A Proof of Theorem 1

Theorem. *Suppose that the EV's reaction depends on the future traffic unidirectionally, then we have* $\mathbb{P}(Y^{EV}, \boldsymbol{Y}^{OV}|Coll = True, X) \propto \mathbb{P}(\boldsymbol{Y}^{OV}|X)\mathbb{P}(Y^{EV}|\boldsymbol{Y}^{OV}, X_t)\mathbb{P}(Coll = True|Y^{EV}, \boldsymbol{Y}^{OV})$.

Proof. According to Bayes theorem, we have

$$\mathbb{P}(Y^{\text{EV}}, \boldsymbol{Y}^{\text{OV}}|Coll = True, X) \propto \mathbb{P}(Coll = True|Y^{\text{EV}}, \boldsymbol{Y}^{\text{OV}}, X)\mathbb{P}(Y^{\text{EV}}, \boldsymbol{Y}^{\text{OV}}, X) \tag{A.1}$$

Since $Coll$ merely depends on $Y^{\text{EV}}_{t:t+l}$ and $\boldsymbol{Y}^{\text{OV}}_{t:t+l}$, (A.1) is equivalent to

$$\mathbb{P}(Y^{\text{EV}}, \boldsymbol{Y}^{\text{OV}}|Coll = True, X) \propto \mathbb{P}(Coll = True|Y^{\text{EV}}, \boldsymbol{Y}^{\text{OV}})\mathbb{P}(Y^{\text{EV}}, \boldsymbol{Y}^{\text{OV}}, X) \tag{A.2}$$

Suppose that the AV's reaction depends on the future traffic unidirectionally; continuing with Bayes theorem, we have

$$\begin{aligned}
&\mathbb{P}(Y^{\text{EV}}, \boldsymbol{Y}^{\text{OV}}|Coll = True, X) \\
&\qquad \propto \mathbb{P}(Coll = True|Y^{\text{EV}}, \boldsymbol{Y}^{\text{OV}})\mathbb{P}(Y^{\text{EV}}|\boldsymbol{Y}^{\text{OV}}, X)\mathbb{P}(\boldsymbol{Y}^{\text{OV}}, X) \\
&\qquad \propto \mathbb{P}(Coll = True|Y^{\text{EV}}, \boldsymbol{Y}^{\text{OV}})\mathbb{P}(Y^{\text{EV}}|\boldsymbol{Y}^{\text{OV}}, X)\mathbb{P}(\boldsymbol{Y}^{\text{OV}}|X)\mathbb{P}(X)
\end{aligned} \tag{A.3}$$

Since the past state X is given, we can omit the last item $\mathbb{P}(X)$ in (A.3). Therefore, it holds that

$$\mathbb{P}(Y^{\text{EV}}, \boldsymbol{Y}^{\text{OV}}|Coll = True, X) \propto \mathbb{P}(\boldsymbol{Y}^{\text{OV}}|X)\mathbb{P}(Y^{\text{EV}}|\boldsymbol{Y}^{\text{OV}}, X)\mathbb{P}(Coll = True|Y^{\text{EV}}, \boldsymbol{Y}^{\text{OV}}) \tag{A.4}$$

The proof of Theorem 1 is completed. □

B Hyper-parameter Settings

Table 3: CAT

Hyper-parameter	Value
Scenario Horizon T	9s
History Horizon t	1s
# of OV candidates M	32
# of EV candidates N	5
Penalty Factor α	0.99
Policy Training Steps	10E6

Table 4: TD3

Hyper-parameter	Value
Discounted Factor γ	0.99
Train Batch Size	256
Critic Learning Rate	3E-4
Actor Learning Rate	3E-4
Policy Delay	2
Target Network τ	0.005

Table 5: DenseTNT and M2I

Hyper-parameter	Value
Train Batch size	256
Train Epoches	30
Sub Graph Depth	3
Global Graph Depth	1
NMS Threshold	7.2
Number of Mode	32

