

## Introduction

- Motivation:** The hybrid, heterogeneous driving behavior and the complex interaction behavior caused by the mixture of different vehicle types are **some of the biggest challenges for automated vehicles** and **significant safety threats for vulnerable traffic participants** in the center area of the intersection.

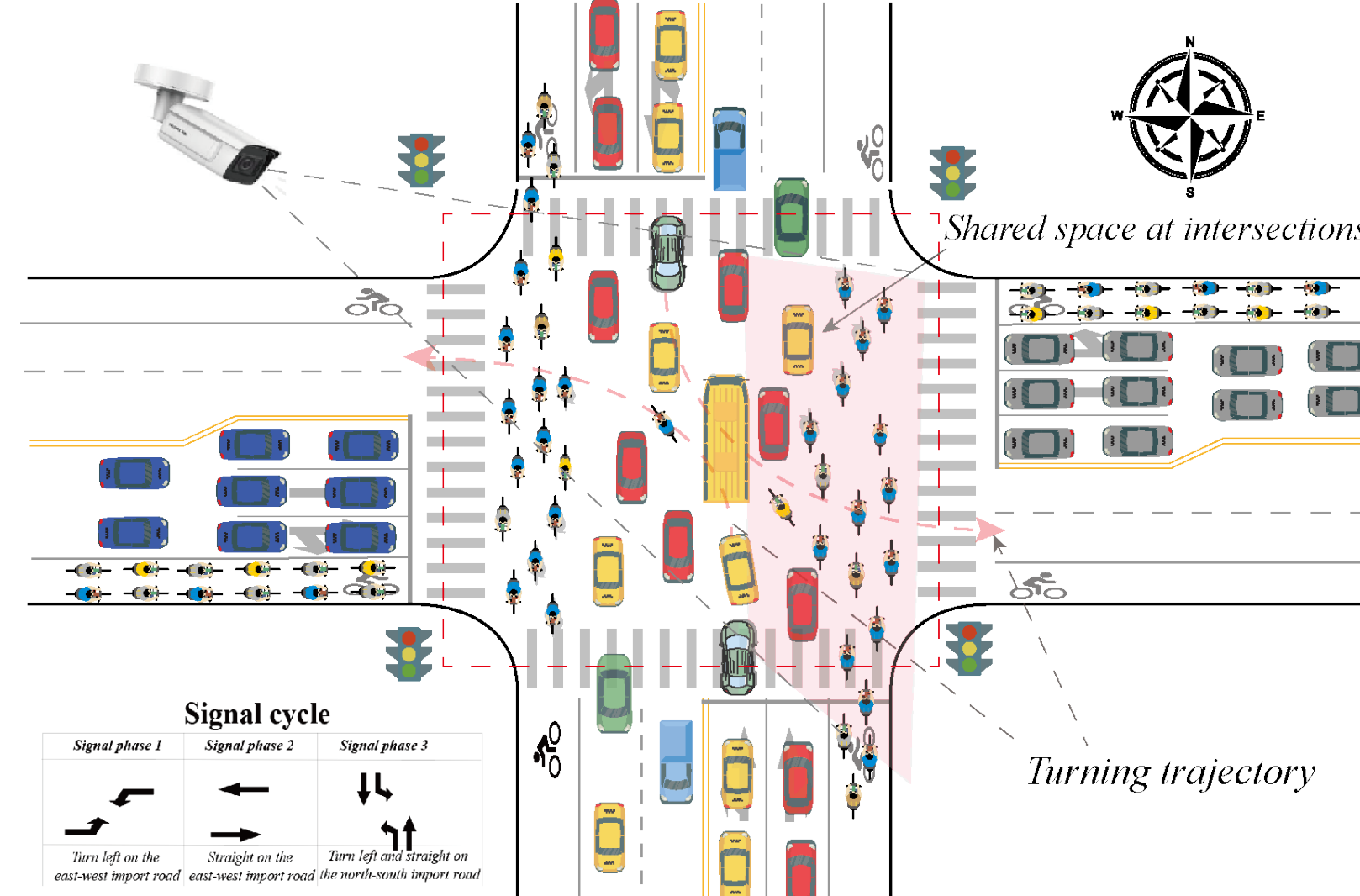


Fig. 1: The center area of the intersection.

