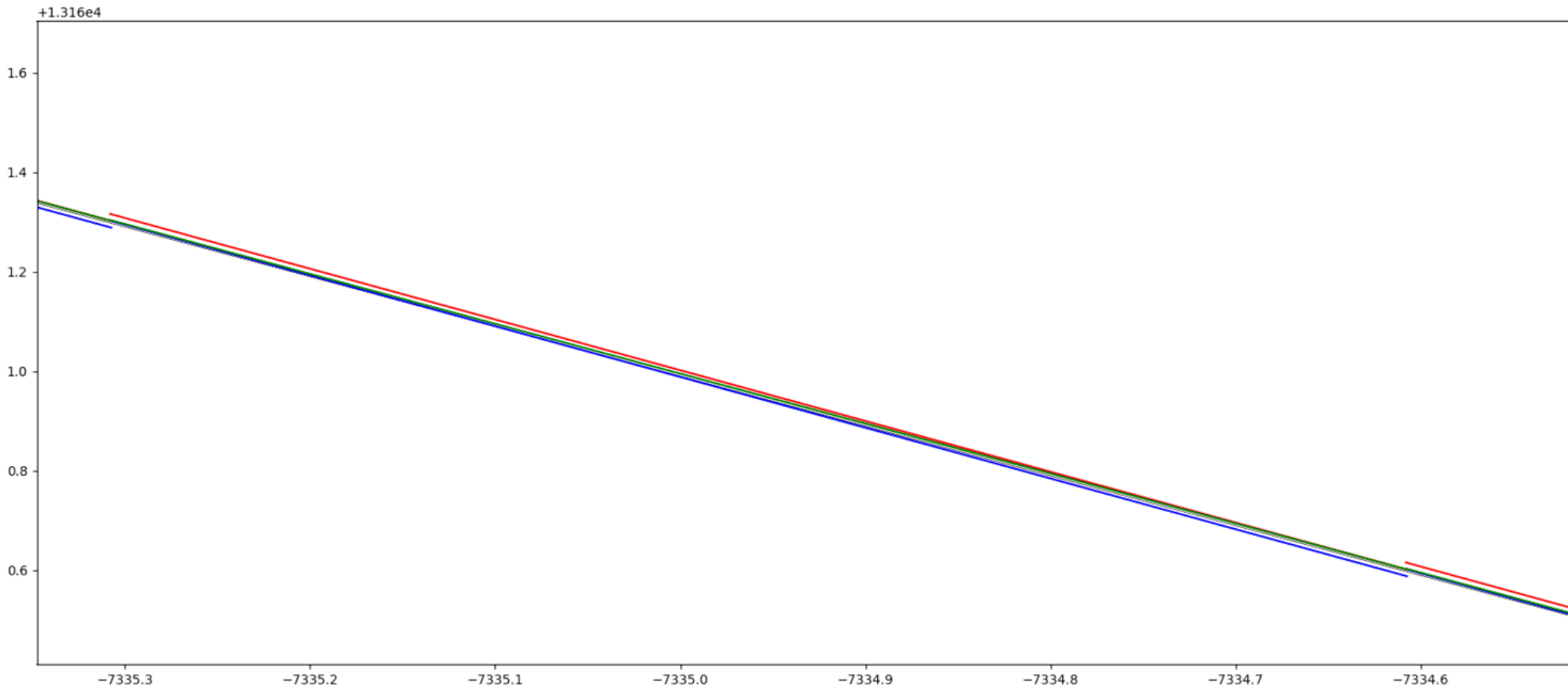$$x_i = \begin{bmatrix} d_i \\ \theta_i \\ ki \end{bmatrix}$$

$$\begin{cases} d_{i+1} = D_i + s_i\theta_i + \dfrac{1}{2}s_i^2 k_i + \dfrac{1}{6}\theta_i^3 dk_i \\[2mm] \theta_{i+1} = Ntheta_i + s_i k_i + \dfrac{1}{2}s_i^2 dk_i \\[2mm] k_{i+1} = k_i + s_i dk_i \end{cases}$$

