Understanding Fixed-Object Crashes with SHRP2 Naturalistic Driving Study Data

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Outline

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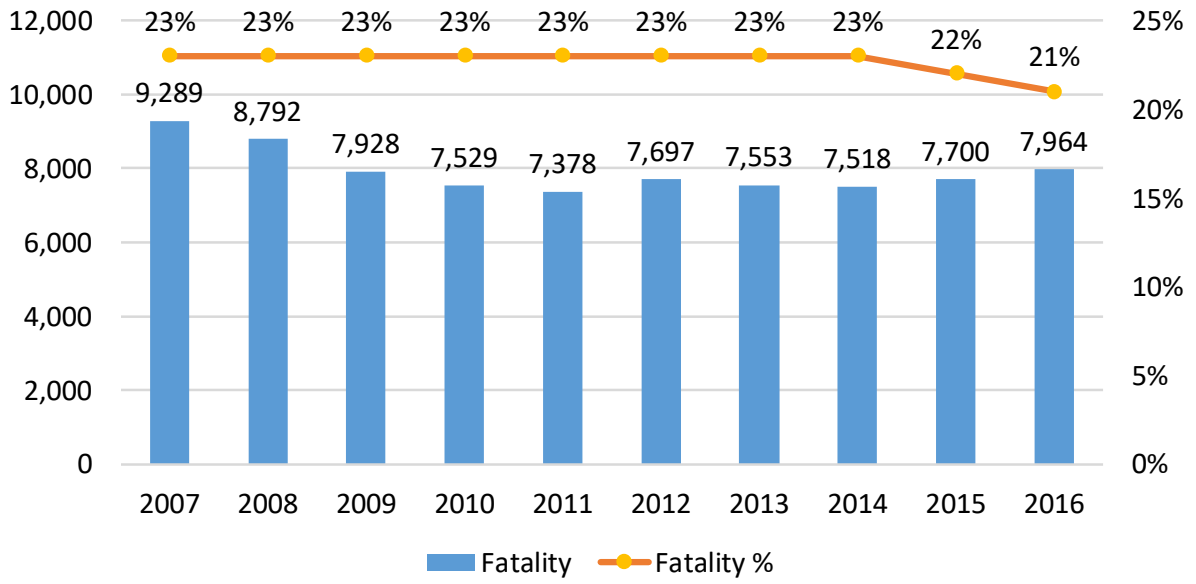
Introduction

Fixed-object crashes happen when a vehicle collides a roadway feature (e.g. channelization devices) or runs off the road and hits a roadside object (e.g. tree, utility pole).

- High frequency
- Severe outcome
  - High fatality rate, accounted for 14.7% of all crashes in 2015, but resulted in 30.9% fatal crashes. (NHSTA, 2015)
  - Traumatic brain injury (TBI), Disability.
- High associated cost
  - Property damage cost, hospital expenses.

Deaths in fixed object crashes as a percent of all motor vehicle crash, 2007-2016. (IIHS)



Source: http://www.iihs.org/iihs/topics/t/roadway-and-environment/fatalityfacts/fixed-object-crashes

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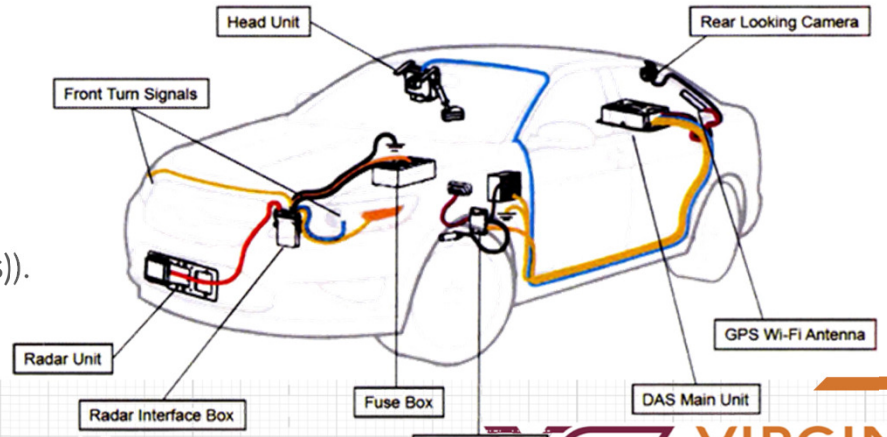
SHRP2 NDS Project - Background

