Predicting Road Accident Risk

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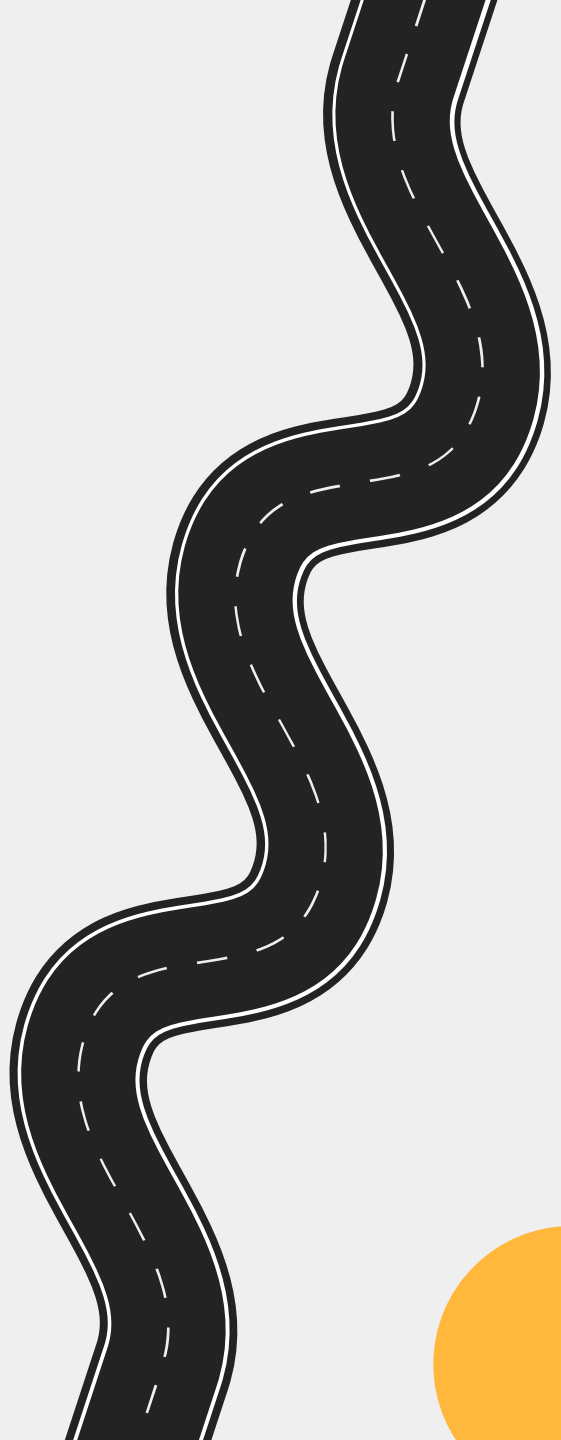
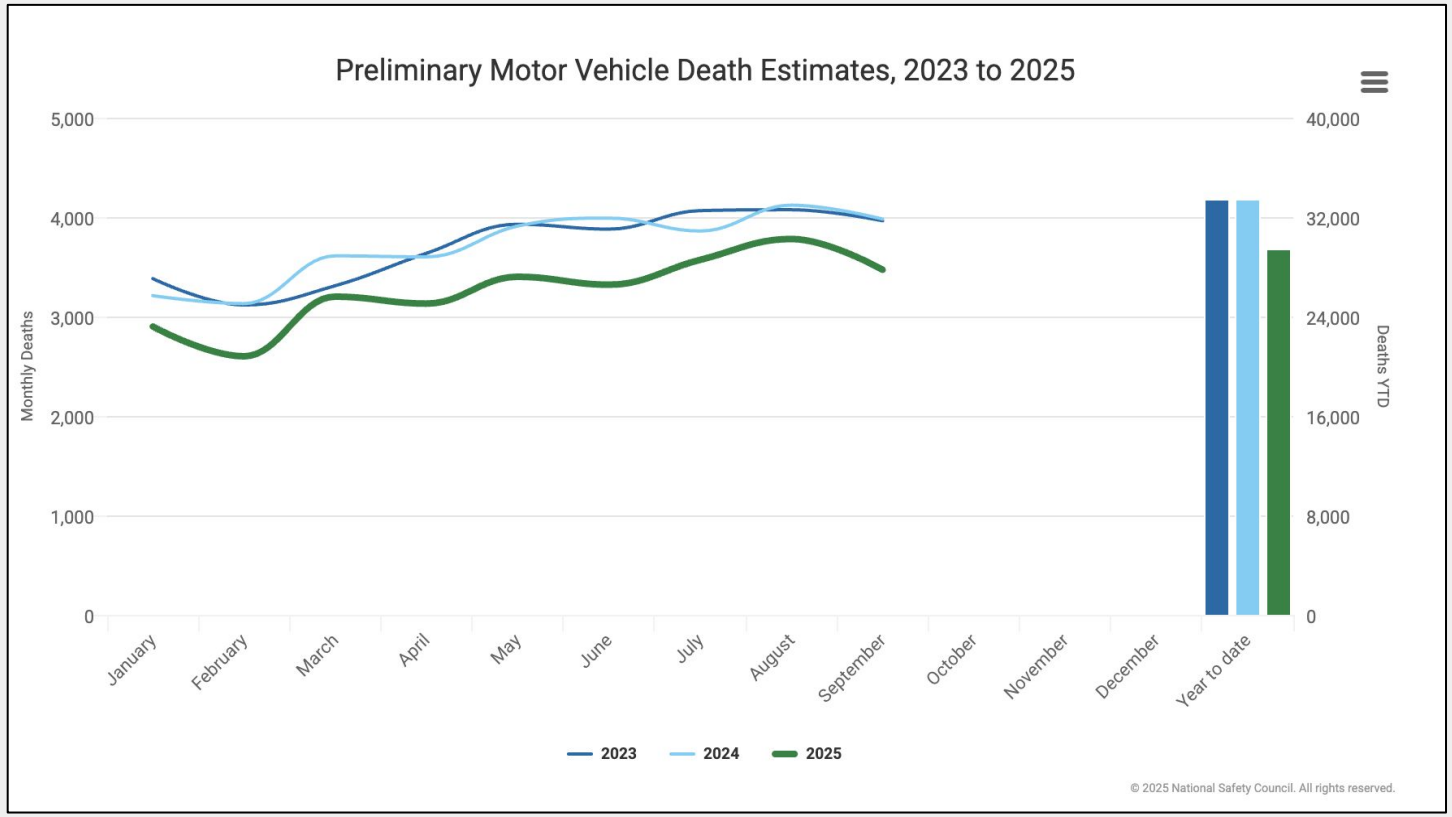


