CASE STUDY OF BRIDGE STRUCTURAL SIMULATION LIFE PREDICTION BASED ON DATA MINING

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***ABSTRACT**: Bridge life prediction based on data mining can produce significant economic benefits in production practice, so there is a wide range of needs in the actual production. However, data mining is applied to the life prediction of bridges. The theory and practical application in this field are rare in China. Therefore, the work of this article not only has some value in the theoretical field, but also has a broad application prospect. Experiments show that, according to specific problems, this algorithm can extract valuable life prediction rules in a group and predict the life expectancy in a group more accurately.*

***KEYWORDS**: Data Mining, Background, Bridge Structure, Simulation, Life Prediction, Instance Analysis*

1 INTRODUCTION

By the end of 2013, the total number of highways and bridges in China exceeded 700,000. Under the complex environment of typhoons, earthquakes, floods, overloading, corrosion and explosions, a large number of existing bridges are facing complex service environments and multi-hazard loads leading to the accelerated evolution of the damage and the overall health and safety of the bridge. In addition, along with a series of extra-large cross-sea and cross-river channels such as the Bohai Bay Passage Project, the Qiongzhou Strait Passage Project, the Hong Kong-Zhuhai-Macao Bridge and the Shanghai-Shanghai Railway Bridge, with the planning and construction of the project, China is facing the daunting technical challenge of building super-large bridges under complicated conditions. At present, the structural health monitoring system with the ultimate goal of ensuring the safe operation of bridges has been widely used in the operation monitoring of long-span bridges. However, most of its applications focus on historical data accumulation and overall safety assessment under accidental events. Bridges SHM faces the technical bottleneck of early damage warning, online safety assessment and future maintenance and repair decisions.

In the design of the concrete structures in the city when the bridge material to use low heat, low alkali content of engineering cement. Similarly, the aggregate of the concrete bridges should be both clean and durable. In the grading and grain grasping of coarse aggregates, it is necessary to control the dosage of unidirectional concrete cement by using a variety of the methods to then minimize the content of Portland cement in the cement material. In general, the bridge structure in the design process to improve the durability of the concrete structure of the specific programs includes the following aspects.

[1] Special corrosion protection measures should be taken for parts that may be subjected to chloride corrosion or dry wet alternation and water level changes, such as concrete surface waterproofing, surface coating or hydrophobic treatment. At the same time, a variety of structural seams should be avoided as far as possible.

[2] Reasonable selection of structure or components. If you want to enhance the overall stiffness of the bridge structure to reduce the fatigue vibration of the bridge, then you should try to use the box section. In addition, we should try to use all pre-stressed structure so as to protect the cross-section in the course of the tensile stress will not occur, and thereby preventing the structure cracks.

[3] In the concrete bridge structure is usually arranging the massive steel bars, once the protector destroys or thickness is unreasonable, it will cause the moisture content, the air and other materials enters corrodes its steel bar will cause the structure the durable drop. Therefore, the bridge structure protector is thicker, the steel bar more has the possibility to avoid the long time the corrosion, the steel bar corrosion speed is lower and thus the bridge structure use is more durable.

[4] Under a certain loading distance, the bearing capacity of pile foundations decreased with the increase of pile loading level. With the decreasing of pile loading distance, the decrease of

bearing capacity of pile foundation became larger; however, the pile loading level increased and the decrease of bearing capacity of the pile foundation gradually decreases. The pile's horizontal displacement increases with the stacking level, but as the stacking level increases to a certain extent, the horizontal displacement remains basically unchanged.

According to the definition of the UNCTAD, the early warning is early warning of impending disaster. In the field of safety engineering science, its connotation includes urgent warning of impending accident and secondary disaster after some time. In order to ensure the structural safety through early warning, it is necessary to deal with technical difficulties so that it can predict the change of complex engineering structure from material and structure to the whole structural behavior to predict the outcome of the whole future. This is the prognosis technique. Prognostic techniques include two parts: prognosis analysis and prognosis control. Prognostic analysis early warning is given when there is a breakdown or injury in complex structures through monitoring, identification, diagnosis and evaluation. Prognosis control is a response to then give prognostic analysis as technical measures and management activities such as maintenance, renewal and reinforcement etc. to prevent and control the trend of the performance decline or change caused by initial failure, damage or abnormal event.

