COLLEGE OF ENGINEERING
THE UNIVERSITY OF ALABAMA IN HUNTSVILLE

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Statistical Study for Bridge Deterioration Across Alabama

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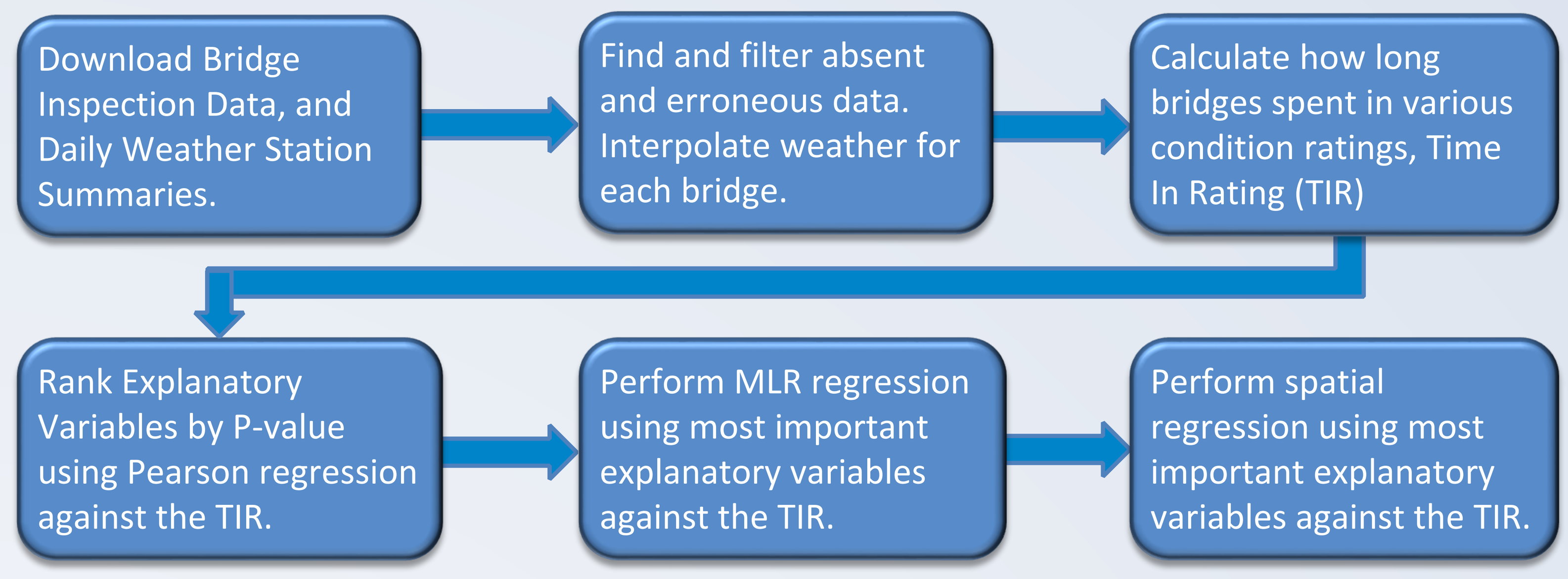
Introduction

The Alabama Department of Transportation oversees the construction, inspection, and maintenance of over 16,000 bridges statewide. Understanding bridges' projected lifespan and quantifying the external stressors which effect the lifespan is imperative to their operation.

Research Goal: Use linear and spatial regression models to quantify the key factors (e.g., environmental effects, daily traffic) on Alabama bridges' deterioration rate.

Data	Bridge Characteristics	Bridge condition (scale of 1-9 where 9 is best)	External Stressors
Minimum bridge inspection frequency of 24 months	Year built, Material/Structure type, Length, Max span, Functional class etc.	Deck, Superstructure, Substructure, Channel, Culvert	Average daily traffic, Precipitation, Freeze/thaw cycles, severe weather

Methodology



Time in Rating (TIR) is essentially the inverse of a differential where the magnitude of deterioration equals 1. This is ideal for the whole numbered rating scale.

$$Deterioration\ Rate = \frac{\Delta Rating}{\Delta Time} = \frac{1}{TIR}$$

Spatial Regression compares an observation against its neighbors seeking to find areas deemed to be non spatially random, either a cluster (high/high or low/low) or checkerboard pattern (high/low or low/high). It determines the significance of these patterns by comparing them to randomized distributions of the same data set. Bivariate spatial regression compares variable x to the surrounding y variables – this means that the y variable is spatially lagged.