$x_{i+1} = Ax_i + Bu_i$

$$u_i = [\, dk_i \,]$$

$D_i = -\sin(ang_{i-1}) * s_{i-1} + \cos(ang_{i-1}) * (d_i + Td_{i-1})$
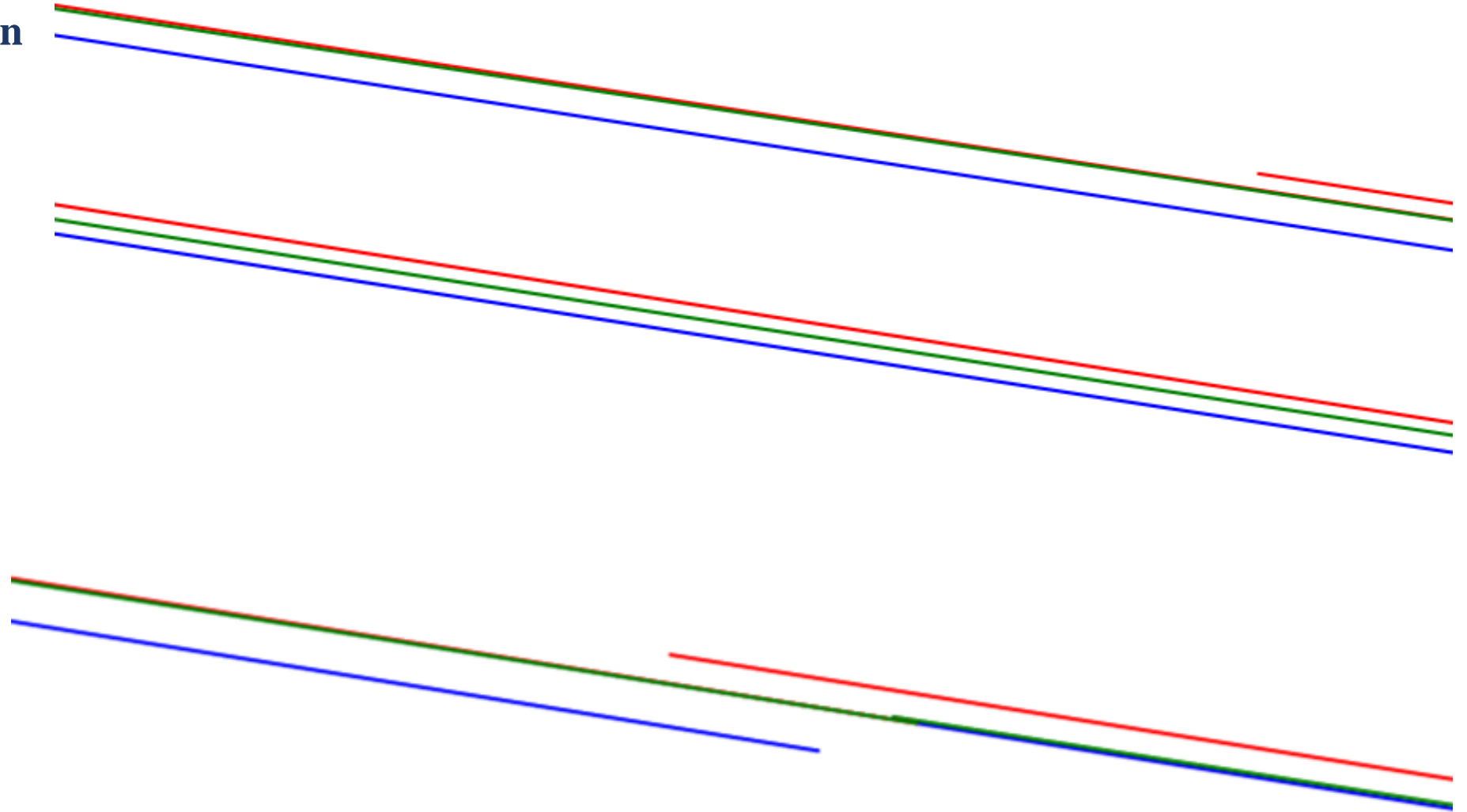
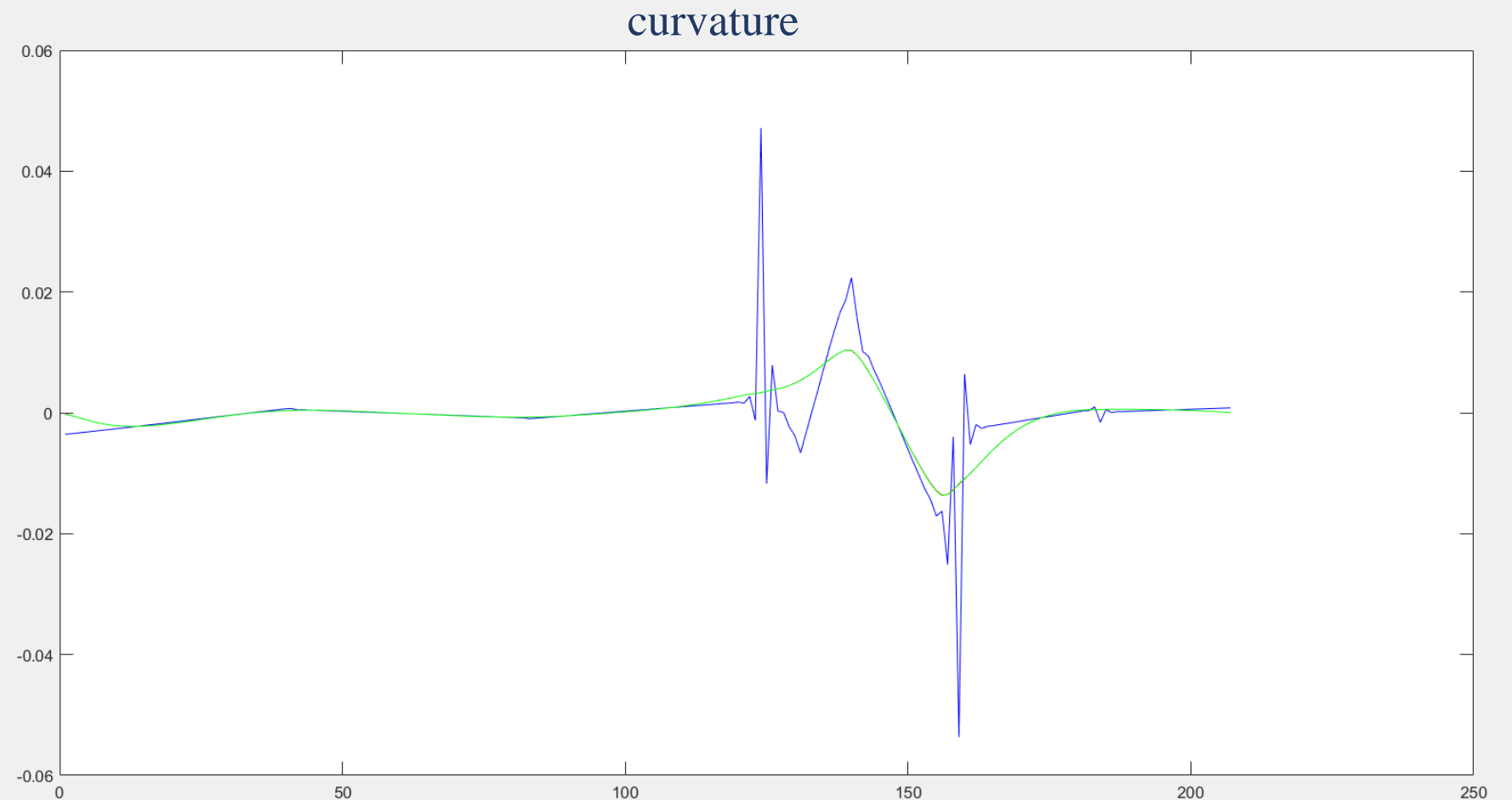$Ntheta_i = theta_i - ang_i$

