Artificial Intelligence Methods Can Assist Bridge Engineers

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Artificial Intelligence (AI) has the potential to provide bridge engineers, especially newer engineers entering the field, with practical, hands-on tools for making better decisions. The Innovative Bridge Technology/Accelerated Bridge Construction University Transportation Center (IBT/ABC-UTC), a U.S. Department of Transportation–funded center, is developing these kinds of AI tools. This article provides background on AI and two examples of the technologies being used in bridge engineering.

What Exactly Is Artificial Intelligence?

Put simply, AI is the art, science, and engineering of creating machines that can do—or assist humans in doing—intelligent things. The term "intelligent" is somewhat elusive and difficult to define, but it traditionally refers to cognitive tasks such as perceiving, learning, classifying, abstracting, reasoning, or acting.[1] As an academic and applied pursuit, AI is subdivided into many areas, including machine learning, natural language processing, multiagent systems, planning, knowledge representation, computer vision, human-machine interaction and teaming, and robotics.

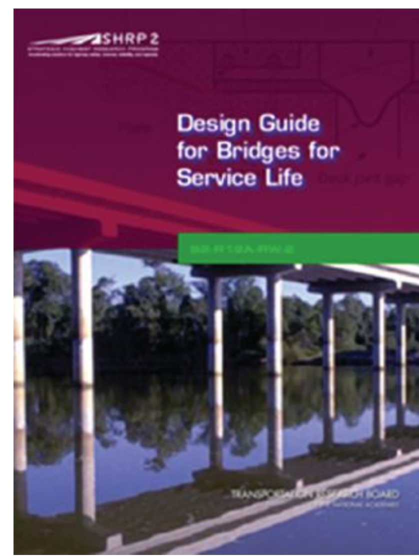
In the popular imagination, AI is a brand-new area that will result in the complete replacement of people in their jobs, with potentially disastrous consequences for the workforce. In reality, AI as a scientific and engineering field is more than 75 years old, and for decades AI systems have been deployed in ways large and small across many industries, making countless people more productive, efficient, and capable than they would have been without AI. Many AI researchers believe that the best use of AI technologies is to assist people in their work, not replace them. With this vision in mind, researchers at IBT/ABC-UTC are developing new AI-enabled technologies for bridge engineers. Two examples of these technologies—BridgeGPT and detecting corrosion of steel strands in external tendons—are presented herein.

BridgeGPT

IBT/ABC-UTC has initiated research to develop an AI tool to assist bridge professionals, called BridgeGPT, which will be similar to ChatGPT, except that BridgeGPT is devoted to bridge engineering.[2] ChatGPT is a type of large language model (LLM) that is trained on vast amounts of text and images, mainly drawn from the internet, to create "conversational" text in response to queries or prompts. The size and diversity of its training data allow ChatGPT to respond to a wide variety of queries; however, when it is asked to focus on a specialized or technical domain, such as bridge engineering, its answers can range from unhelpfully vague to dangerously incorrect. The vision for BridgeGPT is that the system will be trained using verified information drawn from sources used by bridge engineers.

At IBT/ABC-UTC, the first step in developing BridgeGPT is a small one: a module devoted to service-life design of bridges, a topic that was the focus of the Transportation Research Board's second Strategic Highway Research Program (SHRP2) R19A project.

The main deliverable of that project was the 2013 report *Design Guide for Bridges for Service Life*.[3] This document provided the foundation, information, and methodology for development



of the American Association of State Highway and Transportation Officials' (AASHTO's) *Guide Specification for Service Life Design of Highway Bridges*.[4] The SHRP2 R19A report and other project materials, as well as the AASHTO guide specification, contain a wealth of information that can quantitatively predict the service lives of bridge components and subsystems. The 2013 report begins with an overview of the philosophy used for the design of bridges for service life and contains flowcharts guiding the user to the application of the information presented in the document. Each of the report's 11 chapters includes additional flowcharts and information for service-life design of specific bridge components.