Key Findings/Results

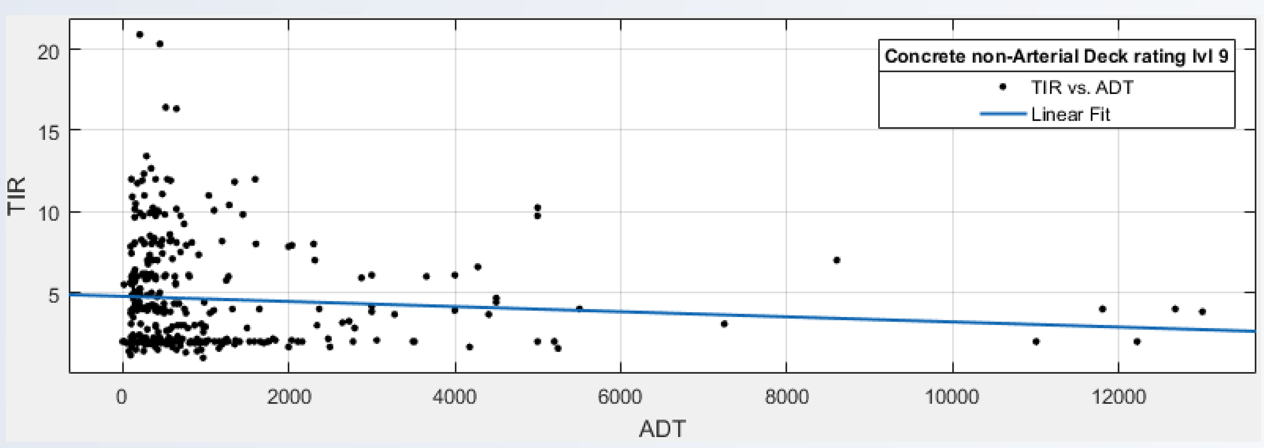


Figure 1: Deck Time in rating as a function of Average Daily Traffic. Time in rating is not explained well in lower amounts of traffic, but is always low in cases of high traffic volume.

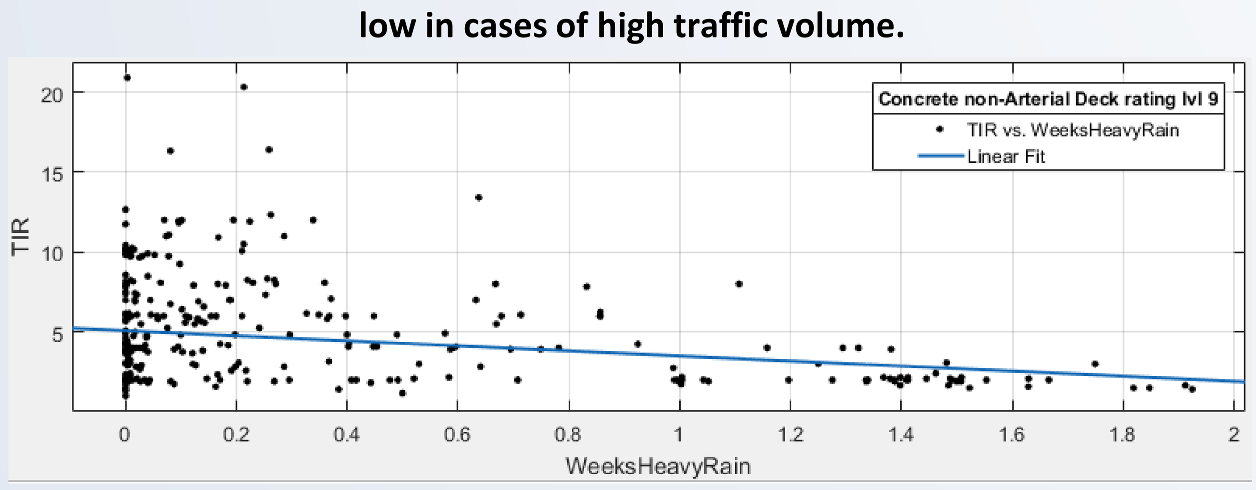


Figure 2: Deck Time in rating as a function of number of weeks > 250 mm precipitation. Time in rating is not explained well in lower amounts of rain, but in cases of much heavy rain low time in rating is always observed.