2 BRIDGE LIFE PREDICTION BASED ON DATA MINING

2.1 Data mining

The attribute set of a certain category of data can form a conceptual hierarchy with a definite partial structure: all the attributes hi (i = 1, ..., n) in the attribute set H = {h1, ..., hi, ..., hn} Concept focused concept. According to the knowledge of domain, some attributes form a partial ordering relationship, corresponding to the partial ordering relationship between the concepts of finite concepts. After an attribute is instantiated, it corresponds to a number of specific attribute values, which are highly semantically formed attributes.

The main tasks of multi-scale data mining are two-fold, that is, multi-scale data realization and knowledge multi-scale mining: the former belongs to data pre-processing and can be realized by using data scale partitioning; the latter needs to improve specific mining techniques and data in multiple scales of expression in the discovery of knowledge, analysis, derivation of knowledge between the interrelated.

Scale conversion is the core content of multi-scale scientific research. Scholars have proposed three kinds of scale conversion approaches for spatial data mining, which can be summed up in two aspects, that is, multi-scale conversion of data and multi-scale conversion of knowledge. In fact, the research method of scale spatial data mining is also applicable to the general research of multi-scale data mining. It is easy to see that the principle of multi-scale conversion of data is simple, but the multi-scale representation of data needs to be excavated separately as multi-scale conversion workload is small, only single-scale data mining, but need to solve the problem of scale effect, the principle is complex. Scaling effect refers to the conclusions drawn on a scale cannot be applied without distinction to another scale, namely: when the research object changes its performance scope, granularity or amplitude, the analysis result will change accordingly. Similarly, the knowledge obtained from a dataset of a basic certain scale cannot be applied to data of other scales indiscriminately, and it is necessary to use the domain knowledge or multi-scale data sets of the relationship between the results of the excavation deduction, reduction, it is possible to achieve a real sense of knowledge It is clear that the multi-scale conversion of knowledge is the essence of multi-scale data mining.

This paper proposes to use the concept of hierarchy to distinguish between the size and scale as in fact extended the concept of scale, that is, concept of partial ordering with the concept of inclusion can be considered as a scale, such as the school's administrative composition, etc. According to the concept of hierarchical knowledge, we It can be considered that any dataset is a multi-scale dataset with mathematical partial ordering relationship, of which the most special case is that all the scales of concept hierarchies are in parallel relationship, that is, there is no inclusion relation between any scales. In the strict sense, the multi-scale of some data does not have practical significance, that is, in practical applications, not the general multi-scale data are of practical and practical significance. Through the above analysis, we can draw the essence of the standard is the size range covered by a certain unit of measure.

$$Z_0^*(x) = \sum_{i=1}^{n+1} \lambda_i Z(x_i) \quad (1)$$

$$\lambda = K^{-1} D \quad (2)$$

The specific forms of matrices K and D are as follows:

$$K = \begin{bmatrix} c_{11},\ldots,c_{1n},1 \\ c_{21},\ldots,c_{2n},1 \\ \ldots \\ c_{n1},\ldots,c_{nn},1 \\ 1,1,\ldots,1,0 \end{bmatrix} \quad (3)$$

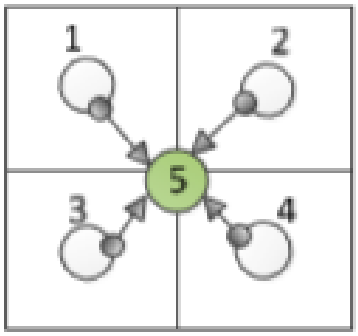

Figure 1. Scaling-Up calculation of region kriging method

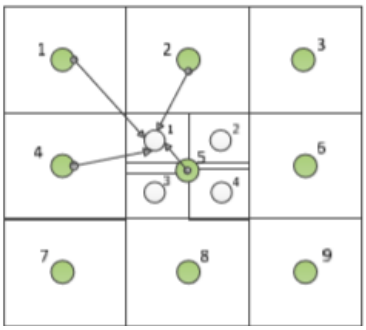

Figure 2. Scaling-Down calculation of point kriging method

2.2 SHM and Damage Identification

SHM is a process of damage detection (DD) in the fields of aviation, civil engineering and machinery. In civil or mechanical systems, damage is defined as the deliberate or unintentional change of material or geometric characteristics, including boundary conditions and connections, to adversely affect the current or future performance of the structure or system. Cracks in a given structural member result in changes in the stresses and stiffness of the structural member. Depending on the size and location of the fracture, and the type and size of the load applied to the structure or system, the detrimental effects of the dehiscence may be either immediate after a certain time to change the mechanical properties of the structure or system. At scale, all damage begins at the material level and then enters the component level and system level at different rates under the appropriate load conditions; on a time scale, damage builds up over time (e.g., associated with fatigue or corrosion), or as a result of planned discrete events (such as aircraft landings) and unplanned discrete event outcomes (such as rapid maneuvers and random shocks), damage can develop on a fairly short time scale. Therefore, the damage has obvious spatiotemporal and multi-scale features.

