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A DEPARTMENT OF HOMELAND SECURITY CENTER OF EXCELLENCE

Development of the Big Bridge Data Across the Conterminous U.S. for Deck Condition Rating Prediction Using Machine Learning Algorithms

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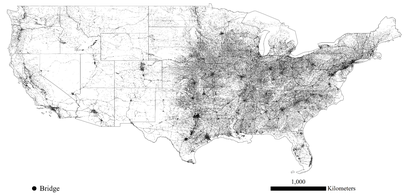
Homeland Security Challenge

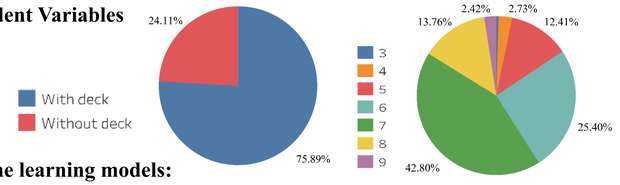
- Bridges are critical nodes in the U.S. transportation system
- 11% of 600,000 bridges structurally deficient (ASCE, 2017)
- Submit National Bridge Inventory (NBI) to FHWA
- Bridge lengths > 20 ft visually inspected →$2.7 billion
- Developing machine learning models:
  - Historical bridge data
  - Environmental data

Approach / Methodology

- **Big Bridge Data (BBD) development (Liu and El_Gohary 2016):**
  - NBI and traffic → FHWA
  - Spatially locating bridges
  - Climate → PRISM
  - Hazard → USGS



- **28 Independent variables:** 19 NBI and traffic, 7 climate, and 2 hazard.
- **Dependent Variables**



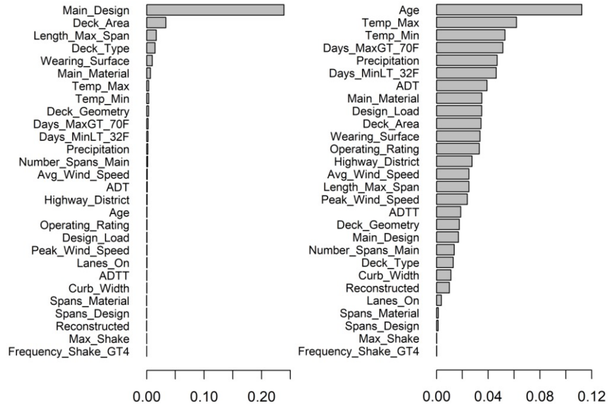
- **Machine learning models:**
  - Has a deck or not → Binary classification → Random Forest
  - Predict deck condition rating → Multiclass classification
    - Random forest
    - XGBoost
    - Multilayer perceptron neural network (NN)

Outcomes / Results

Evaluation of models

Binary classification model	Accuracy
Random forest	99.7 %

#	Multiclass classification models	Accuracy
1	Random forest	60.3 %
2	XGBoost	58.9%
3	Multilayer perceptron NN	50%



- Main design → important predictor variable in identifying bridge decks.
- Contributing predictor variable in determining the deck condition rating:
  - Age or the number of years since the last major reconstruction
  - Climate variables
  - Average Daily traffic (ADT)

References

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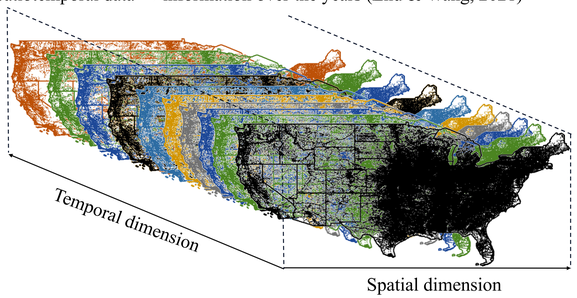
Conclusions and follow-up research

- Spatial data → information at different positions in one year
- Spatiotemporal data → information over the years (Zhu & Wang, 2021)



- **3Vs Characteristics of BBD:**
  - Volume: 30 times bigger than BBD of 2020
  - Velocity: one year updating speed
  - Variety: heterogeneous sources and different formats
- **Five-year spatiotemporal BBD from 2016 to 2020 was collected:**
  - Random forest multiclass classifier → 83.8% accuracy
  - Forecast the condition ratings of 2021 → ≈ 68%
- **More research is needed:**
  - Collecting spatiotemporal BBD of different years (available since 1992)
  - Develop ML models and evaluate their performances for forecasting of 2021 and2022

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