C Qualitative Results of Safety-critical Traffic Generation

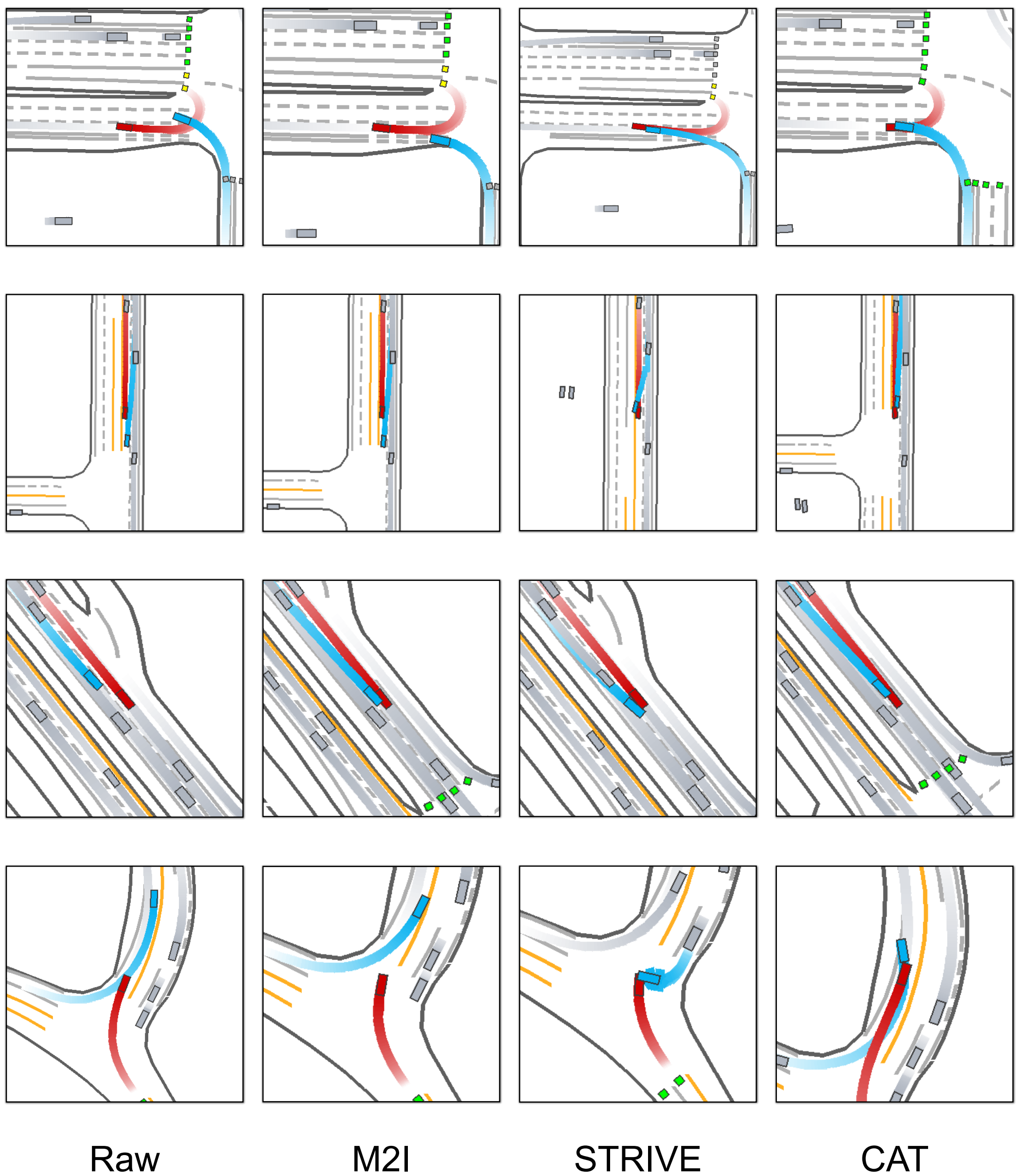

Figure 6: Comparing the different scenario generation methods. M2I and CAT both can determine the object of interest while STRIVE select the closest vehicle as the opponent. The red car is the ego vehicle and the blue car is the opponent vehicle.

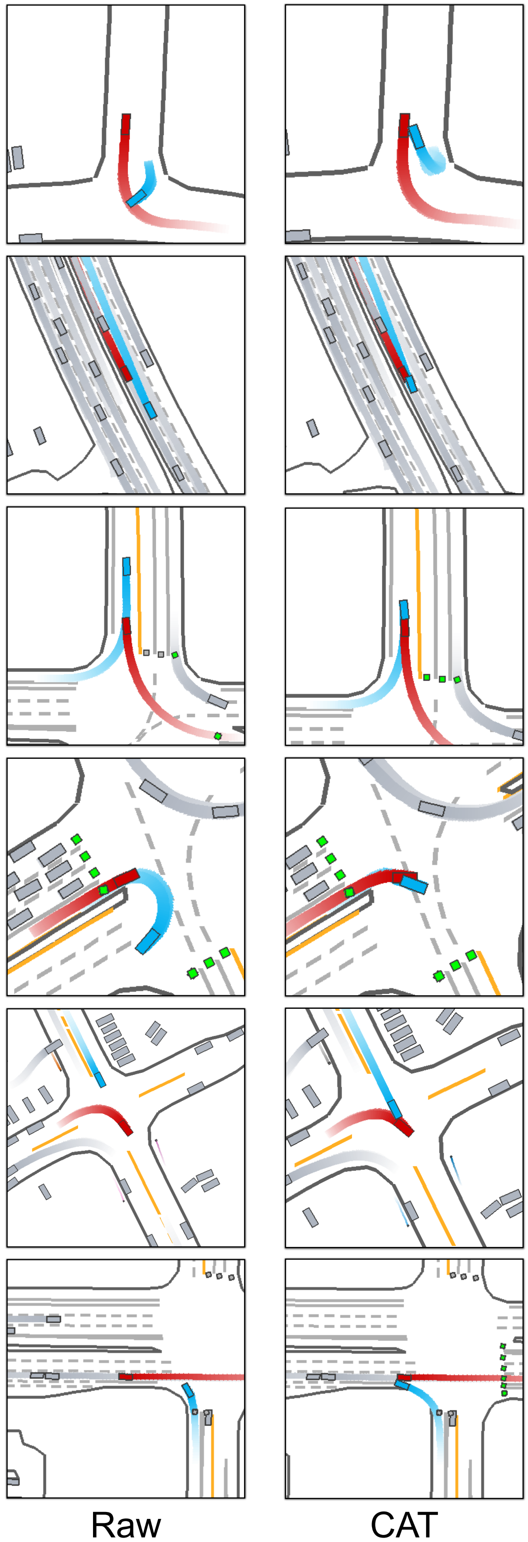

Figure 7: More comparison between the original scenarios in raw datasets and the safety-critical scenarios generated by our method. The red car is ego vehicle and the blue car is the opponent vehicle.