Model

Visualization

Model

Visualization

Test

Validation tests

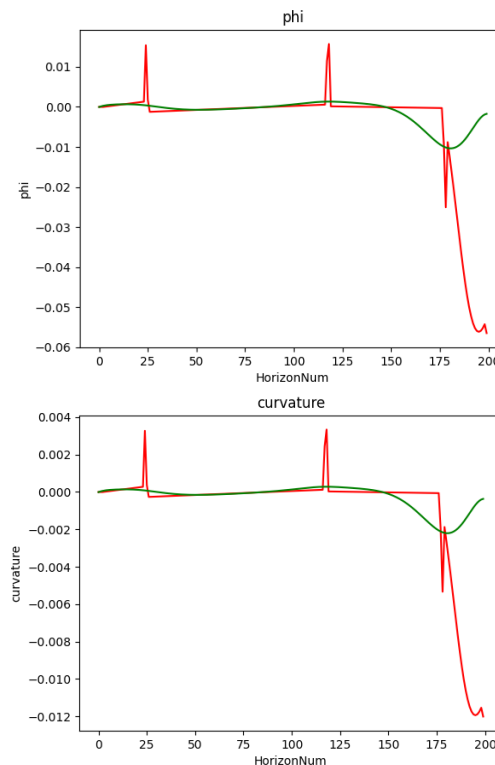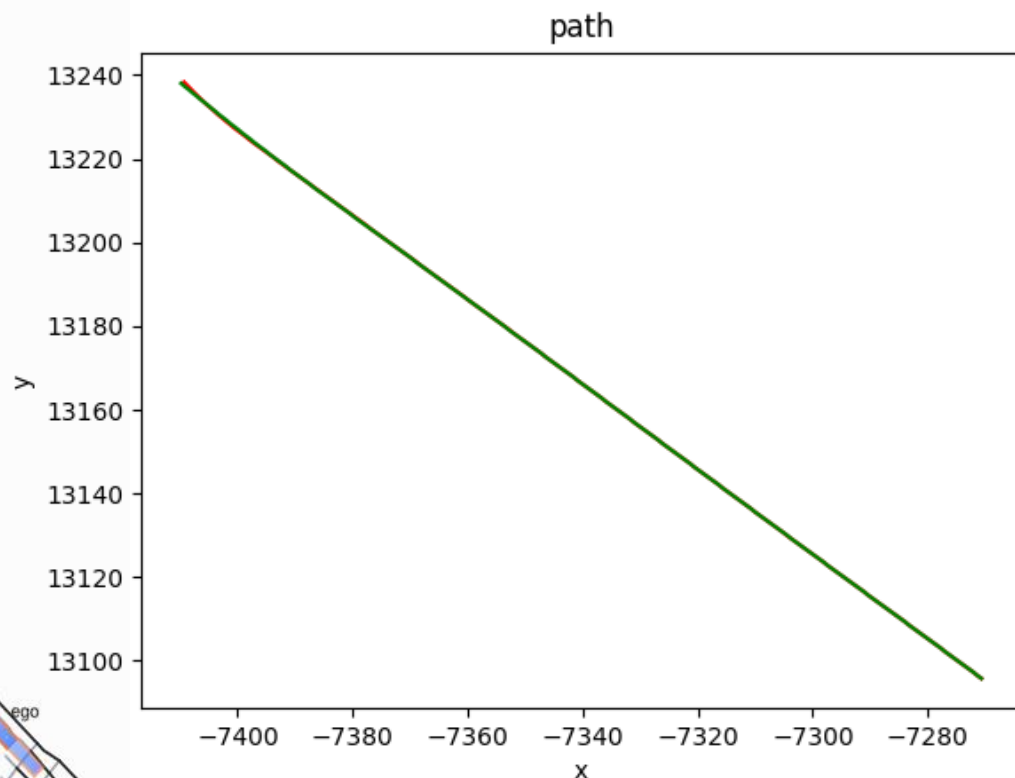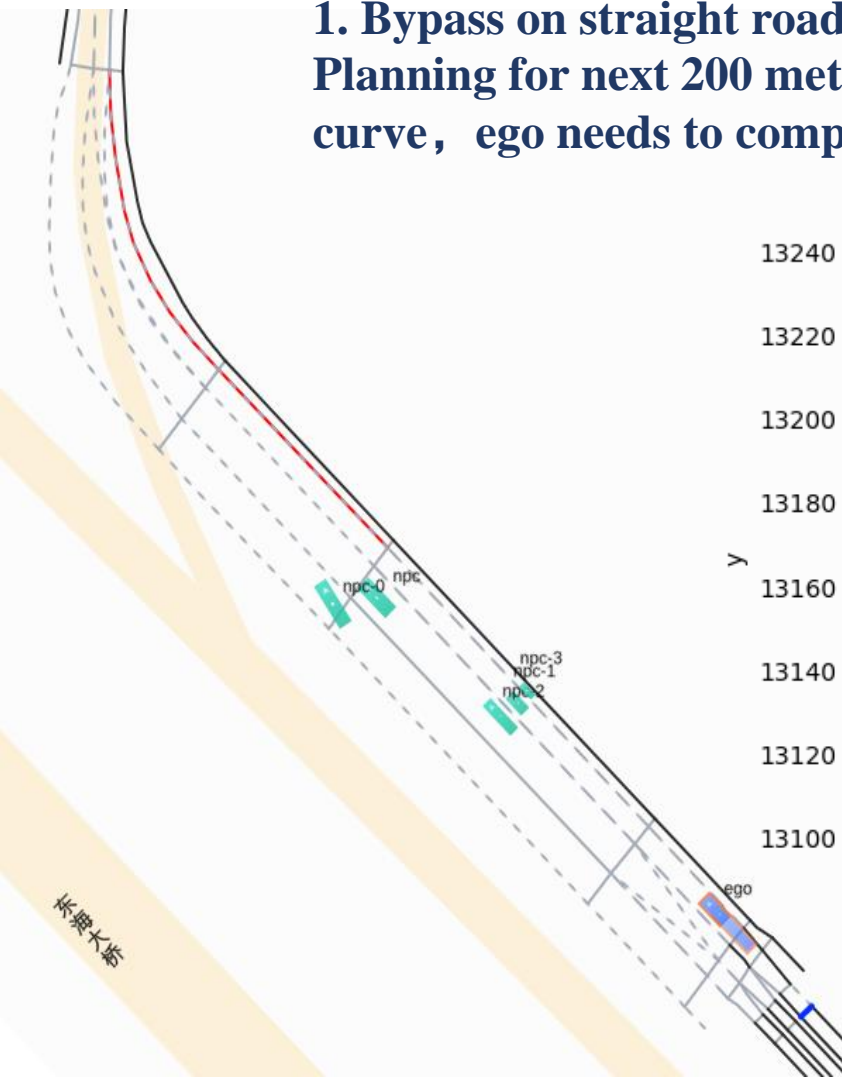Setting: HorizonNum is 20，the interval of discrete points is 4m+，runtime within 3ms.

