Relating Freeway Traffic Accidents to Inductive Loop Detector Data Using Logistic Regression

Junhyeong Park, Graduate Student Researcher

Cheol Oh, Ph.D. Assistant Professor

Department of Transportation Systems Engineering

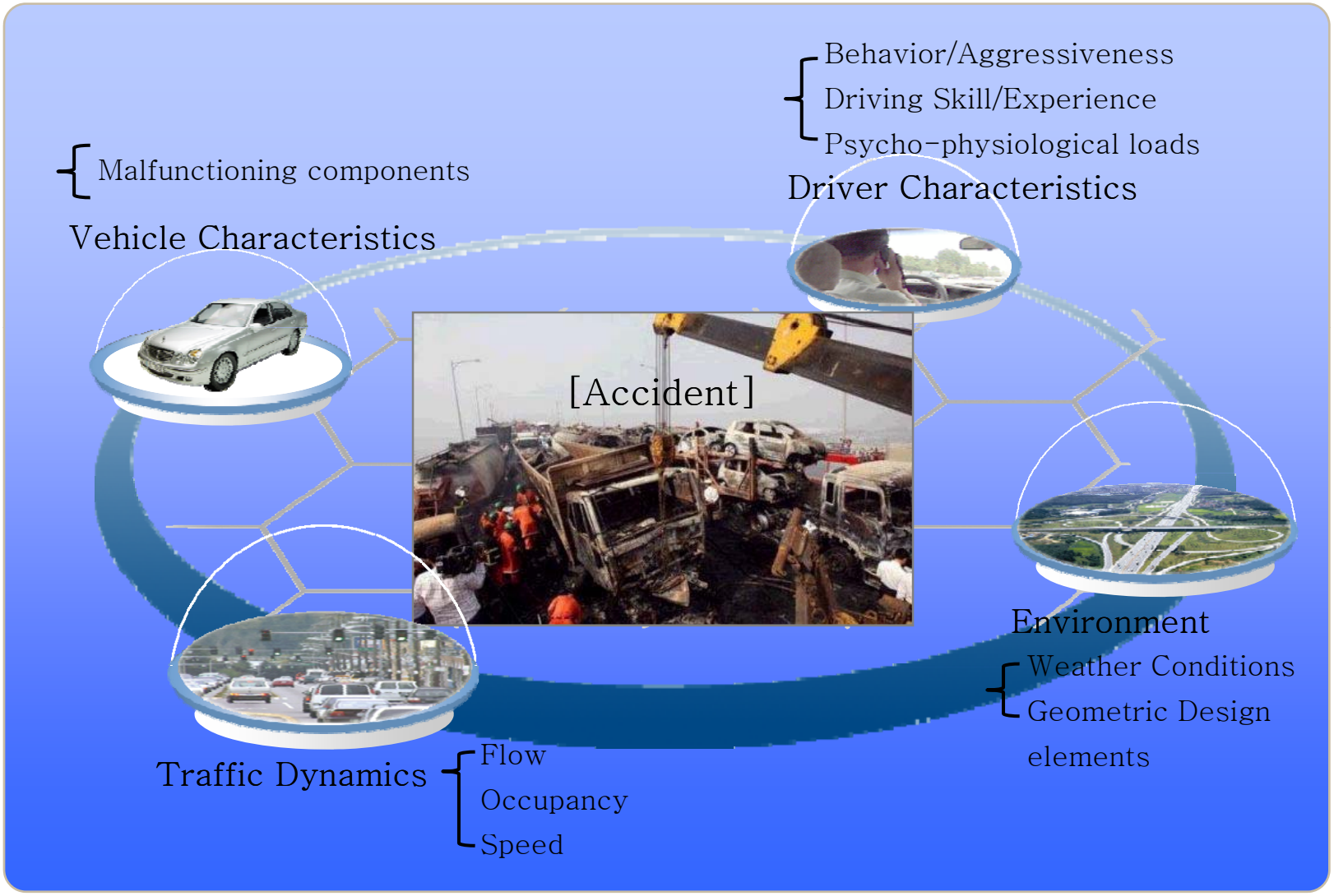
Hanyang University at Ansan

Hanyang University