Current State of Road Safety

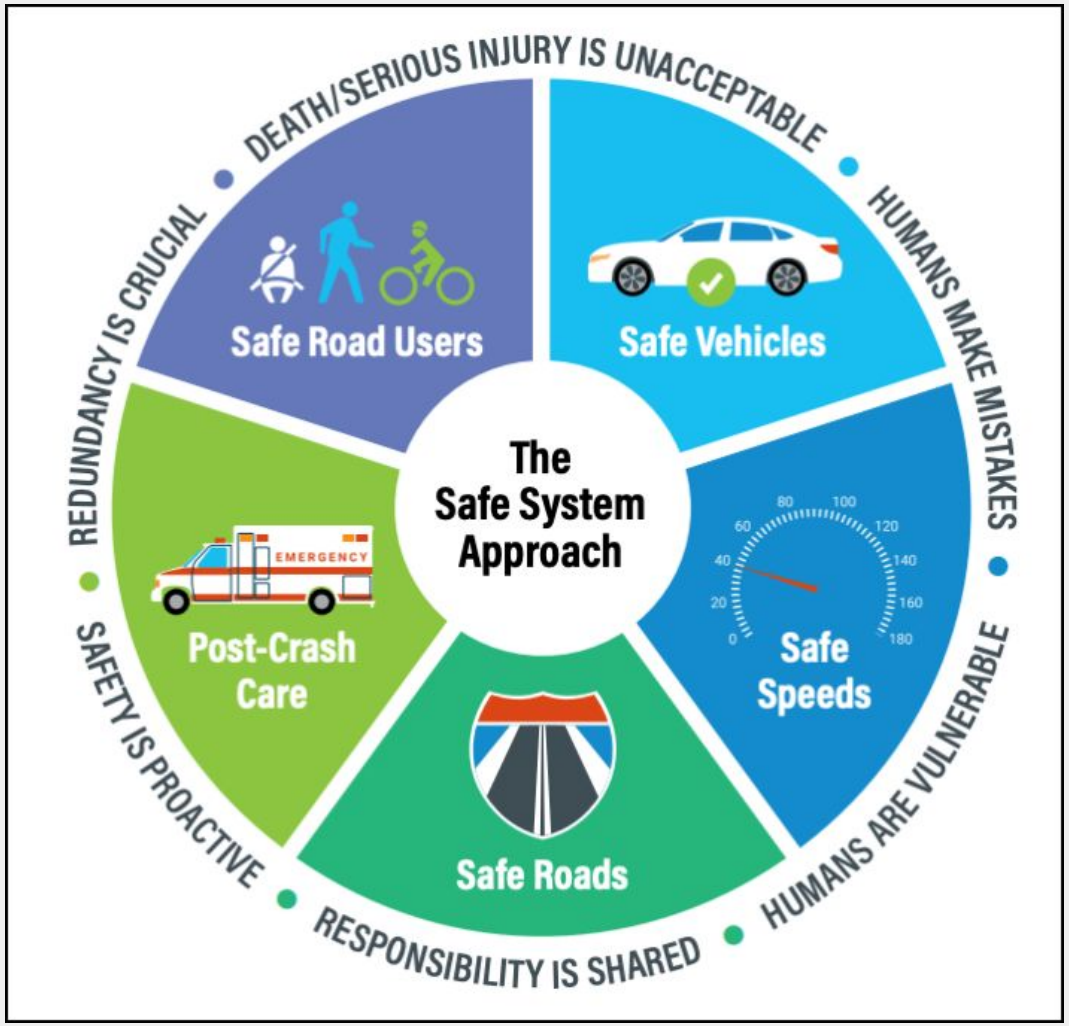
- **13% drop** in traffic fatalities in 2025 (NSC, 2025)
  - **+ 17,000 deaths**
  - **~ $1.8 trillion** in societal harm (value of lives lost, long term disability, pain, suffering, and reduced quality of life)



1. September 2025 Preliminary Crash Fatality Estimates - Injury Facts

Current Solution of Road Safety

- The Safe System approach guides U.S. road safety strategy
- Focuses on safer people, roads, vehicles, speeds, and post crash care
- Agencies often respond ***after*** **crashes occur** and not before



1. What Is a Safe System Approach? | US Department of Transportation

Where Our Model Fits In

- Identifies high-risk road segments using environmental, infrastructure, and temporal data
- Shifts planning from reactive to ***proactive***
- Guides early interventions to prevent accidents

Impact of the Model

- Focuses resources where they prevent the most harm
- Prevents car crashes and cut long-term cost
- Reveals trends for smarter planning, repairs, and patrols
- Builds trust with reliable, accurate predictions for broader infrastructure decisions

Data Overview

- Curvature, speed limit, and nighttime are the most correlated with accident risk
- Some features can be controlled by stakeholders

517K rows

12 base features

Features
road_type
num_lanes
curvature
speed_limit
lighting
weather
road_signs_present
public_road
time_of_day
holiday
school_season
num_reported_accidents
accident_risk

