A New Way to Estimate Crash Exposure

Exposure Able to Capture Traffic Flow Condition in Crash Prediction Models

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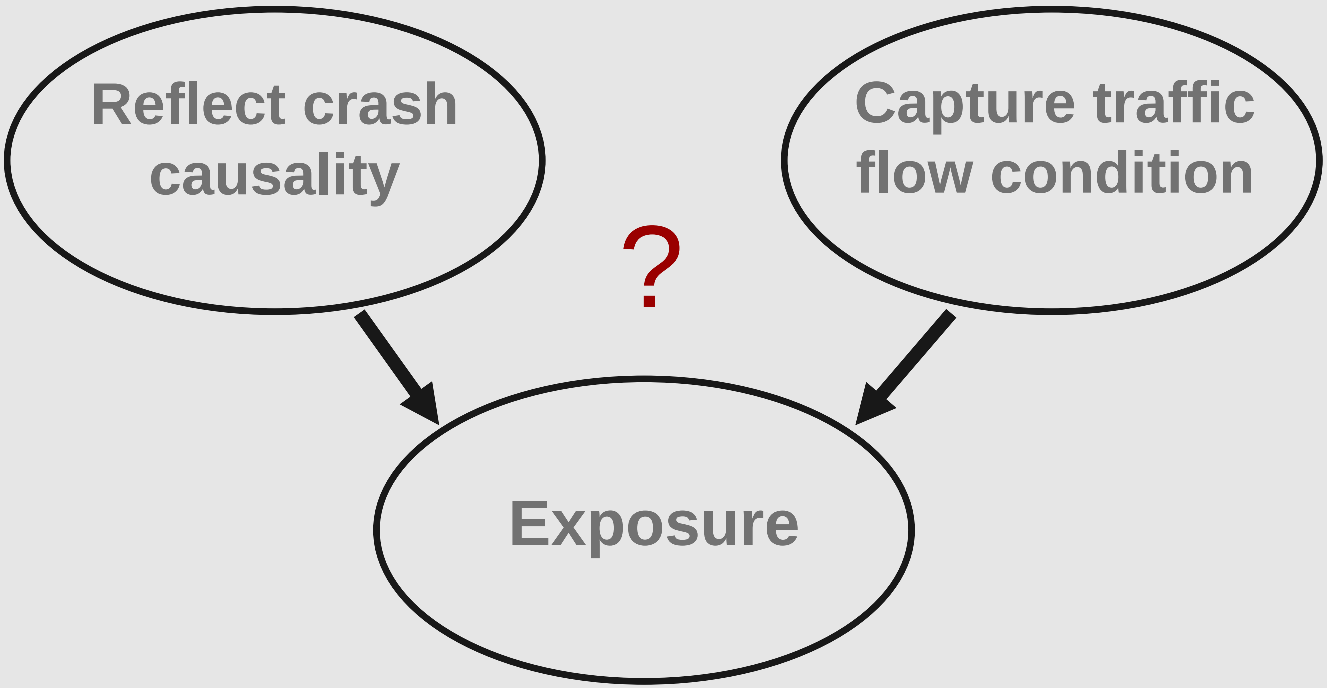
UNIVERSITY OF VERMONT
TRANSPORTATION RESEARCH CENTER

Common Elements of Statistical Crash Prediction Models

- Crash categorization, e.g. single vehicle vs. multi vehicle, intersection vs. segment
- Exposure, e.g. segment length, AADT, VMT (VKT) or hourly flow rate
- Traffic flow condition, e.g. V/C ratio, flow density, level of service, average speed

Limitations of Crash Prediction Models

- Crash causality not able to be linked to the model
- Exposure of traffic flow likely correlates with traffic flow condition variables in the model



	Commonly Used Crash Categories	New Crash Categories
Commonly Used Exposure		
New Exposure		

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Outline

- Define new crash categories based on collision contributing factors
- Propose new exposure definition for one new crash category
- Estimate statistical crash models using the new exposure for the new category

Crash Categories Defined on Collision Contributing Factors

- A subset of Connecticut crash data collected for rural two-lane roads with similar land use character
  - Police reported crash records
  - Tabulated by collision type, contributing factor
- K-means clustering method
- Proposed crash categories each attributed to a common group of frequently occurred contributing factors

