A Study of Seismic Designs and Evaluation Methods for Small and Medium Spanning Highway Girder Bridges Based on Machine Learning and Earthquake Damage Experience

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Abstract

The seismic performance assessment of small-to-medium-span highway bridges in China is an important part in bridge design. This type of bridges has large quantity and wide distribution, similar structure type and the repetitive design work, which shows the statistical significance. The actual earthquake damage in highway network is mainly concentrated in this kind of bridges. In view of the structural characteristics and earthquake damage experience of this kind of bridges, combined with the characteristics of machine learning, the project proposes a seismic performance evaluation method for small-to-medium-span highway girder bridges based on machine learning. First, the normal types of simply supported girder bridges and continuous girder bridges which are used for the highway bridges with medium and small spans in China were summarized. Meanwhile, the earthquake damage phenomena which had been observed for the bridge types during the Wenchuan earthquake were assessed. Second, a series of seismic performance tests which had been conducted by international and domestic academics for the bearings, shear keys, piers, and abutments were summarized in this study, in order to obtain the constitutive relationships for the seismic analysis, and also to determine the seismic design parameters of the bridge components (including the foundations). Finally, an overall analysis methodology based on machine learning was introduced into the bridge seismic analysis, which explained that the machine learning for the bridge seismic tasks mainly had two aspects. The first was to collect a considerable amount of bridge design data and set up datasets. The second was data reduction, including the processing of the raw data, and debugging or developing a reasonable machine learning algorithm model. Furthermore, the short-comings of the existing performance-based probabilistic seismic design and evaluation methods which are currently used to analyze bridges in China were briefly discussed. The results of the current study indicated the potential future major concerns for bridge seismic analysis technology and recommended the established of computational simulations based on artificial intelligence method.

Keywords: bridge engineering; seismic design and evaluation; review; medium and small span girder bridge; machine learning

1. Introduction

Every major global earthquake event has resulted in negative impacts to human society. As a result, increasing attention has been paid to earthquake resistance in engineering structures. Subsequently, the theories and technology related to the seismic analysis of engineering structures have also been improved.

An initial static method was developed in Japan. However, the limitation of its applicable object (rigid body) was high, and the understanding of the dynamic characteristics of ground motion and structures was found to be congenitally insufficient. Following the Kantō earthquake in 1923, the first seismic design code in the world was born. In the United States, special studies of earthquakes had been carried out in California. The concept of response spectrums was proposed in the 1940s, which had resulted from the understanding level of the researchers at the time in regard to ground motion and structural dynamic characteristics. During the San Fernando earthquake of 1972, a large number of structures were broken but had not collapsed. At that point, the plastic behaviors of the structures were recognized. The concept of ductile seismicity was taken seriously, and displacements were taken as the main seismic design parameters. At the same time, nonlinear dynamic time history analyses which fully considered the three elements of ground motion were gradually emerging. In 1989, following the Loma Prieta earthquake in the United States, the concept of performance-based seismic designs was proposed, and seismic theories were formed. These theories were reflected in the seismic design codes of the United States, Japan, and Europe, and have now become hot topics throughout the world.

Seismic analysis methods and theories of performance evaluations, including those for bridges, are continuously being developed. Although the framework for probabilistic seismic engineering analysis has been established and applied in recent years, the foundation of seismic analysis is still to solve structural motion equations by considering the uncertainty of the ground motion input. In brief, it is a combination of the deterministic structural seismic response analysis results and a probability statistical theory. At the present time, new opportunities for progress to be made in the seismic resistance of the engineering structures have been provided by the rapid development of computer technology. Machine learning is an integral part and core technology of artificial intelligence. Since ancient times, there have been many cases in which humans have made predictions based on experience, such as predicting the weather through cloud formations. However, with the development of computer science, such predictions have been gradually moved to computers in order to assist in project completions, and past experience has become the data for the computers. Major developments and wide applications have been achieved in machine learning in various fields. These have mainly included computer vision, such as medical image reading assistance diagnoses [1, 2]; face recognition online payments; natural language processing, including text emotion analyses [4], book user preference analyses [3], voice recognition of Apple's Siri assistant, and machine translations developed by Google and Baidu, and so on; data processing analyses, such as road traffic analyses [5, 6], information dissemination predictions [7], and diagnoses and predictions based on medical data [8, 9].