- Launched between 2010 and 2013, the largest NDS project in United States till now.
- Aimed to study the driver behavior or, performance-related safety problems under real-world scenarios.
- Used an onboard data acquisition system (DAS) for roadway condition, vehicle kinematic, and driver behavior data collection.
- Collected around 5 million vehicle miles and 41,000 events.
    - 8,758 crash and near crash events (referred to as safety critical events (SCEs)).
    - 32,581 baseline events



Source: https://insight.shrp2nds.us/

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Slide 5

HH1 Haiyan Hao, 8/22/2018

SHRP2 NDS Project – Why Study with SHRP2 NDS Events

Previous works relevant to fixed-object crashes:

- Addressed fixed-object crashes in the context of roadway departure.
- Relied on police-reported data.
- Not know the normal driving conditions

This study:

- Struck object types are collected from videos and participant narratives.
- The DASs monitor driving conditions continuously, result in many minor crashes and near crashes.
- Baseline events are acquired to understand the normal driving conditions.

Data - Event Selection

Selection Criteria:

- Event Severity = Crash, near-crash and
- Event Nature = Conflict with parked vehicle; conflict with animal; conflict with obstacle/object in roadway and single vehicle conflict

1,639 SCEs (Crash, near crash events)

1,050 baseline events.

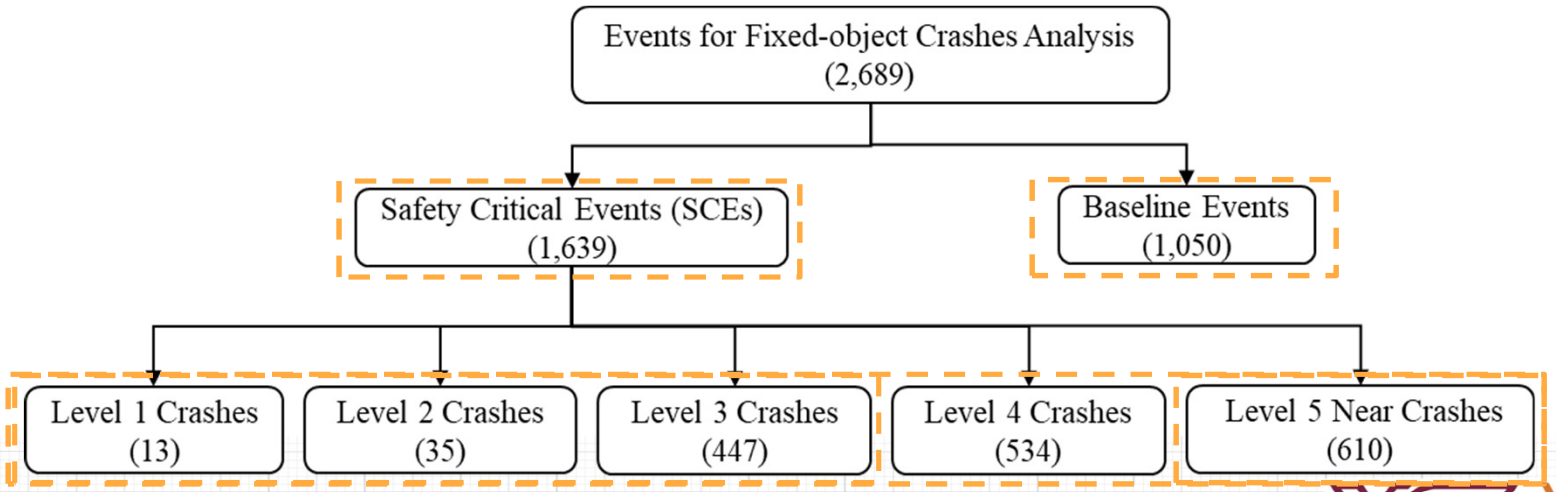
Type	Crash	Near-Crash	Total
Conflict with parked vehicle	5	52	**57**
Conflict with animal	64	301	**365**
Conflict with obstacle/object in roadway	59	65	**124**
Single vehicle conflict*	901	192	**1,093**
Total	**1,029**	**610**	**1,639**

*: Events involving a single vehicle running off the road, or a single vehicle conflicting with roadside objects that were not included in the above types.