A Typical Rural Two-lane Road Segment

Collision Types Coded By Colliding Direction

Crash Type Description	*Abbreviation*
Turning - Same Direction	TSD
Turning – Opposite Direction	TOD
Turning - Intersecting Paths	TIP
Sideswipe - Same Direction	SSD
Sideswipe - Opposite Directions	SOD
Angle	ANG
Rear-end	RE
Head-on	HO
Overturn	OVT
Fixed Object	FO

Typical Contributing Factors

Contributing Factor Description	*Abbreviation*
Fall Asleep	FA
Slippery Surface	SS
Drive on Wrong Side of Road	DOW
Driver Lost Control	DLC
Speed Too Fast for Condition	STF
Following Too Close	FTC
Improper Passing Maneuver	IPM
Improper Turning Maneuver	ITM
Fail to Grant Right of Way	FGR
Violate Traffic Control	VTC
Drive under Influence	DUI
Animal or Foreign Object in Road	AIR

Crash Proportions by Contributing Factor for Each Collision Type

Collision Types

Contributing Factors

	TSD	SSD	RE	TOD	TIP	ANG	SOD	HO	OVT	FO
FA	0	0.005	0.002	0	0	0	0.039	0.052	0.044	0.075
SS	0.004	0.083	0.019	0.007	0.007	0.034	0.078	0.041	**0.126**	0.095
DOW	0	0	0	0.003	0.009	0	**0.274**	**0.279**	0	0.008
DLC	0.004	**0.109**	0.019	0	0.007	0.017	**0.182**	**0.169**	**0.280**	**0.273**
STF	0.036	**0.135**	**0.103**	0.013	0.035	0.082	**0.349**	**0.390**	**0.445**	**0.420**
FTC	**0.184**	**0.145**	**0.834**	0	0	0	0.005	0.012	0.011	0.007
IPM	**0.495**	**0.446**	0.010	0.003	0.007	0.004	0.021	0.017	0.005	0.005
ITM	**0.242**	0.010	0.001	0.044	0.055	0	0	0	0	0.006
FGR	0.032	0.016	0.001	**0.909**	**0.762**	**0.427**	0	0.006	0.022	0.007
VTC	0	0.010	0.001	0.017	**0.105**	**0.431**	0.002	0	0	0.002
UTI	0.004	0.041	0.007	0.003	0.012	0.004	0.051	0.035	0.049	0.056
AIR	0	0	0.003	0	0	0	0	0	0.016	0.045
	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

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K-Means Clustering Methodology

K-means Clustering Algorithm

- An algorithm to cluster objects based on attributes into k partitions
- Attributes form a vector space that contain the objects
- Algorithm goal is to minimize the total intra-cluster variance

New vs. Commonly Used Crash Categories

Collision Type		*New Crash Categories*
Angle	ANG	Intersecting-Direction
Turning – Opposite Direction	TOD	
Turning - Intersecting Paths	TIP	
Turning - Same Direction	TSD	Same-Direction
Sideswipe - Same Direction	SSD	
Rear-end	RE	Rear-end
Sideswipe - Opposite Directions	SOD	Segment-Crashes
Head-on	HO	
Overturn	OVT	
Fixed Object	FO	

New vs. Commonly Used Crash Categories

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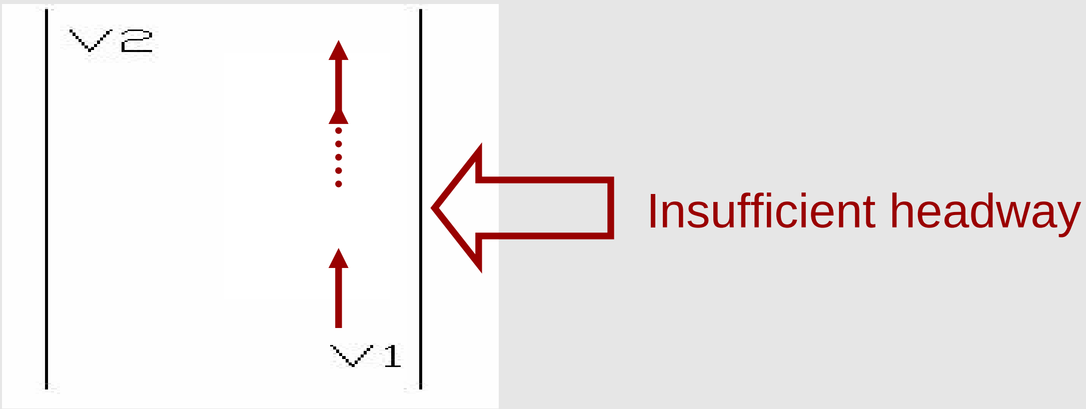
Turning – Opposite Direction	TOD		
Turning - Intersecting Paths	TIP		
Turning - Same Direction	TSD	Same-Direction	Same-Direction
Sideswipe - Same Direction	SSD		
Rear-end	RE	Rear-end	
Sideswipe - Opposite Directions	SOD	Segment-Crashes	Opposite-Direction
Head-on	HO		
Overturn	OVT		Single Vehicle
Fixed Object	FO		