- Challenges:** a). Driving behavior in this area shows higher heterogeneity and non-stationarity; b). Conflict behavior during interaction is temporary and dynamic, which increases the difficulty of mechanism modeling.
- Research gaps:**
  - Lacks attention to the evolution of conflict risk in interaction processes;
  - The impacts of signal control and the environment are ignored.

## Summary

- We proposed a methodology for extracting high-resolution trajectories from the video and created a mixed traffic flow trajectory dataset.
- A framework was established for analyzing the evolution of conflict risk with the interaction between MVs and NMVs and made sure the factor related to the risk level significantly.
- The machines of interaction between MV and NMV are analyzed and the spatiotemporal variables are introduced to describe the interaction behavior.

## Flowchart

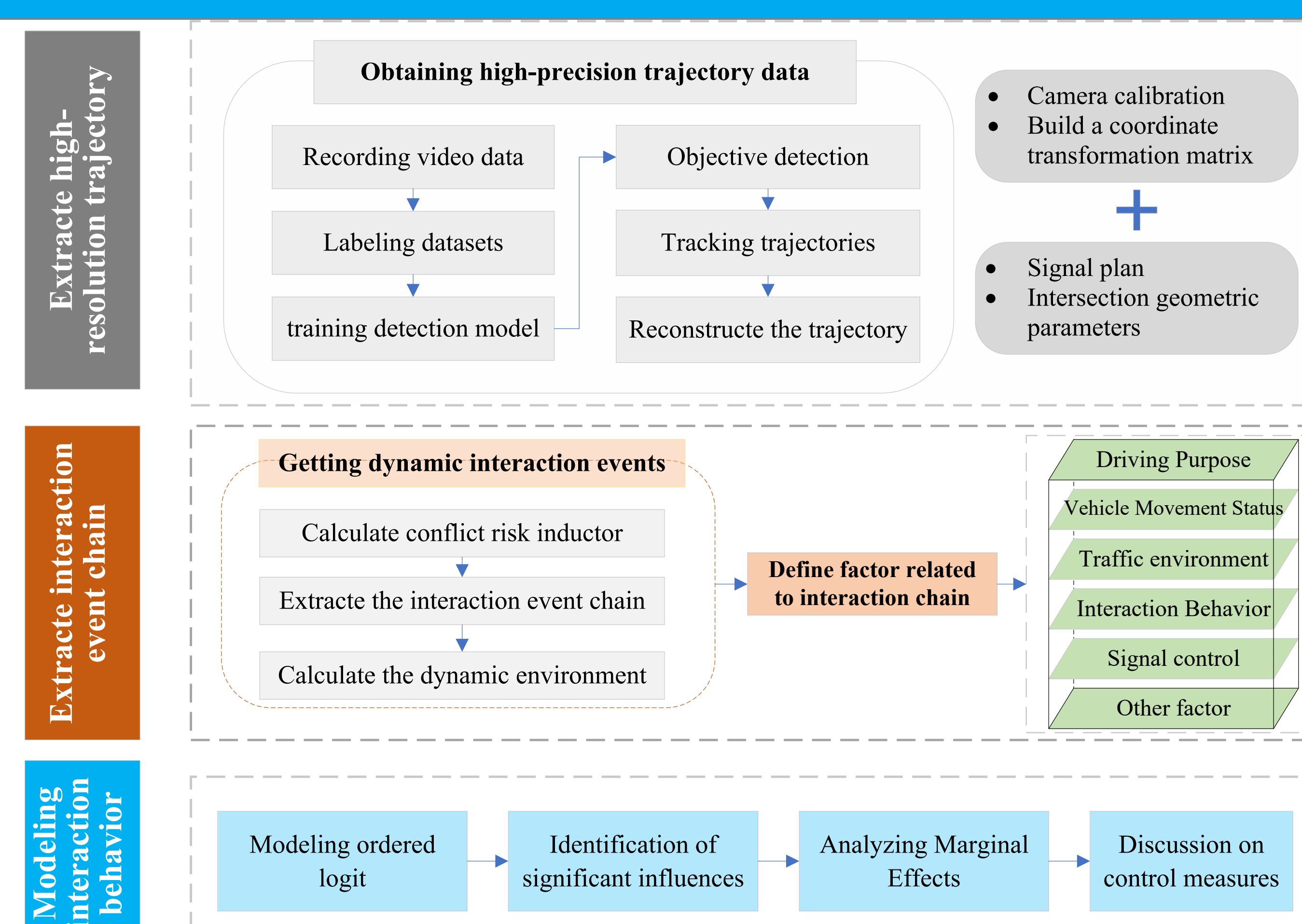


Fig. 2: The flowchart of methodology

## Methodology

- Trajectory Data:** (1) Traffic data show strong spatial and temporal dependencies; (2) Factorization on the Hankel matrix/tensor achieves automatic spatiotemporal modeling.