In the field of civil engineering, the main application form of machine learning has been pattern recognition, which has been widely used in health monitoring and the damage identification of structures [10, 11]. Machine learning has also been applied in the analysis of structural components. For example, decision trees are used to predict the lateral restraint coefficients of reinforced concrete columns [12], and artificial neural networks are used to identify the peeling bond effects of foundation concrete layers [13]. Also, the compressive strengths of high-performance concrete have been analyzed based on multinational data [14]. However, the applications of machine learning in structural designs have been rare. For example, back-propagation algorithms have been used in load case identification, and machine learning has been used in the design and rectangular plate analyses of simply supported concrete beams [15]. Also, the joint control model algorithm of cerebellar models has been previously used to assist in the designing of steel structures [16]. In recent years, evolutionary computing technology has been closely integrated with structural design optimization processes and has been applied in high-rise steel structures [17, 18]. Dr. Jootoo was the first to utilize a supervised learning algorithm in the bridge selection in order to assist the preliminary designing processes of bridges [19].

Machine learning has also been examined in other engineering fields. For example, an optimization scheme was presented by Chen Yuren [20], which used supervised learning and analyses to determine the reasons for the insufficient visual distances at the entrances and exits of expressway tunnels in mountainous areas. Machine learning techniques were also used in adaptive traffic signal designs and bus predictions by Abdulhai et al. [21] and Chienet et al. [22], respectively.

However, when the above-mentioned studies are compared, it can be seen that machine learning methods have not yet been systematically studied in the seismic applications of bridges. Therefore, this study first introduced the basic concepts, common methods, and platforms of machine learning. Then, based on the seismic damage experiences, seismic performance test results, seismic designs, it was determined how to effectively analyze the problems reasonably and quickly. Then, the basic idea of combining machine learning methods with seismic designs and evaluations of bridges was discussed in detail.

2. Overview of machine learning

Over the past 60 years, artificial intelligence technology, including machine learning, has evolved into a new national competitiveness, which has mainly benefited from the improvements of the power of computer hardware, algorithm optimization, and the accumulation of data volumes. Machine learning is the process of enabling computers to realize human learning behavior and constantly improve on their performances. It integrates multiple disciplines and absorbs the research achievements in probability statistics, cybernetics, neural network science, and computational theories in complex environments, as well as some other fields.

The mathematical expressions of machine learning processes are as follows: (x, y) will represent the sample in the problem space W, where x is an n-dimensional vector, and y is a value in an attribute domain. Generally speaking, only one true subset Q of W can be observed and denoted as $Q \subset W$, and is referred to as a data set. Model M is built according to Q, so that the prediction accuracy of M to all of the samples in W can be greater than a given constant θ [23]. The following content are implied in this description:

(1) The establishment of the data set Q makes the sample data have characteristic attributes. Generally speaking, data preprocessing and feature extraction must be completed;

(2) Model M is a generalization process of the problem space W, including the training, verification, and testing of the model algorithm;

(3) The constant θ is a measurement of the correct rate of the model M.

Data (set) characteristics, the model algorithms and measurement strategies are the key factors for the success of the machine learning processes.