Contents

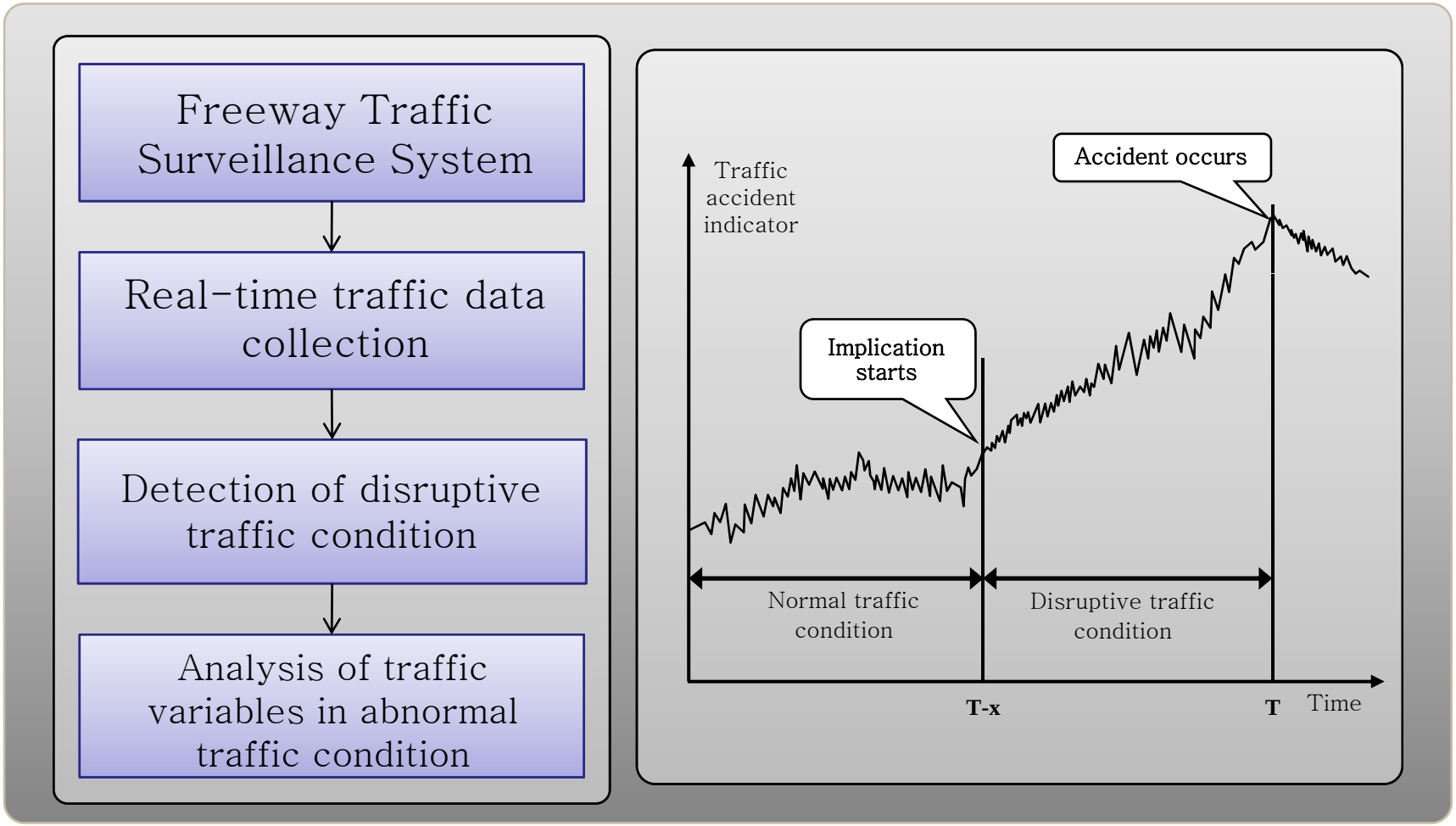
1. Introduction

Background



1. Introduction

Background



1. Introduction

Data

- Seohaean Freeway : Seoul - Mokpo(339.51km)
- Seohaean freeway loop data from detectors and traffic accident data for 3 years - 2004, 2005 and 2006
  - Occupancy, Speed, Volume