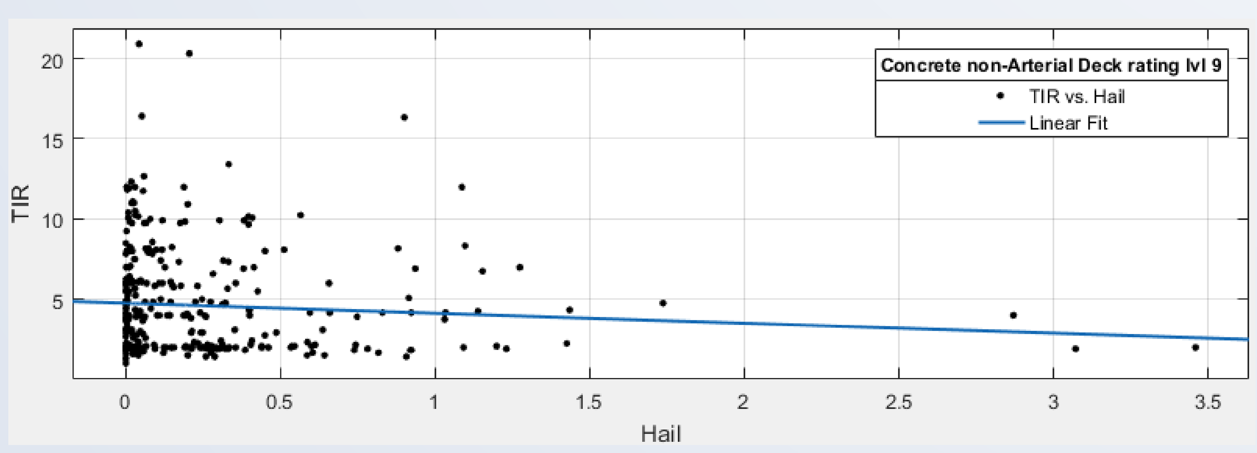


Figure 3: Deck Time in rating as a function of number of occurrences of hail. Time in rating is not explained well in lower amounts of hail, but is always low in cases of significant hail.

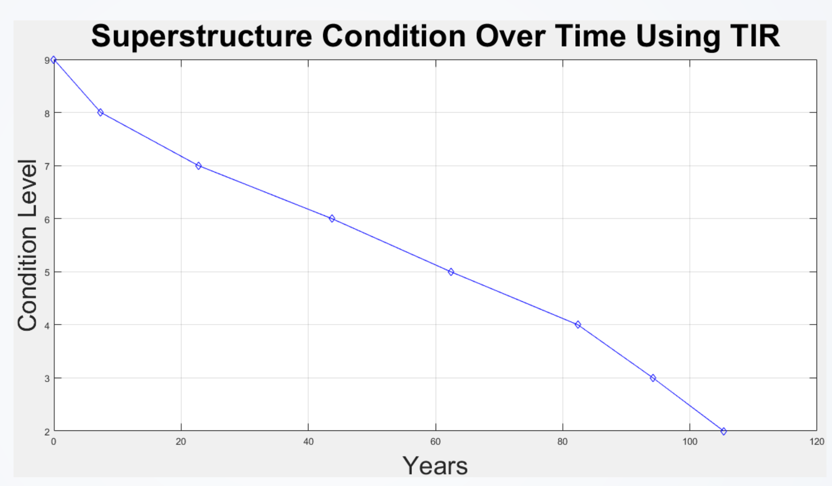


Figure 4: Superstructure condition over time using TIR. Deterioration is slightly non linear.