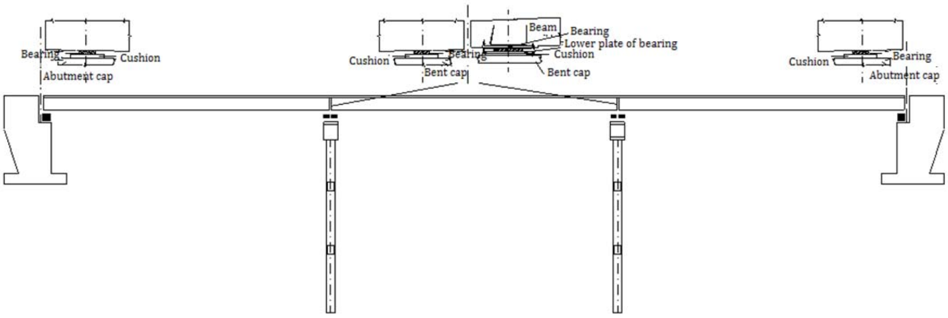
In reviewing the development of machine learning, it was found that the current machine learning mainly involves how to select or improve the algorithm matching tasks, and also about the task-independent learning theories and algorithm research investigations during the task-oriented completion processes. The social and economic benefits of the former are known to be significant. Meanwhile, the latter is the cornerstone of the steady development of machine learning. Previously, machine learning was generally divided into supervised learning and unsupervised learning, which was based on whether or not there were artificial annotations during the processes of the data processing. At the present time, machine learning is generally divided into four categories as follows: Supervised learning; unsupervised learning; semi-supervised learning; and reinforcement learning.

High-level programming languages, such as Python, C, Java, Scala, and so on, are used in the machine learning platforms to implement various machine learning algorithms. For the different machine learning tasks and various user service needs, the machine learning platforms can be selected in a targeted manner. The global business giants have utilized machine learning platforms and professional teams in order achieve major economic benefits, such as the Google Cloud Platform; Microsoft Azure; AmazonML; Tencent TML; Alibaba Cloud DTPAY, and other commercial platforms [25]. For small and medium enterprises, large data analyses and machine learning platform construction services can be provided by SkyTree, BigML, and

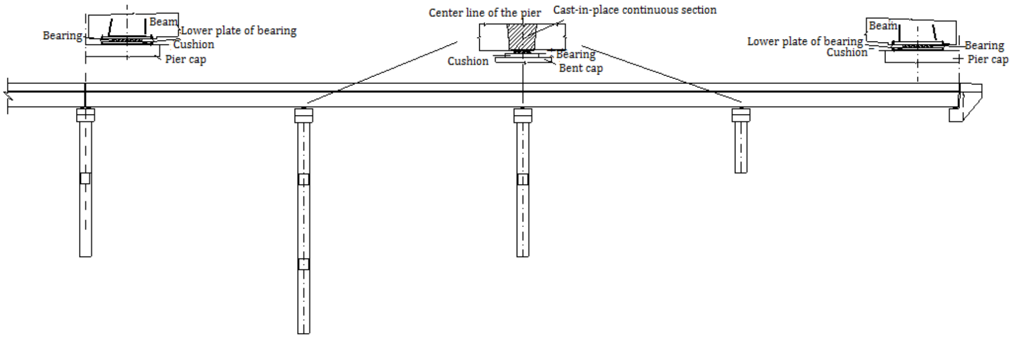
Wise.io, which are based on cloud modes for such users, effectively making machine learning a type of commercial service [26]. Also, GraphLab, Apache Mahout framework, Apache Spark platform, and Petuum are other popular open platforms which are capable of dealing with large-scale data [25]. Parallel data processing methods and computing models are generally used to improve the efficiency of the analysis processes. These are different from the traditional machine learning algorithms for small-scale data. When compared to the mining analyses of large data, the machine learning tools for small-scale data include Scikit-Learn (based on Python), Weka [24], and the Matlab platform developed by Java language, and so on. These tools can provide task-oriented machine learning algorithms and convenient secondary development interfaces for both individuals and research groups.

