APPENDIX A
PROOF OF LEMMA 1

Proof. Since $G(V, E, F)$ is modeled as the realistic road map, the feasible paths to reach the target position must be found.

Therefore, we denote the paths from the source s to the destination d as:

$$L_{sd} = \{l_{sd}^1, l_{sd}^2, ..., l_{sd}^n\}, \quad n > 0 \tag{1}$$

where n represents the number of paths. As for L_{sd} we have:

$$l_{max} = max(l_{sd}^k), \quad k = 1...n \tag{2}$$

since the condition $n > 0$ is always valid. Hence for any path from s to d has the longest length l_{max}. □

APPENDIX B
PROOF OF LEMMA 2

Proof. According to the principle of relax operation, we can learn: only when $N_Q(x)$ .dist +w(x, v)<$N_Q(v)$ .dist, for x ∈v .preds Q_R will update $N_Q(v)$ .dist and $N_Q(v)$. s p . Based on this equation, we prove:
Case 1 Δ w(u, v)>0
Since w(u, v) is increased, Eq.(B) is certainly not satisfied. Thus Q_R remains self-ordered and no changes will occur in Q , only w(u, v) will update to $w'(u, v)$.
Case 2 Δ w(u, v)<0
If $w'(u, v)$ cannot satisfy Eq.(B), it is the same situation with Case 1 . Else, if satisfying, through $w'(u, v)$ we can obtain the updated value:

$N_Q(v)$ · d i s t=$N_Q(u)$ · d i s t+$w'(u, v)$ □

APPENDIX C
PROOF OF LEMMA 3

Proof. We use dist $\min_{\min}(v)$ to denote the minimum value currently calculated from V_s to v . According to the meaning of $N_T(v)$ .dist, the value is always keep in accordance with dist $\min_{\min}(v)$. Based on these characteristics, we prove:

$N_T(v)$ dist. Therefore:

$$\begin{aligned} &\text{dist }_{\min}(v) = N_T(v).\text{dist} \\ &\le N_T(u).\text{dist } + w(u, v) \end{aligned}$$

Assume that we update dist $\min(v)$ to$dist'_{\min}(v)$ instead of doing nothing: $\begin{aligned} dist'_{\min}(v) &= N_T(u) \cdot dist + w'(u, v) \\ &> N_T(u) \cdot dist + w(u, v) \end{aligned}$ However, currently dist $\min_{\min}(v)$>$dist_{\min}(v)$, there is no need to update the value, hence violating our assumption. Case & $\Delta w(u, v)$<0 : When $N_T(u)$ .dist +$w'(u, v)$<$N_T(v)$ .dist, it will trigger rollback operation, modifying relevant values to maintain dist $\min(v)$=$N_T(v)$.dist.

Therefore, there has $N'_T(v)$ .dist =$N_T(u)$ .dist + $\boldsymbol{w}'(u, v)$. Assume the current time t_c, t_e>$N_T(v)$. t . Hence: $T = T + v.suces$, for $t \in [N_T(v).t, t_e]$ At t_c,$N_T(v)$ .dist has updated to $N'_T(v)$ .dist. x ∈ v.succs satisfies the relax condition Eq.(30), the rollback operation will be performed as follows:

$N_T(x)$.dist ← $N'_T(x)$,dist, for $x \in v$. succs

Hence the proof is complete. □