Main Contributing Factors Determining Crash Categories

Crash Category	*Main Contributing Factors*
Intersecting Direction	Fail to grant right-of-way; violate traffic control
Same Direction	Speed too fast; driver lost control
Rear End	**Following too close**
Segment Crashes	Improper passing maneuver; following too close

New Exposure (Crash Opportunities) Defined for Rear-end Crashes



- Focus on crash scenario
- Add traffic condition components to exposure
- Create a link to crash causalities

New Exposure – Opportunities Function for Rear-end Crashes

$$VTSF_{it} = \sum_{h \in H_t} \frac{V_{ih} L_i}{\bar{u}_{ih}} \times PTSF_{ih}$$

- $VTSF_{it}$: Vehicle Time Spent Following on segment *i* in time period *t*
- $PTSF_{ih}$: Percent Time Spent Following (HCM, 2000) on segment *i* in time period *t*
- $\boldsymbol{V_{ih}}$: is the traffic volume on segment *i* in hour *h*
- L_i : is the length of segment *i*
- $\boldsymbol{\bar{u}_{ih}}$: is the average traffic speed on segment *i* in hour *h*, *ap*proximated by speed limit in this study
- compared with VMT, vehicle miles traveled in period

Data Collection

- 95 two-lane rural road segments in Connecticut with uniform length
- 24-hour directional hourly traffic flow data
- Geometry variables: roadway width (narrow, medium, wide), speed limit (< 45 mph, >=45 mph), and # of access points
- Rear-end crash data by segment from 1996 to 2001

Statistical Model Methodology

- Generalized linear models
- Over-dispersion corrected by (selected by maximum log likelihood value)
  - Deviance-scaled Poisson
  - Pearson-scaled Poisson
  - Negative binomial

Model with Best Variable Selection

	Estimate (std. error)
Best Distribution Assumption	Scaled Poisson (Deviance)
Scale/Dispersion	1.151
Log likelihood	-186.543
Intercept	-16.327** (1.121)
VTSF	1.097** (0.072)
VTSF 95% CI Limits	0.956, 1.239
Narrow vs. Medium Width	0.023 (0.150)
Wide vs. Medium Width	-0.459** (0.156)
No. of Access Points	0.057** (0.011)

**: Significant on 95% confidence level

Models Treating Exposure as Offset

	VMT	*VTSF*
Distribution	Pearson-scaled Poisson	Pearson-scaled Poisson
Log-likelihood	-203.434	-185.601
Scale/Dispersion	1.076	1.103
Intercept	-15.884** (0.351)	-15.187** (0.357)
2 – 6 AM	-0.936 (0.701)	0.273 (0.718)
6 – 10 AM	0.369 (0.344)	0.422 (0.352)
10 AM – 2 PM	0.572 (0.344)	0.584 (0.352)
2 – 6 PM	0.635 (0.337)	0.604 (0.345)
6 – 10 PM	0.082 (0.364)	-0.321 (0.373)
Pavement Width Narrow	-0.007 (0.136)	0.022 (0.140)
Pavement Width Wide	-0.679** (0.150)	-0.578** (0.153)
Posted Speed < 45 mph	-0.194 (0.129)	-0.296** (0.135)
Number of Access Points	0.041** (0.010)	0.059** (0.010)

**: Significant on 95% confidence level

Implications of Model Results

- Crash opportunities – better exposure
- Reduce potential confounding problem
- Generate meaningful “crash rate”
- Support contributing factor-based crash categorization

Future Work

1. Generate more robust Safety Performance Function (SPF) for rear-end crashes
2. Define crash opportunities under the similar concept for other crash categories considering contributing factors

Thank You!