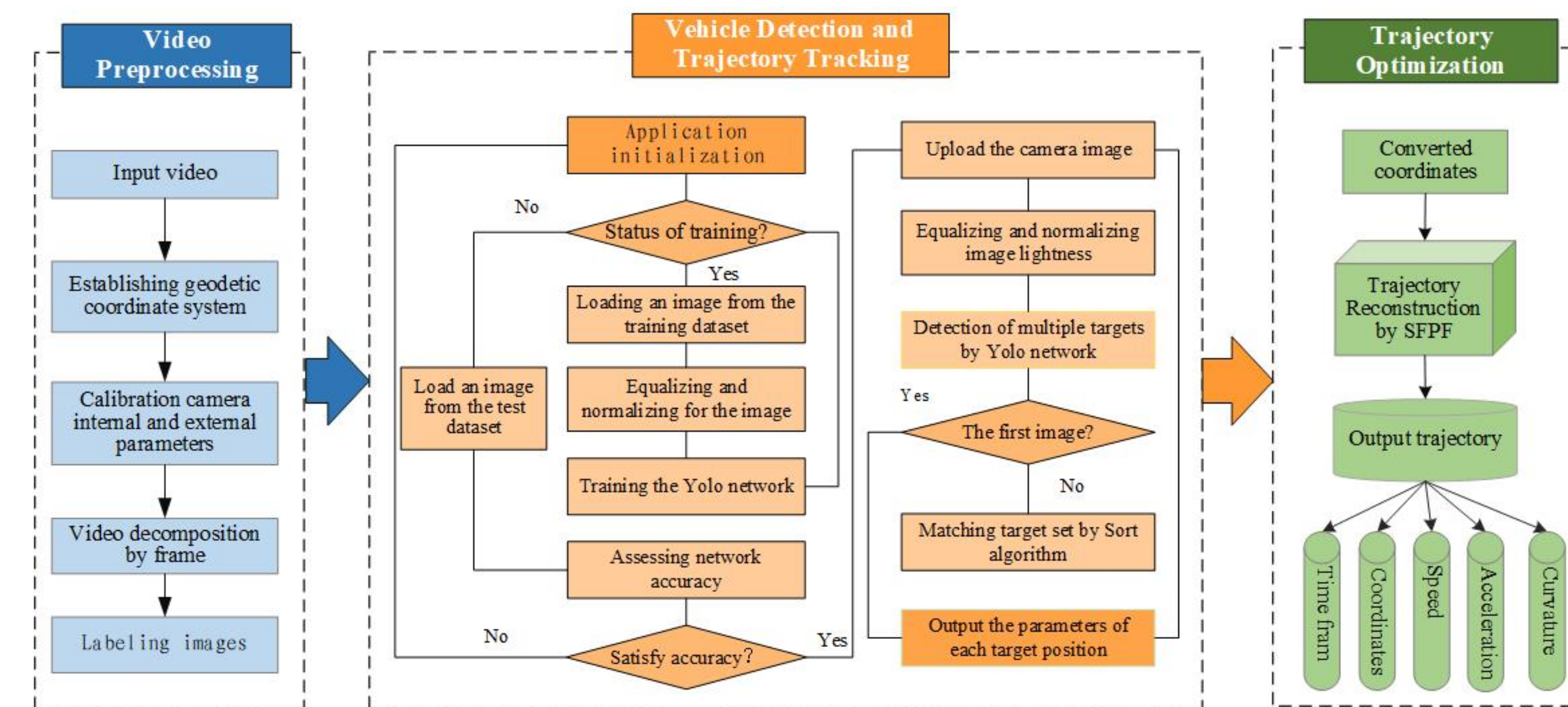


Fig. 3: Trajectory extraction and reconstruction based on Yolov7 and SFPP.

- Extracting interaction event chain:** Extracting the interaction process based on two dimensional TTC.