SHM involves: ① using a series of sensors to periodically collect the dynamic response of the system and observe the system over time; ② extracting damage-sensitive indicators from the measured mass information; ③ statistically analyzing these indicators to determine the current damage status of the system. For long-term SHM, the output of the system provides continuously updated information to reflect the expected function of the structure to accomplish its constant aging and degradation. After extreme events such as earthquakes or explosive loads, the SHM can be used for fast and rapid state assessment, with the goal of providing reliable information that reflects structural integrity in near real time, a process known as condition monitoring or simple diagnostics. The original goal of the SHM system was to replace the inefficient manual inspection cycle with a continuous monitoring system to reduce the frequency of traffic closures and increase the probability of damage detection prior to a catastrophic failure. More importantly, on-line continuous monitoring allows cost-optimized state-based maintenance.

2.3 Security testing

Bridge assessment is the use of specific information to analyze the reliability of existing bridges and bridge to maintain a certain level of reliability and make the appropriate engineering decision-making process, including safety assessment, durability assessment and reliability assessment. In practical assessment, small and medium-sized bridges generally focus on the method of carrying capacity assessment. For large bridges, the emphasis is placed on the safety assessment, that is, based on the monitoring information of the SHM system, combined with the theoretical analysis model, the characteristics of the structure, the experience of experts and relevant normative documents, effective assessment methods and methods are used to analyze the current health status. Using performance and safety rating for evaluation and make maintenance decisions based on this. The main methods of safety assessment include routine comprehensive assessment, fuzzy comprehensive assessment, gray relational assessment, neural network and genetic algorithm safety assessment and modified model assessment.

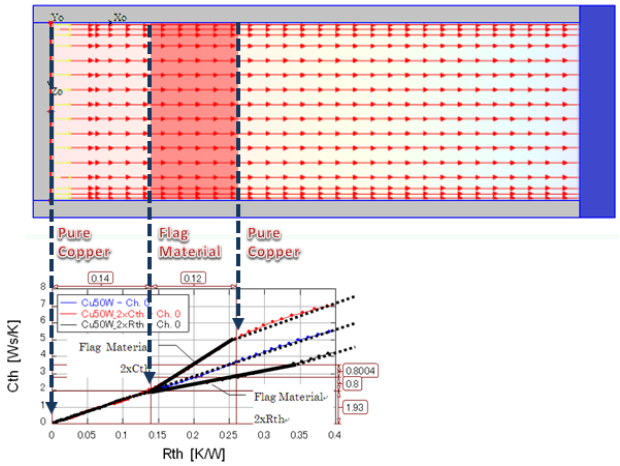

Figure 3. The security modelling of the testing

The city concrete structure bridge flooring took the vehicles and the bridge direct contact part, while load bearing vehicles, is the draining water first defense line, adds the stress and flexure which the king post transmits change, very easy to have plant diseases and so on early bridge floor breakage, thus and so on has the influence to bridge floor draining water, but corrodes the bridge the main reinforcement. When the city concrete bridge paving concrete and the king post peeling situation occurs, can to the entire king post stress performance, the bridge durability and the security has the direct influence and the concrete structure bridge floor waterproof layer is avoids the bridge floor the rain water under and so on infiltrating effectively to a king post defense line, but in the concrete structure bridge construction process, some construction uses the waterproof concrete to turn on the water merely, this waterproof effect is by far insufficient.

