ANALYSIS OF INCIDENT INJURY SEVERITY ON NJ ROADWAYS

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OUTLINE

- Introduction
- Background/Objective
- Data Acquisition
- Methodology
- Results
- Conclusions

INTRODUCTION

- In 2015, motor vehicle crashes were the leading cause of death for ages 16 through 23 in the United States
- In 2016, more than 37,000 persons were killed in crashes across the United States
- Beside injury levels, normal flow of traffic is disrupted due to such crashes

INTRODUCTION

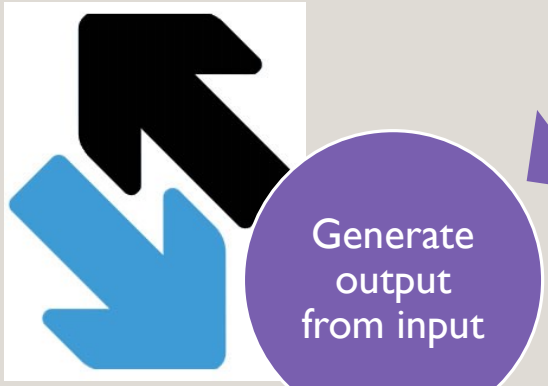
- Understanding safety problems
- Solving them with data-driven decisions
- Crash prediction models

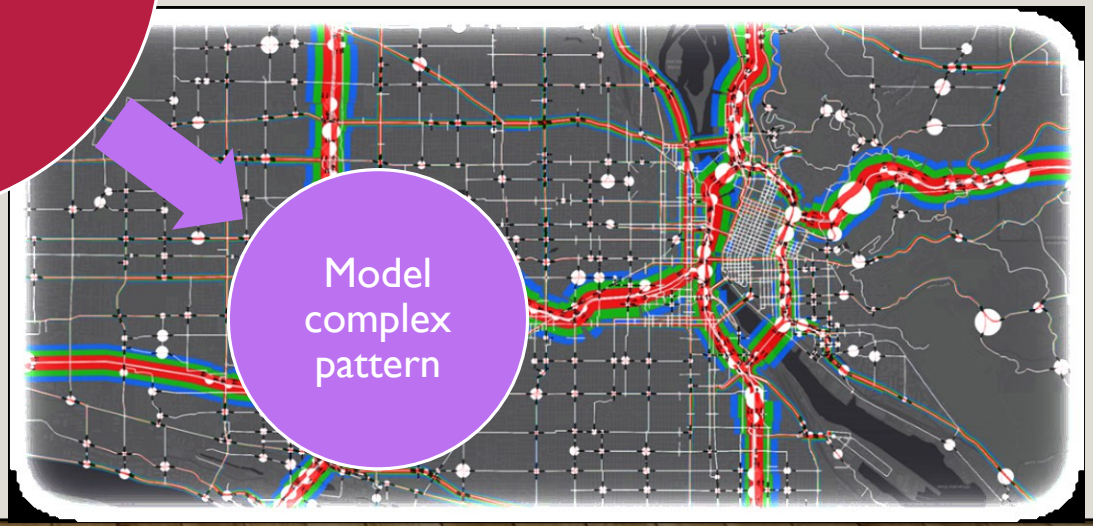
BACKGROUND

- Previous research examined crash injury severity using different approaches such as:
  - Poisson Lognormal Regression models
  - Negative Binomial Distribution
  - Zero-inflated Poisson and zero-inflated Negative Binomial models
- The stochastic nature of crashes is poorly described by linear functions
- Other models are explored such as **Artificial Neural Network** (ANN)

ANN (Artificial Neural Networks) CHARACTERISTICS

ANN





CRASH FACTORS

DRIVER characteristics

ROADWAY characteristics

VEHICLE characteristics

CRASH FACTORS

TRAFFIC VOLUME & SPEED

TIME characteristics

ENVIRONMENTAL CONDITIONS

OBJECTIVE

The objective of this study is to **develop a ANN model for Crash Injury Severity prediction** that considers:

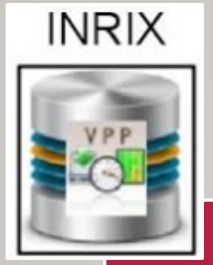
- **Roadway** characteristics
- **Traffic volume and speed**
- **Environmental** conditions
- **Time** characteristics