The volume of information developed on service-life design may seem overwhelming to bridge engineers who wish to apply it. This is where AI can help. Researchers and system developers can use the guides and specifications

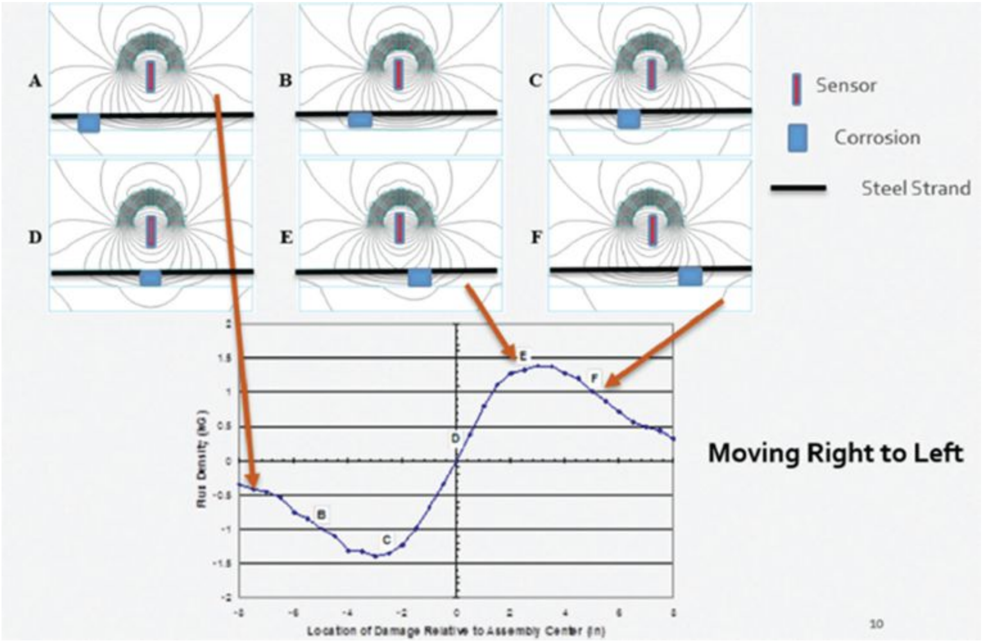


Figure 1. Results from the experimental residual magnetic flux leakage (MFL) method where a sinusoidal graph indicates the location of steel strand section loss. Figure: Florida International University.

just described to train an off-the-shelf, general LLM to specialize in the bridge engineering domain. Such a system could then respond to prompts related to design for service life, including answering factually based questions, finding relevant sections from reference materials, and integrating information drawn from several different documents. While we envision that the first version of BridgeGPT will focus specifically on service-life design, the architecture of BridgeGPT is such that additional knowledge can be included in the future, expanding the utility of BridgeGPT to other areas of bridge design and engineering.

Detecting Corrosion of Steel Strands in External Tendons

The Florida Department of Transportation and IBT/ABC-UTC are sponsoring the development of a technology to inspect external tendons in concrete segmental bridges for corrosion. The residual magnetic flux leakage (MFL) method is used to identify the sections of external tendons with steel section loss because of corrosion. In this method, an MFL device automatically runs across a tendon duct and develops a signal that is relayed to computer software for plotting. The presence of steel section loss coincides with a signal that has a sinusoidal shape (Fig. 1).

In general, the MFL method requires a trained eye to evaluate the signals and locate the regions of the tendon with steel section losses. In this project, machine learning (a type of AI) is used to analyze the data and assist the user in locating the regions of the tendon with potential steel section loss. To achieve this objective, various tests are being conducted to obtain signals from the MFL equipment. Signals from numerous experiments—each having different numbers and locations of steel wires within the strands removed—are obtained. These data are then used to train the system and develop machine learning algorithms that can help the user identify the regions along the tendons with potential steel section losses. The technology developed is quite accurate, capable of identifying steel section losses of less than 1%, regardless of the location of steel corrosion.

Conclusion

In the two examples provided, AI will not replace bridge engineers. Instead, it will provide valuable tools to facilitate decision-making processes and help engineers navigate through large amounts of data.

References

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EDITOR'S NOTE

For further information on magnetic flux-based nondestructive evaluation for post-tensioned tendons see the Federal Highway Administration's 2022 report FHWA-HRT-23-005 (https://highways.dot.gov/sites/fhwa.dot.gov/files/FHWA-HRT-23-005.pdf).