Feature Engineering

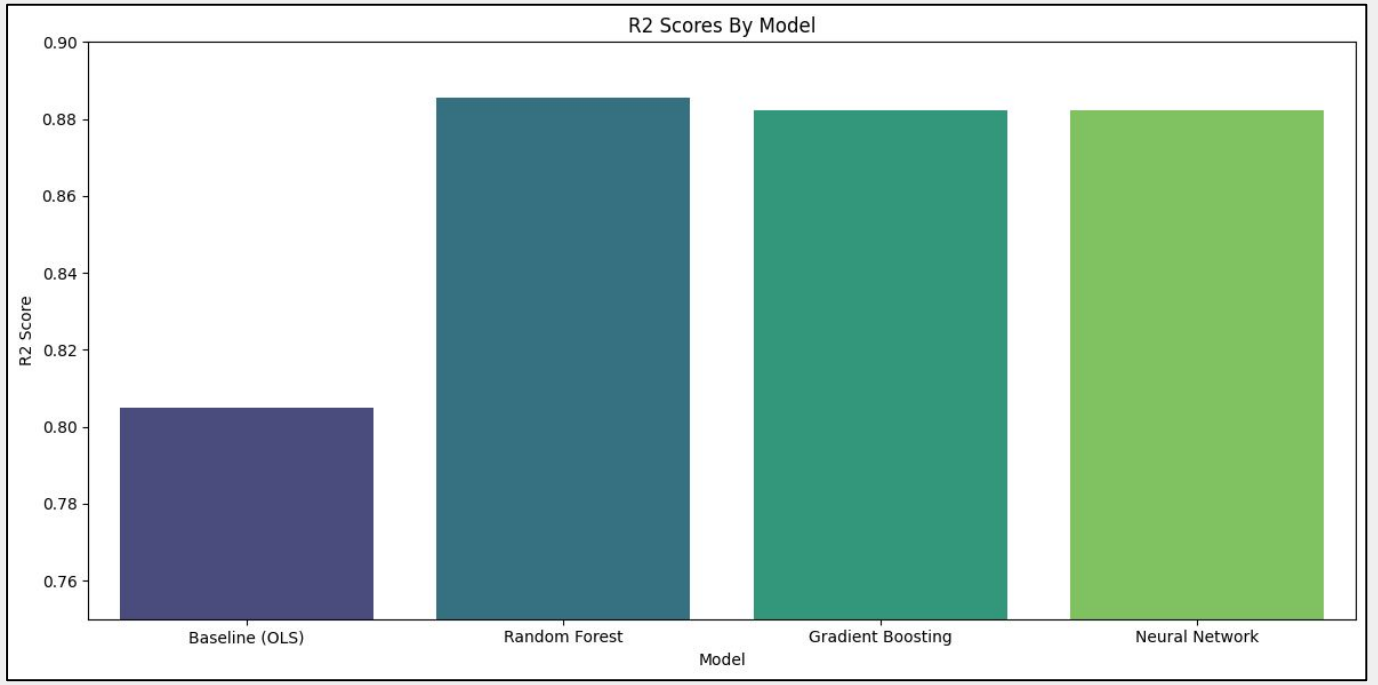
- Curve Danger = speed_limit ✖ curvature
  - Tighter corners with higher speed limits are more dangerous
- Low Light = rural_road ✖ dark_lighting
  - Rural roads lacking street lighting may be more dangerous at night
- Low Visibility = poor_weather ✖ dark_lighting
  - Combination of poor weather and low light may increase accidents