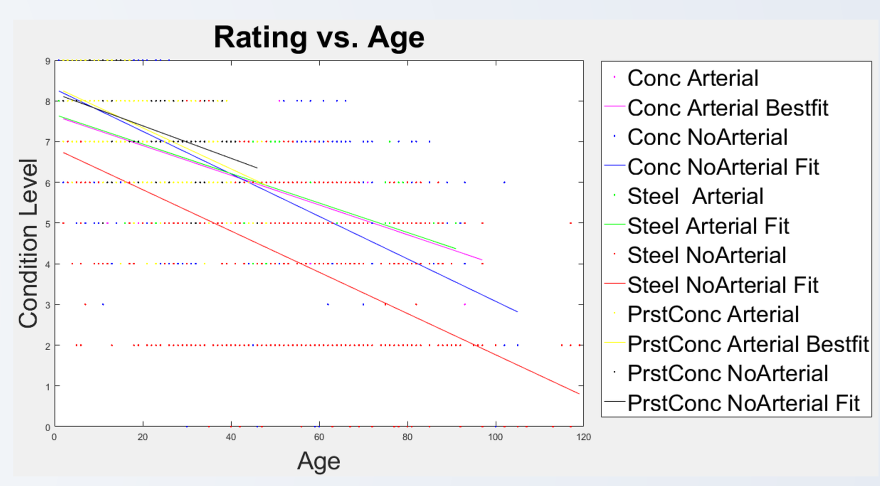


Figure 5: Bridge rating as a function of age. Steel non arterial fares poorly.

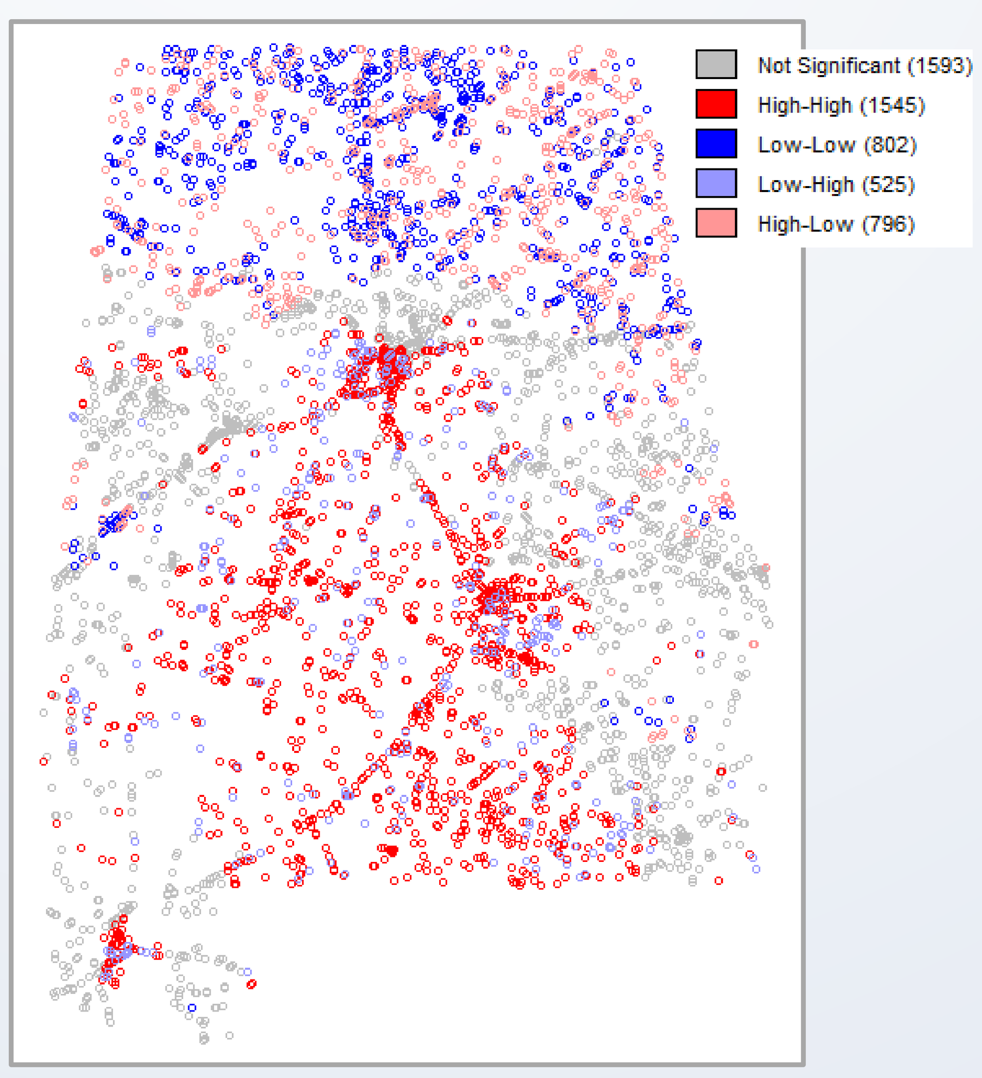


Figure 6: Total substructure deterioration from 1993 – 2016. A light red dot means high bridge deterioration surrounded by low deteriorations.