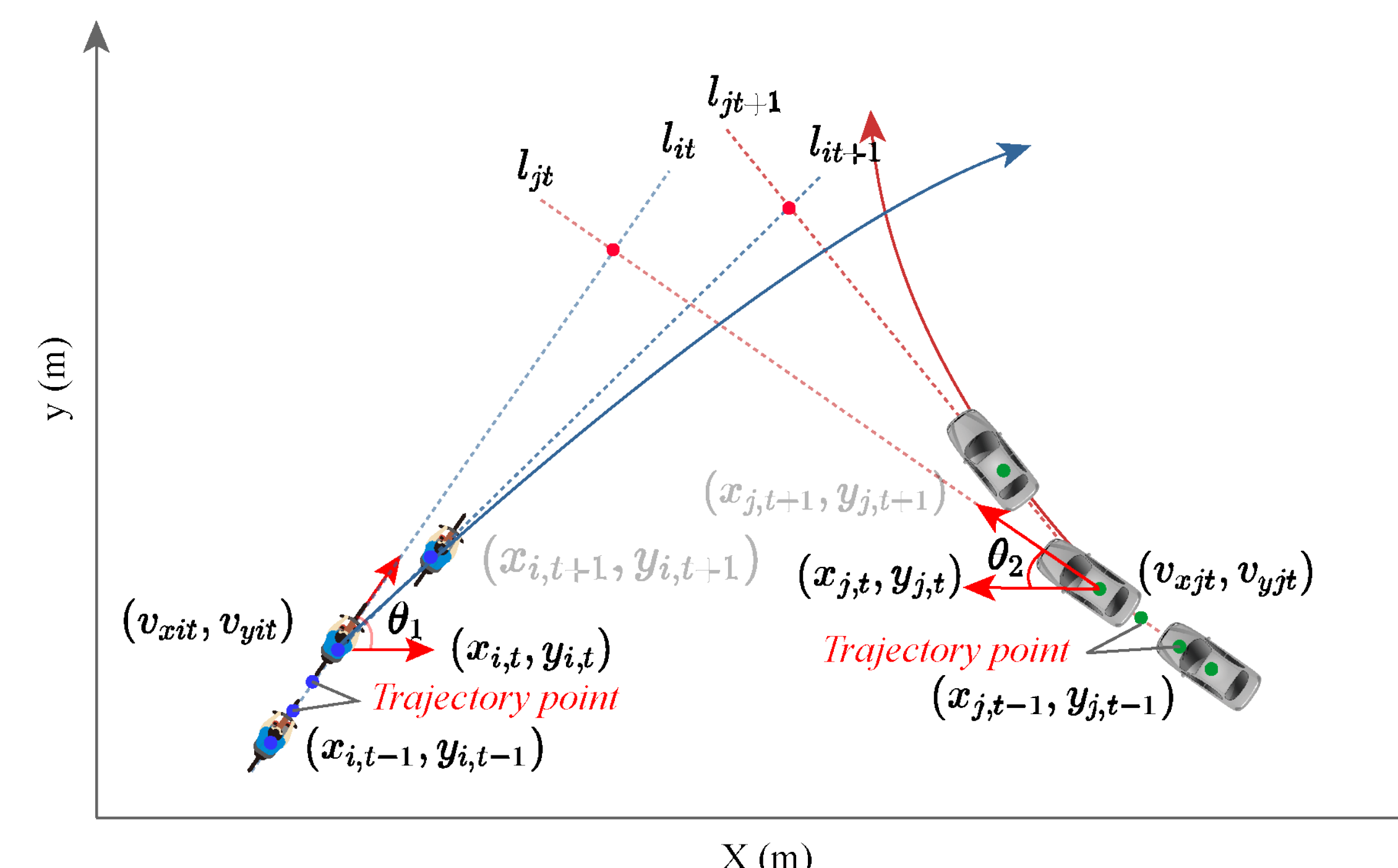


Fig. 4: The process of interaction between MVS and NMVs

- Defining interaction variables:** We categorize the potential influencing factors affecting the risk of vehicular conflicts according to driving direction, motion states, interaction behavior, environment, vehicle type and signal. 22 variables related to the level of conflict risk were selected.

- Model:** Ordinal logit model is employed to analyze the relationship between risk level and the impact factors which were predefined.
  - continuous variable  $y_i^*$  into an observable ordered variable  $y$  to represent conflict severity,  $y \in [-\infty, +\infty]$ .  $y_i = j$  if  $\gamma_{j-1} < y_i^* \leq \gamma_j$

