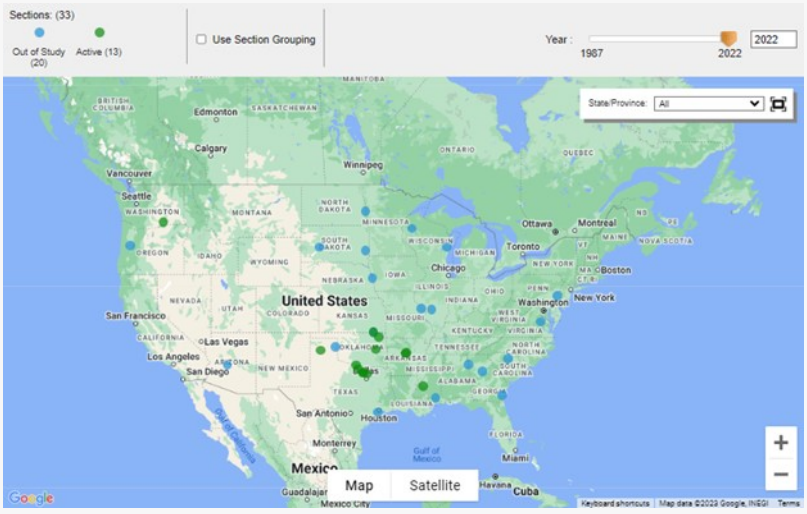
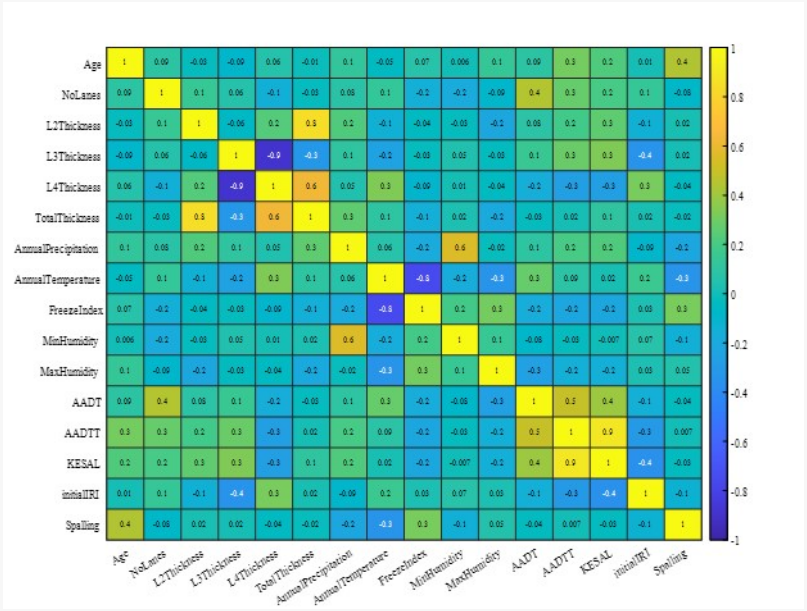
Machine learning models could alleviate risks posed by cracking and corroding concrete structures, say scientists

Scientists design machine learning models that can say when and why concrete structures start cracking and deteriorating.

SHARJAH, EMIRATE OF SHARJAH, UNITED ARAB EMIRATES, October 14, 2024 /EINPresswire.com/ -- Scientists say they have designed machine learning models able to predict when and why structures built of reinforced concrete start deteriorating and cracking.



Mapping the geographic locations of the chosen asphalt pavement sections



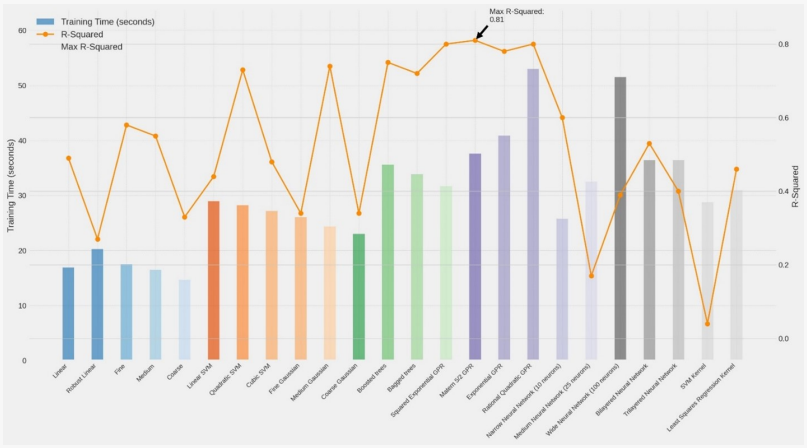
Heat map correlation results

Concrete is the modern world's most common construction material used in the building of a wide variety of structures like bridges, jetties, houses, multi-story car parks and buildings.

