A Correlation Network Model for Managing Safety and Performance Issues in Bridges and Civil Infrastructures

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ABSTRACT

Many recent studies have shown that a large percentage of bridges in many parts of the world have low safety rating. National Bridge Inventory (NBI) database contains the information of more than 600,000 bridges, where each bridge has 116 parameters. Current safety inspections require bridge inspectors to manually inspect each bridge every few years. Manpower and budget constraints limit such approach from inspecting the bridges more frequently. Clearly, more efficient approaches need to be developed to improve the process of bridge inspection and increase the overall safety of bridges and civil infrastructures. In this study, we propose a Correlation Network Model (CNM) to analyze and visualize the big-data associated with more than 600,000 bridges of NBI database. We use Correlation Networks based on various safety parameters (deck rating in this case), then apply community clustering algorithm such as GLay to analyze a population of 8,712 Nebraska non-culvert bridges. Our results show that out of top5 clusters, two clusters have highly negative correlations with average deck ratings and one cluster have highly negative correlation with the average daily traffic. So these clusters need more attention than other clusters as these clusters are sensitive to the age and average daily traffic.

MAIN HYPOTHESIS

The main idea behind this work is to use population analysis to assess the health level of each bridge and predict potential health hazards of bridges before they happen. Our main hypothesis is that bridges with similar deck ratings are included in a common cluster in the correlation network model and have similar behavioral pattern.

METHODOLOGY

- Data Collection from NBI Database and Inputs from Engineering Team
- Creating a Correlation Network and Apply Community Clustering (GLay)
- Visualizing and Analyzing Individual Clusters
- Developing a Decision Support System (DSS)

RESULTS

- Correlation Network Model (CNM) is a Graph Theoretic Model
- Each bridge is represented by a node
- Bridges with high correlation ($\rho > 0.96$) in Deck Rating are connected by edges
- Correlation Network of 6,401 Nebraska non-culvert bridges, with 161428 edges and 410 Connected Components
- Top-5 clusters with high density (density: 1.0, which is in fact a complete graph) were selected for further analysis

CONCLUSION

- Correlation Network Model (CNM) with population analysis is appropriate to the traditional Structural Health Monitoring (SHM) methods to identifying which bridges need to be serviced first
- In clusters 1 and 4, deck rating is highly negatively correlated with age, and in case of cluster-5, deck rating is highly negatively correlated with deck rating. Hence these clusters need more attention in terms of considering the age growth and controlling the average daily traffic. Our highly enriched parameters also show this.
- Post Hoc tests for multiple comparisons show that cluster-1’s coefficient of variation (CV) for the last 25 years deck ratings is high and significantly different with all the remaining clusters. So these bridges are deteriorating fast.
- CNM provides a Decision Support System (DSS) to predict the health of the civil infrastructures so as to save many human lives.

REFERENCES


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