Interact with various real-time data

Predict injury severity levels

Support traffic management agencies

DATA ACQUISITION



INRIX

- Crash Speed
- Normal Speed

NJ CMS

- Traffic Volume

NJ SLD

- Posted Speed Limit
- Number of Crashes

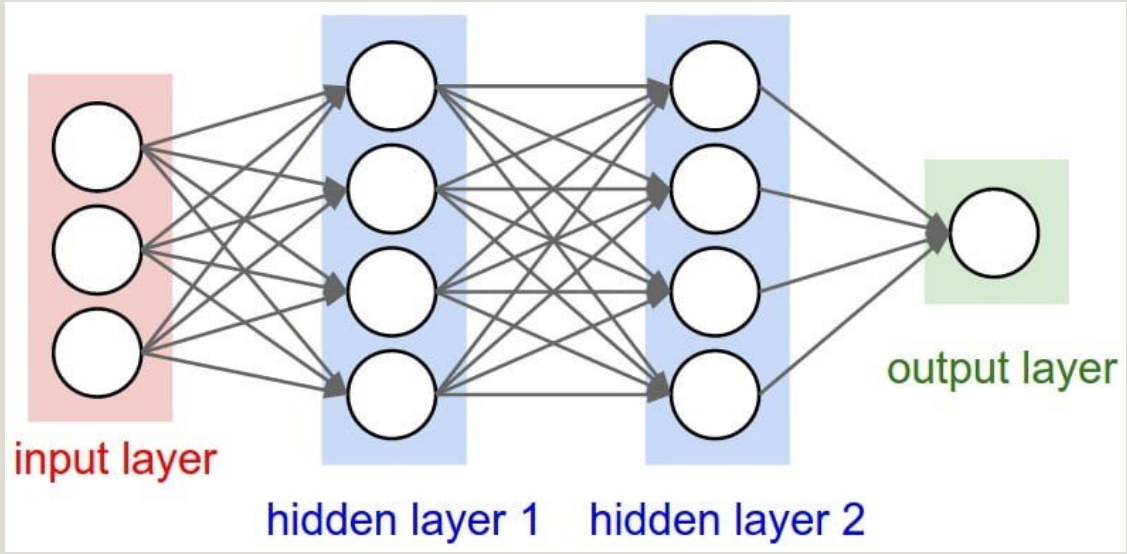
Plan4safety

- Crash Date and Time
- Crash Severity
- Location
- Direction
- Milepost
- Pavement Condition
- Light Condition
- Median Type
- Road Characteristics
- Alcohol Involvement
- Weather Condition

* Data for a total of 5,926 crashes was collected on NJ freeways.

METHODOLOGY

- By adopting several forms of ANN, this study aims to identify the best model suitable for predicting crash injury severity.
- The 37 ANNs differ by the following criteria:
  - Type
  - Training algorithm
  - Activation function
  - Number of input neurons, and
  - Input parameters



METHODOLOGY

- Identify potential independent variables
- Select structure of ANN
- Configure network and initialize weights
- Train and test the network

METHODOLOGY

The model is evaluated by calculation of the **Root Mean Square Error** (RMSE) as follows:

$$\mathbf{RMSE} = \sqrt{\frac{\sum_{i=1}^{N}(\hat{y}_i - y_i)^2}{N}}$$

where:

- **"$\hat{y}_i$"** is the observed values for i^{th} data
- **"y_i"** is the estimated ANN values for i^{th} data
- ***"N"*** is the number of data points

RESULTS

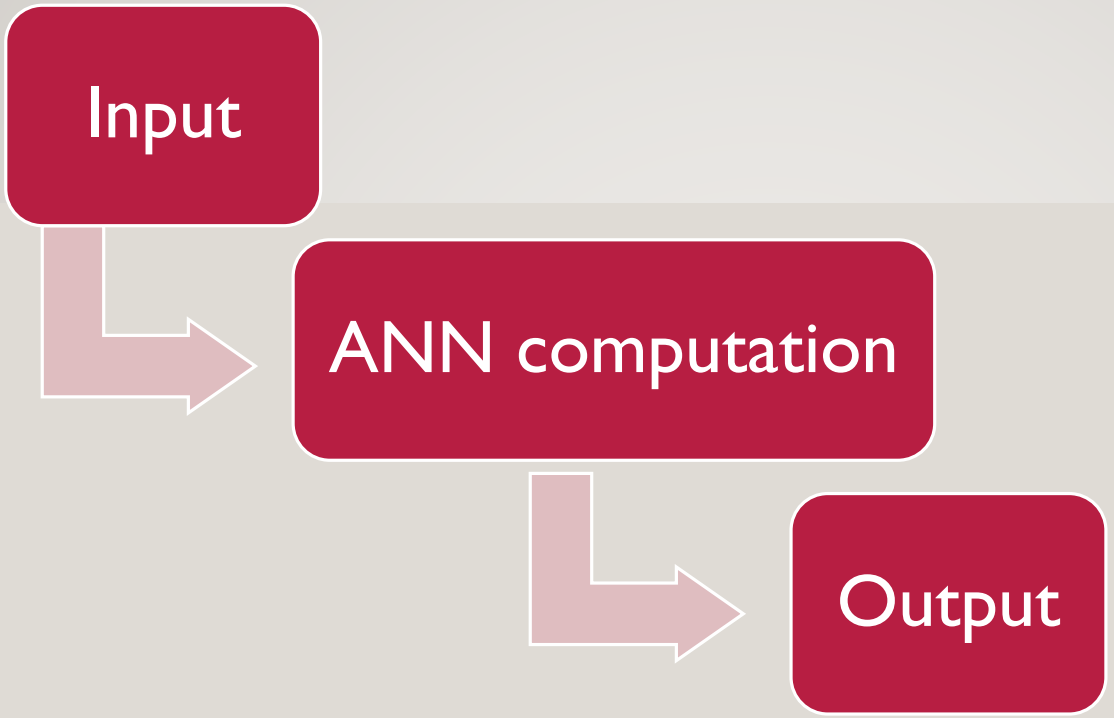
Best performing ANN characteristics:

- Deep-Feed Forward
- 15 input neurons including weighted speed variance
- Resilient Backpropagation training algorithm
- Logistic activation function.