Application

Validation tests

1. Bypass on straight road
Planning for next 200 meters，need to bypass the two vehicles ahead, and the end of the path has a sharp curve，ego needs to complete two bypasses before entering the curve

The first stage: DP has not yet triggered the bypass module, mainly smoothing the path
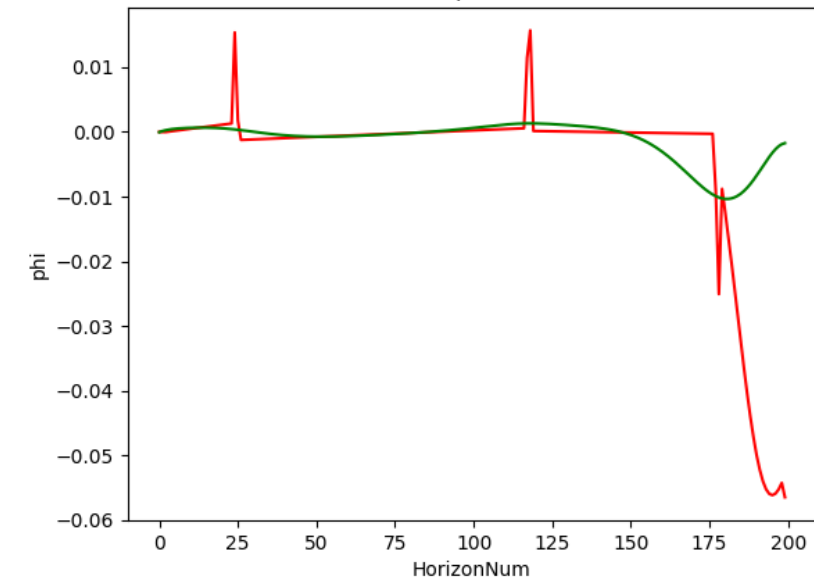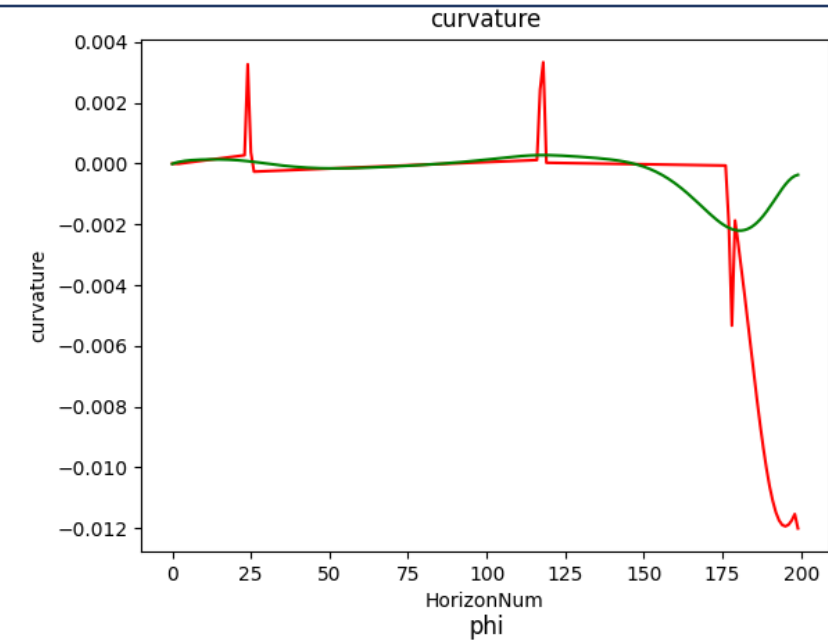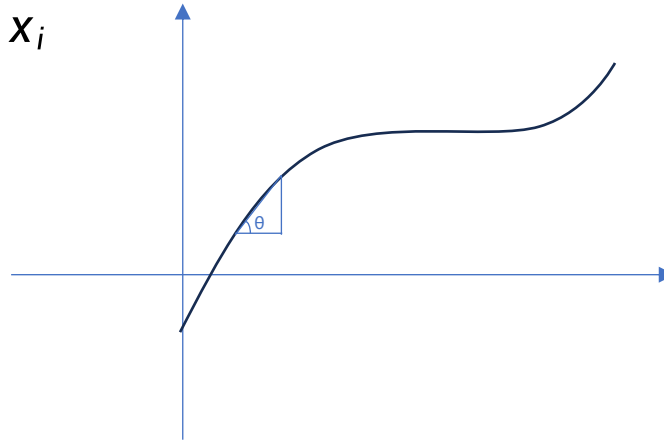
Application

平滑DP搜索出的粗略路径

Validation tests

$$curvature = \frac{1}{r}, \quad r = \frac{L_w}{sin\varphi}$$

L_w ：wheelbase

Visualization of the front wheel angle and curvature of the smoothed previous and subsequent paths:

$$\theta = \begin{cases} \arctan\dfrac{y_{i+1} - y_i}{x_{i+1} - x_i}, \ x_{i+1} \neq x_i \\ \dfrac{\pi}{2}, \ x_{i+1} = x_i, \ y_{i+1} > y_i \\ -\dfrac{\pi}{2}, x_{i+1} = x_i, \ y_{i+1} < y_i \end{cases}$$