General structure of the bridge are fixed refers to the superstructure. Then the specific construction technology is; increase the cross-section of the road to do a good job of top reinforcement, fixed bonded external structure as additional stringers and so on. In general, the surface area is increased by means of loading and clearance, and then by increasing the cross section and reinforcing steel reinforcement and paste structure is adopted with adhesiveness quality assurance binder (usually refers to epoxy resin), wake up after about FRP or material paste the outside of the bridge structure, increase its load capacity, and thus reduce the damage of the general bridge. The peak reinforcement is generally refers in the structure addition construction, or is the rate of head movement achieves the bridge floor path reinforcement goal in the original construction, counterbalances own gravity with the aid of the compelling force the function, then closed crevasse and reduced crevasse continuation growth. Supposition carline is refers in the original bridge structure additionally builds the bridge pier or other backings, uses for to enlarge the pontic structure support strength, then reduced destruction. On the other hand is the level of the lateral displacement of soil around pile, which can lead to pile body to produce the problem such as deflection and the horizontal displacement is too large, this a series of problems will cause pile under the bending moment of actual value is greater than originally designed bending moment value that will affect the normal use of the upper structure. The so-called negative frictional resistance is caused by the relative movement between the pile and the pile foundation due to the settlement deformation of the soil.

The existence of negative friction force will lead to the increase of the force and deformation of the pile, and even the pile foundation will be destroyed. Above scholars conclusion shows that the causes of pile settlement is in the peripheral produced negative friction resistance, the cause of pile settlement and other: due to the force to pile load of pile after pile and soil pile side, lead to lower part of the pile end soil compression deformation, further increase the settlement of the pile body. Therefore, the following aspects should be highlighted.

[1] Steel reinforcement plays an important role in bridge construction, which is a very important construction material. Therefore, strict quality inspection and inspection should be carried out when reinforcing steel bars.

[2] Application of construction technology and construction technology of the content clear view and verification, to ensure that the expected design of bridge engineering construction technology application results meet well site construction technology application in the process of supervision and inspection work details, make sure that the application of the construction technology of beam bridge engineering achieved satisfactory results.

The basic idea of bridge safety early warning is based on the data analysis of real-time monitoring information of bridge structure. Based on the safety assessment, the measured value of the early warning indicator is compared with the set thresholds of different safety levels to determine what pre-warning state the structure enters. Bringing alarms to the bridge custodial staff and researchers enables the relevant departments to enter the scene as soon as possible and confirm the possibility of a disaster so that timely and effective measures can be taken

to prevent the occurrence of the disaster or reduce the losses caused by the disaster.

Therefore, the bridge structure safety assessment is the first level of the SHM safety prognosis of the bridge. The goal is to evaluate the current health status, service performance and safety grade of the bridge structure in combination with a monitoring or test. The maintenance and repair strategy is suggested. The safety early warning of bridge structure is the second level of the safety prognosis of bridge SHM. Its goal is to carry out safety alarm on the abnormality of the bridge structure (exceeding the indicator) or the limit state exceeding the carrying capacity on the basis of the bridge safety assessment so that Relevant departments can take timely and effective measures to prevent disasters or reduce the losses caused by disasters. The bridge safety prognosis is the ultimate goal of the bridge SHM. It predicts the safety performance of future load environment and structure on the basis of safety assessment and safety warning. Take the necessary safety precaution measures and carry out necessary reinforcement construction so as to avoid the occurrence of major losses to the greatest extent and ensure the basic functions and safe operation of the structure.

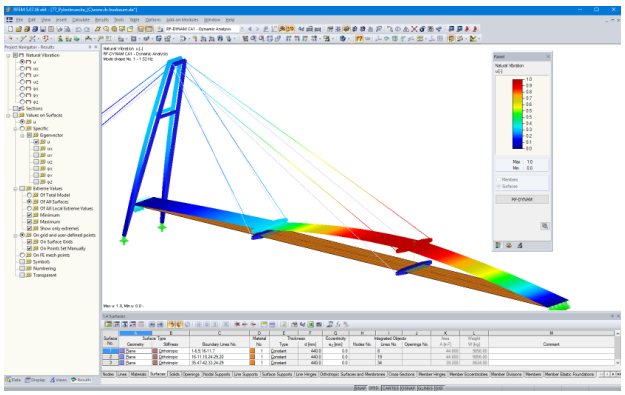

Figure 4. The sample testing system UI

The safety warning and the safety prognosis all have the predicting function, but their respective focuses are different: the safety warning is mainly based on the regulatory limit or the theoretical limit, and the structural monitoring parameters are judged to exceed the thresholds of different safety warning levels. If the safety threshold is exceeded, analysis is needed determine whether there is a corresponding damage to the bridge structure and make reasonable disposal decisions. The safety prognosis is based on the historical data of health monitoring and its development trend to predict the future security status of the bridge structure, to make the appropriate engineering decisions and maintenance of the updated construction. Obviously, the prognosis of structural injury can provide strong support for structural safety prognosis.