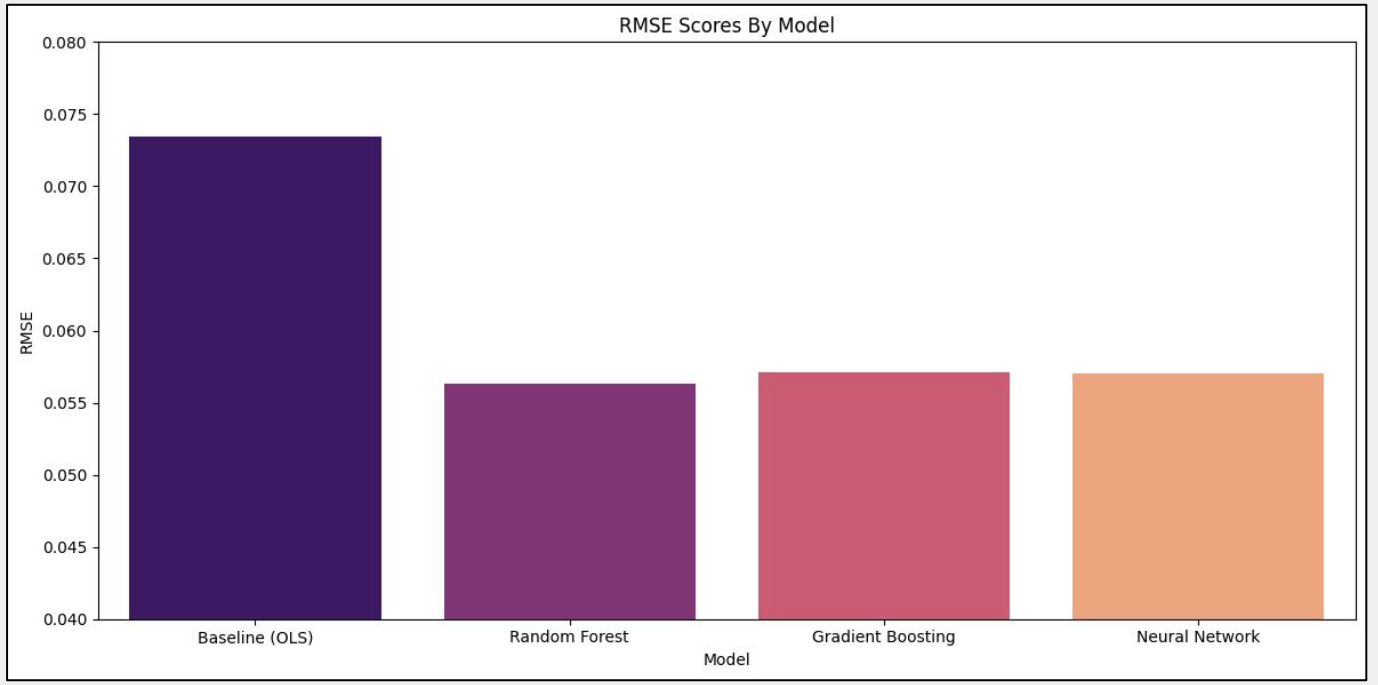
Modeling Goals

- Use regressors to model continuous output
- Compare effectiveness and trade-offs between various strategies
- Measure improvements from baseline OLS to more advanced models
- Determine which factors influence outputs the most

Model Comparisons

- Advanced models consistently outperformed OLS
- Random Forest was tuned with grid search
- Deeper neural networks performed worse