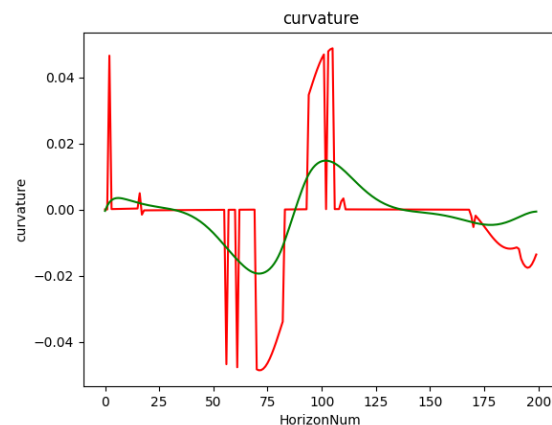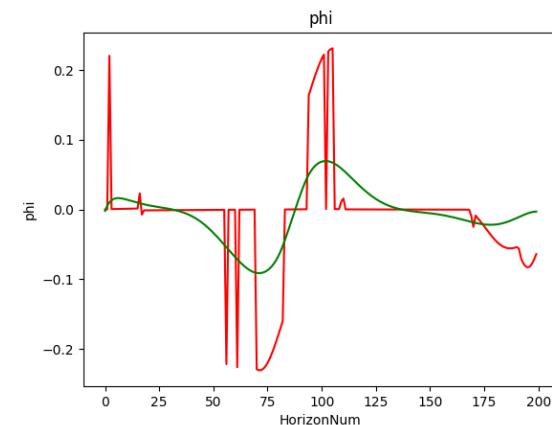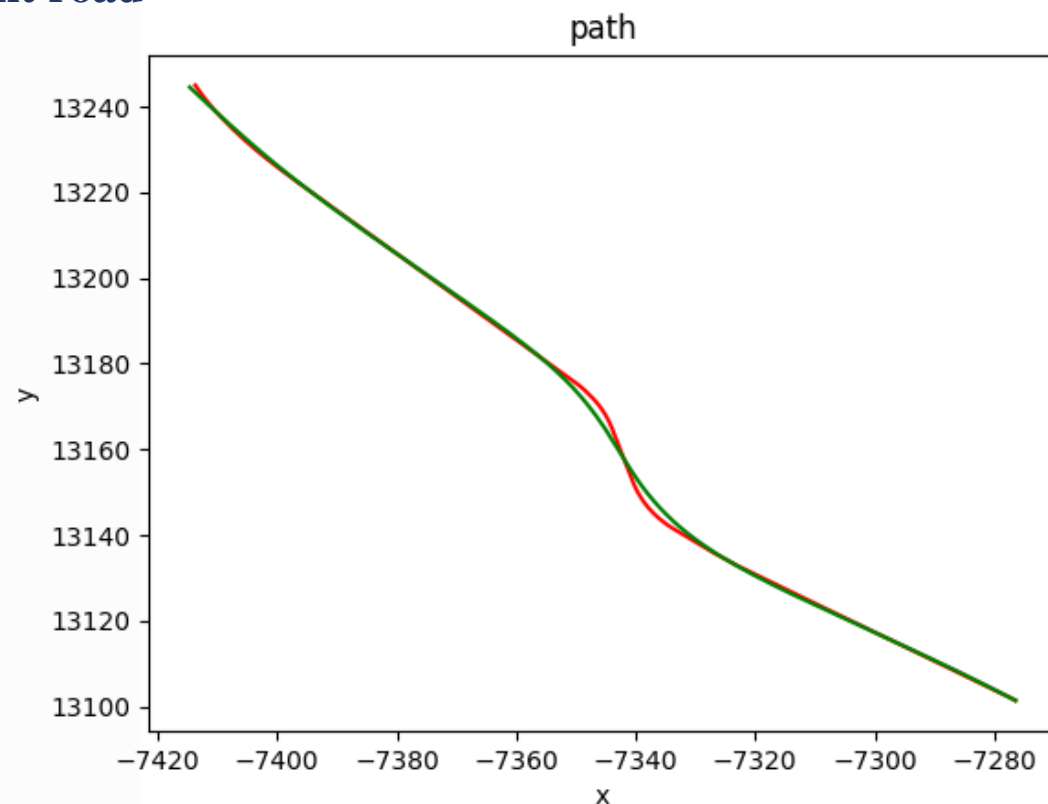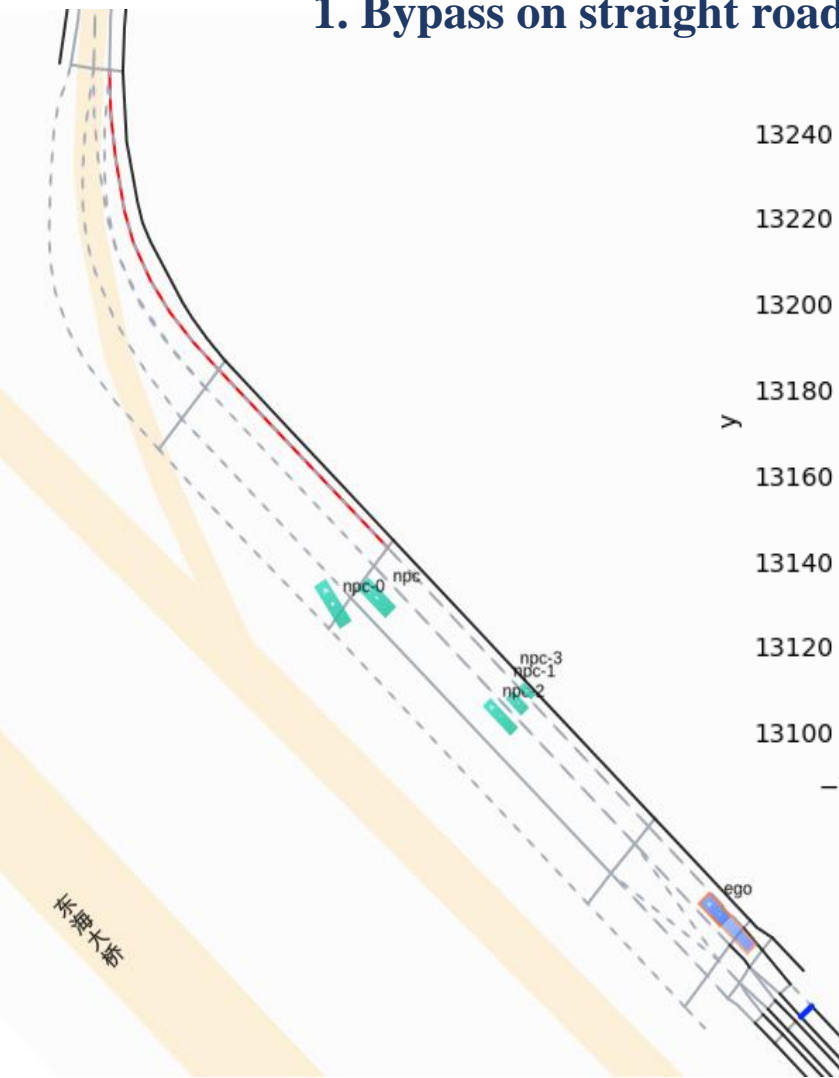$$\dot{\theta} = \frac{v \cdot \tan\varphi}{L_w}$$