3. Aseismic points of medium and small span bridges

In highway networks of China, the structural types which are generally adopted in medium and small span bridges are simple supported girder bridges, and continuous girder bridges (with statistical significance). The superstructures of the simple supported girder bridges are generally supported by elastomeric pad bearings. For the continuous girder bridges, the fixed piers (or pot bearings) are generally set, and the rest of the piers adopt movable supports. In other words, the superstructures of such bridges are not rigidly connected with the piers or the steel support connections, as shown in Fig. 1. The statistical results of the 2008 Wenchuan Earthquake [27] indicated that the main seismic damages to the medium and small span bridges were longitudinal and lateral displacements (collisions) of the main beams; failures of the bridge supports; and failures of the bridge blocks. For the simple supported girder bridges, falling beams have been observed to easily occur, and the damage rate of the piers was only 2.4%. Falling beams did not occurred in continuous girder bridges. However, the damage rate of the piers was determined to be 35.6%, and the damages to the fixed piers were observed to be more serious.



Simple supported girder bridges



Continuous girder bridges

Fig.1 Normal types of medium and small span bridges in China

In this study, in order to complete a statistical analysis and objective evaluation of the bridge seismic damages, the seismic damage degrees of the bridges were divided. The seismic designs of the bridges during the life cycles of the bridges should meet a philosophy of “multilevel fortification, hierarchical energy-consumption”, as well as adhere to the principle of “one-can and three-easy”. In other words, during devastating earthquake events, “the injuries to the bridge components and the extent of those injuries can be controlled, due to the fact that the injury positions can be easily checked, the injured components can be easily repaired, and the damaged components can be easily changed”. Also, it is recommended that damages of bridge bearings (as fuse elements) should be priority generated in medium and small span girder bridges with cover beams which have undergone earthquake events [28]. However, the primary goal should be to ensure the availability of the bridges during the disaster emergency phases, which could potentially avoid cutting off external traffic in disaster areas. The second goal should be the maintenance and reinforcement of the affected bridges during normal use stages. Therefore, in order to achieve these goals, it is necessary to confirm the seismic damage degrees of the affected bridges. By examining the descriptions of the main seismic features which pertained to the Wenchuan earthquake event of 2008, the superstructures, substructures, piers, and abutments in the seismic design of the medium and small span bridges should be focused on. It was found that for the foundations, which were considered to be concealed projects, it was difficult to carry out large-scale and detailed seismic damage statistical evaluations. However, the seismic designs of the foundations could not be ignored.

In this study, in accordance with the structural types commonly used in medium and small span bridges in China, a series of seismic performance tests were carried out by Chinese and international researchers, which included bearings, blocks, piers, and so on. The purpose of the experimental research was to identify the factors affecting the seismic behaviors of the structural members of bridges, and to then regress the constitutive relationships for seismic simulation analyses purposes.

The seismic performances of the elastomeric pad bearings [29-37] which have been previously reported have mainly explained the phenomenon of friction slip. The main factors which affect friction slip are the constraint conditions of the bearings (whether they are anchored or not); friction coefficient μ; vertical pressure P (related to the span of the main girder and the cross-sectional area); total net thicknesses of the rubber layers Σt; shear modulus G; and the shearing areas of the rubber layers A_r. The constitutive relationships which are commonly used are shown in Fig. 2. The seismic designs of the supports can be roughly carried out once the above factors and arrangements of the supports have been taken into account.