Traffic accident data

ID	사고일자	사고시간	이정	방향	노선명	주야구분	사고유형
1	2004-01-02	03 : 40	152	서울	서해안선	야간	차-시설
2	2004-01-02	08 : 50	36.6	무안	서해안선	주간	차-시설
3	2004-01-02	20 : 40	81.2	서울	서해안선	야간	차-시설
4	2004-01-02	22 : 00	179.8	서울	서해안선	주간	차-시설
5	2004-01-03	07 : 10	335.6	무안	서해안선	주간	단독
6	2004-01-07	05 : 45	218.4	서울	서해안선	야간	차-시설
7	2004-01-09	10 : 20	106.8	무안	서해안선	주간	차-시설

- Traffic accident data from Seohaean freeway for three years (2004~2006)
- Date, Time, Location, Postmile, Direction, Type

Loop data

1	< VDS Hourly DATA >									
2										
3	작업 일자 : 20060101									
4										
5	VDS_ID	구분	0000	0015	0030	0045	0100	0115	0130	0145	0200
6	0010VDE11311	Occ	1	1	1	1	1	1	1	1	1
7	0010VDE11311	Vol	188	184	167	173	169	171	173	155	174
8	0010VDE11311	Spd	92	92	91	92	93	91	90	90	89
9	0010VDE11411	Occ	1	1	0	0	1	1	1	0	1

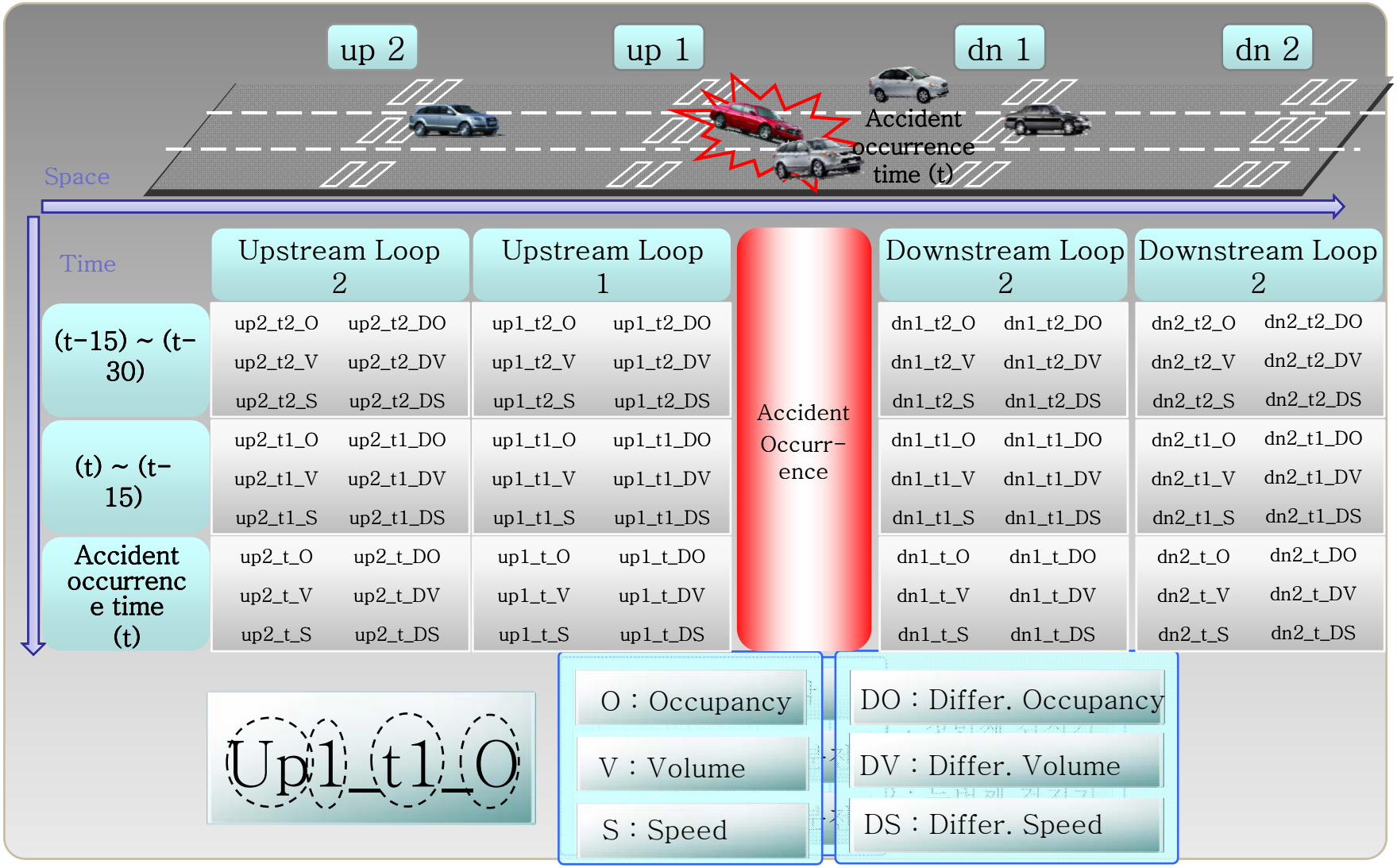
- Loop data from Seohaean freeway for three years (2004~2006)
- Extraction of traffic data from accident-involved loop data

