1 Constraints of Participant Basic Driving Actions

1.1 The constraints for "stop"

(1) $\forall i \in (1, e], X_i^b.pos = X_{i-1}^b.pos$

(2) $\forall i \in [1, e], spd_i = 0$

1.2 The constraints for "U-turn"

(1) $X_1^b.pos \in l_m \wedge l_m \in R_i, X_e^b.pos \in l_n \wedge l_n \in R_{j,}\ i \neq j$

(2) $X_s^b.pos \in \mathrm{ITS}(R_i, R_j)$

(3) $\left(X_1^b.x - X_s^b.x\right) = DX(1, s), \left(X_1^b.y - X_s^b.y\right) = DY(1, s)$

(4) $\left(w_s^b.x - w_e^b.x\right) = DX(s, e), \left(w_s^b.y - w_e^b.y\right) = DY(s, e)$

(5) $\forall i \in (1, \mathrm{e}], 0 < spd_{i-1}^X = spd_i^X \leq spd^{limit}$

1.3 The constraints for "follow lane"

(1) $X_1^b.pos \in l_m, X_e^b.pos \in l_m, l_m \in R_i$

(2) $fd\left(X_1^b.pos, X_e^b.pos, l_m\right) = 1$

(3) $\left(X_1^b.x - X_e^b.x\right) = DX(1, e), \left(X_1^b.y - X_e^b.y\right) = DY(1, e)$

(4) $\forall i \in (1, \mathrm{e}], 0 < spd_{i-1}^X = spd_i^X \leq spd^{limit}$

1.4 The constraints for "change lane"

(1) $X_1^b.pos \in l_m \wedge l_m \in R_i, X_e^b.pos \in l_n \wedge l_n \in R_j, i = j, m \neq n$

(2) $fd\left(X_1^b.pos, X_e^b.pos, l_m\right) = 1$

(3) $X_s^b.pos \in \mathrm{ITS}(l_m, l_n)$

(4) $\left(X_1^b.x - X_s^b.x\right) = DX(1, s), \left(X_1^b.y - X_s^b.y\right) = DY(1, s)$

(5) $\left(X_s^b.x - X_e^b.x\right) = DX(s, e), \left(X_s^b.y - X_e^b.y\right) = DY(s, e)$

(6) $\forall i \in (1, \mathrm{e}], 0 < spd_{i-1}^X = spd_i^X \leq spd^{limit}$

1.5 The constraints for "turn left"

(1) $\begin{cases} X_1^b.pos \in l_m \wedge l_m \in R_i, X_e^b.pos \in l_n \wedge l_n \in R_{j,}\ i \neq j \text{ , when not lead to collision} \\ X_1^b.pos \in l_m \wedge l_m \in R_i, w_e^X.pos \in C_A, \text{when lead to collision} \end{cases}$

(2) $\forall i \in [1, e-1), \overrightarrow{s_1 s_{1+1}} \cdot \overrightarrow{s_1 s_{1+2}}' > 0$

(3)$k_1 * k2 = -1$, $k_1 = (l_{ex}^m.y - l_{en}^m.y)/(l_{ex}^m.x - l_{en}^m.x), k_2 = (l_{ex}^n.y - l_{en}^n.y)/(l_{ex}^n.x - l_{en}^n.x), l_{ex}^m, l_{en}^m \in l_m, l_{ex}^n, l_{en}^n \in l_n$

(4) $\left(X_1^b.x - X_e^b.x\right) = DX(1,e), \left(X_1^b.y - X_e^b.y\right) = DY(1,e)$

(5) $\forall i \in (1, \mathrm{e}], 0 < spd_{i-1}^X = spd_i^X \leq spd^{limit}$

1.6 The constraints for "turn right"

(1) $\begin{cases} X_1^b.pos \in l_m \wedge l_m \in R_i, X_e^b.pos \in l_n \wedge l_n \in R_{j,}\ i \neq j \text{ , when not lead to collision} \\ X_1^b.pos \in l_m \wedge l_m \in R_i, X_e^b.pos \in C_A, \text{when lead to collision} \end{cases}$

(2)$\forall i \in [1, e-1), \overrightarrow{s_1 s_{1+1}} \cdot \overrightarrow{s_1 s_{1+2}}' < 0$

(3) $k_1 * k2 = -1$, $k_1 = (l_{ex}^m \cdot y - l_{en}^m \cdot y)/(l_{ex}^m \cdot x - l_{en}^m \cdot x), k_2 = (l_{ex}^n \cdot y - l_{en}^n \cdot y)/(l_{ex}^n \cdot x - l_{en}^n \cdot x), l_{ex}^m, l_{en}^m \in l_m, l_{ex}^n, l_{en}^n \in l_n$

