Editorial

Developing data science for structural safety analysis and pre-warning in civil engineering

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Abstract: The development of data science in civil engineering has benefited from the rapid advances in sensor technology as well as data acquisition and storage. In contrast to traditional analysis and evaluation based on periodic inspection and full-scale test, the structural safety analysis and pre-warning can be achieved directly through the analysis of the design data of the newly built bridge and the monitoring data & test data of the bridge in service. Specifically, structural geometric data (length and cross-sectional area etc.), physical response data like displacement and stress, and vibration response data, such as acceleration and frequency, as well as the influence of the environment, e.g., temperature and humidity, must all be taken into account. Furthermore, the different sensitivity of different response data, which in turn affects structural safety analysis and pre-warning accuracy, is one of the current frontier sciences, i.e., the problem of multi-source (different response) data. It is expected that the development of data science will have very important theoretical research value and engineering practice significance for safety analysis and pre-warning in civil engineering, and is expected to bring new prospects for academia and industry.

Keywords: Civil engineering, Design data, Test data, Monitoring data, Elementary statistical analysis, In-depth data fusion, Structural member analysis, Whole structural visualization.

Introduction & observation

It is generally stated that the data science for structural safety analysis and pre-warning in civil engineering is made up of three main sections, and the details can be shown as follows:

Section one: common elementary statistical analysis for structural member.

In terms of elementary statistical analysis of data, this usually includes the analysis of the maximum and minimum values of the data, the increasing and decreasing rules of the data overtime, the regression analysis of the data to predict[1], as well as the fitting and even the intelligent discovery of mathematical equations for the data[2]. Then, the macroscopic structural safety can be easily grasped by comparing the stress and displacement values of the cross section of the structural member with the limit values of the corresponding current design or inspection or test code[1]. Taking the bridge engineering as an example, the different precast beams of the superstructure of the slab-on-girder bridge (i.e., prefabricated T-type bridge) and the different cables of the cable-stayed bridges (e.g., cable-stayed bridge) should also be considered in detail.

Section two: more in-depth data fusion for whole structural visualization.

The more in-depth data analysis herein refers to the multi-dimensional spatio-temporal distribution and visualization of data[3]. The spatial dimension is mainly the dimension in which the structural prefabricated beams

Received: 15 July 2023 Accepted: 18 July 2023 Available online: 20 November 2023

are located and the dimension in which the structure as a whole is located. The temporal dimension is mainly the hourly, daily, weekly, monthly and yearly dimensions of the time series data. The visualization is the dynamic presentation of the data in different temporal and spatial dimensions for analysis and forecasting. One example of the forefront of data science is the statistical shape analysis, which is very much in use in the medical field[4].

While the new advance in civil engineering is based on a twin model of data and physics[5]. Not only can structural safety and pre-warning be derived from the data analysis, but different damage locations and degrees can also be induced in the model. The corresponding data analysis can be further performed in turn.

Section three: additional management of traffic load and pedestrian load etc.

In contrast to most of the studies that focus on structural safety and pre-warning, the studies on external loads, such as the traffic loads on highway bridges and the pedestrian loads on scenic bridges, are also of great theoretical and practical importance[6] . Firstly, it is possible to identify traffic and pedestrian movement rules at the bridge location. This will facilitate traffic management, such as the development of contingency plans for traffic diversion and even further traffic planning. Secondly, the risk of structural collapse due to overcrowding, which is a common accident, will be reduced by the timely implementation of traffic restrictions in pedestrianised areas.

Therefore, it can be indicated that the development of data science will have very important theoretical research value and engineering practice significance for safety analysis and pre-warning in civil engineering, and is expected to bring new prospects for academia and industry.

Conflict of interest

The authors declare no conflict of interest.

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