However, and despite its strength and durability, reinforced concrete may crack, and delaminate as part of a process called spalling, which is commonly caused by the corrosion of steel sections in the concrete.

Researchers from the University of Sharjah now claim to have designed new machine learning models which they believe can predict when and why spalling can occur, thereby providing engineers with ample time to offer solutions and practices on how to stall spalling and its detrimental effects.

The research, published in Scientific Reports, "investigates the multifaceted factors influencing spalling, employing a comprehensive approach that integrates statistical and machine learning techniques for predictive modeling. (Original Source URL: https://www.nature.com/articles/s41598-024-69999-9)



Machine learning results

"Descriptive statistics meticulously profile the dataset, emphasizing age, thickness, precipitation, temperature, and traffic parameters," the scientists write.

Spalling has many adverse effects. In the absence of proper assessment and prediction as well as right treatment, it can lead to hazardous consequences.

When steel corrodes, it expands much beyond its original volume, pressuring the surrounding cement and leading to the emergence of cracks and deterioration in concrete structures.

Cracking of concrete structures is a distress phenomenon, posing a threat not only to concrete pavements and buildings but is also a health and safety risk.

Dr. Ghazi Al-Khateeb the lead author, and Sharjah University's Professor of asphalt pavements, pavement damage and mechanics, said key factors influencing spalling were considered in the study, particularly their impact on Continuously Reinforced Concrete Pavement (CRCP).

CRCP has emerged as the most common concrete pavement in modern age as it eliminates the inclusion of transvers joints which usually require continuous and costly maintenance. It is adopted as part of measures to help concrete weather environmental and traffic pressures.

The authors also considered in their analysis the Annual Average Daily Traffic or AADT, which calculates the sum of total traffic over a pavement for the entire year divided by 365 days.

Prof. Al-Khateeb said, "The research study identified key factors influencing spalling in Continuously Reinforced Concrete Pavement (CRCP), including age, climate variables such as temperature, precipitation, and humidity, as well as Annual Average Daily Traffic (AADT) and pavement thickness.

"These factors were highlighted as primary contributors to the deterioration of CRCP."

The research study, the authors write, "adhered to a systematic methodology, comprising several

stages to ensure robustness … Descriptive statistics meticulously profile the dataset, emphasizing age, thickness, precipitation, temperature, and traffic parameters."

The authors employed regression analysis to key relationships of different factors causing spalling. Their results emphasized "significance of age, annual temperature, annual precipitation, maximum humidity, and the initial International Roughness Index (IRI) as influential factors.

"The selection of Gaussian Process Regression and ensemble tree models stems from their adaptability to capture intricate relationships within the dataset, and their comparative performance provides valuable insights into the diverse predictive capabilities of these models in the context of CRCP spalling."

When feeding the results of the analysis of these factors into the models they designed, the authors found their learning machines to have the capacity to forecast when deterioration of reinforced concrete can occur and the factors posing a threat to concrete durability.

The machine learning models the authors employed, according to Prof. Al-Khateeb, were mostly of the type of Gaussian Process Regression and ensemble tree models, which "demonstrated the highest accuracy in predicting spalling.

"However, it was noted that model performance varied depending on the specific architecture and characteristics of the dataset used, indicating the importance of careful model selection."

Hence, the authors advised engineers and practitioners to be cautious when employing machine learning models, noting that in "machine learning, adopting models, including Gaussian Process Regression and ensemble tree models, is grounded in their diverse capabilities and suitability for the complex task at hand. Their varying predictive accuracies underscore the importance of judicious model selection."

The research study, in the authors words, "advances pavement engineering practices by offering nuanced insights into factors influencing spalling in CRCP, refining our understanding of spalling influences.

"Consequently, the study not only opens avenues for developing improved predictive methodologies but also enhances the durability of CRCP infrastructure, addressing broader implications for informed decision-making in transportation infrastructure management."

Asked about the immediate practical implications of the study, Prof. Al-Khateeb referred to the authors' research findings which he said they highlighted "the need for maintenance strategies that incorporate critical factors such as age, traffic load, and pavement thickness. By addressing these variables, practitioners can enhance the durability of CRCP and reduce the risks of spalling."

Prof. Al-Khateeb said there was still room for further research to solidify the findings by placing more focus on “exploring the temporal changes in spalling patterns, integrating real-time sensor data for more accurate predictions, addressing regional data variability, and examining the impacts of climate change on spalling.

“These avenues could significantly improve predictive methodologies and enhance the resilience of concrete pavement systems.”

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