Data – Data Acquisition

3 response variables:

- Event occurrence (SCE vs. baseline events);
- Ordinal event severity (5 ordinal event severity).
- Binary event severity (level 1-3 crashes vs. near crashes)



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Data – Data Acquisition

For each selected event, the following dataset are acquired:

NDS Database

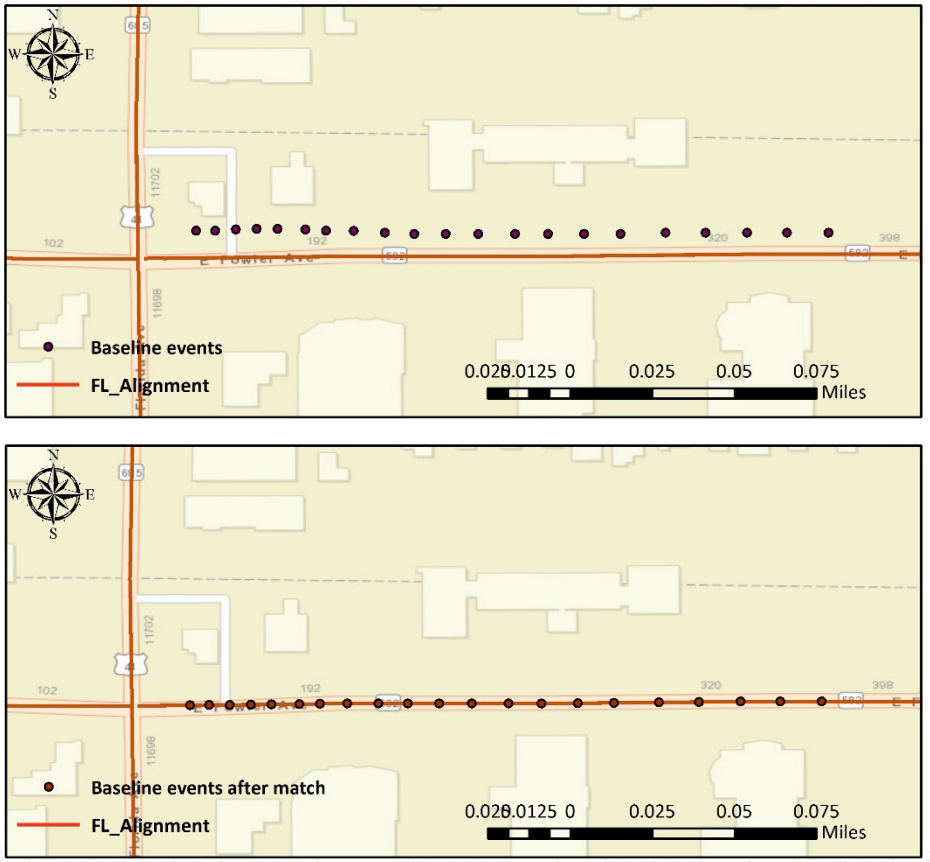
- Event Detail Table
- Time series data
- Driver age, driving history
- Front view videos (only for SCEs)

RID Database

- RID data in GIS format

Data – GIS Matching

- Integrated SHRP2 NDS and RID databases.
- Achieved by linking the GPS location variables (longitudes and latitudes) provided in time series data with the RID data provided in GIS format.
- Fulfilled on ArcGIS® software
- Matched RID data for 1,538 events (694 SCEs and 844 baseline events).



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Data - Variables

- 33 explanatory variables
  - Driver;
  - Roadway and traffic; and
  - Environment.
- 3 response variables:
  - Event occurrence (SCE vs. baseline events);
  - Ordinal event severity (5 ordinal event severity).
  - Binary event severity (level 1-3 crashes vs. near crashes)

Driver-related Variables	Roadway and Traffic Variables
Age Group	Traffic Flow
Annual Miles	Traffic Density
Number of Violation	Contiguous Travel Lane
State	Traffic Control
Years of Driving	Relation to Junction
Pre-incident Maneuver	Alignment
Maneuver Judgement	Grade
Driver Behavior	Locality
Driver Impairments	Construction Zone
Passenger Existence	AADT
Secondary Task	Speed Limit
Hands on Wheel	IRI
Driver Seatbelt Usage	Radius
Critical Speed	Curve Direction
Reaction Time	Struck Object Type
Environment-related Variables	
Lighting	
Weather	
Road Surface Condition	