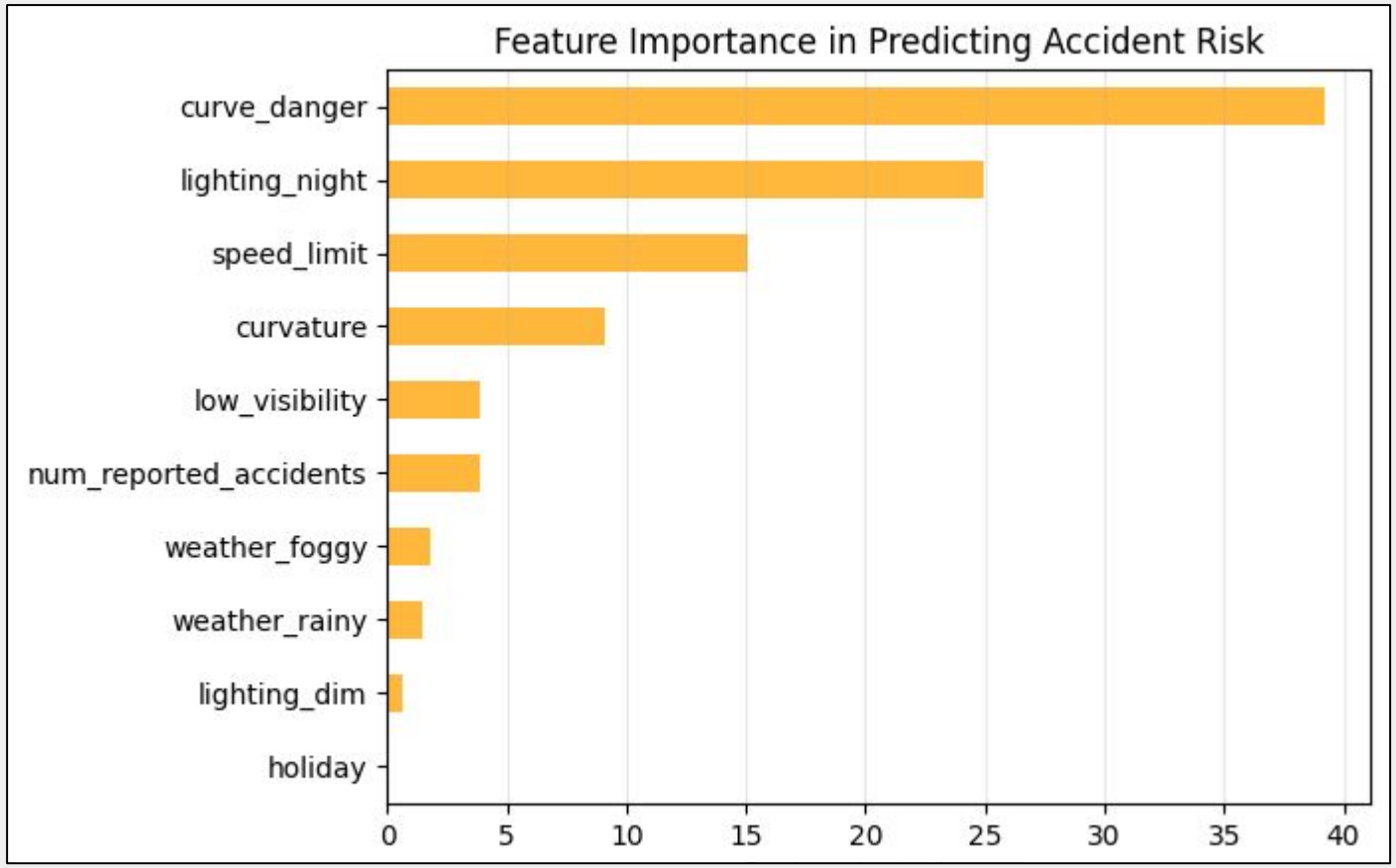
Optimal Parameter Selection

- Random search used **60 total fits** across **3 folds**
- Grid search used **162 total fits** across **3 folds**
- Achieved similar results