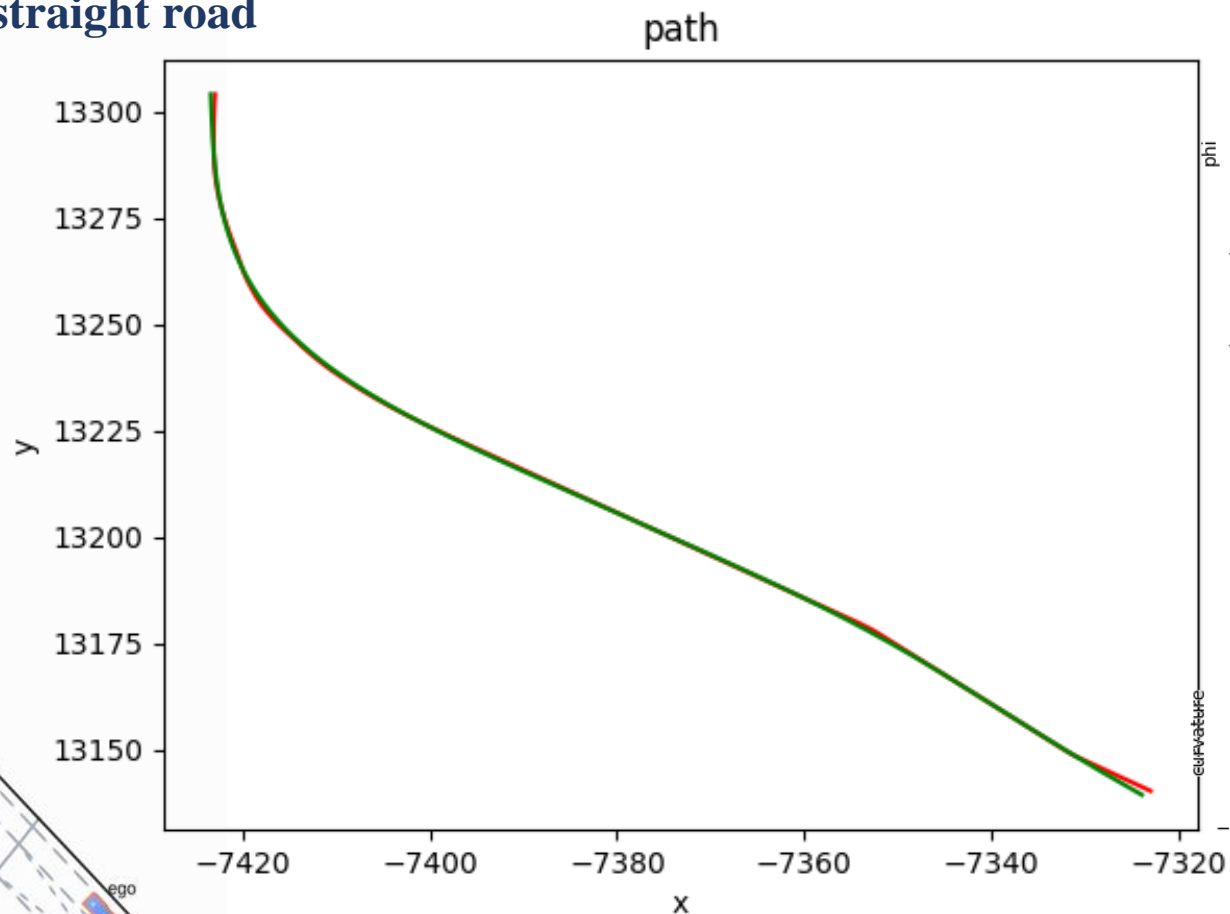**Validation tests**
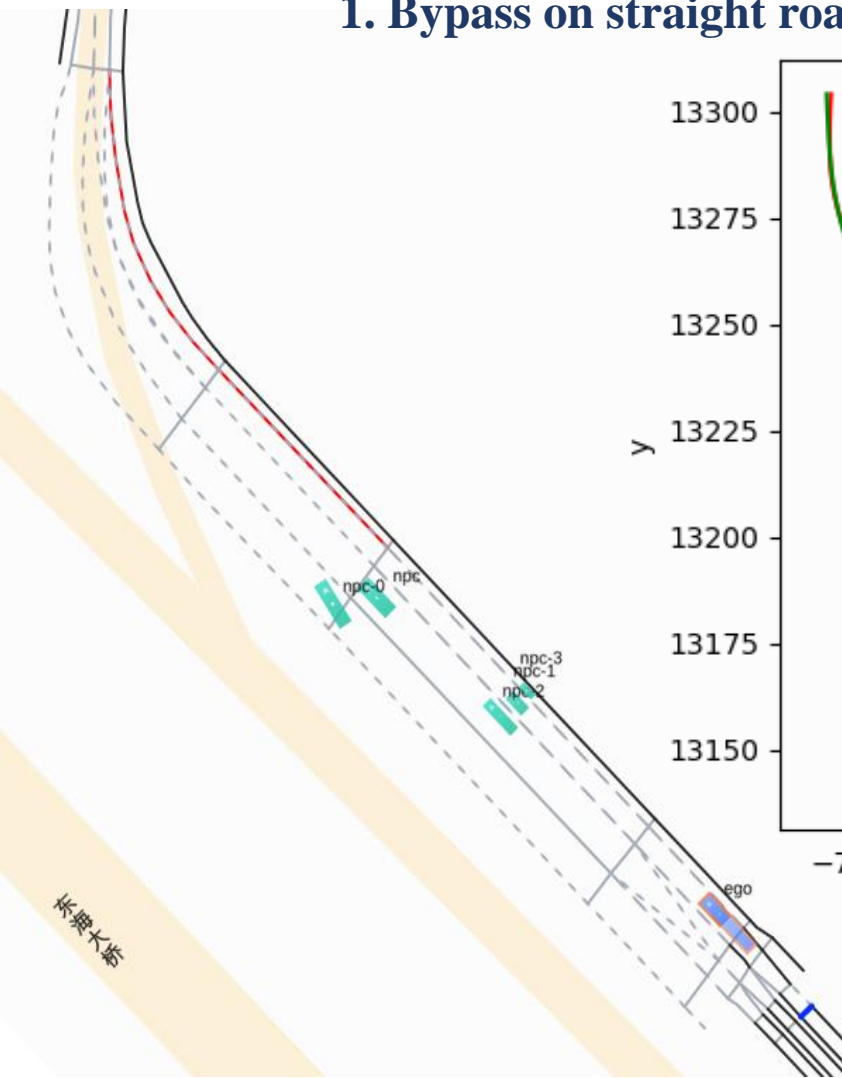
1. Bypass on straight road