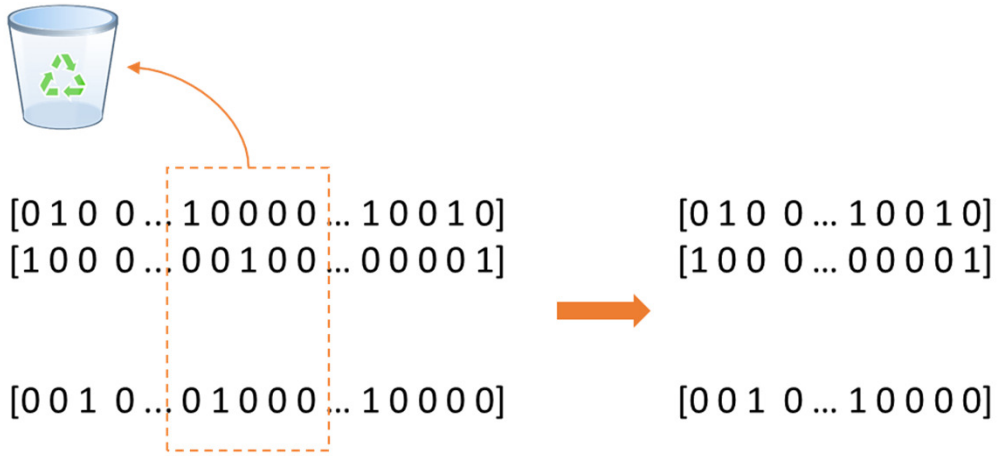
Methods

- Logistic Regression
  - Three models: two binary logistic regression and an ordinal logistic regression
  - Significance level of 0.1.
  - Fulfilled with SAS® Studio software.

- Support Vector Machine (SVM)
  - Three classifiers: two binary SVM classifier and a multi-class SVM classifier.
  - Used all NDS variables (28 variables); five-fold cross validation; six kernel functions
  - Fulfilled with MATLAB® Classification Learner Application.

Methods - Sensitivity Analysis

- SVM analysis method works like black box.
- Sensitivity analyses are conducted to evaluate the contributing effects of explanatory variables on responses.



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Logistic Regression Analyses Results – Findings

Effects of Driver-Related Factors

Variable	Values	Binary Event Occurrence	Ordinal Event Severity	Binary Event Severity
Driver-related Factors				
Pre-incident Maneuver	Changing lanes	2.566	-	-
	Going straight – unintentional drifting	4.028	1.646	-
	Making a turn	9.963	1.358	1.814
	Going straight	Reference		
Driver Behavior/Error	Unfamiliar with roadway	-	3.954	4.069
	Avoiding animal or other vehicle	38.362	0.321	-
	Distracted	-	2.971	2.287
	Drowsy, sleepy, asleep, fatigued	-	3.617	4.350
	Failed to signal, improper signal	6.319	-	-
	Exceeded safe speed, or speed limit	-	3.765	3.332
	Improper turn	87.82	-	1.992
	Other	2.675	-	-
	Sign, signal violation	5.318	-	4.546
	None	Reference		
Secondary Task	Adjusting/monitoring vehicle devices	2.406	-	-
	Personal hygiene	2.286	-	-
	Reaching, moving object in vehicle	28.624	-	-
	No secondary tasks	Reference		
Travelling speed		0.976	1.006	-
Reaction Time		-	0.551	0.551

Logistic Regression Analyses Results – Findings

Variable	Values	Binary Event Occurrence	Ordinal Event Severity	Binary Event Severity
Roadway and Traffic-related Factors				
Traffic Density	LOS A2	0.52	0.714	0.55
	LOS B	0.7	0.725	0.546
	LOS C	-	0.414	0.351
	LOS D/E/F	0.021	-	-
	LOS A1	Reference		
Locality	Business/Industrial	2.268	2.234	-
	Bypass/Divided Highway with traffic signals	-	2.256	-
	Church/school/playground	2.225	2.777	2.033
	Open Country	2.956	16.624	9.273
	Residential area	3.851	2.238	-
	Urban	-	1.900	-
	Interstate/Bypass/Divided Highway without signals	Reference		
Struck Object Type	Animal	-	0.104	0.095
	Ditch	-	21.688	-
	Pavement edge/edge line	-	-	0.408
	Raised Median	-	-	0.503
	Roadway debris	-	2.507	-
	Stopped, backing, pulling out car	-	0.039	0.036
	Tree/shrub	-	4.451	-
	Utility/light pole	-	4.451	-
	Others	-	8.452	0.402
	Curb	Reference		