# Estimators	100	**200**	300
Max Depth	None	**10**	20
Min samples split	2	**5**	10
Min samples leaf	**1**	2	4

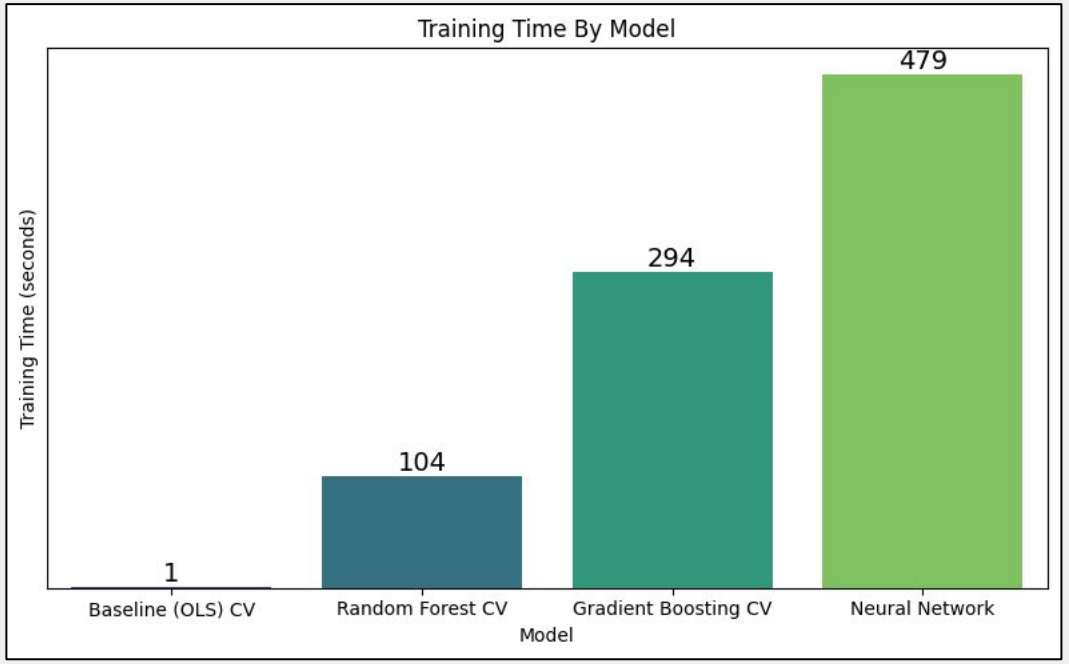
Key Model Features

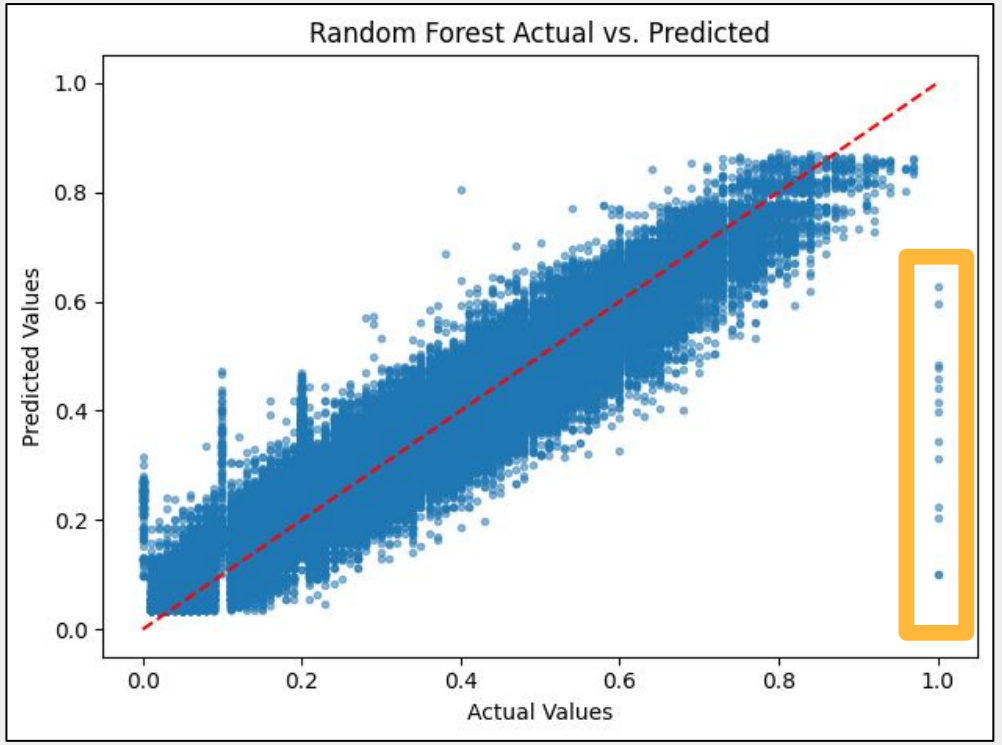
- Engineered features are selected by models
- Weather, speed, and lighting are influential across models
- Speed, curvature, and artificial lighting can be affected by government decisions