150	1	250.31	occ	3	**3**	**4**	**4**	4
150	1	250.31	vol	237	**234**	**279**	**271**	279
150	1	250.31	spd	111	**109**	**110**	**111**	111
150	1	251.11	occ	3	**3**	**4**	**4**	4
150	1	251.11	vol	236	**227**	**269**	**290**	274
150	1	251.11	spd	113	**111**	**113**	**112**	113
150	1	**252.11**	occ	2	2	3	**4**	3
150	1	**252.11**	vol	218	214	246	**338**	286
150	1	**252.11**	spd	117	115	116	**111**	109
150	1	253.31	occ	3	**3**	**4**	**4**	5
150	1	253.31	vol	251	**234**	**298**	**293**	305
150	1	253.31	spd	110	**108**	**109**	**96**	100
150	1	254.71	occ	1.5	**1.5**	**2**	**2**	2.5
150	1	254.71	vol	179	**161**	**209**	**212**	206
150	1	254.71	spd	110	**108**	**110**	**102**	105

Derivation of explanatory variables for traffic conditions

2. Data Preparation

Conceptual illustration for loop detector data processing



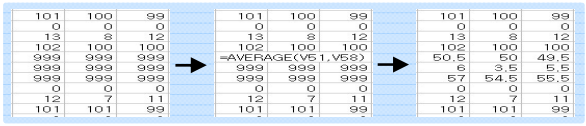
2. Data Preparation

Loop data processing procedure

STEP 1 — Archiving loop detector data for analysis

날짜 / 노선	방향	이정	구분	시간(00시00분) 0000	0015	0030	0045	0100	0115
20060127									
150	서울	0.43	Occ	0	0	0	0	0	0
150	서울	0.43	Vol	25	22	22	19	19	30
150	서울	0.43	Spd	100	95	98	97	98	99
150	서울	2.01	Occ	0	0	0	0	0	0
150	서울	2.01	Vol	7	5	10	4	4	6
150	서울	2.01	Spd	101	99	99	99	100	101

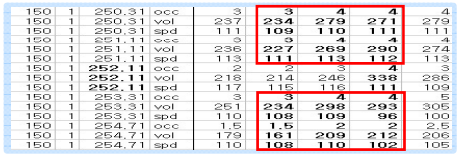
STEP 2 — Missing data imputation



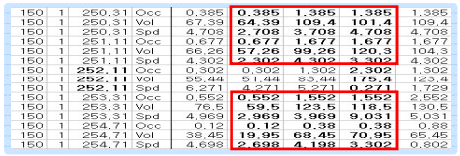
STEP 3 — Allocation of individual accident ID

Direction Time
ID : 15_1 20060102 1300_240.1
Route Date Postmile

STEP 4 — Derivation of explanatory Variables for traffic conditions



STEP 5 — Dataset establishment for normal traffic conditions



Spatio-temperal traffic variable analysis

사고 유무	ID	유형	up1_t_O	up1_t_V	up1_t_S	up1_t1_O
1	15 1 20060102 1300 240.1	1	4	319	106	3
0	15 1 20060101 1300 240.1	0	10	745	90	9
1	15 1 20060103 0800 316.5	1	2	248	104	2