Effects of Roadway and Traffic-Related Factors

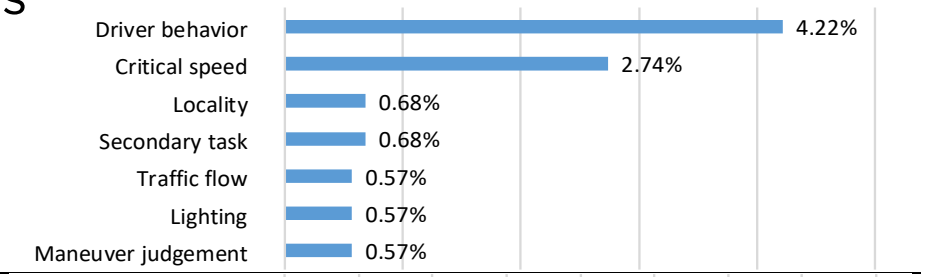
Results – Logistic Regression

Effects of Environment-Related Factors

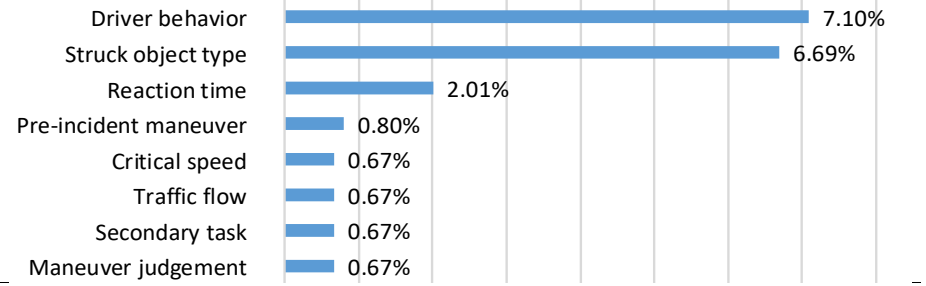
Variable	Values	Binary Event Occurrence	Ordinal Event Severity	Binary Event Severity
Environment-related Factors				
Lighting	Darkness, lighted	1.939	-	-
	Darkness, not lighted	1.583	-	-
	Daylight	Reference		
Roadway Surface	Icy/snowy/wet	1.418	-	-
	Dry	Reference		
Weather	Adverse weather	-	1.302	-
	No adverse weather	Reference		

Results – SVM Sensitivity Analysis

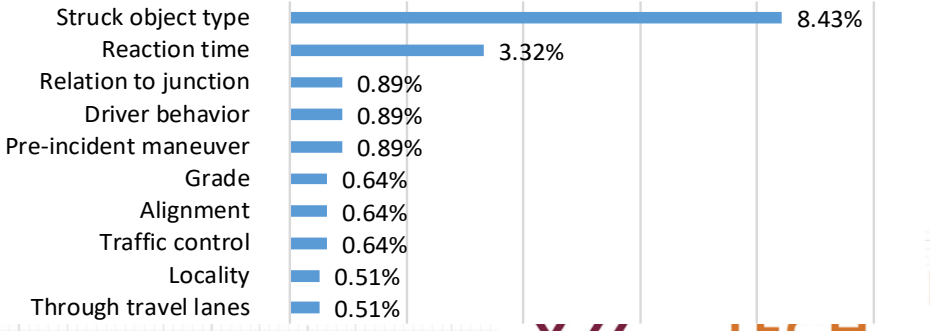
a: SCEs versus Baselines
Quadratic Kernel
Accuracy = 87.4%



b: Multi-Class Severity (All SCEs)
Linear Kernel
Accuracy = 74.7%



c: Level 1-3 Crashes Versus Near Crashes
Quadratic Kernel
Accuracy = 78.3%



Conclusion and Recommendation

- Roadway deficiency → roadway improvement countermeasures
- Driver errors → driver education
- Driver impairments → autonomous vehicle or ADAS (Advanced Driving Assistance System) technology

Thank You!

Reference

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