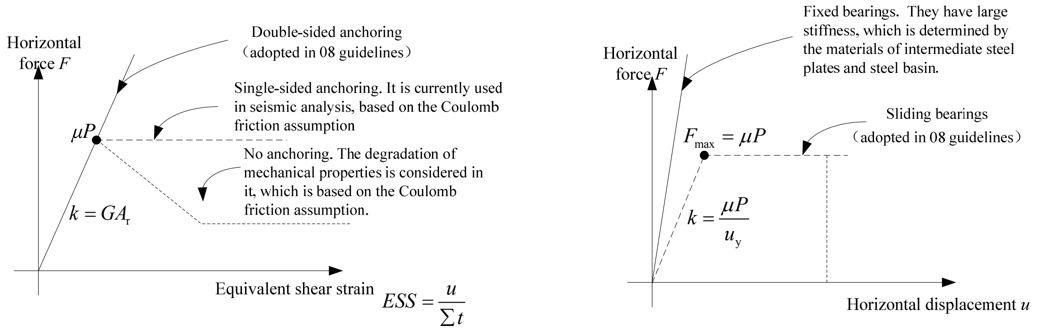


Fig. 2 Constitutive of the bridge bearings

Due to the manufacturing specialization, the rubber of the improved pot bearings (based in the elastomeric pad bearings) should be in a three-direction restrained condition, which could potentially improve the vertical bearing capacities of the bearings and meet the rotation requirements. The PTFE plates located between the upper and lower plates are able to slide horizontally. According to the design requirements, one-way sliding or fixation can be realized by providing a block or a sliding groove between the upper and lower plates. The seismic damages to bridge pot bearings following the Wenchuan earthquake were found to be complex, and could be roughly divided into the following three types:

(1) Undamaged: The stiffness of the fixed bearings could be considered as a constant, and a stable friction sliding surface could be formed by the movable bearings;

(2) Partial damages: The stiffness of the fixed bearings had been reduced. The displacements of the movable bearings had exceeded the design displacements, which made either slip out and take off empty;

(3) Complete damages: Dry friction had occurred between the bearing components and the superstructures or substructures. Also, the components may have become stuck resulting in consolidated formations.

The results of the seismic test studies of the elastomeric pad bearings which have been previously reported [38-40] have shown the seismic performances of the bearings were mainly affected by the friction coefficients, along with the mechanical properties of the intermediate steel liners and steel basin bearings. The performance parameters of bridge bearings have been stipulated in the "Pot Bearings for Highway Bridges" (JT/T 391-2009) [41], which mainly includes the vertical bearing capacity P; horizontal bearing capacity $F_{\max}$; friction coefficient μ; and the allowable displacement. The seismic checking method for pot bearings was stipulated in the "Guidelines for Seismic Designs of Highway Bridges" (JTG/T B02-01-2008) [42], and was referred to as the guideline in this study. The constitutive relationship which was adopted in the guidelines is shown in Fig. 2. At the present, the constitutive relationship of the state (1) is adopted in "08 guidelines", and it should be checked whether states (2) and (3) will occur. However, the aforementioned remains debatable.

The collisions between bridge beams, or between beams and blocks, are caused by the longitudinal and transverse displacements of the main girders. In severe cases, falling beams may occur. The transverse seismic damage statistics of the medium and small span bridges during the Wenchuan earthquake indicated that shear failures had occurred in the bridge blocks. A series of studies regarding the mechanical properties of reinforced concrete blocks were carried out by Megally et al. [42]. The contributions of the concrete and reinforcement parts were separated, and a hysteretic model was created. In accordance with the general forms of bridge blocks in China, seismic performance tests were carried out by Xu Luqin [43-45], and a simplified model was proposed, as shown in Fig. 3.

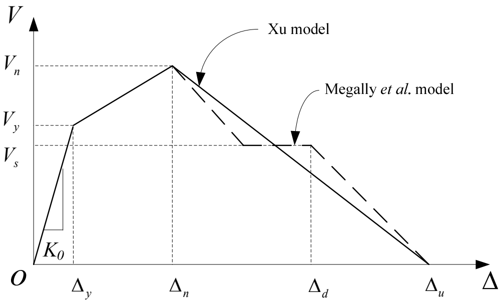


Fig.3 Mechanism model of shear key

The results of the comprehensive test were used to determine the parameters which influenced the hysteresis model of the shear keys. The parameters were determined to be the concrete compressive strength f_c; shearing area A_c (width $b(B)$ and height $h(H)$ of the capping beam); yield strength of shear reinforcements; horizontal stirrups f_{yv}, f_{yt}; area A_v, A_t of these reinforcements; and the arrangement.