2.4 Injury prognosis method

Methods based on data mining may be the most efficient and intuitive, focusing on material deformation, fracture, fatigue and damage, and the connection between materials. Model-based structural damage prognosis is bound to face two core scientific issues, that is, multi-scale simulation and simulation methods of complex engineering structure from micro to macro, as well as the numerical simulation results obtained under the specified accuracy and reliability.

One of the key problems in the prognosis of structural damage is the uncertainty in the analysis of the damage prognosis. The numerical simulation analysis under the specified accuracy and reliability must consider the uncertainty. Only when the variability of structural calculation parameters is small, the deterministic analysis of the model can give more realistic results. In order to ensure the reliability of the model, the uncertainties of the parameters in the model must be integrated into the simulation analysis. Therefore, the analysis on the bridge data will be essential. Change the structure of the stress system reinforcement method by changing the bridge structure of the stress system in order to achieve the purpose of improving the overall load carrying capacity of the structure is a passive to active reinforcement method. Including the addition of the fulcrum in the middle of the beam, the addition of joists, the removal of pillars, and the conversion of multi-span simply supported beams into basic continuous beams. "Changing the stress-bearing system of the structure can greatly reduce the calculated bending moment and improve the structural components of the bearing capacity to achieve the purpose of strengthening the original structure.

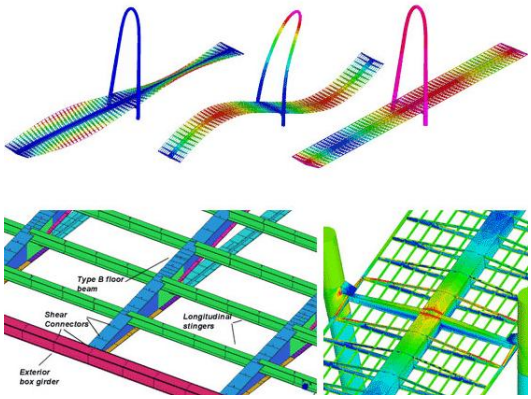

Figure 5. The optimized structure of the proposed model

Usually, the pillars of brick columns, reinforced concrete columns, steel pipe injection or steel columns, brackets, joist often reinforced concrete or steel structure. The monitoring values of all parts of the bridge are within the specified range under normal conditions and the upper and lower limits of the core normal range are set. When the monitoring data exceeds this range, attention should be paid to it, which may be erroneous data or may be a bridge structure has been abnormal. In addition, you can also use the variance and mean to help judge, by analyzing the changes in the specific parts of the bridge monitoring the trend of parameter values, can help to examine the changes in the bridge structure is normal. Therefore, the following countermeasures of the core skill of monitoring bridge can be summarized as the follows.

The static load test of the bridge is generally to load the vehicle load in the specified position, observe its performance parameters such as displacement, strain and deflection under the action of the experimental load, and check the condition of the bridge in order to understand the influence of the bridge structure on the load conditions and Static load test under mechanical properties to determine the actual carrying capacity of the bridge to determine the bridge structure under load performance and load carrying capacity.

First of all, according to the design drawings, the first to establish the finite element model of the bridge, the real bridge dynamic load characteristics through the real test to obtain the bridge load test, measured using optimization algorithm or the genetic algorithm to bridge dynamic characteristics as a result of the target, the correction of the initial finite element model, the dynamic characteristics and measurement for finite element model the value is consistent, if the characteristics are basically the same, the benchmark model representing the correction can be then used for bridge damage identification comparison model.

The bridge health monitoring system has accumulated a large number of the health monitoring information in the long-term operation, which can be used to construct the state equation of the model after five or three smoothness. Long-term health monitoring data based on bridge structure.

3 CONCLUSION

Existing bridge structure life assessment methods all have certain one-sidedness. By applying the principle of system simulation and time-varying reliability theory, we make the time-varying factors that affect the structural resistance and obtain the time-varying equations of the structural resistance variation with time. This method only qualitatively evaluates the structure and is generally used when the maintenance component of a bridge decides which method of the conservation to adopt, rather than quantitatively reflecting the actual capabilities of the structure.

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