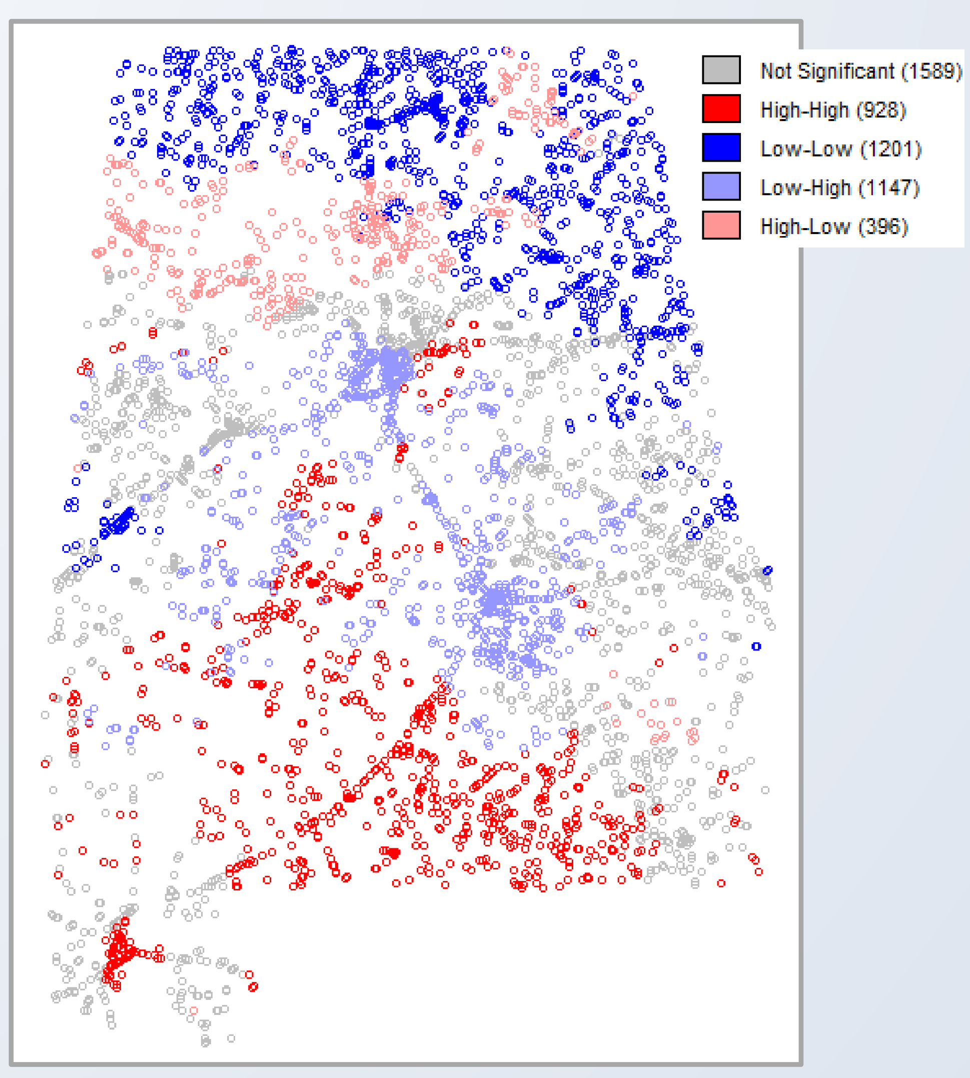


Figure 7: Substructure deterioration from 1993 – 2016 spatially lagged with respect to number of days precipitation > 75 mm. A light red dot means high bridge deterioration surrounded by low precipitation.

Conclusions

With the linear models used, the precipitation and freeze thaw cycles analyzed did not account for a substantial amount of the variance (≈24%) in deterioration rate. However, under increasingly excessive weather conditions, lower time in rating is almost always observed. This result is understandable as bridge construction likely focuses primarily on weathering normal climate conditions compared to extreme ones. Overall, steel bridges on non arterial roads fared poorly in Alabama's climate. Future forecasting models should explore more deeply the effects of severe weather instances on bridge deterioration.

Acknowledgements

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