For the longitudinal displacements of the main girders, which could potential cause unseated and even falling beams, the minimum shelving lengths of the beams should be focuses of the bridge designs.

Also, piers are important components in the bridge seismic resistance. Extensive experimental research studies and numerical simulations have been conducted by Chinese and international researcher groups, which have focused on the designs of plastic hinged areas on reinforced concrete columns. The summations of the experimental research results [46-51] have presented that the seismic performances of reinforced concrete piers were characterized by the displacement ductility index μ_Δ. The functional expression can be written as follows:

$$\mu_\Delta = \mu_\Delta(\eta, L, A, c, f_c, \rho_l, f_{yl}, \rho_\omega, f_{y\omega}, s, s') \tag{1}$$

In which η is the axial compression ratio, which reflects the vertical pressure of the pier top; L denotes the pier height; A is the cross-section size of the pier; f_c represents the compressive strength of the concrete; ρ_l, f_{yl} are the longitudinal reinforcement ratio and yield strength, respectively; and ρ_ω, $f_{y\omega}$, s, and s' denote the stirrup ratio, yield strength of the stirrup, stirrup spacing, and arrangement form, respectively.

In numerical simulations, fiber models of the reinforced concrete columns were the first choice of the researchers. The fiber models consisted of confined concrete, unconstrained concrete and longitudinal reinforcements. Different constitutive relationships between the three types of material fibers have been proposed by researchers. The constitutive relationships of the concrete were the Kent-Park model [52], Scott-Park model [53], Mander model [54]. The relationship differed depending on the conditions of the stirrups. The parameters of the constitutive relationship of the confined concrete and the unconstrained concrete could be connected by the stirrup ratio. For the reinforcements (soft steel), the main mechanical indexes included the yield strength, elastic modulus, and ultimate strength, which were reflected by the ratio between the ultimate strength and the yield strength.

The seismic damage formations of the abutments could be mainly divided into two types according to the seismic damage data. The first group was the slippage of the abutments due to the foundation failures and the subsidence caused by the soil filling. The second group included the abutment cracking due to the collisions between the superstructures and the abutments. Therefore, both anti-sliding stability and strength evaluations of the abutment components are necessary for bridge safety. The seismic responses of the abutments can generally be simulated according to the research results of the California Code [55]. The sizes and design material of the abutments should be considered, as well as the mechanical properties of the backfill.

In recent years, research studies regarding foundation (pile)-soil-structure interactions have been continuously carried out. The mechanical state of the soil around bridge foundations (piles), as well as the dynamic impedance of the lateral soil to the piles, have been examined. Also, simulation models of pile- soil-structure interactions have been previously proposed [56]. However, from a design point of view, pile foundations are generally used as capacity protection members, and should maintain elasticity under earthquakes and meet bearing capacity requirements [57]. The design parameters should include the following: Diameters of the piles; lengths of the piles; layout formations; material; reinforcements; and the proportional coefficients of the foundation coefficients.

Finally, independent of the structures themselves, the most fundamental elements of seismic analyses are the uncertainties of the ground motions. The randomness of the ground motions tend to lead to differences in the demands of the structural responses. Therefore, it was necessary to select reasonable ground motions for this study's analysis. It is recommended that researchers select a certain number of ground motions for analysis and statistical processes in accordance with the site conditions, magnitudes, epicentral distances, and fault distances.

4. Realization of machine learning in bridge seismic design and evaluation

In comparison with other professional fields, machine learning has not yet been used in the seismic designs of bridge structures. Therefore, in order to address the forward-looking needs, the study of the applicability of machine learning technology in the seismic designs and evaluations of bridges was introduced in this study, and the shortcomings of the current vulnerability analysis processes for Chinese bridges was briefly discussed in the following section.