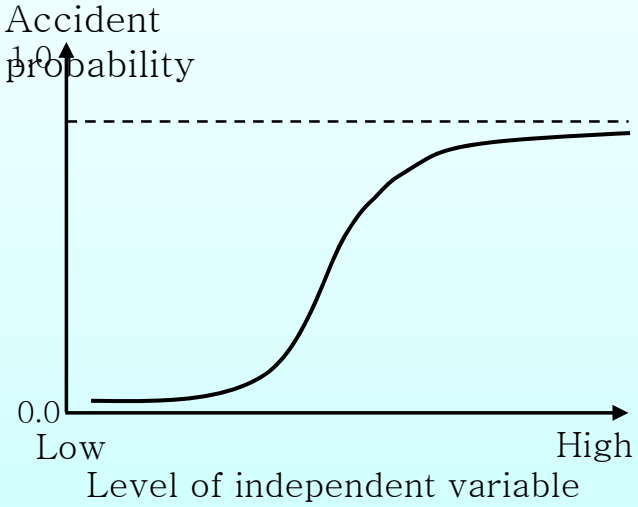
3. Methodology and Model Development

Binary Logistic Regression

- BLR can be applied to binary classification problem

1 : Hazardous traffic condition
2 : Accident-free condition

→ Binary Classification



$$\Pr(ACC_i = 1 \mid X_i) = \frac{\exp[\, f(X_i, \beta)]}{1 + \exp[\, f(X_i, \beta)]}$$

where,

- $\Pr(ACC_i)$: Probability of accident likelihood
- X_i : accident involved traffic variables
- $f(X_i, \beta)$: Function of X_i and parameters

3. Methodology and Model Development

Result of Model Development – Case 4

R-square

CASE	-2 Log Likelihood	Cox와 Snell의 R-Square	Nagelkerke R-Square	Number of accident
CASE 4	264.329	0.226	0.301	142 건

Correct classification Rate(CCR)

CASE	Observed		Predicted								
			Accident Occurrence		Percent Correct (%)	Accident Occurrence		Percent Correct (%)	Accident Occurrence		Percent Correct (%)
			0	1	0.5	0	1	0.7	0	1	0.8
case4	Accident Occurrence	0	89	25	78.070	108	6	94.737	112	2	98.246
		1	37	83	69.167	77	43	35.833	82	38	31.667
	Total %				73.504			64.530			64.103

3. Methodology and Model Development

Result of Model Development – Case 4

- Significant Variables

CASE	Variable	Beta	Sig.
case 4 collision and rear-end collision	up1_t1_O	0.63607	0.03142
	up1_t2_V	-0.00701	0.03692
	up2_t1_O	-0.54779	0.02818
	up2_t2_V	0.00671	0.01903
	up1_t1_DO	-1.23492	0.01089
	up1_t2_DO	1.11977	0.02173
	up2_t1_DS	0.06987	0.05738
	dn2_t1_DV	0.00816	0.00346
	dn2_t1_DS	0.20489	0.00047
	dn2_t2_DS	-0.12514	0.02855
	Constant	-1.13773	0.00013

3. Methodology and Model Development

Significant traffic variables for accident likelihood

Significant traffic variables in Case4

	Up2		Up1			Dn1		Dn2	
t-30min (t2)	up2_t2_O	up2_t2_DO	up1_t2_O	**up1_t2_DO**		dn1_t2_O	dn1_t2_DO	dn2_t2_O	dn2_t2_DO
	up2_t2_V	up2_t2_DV	**up1_t2_V**	up1_t2_DV		dn1_t2_V	dn1_t2_DV	dn2_t2_V	dn2_t2_DV
	up2_t2_S	up2_t2_DS	up1_t2_S	up1_t2_DS		dn1_t2_S	dn1_t2_DS	dn2_t2_S	**dn2_t2_DS**
t-15min (t1)	**up2_t1_O**	up2_t1_DO	**up1_t1_O**	**up1_t1_DO**		dn1_t1_O	dn1_t1_DO	dn2_t1_O	dn2_t1_DO
	up2_t1_V	up2_t1_DV	up1_t1_V	up1_t1_DV		dn1_t1_V	dn1_t1_DV	dn2_t1_V	**dn2_t1_DV**
	up2_t1_S	**up2_t1_DS**	up1_t1_S	up1_t1_DS		dn1_t1_S	dn1_t1_DS	dn2_t1_S	**dn2_t1_DS**
t	up2_t_O	up2_t_DO	up1_t_O	up1_t_DO	Acc Occurre-nce	dn1_t_O	dn1_t_DO	dn2_t_O	dn2_t_DO
	up2_t_V	up2_t_DV	up1_t_V	up1_t_DV		dn1_t_V	dn1_t_DV	dn2_t_V	dn2_t_DV
	up2_t_S	up2_t_DS	up1_t_S	up1_t_DS		dn1_t_S	dn1_t_DS	dn2_t_S	dn2_t_DS