ANN DEVELOPMENT

The input layer consists of combinations of the following independent variables:

- Time (Day of the week, Month, Time of the day
- Alcohol involvement
- Road characteristics
- Median type
- Light conditions
- Environmental conditions
- Posted speed limit
- Pavement condition
- Crash type
- Traffic volume
- Normal speed and crash speed
- Weighted speed variance

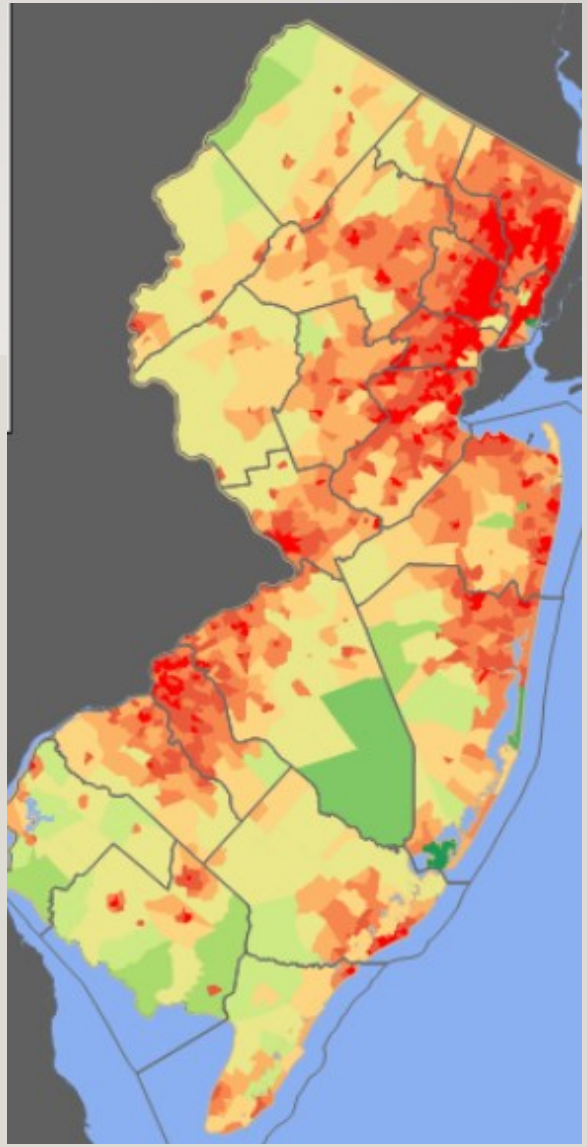


- Fatality/Injury/Property damage probability

TMC	Property damage probability									
	Timestamp									
	4:00	6:00	8:00	10:00	12:00	14:00	16:00	18:00	20:00	22:00
1										
2										
3										
4										
5										

APPLICATION

- Predict potential injury severity level given real-time information.
- Produce injury severity heat maps.
- Show different colors depending on risk
- Identify most dangerous segments prone to fatality and/or injury.



SENSITIVITY ANALYSIS

TMC	Injury probability/Weekday									
	Timestamp									
	4:00	6:00	8:00	10:00	12:00	14:00	16:00	18:00	20:00	22:00
1										
2										

TMC	Injury probability/Weekend									
	Timestamp									
	4:00	6:00	8:00	10:00	12:00	14:00	16:00	18:00	20:00	22:00
1										
2										

SENSITIVITY ANALYSIS

1. Fatalities and injuries are more likely to occur on weekends.
2. Injuries and fatalities happen mostly during the day.
3. Under adverse weather conditions, fatality and injury rates are lower.

SENSITIVITY ANALYSIS

4. Higher posted speed limit, as well as higher travelling speeds more likely lead to fatal crashes.
5. As traffic volume increases, the fatality probability decreases.
6. As speed variance increases, fatality possibility increases.

RESEARCH OPPORTUNITIES

RESEARCH OPPORTUNITIES

- Increase safety service patrol coverage (Maryland CHART, Pennsylvania IF)
- Explore crowdsourced data (Connected Citizens Program)
- Implement stricter speed rules/ Dynamic speed limits

CONCLUSIONS

- The model uses weighted speed variance as an important variable affecting the output.
- The model separates fatality crashes, and the ability to accurately predict fatality probability is not common in the literature and is a substantial contribution of this model.
- The multiplicity and stochastic nature of crash factors make it challenging to predict crash injury severity.

QUESTIONS ?