The second stage: bypass the front vehicle, the smoothing model has constraints on the distance to static obstacles, but the penalty is light
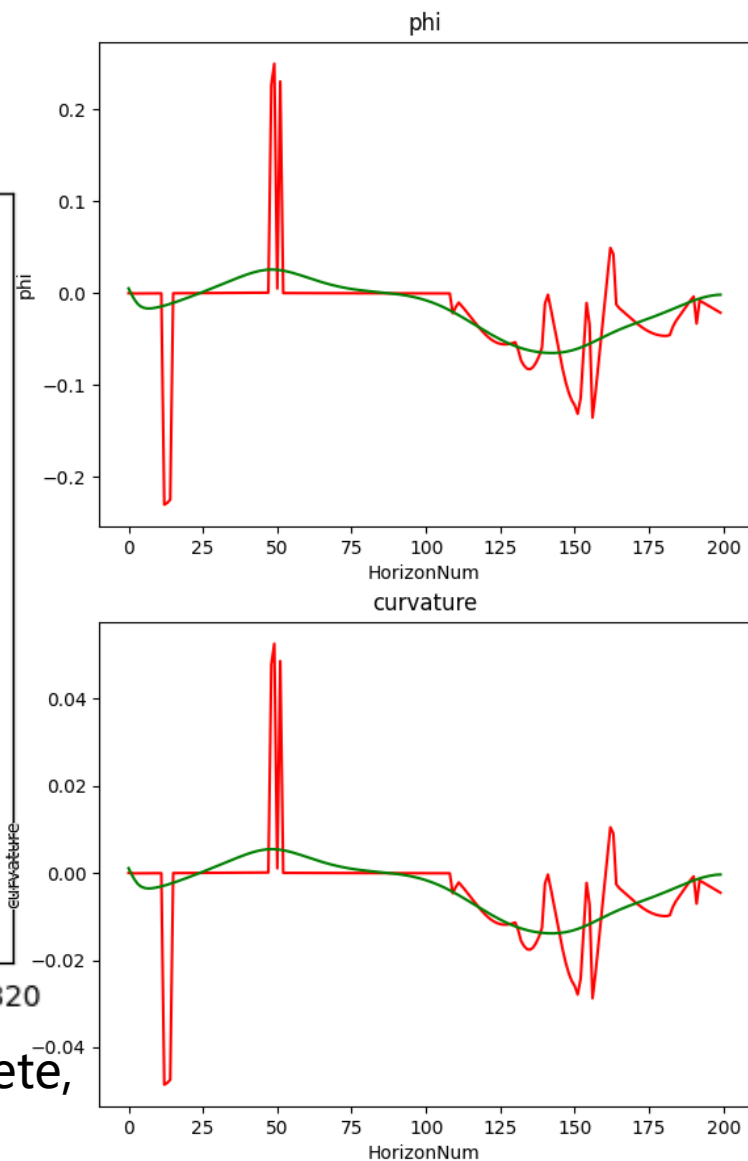
Application