3. Methodology and Model Development

Accident Likelihood

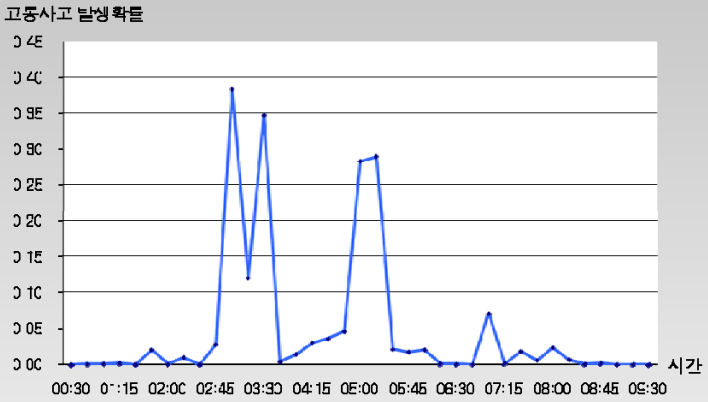
- Estimate probability of accident likelihood using Binary Logistic Regression

$$\Pr(ACC_i = 1 \mid X_i) = \frac{\exp[f(X_i, \beta)]}{1 + \exp[f(X_i, \beta)]}$$

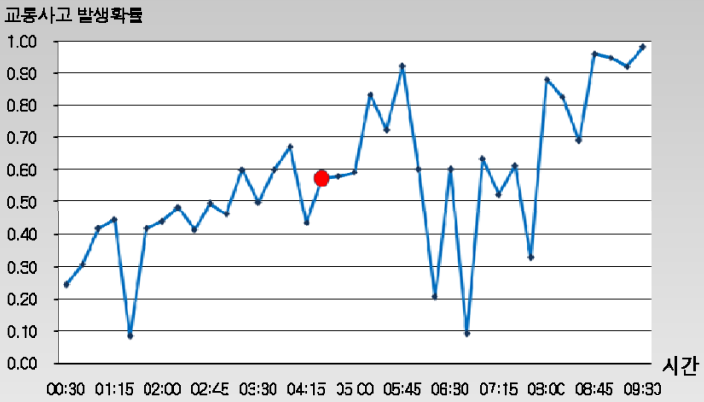
$$f(X_i, \beta) = 0.636X_1 - 0.007X_2 - 0.548X_3 + 0.006X_4 - 1.235X_5 + 1.120X_6 + 0.070X_7 + 0.008X_8 + 0.205X_9 - 0.125X_{10} - 1.138X_{11}$$

up1_t1_O	up1_t2_V	up2_t1_O	up2_t2_V	up1_t1_DO	up1_t2_DO	up2_t1_DS	dn2_t1_DV	dn2_t1_DS	dn2_t2_DS	상수
0.63607	-0.00701	-0.54779	0.00671	-1.23492	1.11977	0.06987	0.00816	0.20489	-0.12514	-1.13773