When based on large amounts of data, machine learning algorithms can usually create statistical models which can make predictions from similar data instances. Therefore, the selected bridges in this study were mainly medium and small span girder bridges which had similar structure types, and clear seismic design goals making them statistically significant. The primary tasks of machine learning were to obtain the data of the bridge designs and compile it into a data set. The data in this data set had the attributes which represented the seismic design factors (SDP) of the bridge components; engineering demand parameters (EDP); and seismic performance indicators (SPI) in the seismic analysis. The seismic design factors were summarized based on the seismic damage phenomena, seismic tests, and design data. The engineering demand parameters were obtained by a large number of finite element analyses. Those parameters reflected the seismic damage phenomena, and had a good correspondence with the seismic performance index. The seismic performance indexes should be determined according to the seismic damage phenomena, seismic test rules, and seismic fortification targets. In the finite element analyses, the uncertainties of the ground motions and structural modeling should be fully considered. Second, the data sets used in this study's machine learning were processed to prevent false correlations of the attribute data. The calculation efficiency was improved by reducing the dimensions of the data sets. Finally, the reduced data sets were used to train and validate the selected model algorithms, and the algorithms could then be used in the seismic designs and evaluations of the new instances. These processes were the induction and deduction processes. The execution process of the machine learning model is required to be easily communicated to the bridge engineers, which will result in the engineers having good trust in the seismic designs and evaluations based on machine learning. The general idea of the aforementioned approach is described in Fig. 4, which can be potentially used to judge whether a seismic design is reasonable, conservative or non-conservative. Then, reasonable predictions can be provided for the new examples.

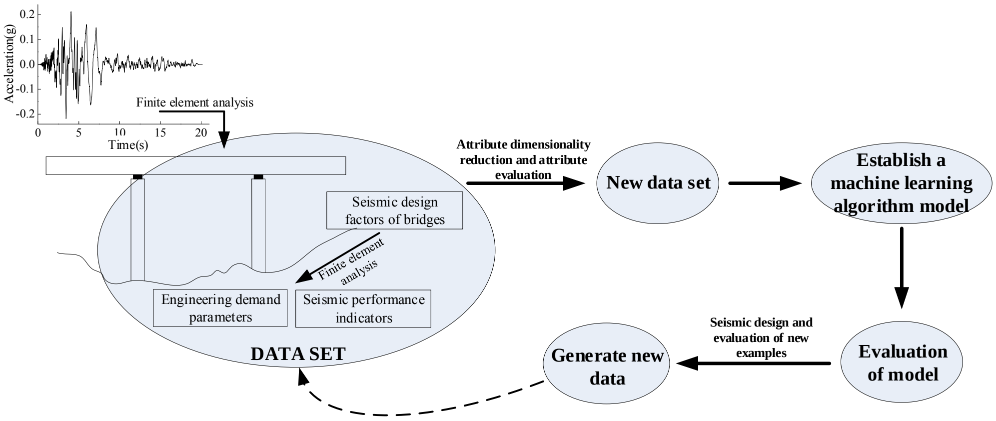


Fig.4 Overall analysis methodology

As can be seen from the flow chart detailed in Fig.8, the seismic design and evaluation method of the bridge based on machine learning involved the entire process, from "the summary of the seismic damages" to "the discovery of the seismic law". There were two main aspects in task-oriented machine learning process. The first was to collect a large number of bridge design data in order to carry out a large number of finite element analyses and establish the data sets. This was the fundamental aspect. The second was the data mining, including the processing of the raw data, and debugging or developing a reasonable machine learning algorithm model to complete the set tasks. This was also a key aspect of the process. The new data generated in the application of the new instances could be continuously filled into the data sets, thereby improving the performances of the model algorithm, and avoiding the phenomenon of "over-fitting", which constituted a system of continuous optimization and a closed loop.