- The general form of the model is shown in the following equation.

$$y_i^* = BX_i^T + \varepsilon$$

- The probability that the severity of the  $i$ -th accident follows the equation.

$$\begin{aligned} Pr(y_i = j | X_i, B, \Gamma) &= Pr(\gamma_{j-1} - X_i^T B < \varepsilon_i \leq \gamma_j - X_i^T B) \\ &= F(\gamma_j - X_i^T B) - F(\gamma_{j-1} - X_i^T B) \end{aligned}$$

- The coefficients  $\beta$  and the severity grading points  $\tau$  of each influencing factor were estimated using maximum likelihood estimation.

## Experiments & Results

- Model results:**

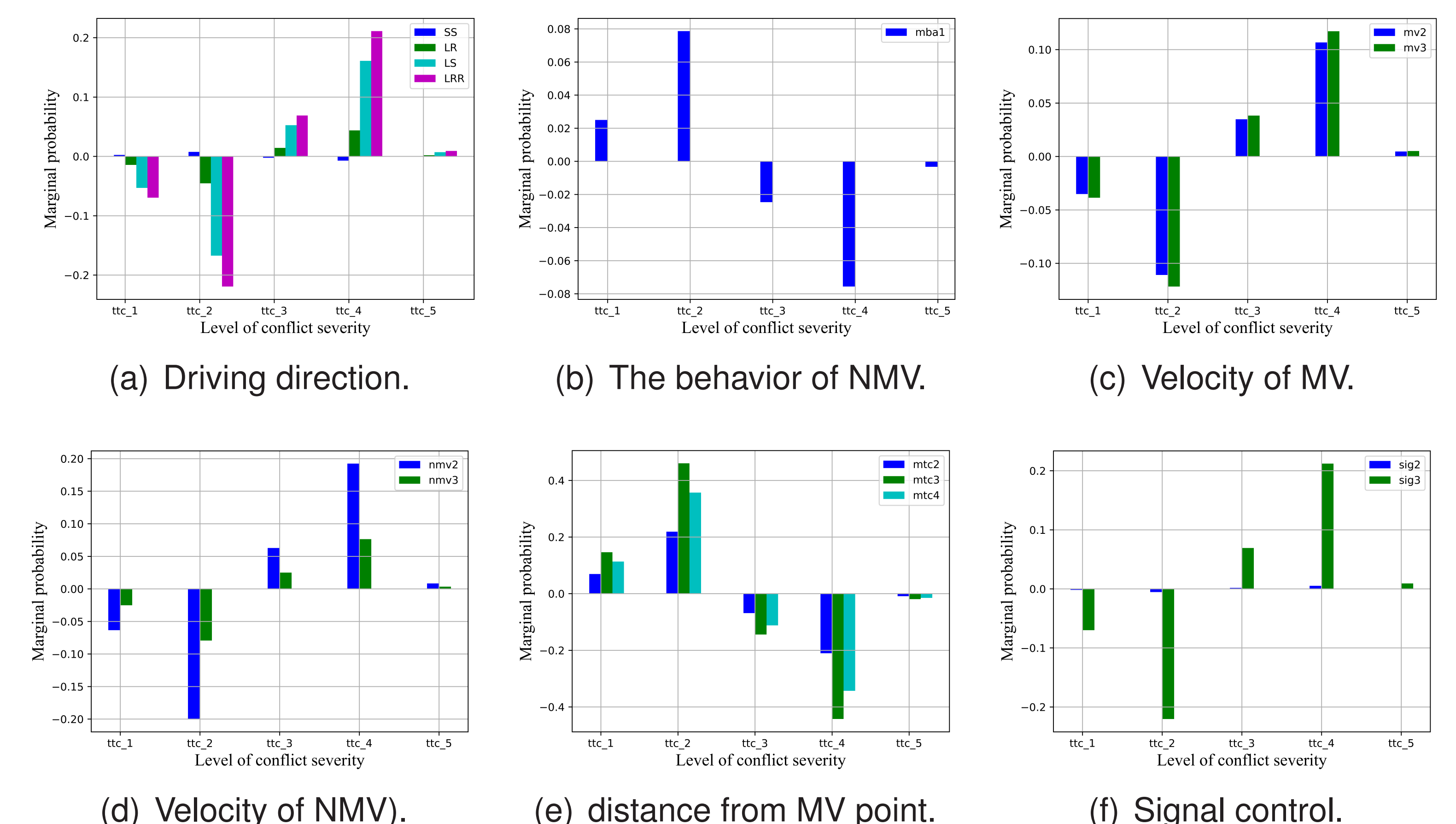
- There are 10 variables that have a significant effect on conflict risk severity with a p-value less than 0.1.