Accident-free traffic Condition



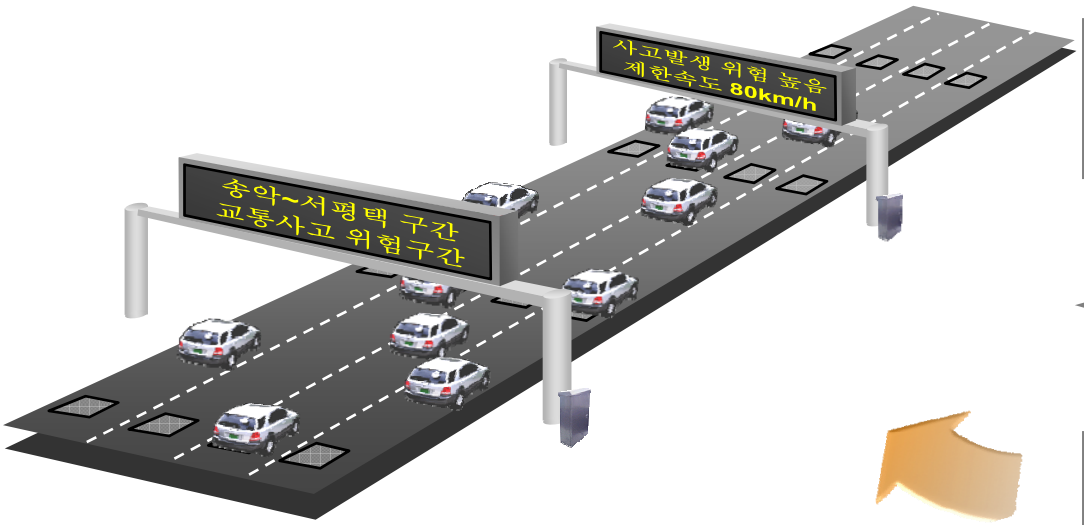
Abnormal traffic Condition

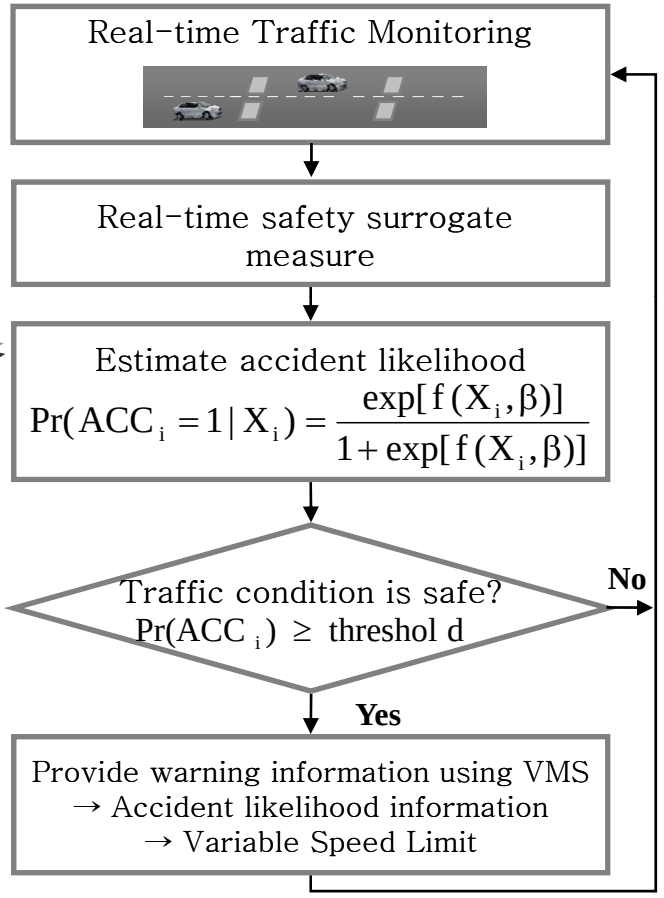


4. Application and Technical Issue

Application

- Warning Information System
  - Variable speed limit
  - Accident likelihood information