Machine learning is not a substitute for traditional statistical analysis techniques. Instead, it is an extension of the statistical methodology. In the current performance-based bridge seismic design and evaluation methods, a nonlinear time history method with the probability form of statistical regression became an effective tool for quantifying the seismic performance of the bridges. This method has been widely used in seismic vulnerability analyses. However, the following points were found to be difficult to grasp in the vulnerability analysis of the examined Chinese bridges in this study:

(1) Based on Probabilistic Seismic Demand Model (PSDM) methods for the seismic demand distributions of structures, quantitative methods of the uncertainties of structural capabilities have been assumed. However, minimal attention has been paid to the methods by researchers in China, who have mainly referred to the recommended values of Nielson [57] and Ramanathan [58]. It should be noted that the structural systems, material properties, and structural designs of Chinese bridges are different from those of bridges in the United States.

(2) The structures and parameters of the ground motions have a certain randomness. When researchers have used nonlinear time history methods for the seismic vulnerability analysis of each bridge, the randomness of the parameters should be considered through multiple repeated tests, but the selection of these parameters will be greatly influenced by the subjective factors introduced by individual researchers.

(3) In the formation processes regarding the vulnerabilities of the bridge components to the vulnerabilities of the systems, it was necessary to assume correlations among the seismic demands of each component. It was also assumed that the seismic demands of the components were in complete correlation, zero correlation (first-order boundary method), or linear correlation (Monte-Carlo Method). The correlation of the seismic demands of the various components has been disposed by the Copula function in the previous research results [59]. However, it was found difficult to choose the appropriate Copula function in this study. Therefore, it was difficult to accurately describe the nonlinear correlations among the seismic demands of the components.

Clearly, vulnerability technology is based on perfect mathematical theories and strict assumptions. However, the performances of computers have developed rapidly. Subsequently, seismic designs, related experimental research, and the seismic damage experiences of bridges have also rapidly accumulated in the past few decades. In particular, the performances of medium and small span highway bridges have attained large quantities of data, and a great deal of repetitive and learnable data has been collected. Therefore, it is now possible to complete engineering requirements quickly and efficiently through "data science" (performance-based seismic designs and evaluations). In the face of the characteristics of the aforementioned tasks, it is possible to obtain effects and purposes using machine learning which traditional analysis techniques could not previously achieve.

5. Conclusions

In this research study, it was found that very large amounts manpower and financial resources were being invested in single projects (medium and small span girder bridge) that had the same or similar structural characteristics. It was determined that due to the high repeatability of these design processes, as well as the rich experience of the designers, the power of artificial intelligence should be strongly utilized. In this study, it was necessary to convert the design experiences into data for computer systems and establish data sets. Also, the design was assisted by a reasonable algorithm model. This method was applied to a large number of bridges in a certain area, and a database was established. The model algorithm which was suitable for the task was then debugged. In accordance with the research plan, the machine learning methods were used to conduct the seismic designs and evaluations of medium and small span girder bridges in a certain region of China. Then, data sets and applicable model algorithms were formed. Finally, the data sets and the related model algorithms were provided online. The bridge engineers conducted their own seismic analyses of bridges through Internet users and contributed more bridge data to the open data set in order to improve the universality and applicability. With the development of science and technology, disaster prevention measures and the mitigation of engineering structures should not only be limited to single projects, such as one bridge or one building. The structural, regional, and socio-economic characteristics should all be considered [60]. Therefore, by analyzing regions and lines, and establishing computational simulations based on artificial intelligence method, raw data collecting ability, data mining ability and analytical result capability will be improved.

In the field of disaster prevention and reductions in engineering structures, the applications of new technologies and methods have become a growing trend. In the future, scientific research personnel will be required to correctly understand and firmly grasp the related professional knowledge in order that they could possess excellent professional qualities. Also, cross-professional innovations need to be encouraged so that the integration of disciplines can be promoted, and the exchanges between different professionals can be strengthened.

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