(4) $\left(X_1^b \cdot x - X_e^b \cdot x\right) = DX(1,e), \left(X_1^b \cdot y - X_e^b \cdot y\right) = DY(1,e)$

(5) $\forall i \in (1, \mathrm{e}], 0 < spd_{i-1}^X = spd_i^X \leq spd^{limit}$

1.7 The constraints for "vehicle across"

(1) $\begin{cases} X_1^b.pos \in l_m \wedge l_m \in R_i, X_e^b.pos \in l_n \wedge l_n \in R_{j,}\ i \neq j \text{ , when not lead to collision} \\ X_1^b.pos \in l_m \wedge l_m \in R_i, X_e^b.pos \in C_A, \text{when lead to collision} \end{cases}$

(2) $fd\left(X_1^b.pos, X_e^b.pos, l_m\right) = 1$

(3)$\arctan|(k_1 - k_2)/(1 + k_1 k_2)| < \frac{\pi}{2}, k_1 = (l_{ex}^m.y - l_{en}^m.y)/(l_{ex}^m.x - l_{en}^m.x), k_2 = (l_{ex}^n.y - l_{en}^n.y)/(l_{ex}^n \cdot x - l_{en}^n.x), l_{ex}^m, l_{en}^m \in l_m, l_{ex}^n, l_{en}^n \in l_n$

(4) $\left(X_1^b.x - X_e^b.x\right) = DX(1,e), \left(X_1^b.y - X_e^b.y\right) = DY(1,e)$

(5) $\forall i \in (1,\mathrm{e}], 0 < spd_{i-1}^X = spd_i^X \leq spd^{limit}$

1.8 The constraints for "drive into the road"

(1) $X_1^b.pos \notin R, X_e^b.pos \in l_m \wedge l_m \in R_i$

(2) $fd\left(X_1^b.pos, X_e^b.pos, l_m\right) = 1$

(3) $\left(X_e^b.x - X_1^b.x\right) = DX(1,e), \left(X_e^b.y - X_1^b.y\right) = DY(1,e)$

(4) $\forall i \in (1,\mathrm{e}], 0 < spd_{i-1}^X = spd_i^X \leq spd^{limit}$

1.9 The constraints for "pedestrian walk"

(1) $\forall i \in [1,e], V_i^b.pos \notin \mathrm{R}$

(2) $\left(X_1^b.x - X_e^b.x\right) = DX(1,e), \left(X_1^b.y - X_e^b.y\right) = DY(1,e)$

(3) $\forall i \in [1,e], 0 < spd_i \leq 5$

1.10 The constraints for "pedestrian cross"

(1) $i \in [1,e], V_i^b.pos \in \mathrm{R}$

(2) $\left(V_1^b.x - V_e^b.x\right) = DX(1,e), \left(V_1^b.y - V_e^b.y\right) = DY(1,e)$

(3)$\forall i \in [1,e], 0 < spd_i \leq 5$

1.11 The constraints for “drive off the road”

(1) $X_1^b.pos \in l_m \wedge l_m \in R_i, X_e^b.pos \notin R_i$

(2) $fd\left(X_1^b.pos, X_e^b.pos, l_m\right) = 1$

(3) $\left(X_1^b.x - X_e^b.x\right) = DX(1,e), \left(X_1^b.y - X_e^b.y\right) = DY(1,e)$

(4) $\forall i \in (1,\mathrm{e}], 0 < spd_{i-1}^X = spd_i^X \leq spd^{limit}$

1.12 The constraints for "retrograde"

(1) $X_1^b.pos \in l_m \wedge l_m \in R_i, X_e^b.pos \in l_n, l_n \in R_j, i \neq j, m \neq n$ (R_i and R_j are adjacent)

(2) $fd\left(X_1^b.pos, X_e^b.pos, l_m\right) = 1$

(3) $\left(X_e^b.x - X_1^b.x\right) = DX(1,e), \left(X_e^b.y - X_1^b.y\right) = DY(1,e)$

(4) $\forall i \in (1,\mathrm{e}], 0 < spd_{i-1}^X = spd_i^X \leq spd^{limit}$

2. Constraints between Multiple Driving Actions of Participants

(1) $\forall p \in (1,\mathrm{n}], S_1^p.pos = S_{\mathrm{e}}^{p-1}.pos$

(2) $\forall q \in (1,\mathrm{m}], V_1^q.pos = V_{\mathrm{e}}^{q-1}.pos$

(3) $S_{\mathrm{e}}^n.pos = V_{\mathrm{e}}^m.pos \wedge S_{\mathrm{e}}^n \cdot pos \in C_A \wedge V_{\mathrm{e}}^m.pos \in C_A$

(4) $\sum_{i=1}^n A_{t_i} = \sum_{i=1}^m V_{t_i}$