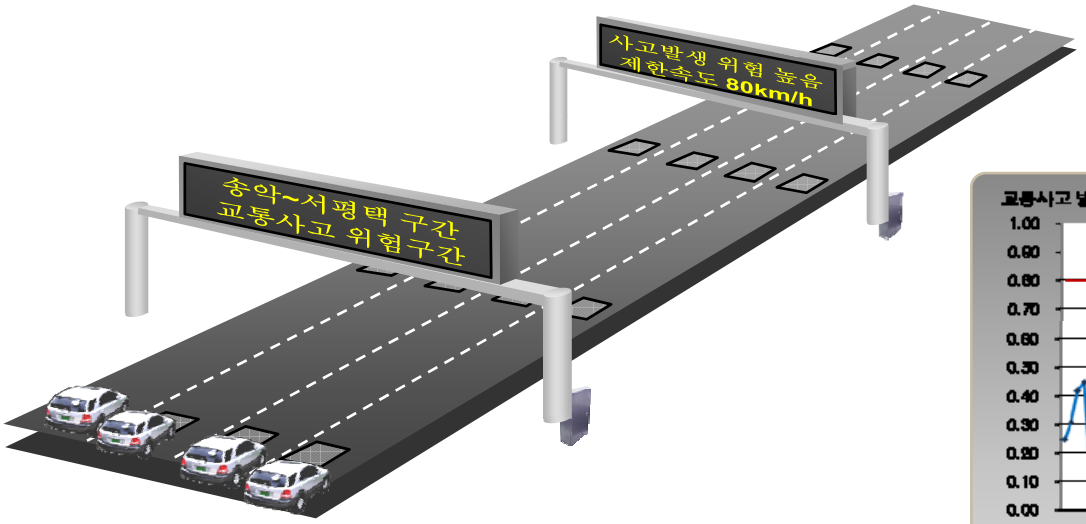




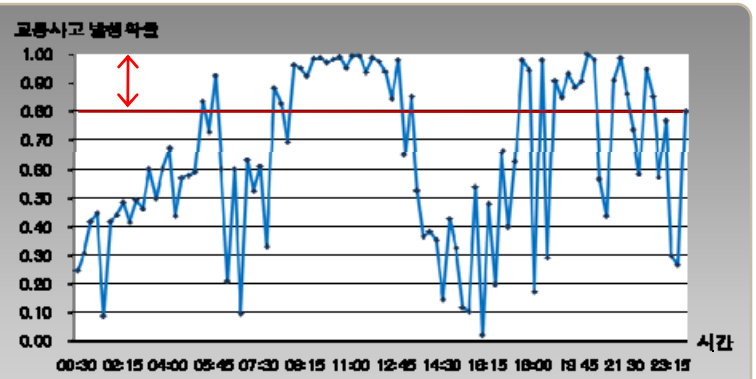
4. Application and Technical Issue

Technical Issue

- Resolution of traffic data
- Duration and frequency for warning information provision



threshold	Time(min)	Warning Information Rate
0.5	915	64%
0.7	615	43%
0.8	555	38%

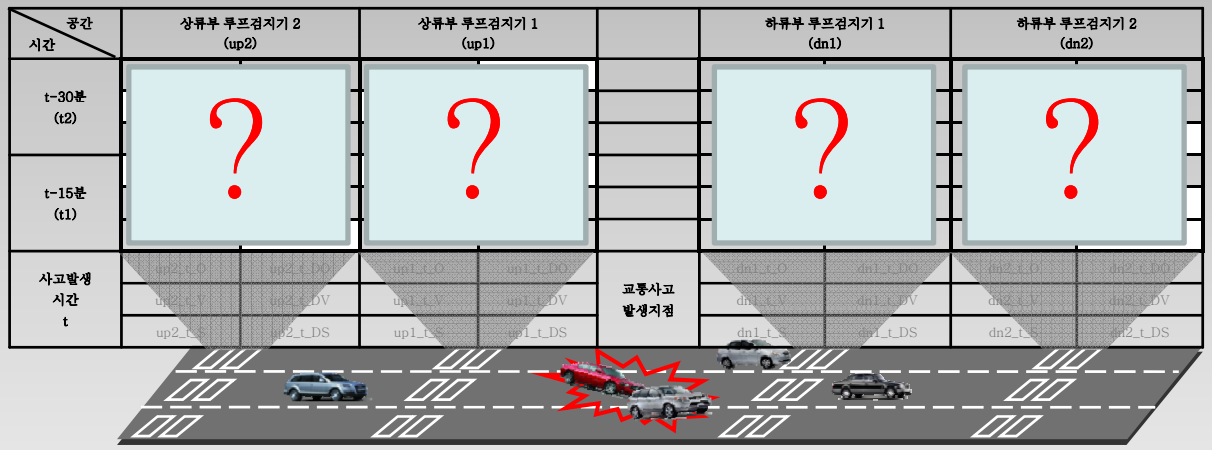


- When accident likelihood index exceeds the threshold, provide warning information

5. Conclusion

Future studies

- Adaptive Variable Speed Limit system
- Study for various traffic accident type and model application
- Field tests for enhancing transferability



5. Conclusion

Conclusion

- Proposed a model to estimate traffic accident likelihood using real-time traffic data
- Application for Warning information and VSL
- Proposed system can lead to safer driving leading to accident prevention

Warning information
Variable Speed Limit

↓

Safe Driving
Reducing vehicle speed

↓

Decrease accident likelihood