Supplementary Material for *IDCode: An End-to-end Decision and Control Library for High-level Autonomous Driving System*

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I. Evaluation Metrics

To evaluate the performance of the proposed methods, we employ several metrics, including safety, comfort, and traffic efficiency. These indexes are defined as follows.

The safety index evaluates the potential risks between the ego vehicle and obstacles, which is computed by the position and speed of ego vehicle and obstacles, i.e.,

$$
\begin{aligned}
V_t &= \alpha \cdot \frac{(\boldsymbol{v}_t^i - \boldsymbol{v}_t)\cdot(\boldsymbol{p}_t - \boldsymbol{p}_t^i)}{|\boldsymbol{p}_t - \boldsymbol{p}_t^i|} + (1-\alpha)(|\boldsymbol{v}_t^i| + |\boldsymbol{v}_t|)\\
G_t &= (M + M^i)\cdot \log(V_t + 1.8)\\
\omega_T &= \exp\left(-0.1 t\beta_a\right)\\
\omega_d &= \exp\left(-d_{\min\beta_\mathrm{b}}\right)\\
I_{\text{Safety}}^{i,t} &= \omega_T \cdot \omega_d \cdot G_t\\
I_{\text{Safety}} &= \max_{i,t} I_{\text{Safety}}^{i,t},
\end{aligned}
$$

where $\alpha = 0.7, \beta_a = 1.04, \beta_b = 1.94, M = M^i = 1$, $\boldsymbol{v}_t^i$ and $\boldsymbol{v}_t$ are the velocity vectors of i-th obstacle and ego vehicle, $\boldsymbol{p}_t^i$ and $\boldsymbol{p}_t$ are the position vectors of i-th obstacle and ego vehicle.

The traffic efficiency index is the ratio between the speed of ego vehicle and the average speed of obstacle vehicles, which is defined as

$$
I_{\text{efficiency}} = \frac{v}{\bar{v}}, \tag{1}
$$

where v is the speed of the ego vehicle, and $\bar{v}$ is the average speed of the obstacle vehicles. If there is no obstacle, $\bar{v}$ is set to the speed limit of the road.

The comfort index is calculated using lateral and longitudinal acceleration:

$$
I_{\text{comfort}} = \sqrt{(I_{\text{lat}}^2 + I_{\text{lon}}^2)/2},
$$

where I_{lat} and I_{lon} are computed through interpolation of the data in Table I. Higher accelerations lead to more pronounced changes in vehicle motion, resulting in a diminished level of occupant comfort and subsequently yielding a lower corresponding comfort index.

TABLE I
I_{lat} AND I_{lon}

Longitudinal Acc.	I_{lon}	Lateral Acc.	I_{lat}
7.6,	0.6	7.6	0.6
3.07,	0.4	5.6	0.4
1.47,	0.2	4.0	0.2
0,	0,	0	0
-2,	0.2	-4.0	0.2
-5.08,	0.4	-5.6	0.4
-7.6,	0.6	-7.6	0.6

TABLE II
KEY PARAMETERS

Parameters of vehicle dynamics	Value
Mass, m	1200 [kg]
Polar moment of inertia at CG, I_z	1600 [kg·m^2]
Distance from CG to front axle, L_f	1.1 [m]
Distance from CG to rear axle, L_r	1.2 [m]
Front-wheel cornering stiffness, C_f	-90000 [N/rad]
Rear-wheel cornering stiffness, C_r	-90000 [N/rad]
Time interval, ΔT	0.1 [s]

II. Vehicle Model used in the experiments

The vehicle model used in the experiments is defined as

$$
F_{\text{ego}} = \begin{bmatrix}
p_x + \Delta T(v_x\cos\phi - v_y\sin\phi)\\
p_y + \Delta T(v_x\sin\phi + v_y\cos\phi)\\
\phi_t + \Delta T\omega_t\\
v_x + \Delta T(a_x + v_y\omega)\\
\frac{m v_x v_y + \Delta T[(L_f C_f - L_r C_r)\omega - C_f\delta v_x - m v_x^2\omega]}{m v_x - \Delta T(C_f + C_r)}\\
\frac{-I_z\omega v_x - \Delta T[(L_f C_f - L_r C_r)v_y - L_f C_f \delta v_x]}{\Delta T(L_f^2 C_f + L_r^2 C_r) - I_z v_x}
\end{bmatrix}. \tag{2}
$$

The calibration results of the vehicle dynamics are shown in Table II.