Technical Challenges

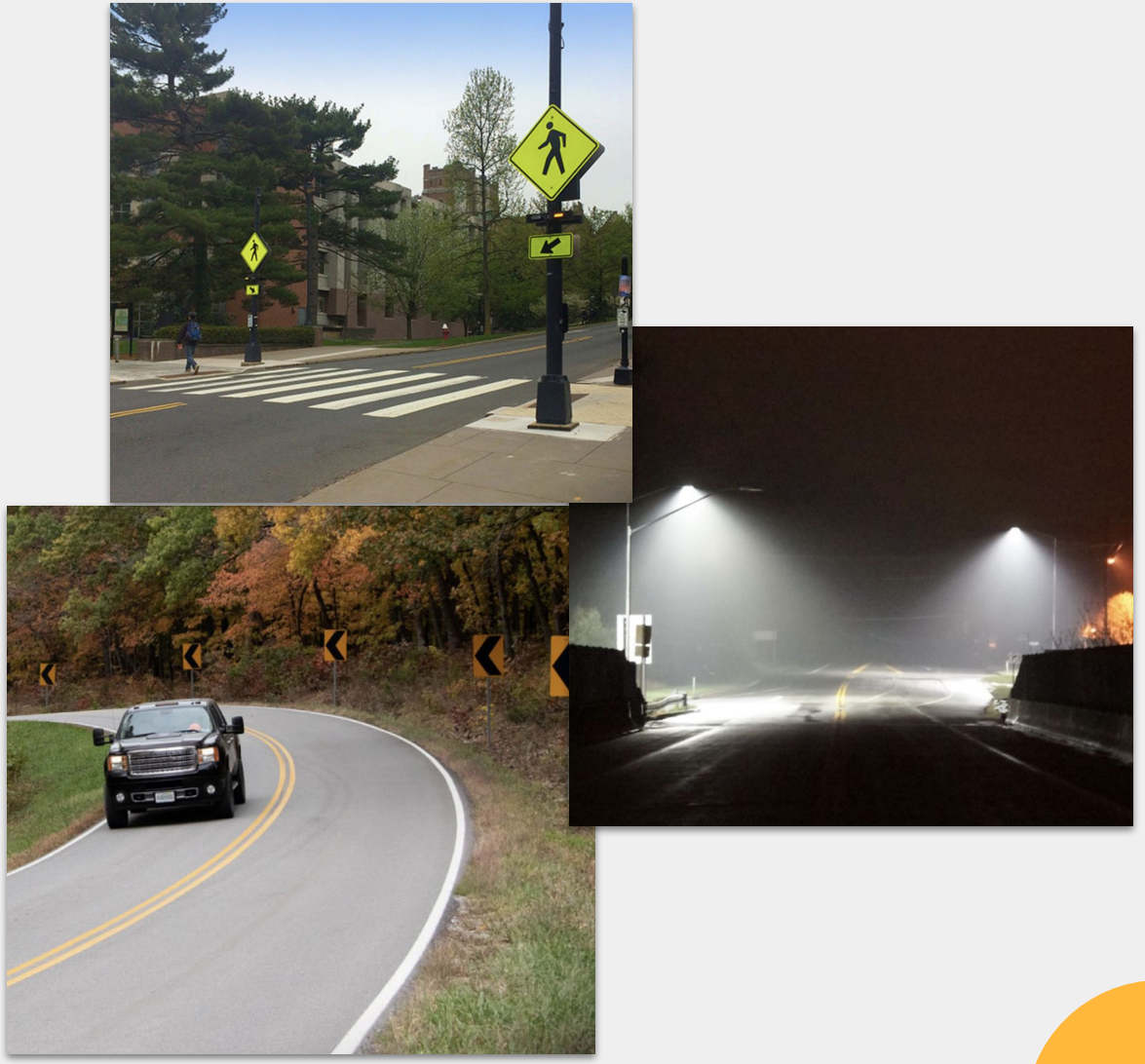
- Time complexity of fitting and hyperparameter tuning
  - **413K** training split
  - CV random search took **42 minutes**
- Utilizing models that support GPU acceleration
- Overfitting and outliers due to natural scenarios





Action Items

- Increase artificial lighting, especially in rural areas
- Consider speed limit reductions in roads with higher curvature
- Maintain road monitoring during low-visibility weather conditions



Future Opportunities

Connect to regional weather data to show accident likelihoods by region based on climate

Leverage existing mapping and street data services to highlight sections of road that are most likely to have accidents

Add features to answer questions for target industries, such as safety features for automobiles

Summary

- Applied modeling techniques to road safety predictions with the goal of making roads safer as a government
- Compared baseline model to more advanced techniques
- Tuned random forest model and discussed technical challenges
- Identified the key action items to improve road safety before accidents happen
- Highlighted opportunities for future model expansion

Thank You!