平滑DP搜索出的粗略路径

Validation tests

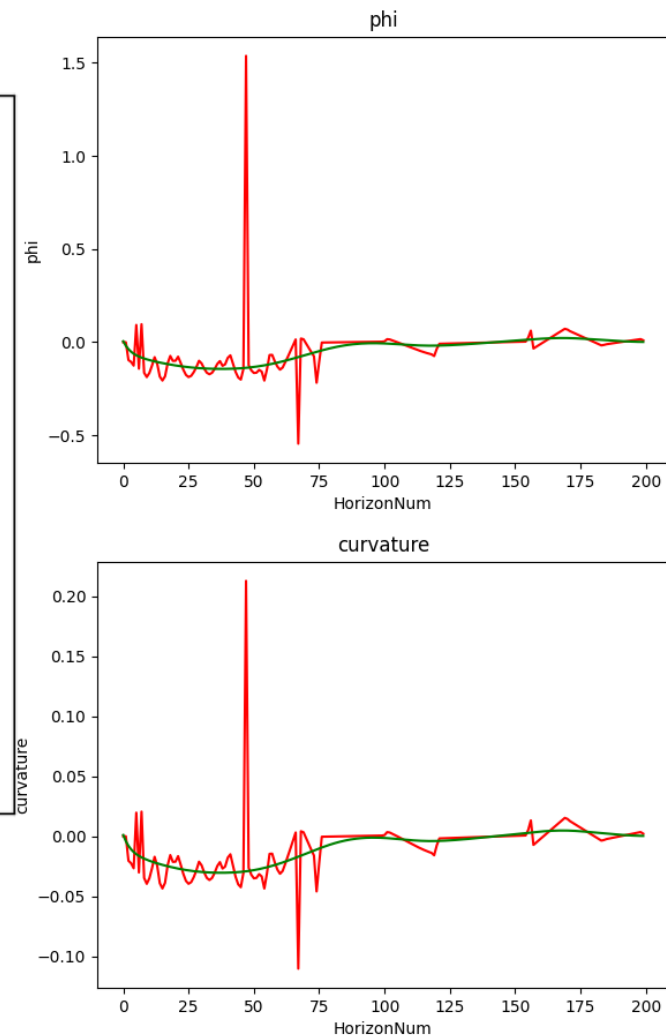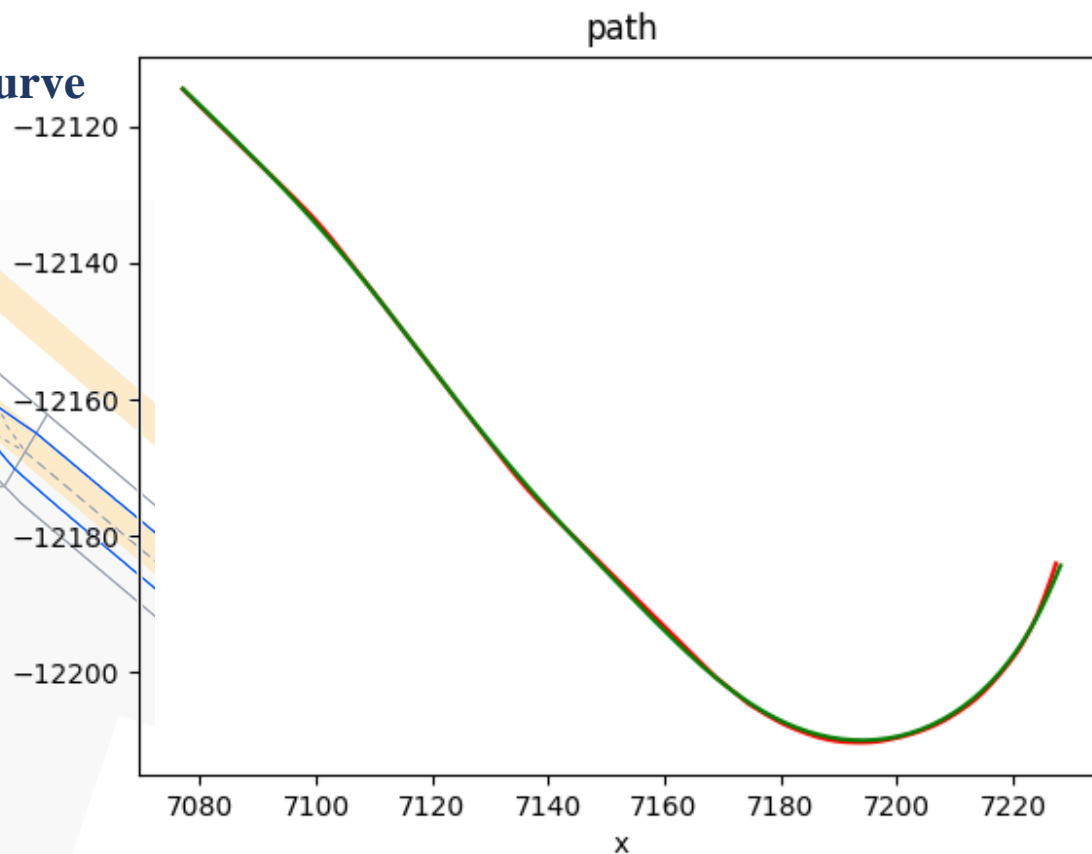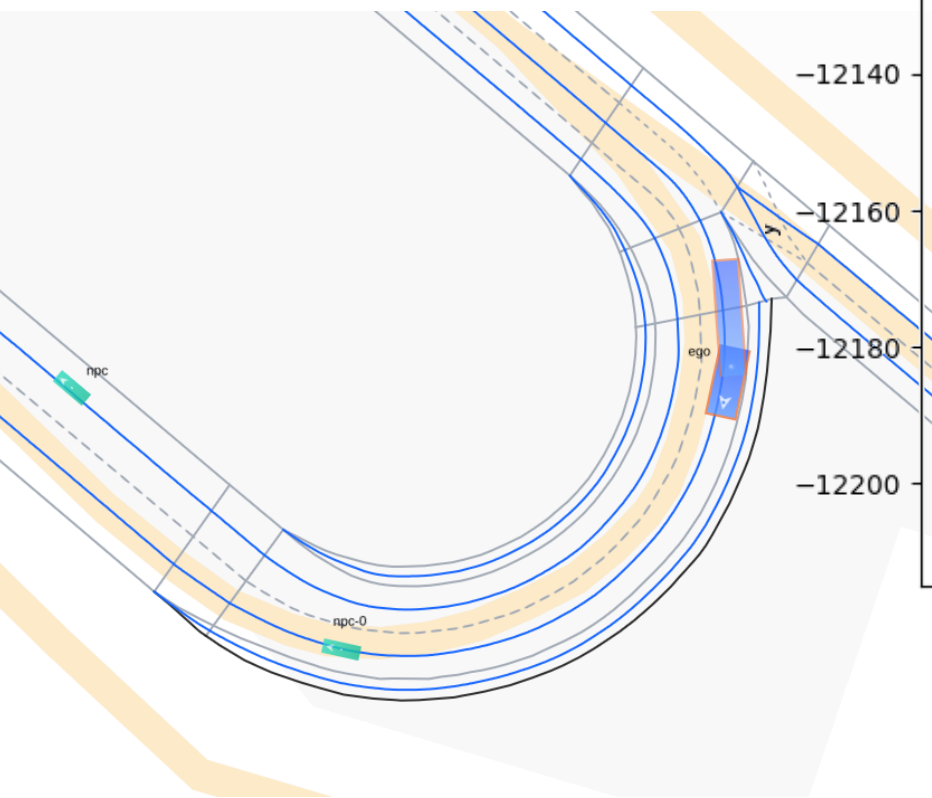**1. Bypass on straight road**

The third stage: the first bypass is complete, the second bypass continues as the ego prepares to enter the large curvature curve

Application 平滑DP搜索出的粗略路径

Validation tests

1. Bypass around the curve

Thanks

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