Table 1: The significance variables from ordinal logistics Model ( $p < 0.05$ )

Variable	Coefficient	Std.err.	$P >  z $	Variable	Coefficient	Std.err.	$P >  z $
$mdir_1$	0.729	0.371	0.049	$mbh_1$	-0.164	0.223	0.462
$mdir_3$	0.574	0.271	0.034	$mbh_2$	-0.581	0.340	0.088
$nmdir_1$	0.873	0.265	0.001	$nmv_2$	1.195	0.164	0.000
$nmdir_3$	1.184	0.534	0.027	$nmv_3$	0.454	0.636	0.475
$mv_2$	0.606	0.159	0.000	$nmmn_1$	0.267	0.168	0.112
$mv_3$	0.733	0.368	0.046	$nmtc_1$	5.178	0.710	0.000
$mba_1$	-0.495	0.188	0.009	$nmtc_2$	3.703	0.700	0.000
$mtc_2$	-1.308	0.163	0.000	$nmtc_3$	1.863	0.684	0.006
$mtc_3$	-2.735	0.20	0.000	$sig_1$	-1.297	-3.48	0.001
$mtc_4$	-2.123	0.609	0.000	$sig_3$	-1.256	-4.06	0.000
$nma_1$	-0.642	0.172	0.000	$nmt_2$	0.609	0.167	0.000
$\gamma_4$	8.032	0.839					

- Marginal effects:**

- Here take the average of the other variables and calculate the change in the probability of a different conflict risk level when the observed variable is changed by one unit.



## conclusion

- The main variables affecting the severity of conflict between MV and NMV are direction, speed, Evasive behavior, distance to conflict point, the number of MV surrounding NMV, signal time and type of NMV.
- The probability of serious conflict for interaction events that occurred within 10 seconds of the end of the green light phase was 20% higher than beginning of the green light.
- Significant variables related to interaction behavior show that the probability of a serious conflict decreases by 20% when the distance to conflict point is more than 15 meters, compared to a distance of less than 5 meters.

## Shanghai-Mixed-Traffic-Flow-Trajectory

- <https://www.kaggle.com/datasets/zcyan2/mixed-traffic-trajectory-dataset-in-from-shanghai>