Construction of Automatic Identification System for Bridge Structural Parameters Based on Improved Damage Algorithm

Baoshun Liu

{baoshun2000@163.com}

School of Road Bridge and Architecture, Chongqing Vocational College of Transportation, Chongqing, 402247, China

Abstract. As a type of transportation building, bridges can help pedestrians cross rivers, lakes, and seas. However, in addition to serving as infrastructure, they can also take on aesthetic responsibilities in some landscape designs. In addition to considering their practicality and stability, bridge structural design also needs to consider appearance and aesthetics at certain times. In order to build a qualified bridge and ensure its safety, the parameters need to be strictly designed. Therefore, this paper proposes a related Automatic identification system based on the improved damage algorithm, which can automatically analyze and access the bridge structural parameters, and calculate and predict the damage degree of bridge building materials. These data can also be fed back to users through the Automatic identification system.

Keywords: Improved Damage Algorithm, Bridge Structure Parameters, Automatic Identification System, Sensitivity Matrix

1 Introduction

Since the monitoring of bridge structure and its related parameters cannot be ignored, and the Automatic identification system is just competent for this work, and the improved damage algorithm is also specialized in studying the damage degree of building materials, this paper would apply these technologies to bridge construction.
Monitoring bridge structures is a crucial task for bridge construction. El Dahr R proposed that the use of Structural health monitoring is an effective operational technology to enhance the robustness of infrastructure [1]. Amendola G analyzed the impact of the performance of double concave friction pendulum isolators on the seismic performance of isolated multi-span continuous bridge decks in her research [2]. Dang H V proposed using deep learning technology for health detection of bridge structures [3]. Mousavi A A believes that bridging is an important process in conducting damage assessment [4]. Castaldo P proposed the need to study the optimal Sliding friction coefficient of the bridge [5]. Many of them are for the design of bridge structural parameters.

In order to pay attention to the bridge construction and the monitoring of

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parameters in real time, this paper believes that the Automatic identification system can play a role in this work. Nogay H S believes that Automatic identification system can be used to detect Seizure [6]. Kasinathan T proposed that the Automatic identification system can be used to classify and detect insects in field crops [7]. Gedon D believes that the deep state space model can be constructed by using nonlinear System identification [8]. March D proposed that many emerging technologies such as micro Satellite constellation can help the Automatic identification system of ships [9]. And this article believes that improving the damage algorithm can be used as the basis for real-time evaluation of damage to building materials. In addition, Gomes G F proposes using a sunflower optimization algorithm to evaluate the performance of laminated composite structures for damage [10]. Voyiadjis G Z believes that damage algorithms can be used to solve some problems in concrete damage modeling [11].

This article first provides an overview of the design of bridge structural parameters, and uses sensitivity matrices to assist in constructing finite element models. Then, it analyzes the operational mechanism of improved damage algorithms and monitors the degree of damage to bridge building materials, serving as a bridge for infrastructure construction. It is common for them to experience various stresses and cause damage after being put into use. Finally, the Automatic identification system is established to identify and access the bridge structure parameters. Through this system, users can easily learn the bridge structure parameters in real time through the terminal, and make decisions at any time to adjust the design.

2 Design Process of Bridge Structural Parameters

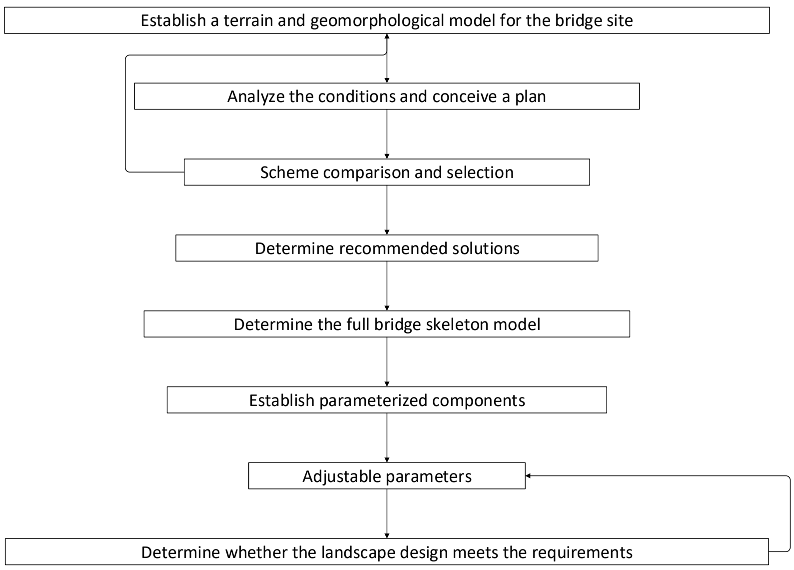

Fig.1 Determination of Scheme and Component Parts in Bridge Parametric Design

Basar IA believes that operational parameters would become important reference objects in the field of chemistry [12]. And the design of bridge structures is also difficult to depart from its parameter design, as Wang G N said, the core of parametric design lies in "parameters" and "correlations" [13]. It has to be said that parametric design can highly refine the design of buildings and effectively improve the efficiency of structural adjustment and improvement. In his research, he classified and summarized the process of parametric design for bridges.

In the parameterized design of bridges, the determination and composition of the scheme are shown in Figure 1, and it can be seen that the entire process is very detailed. Firstly, the terrain and geomorphology model of the bridge site needs to be constructed, followed by analyzing the conditions and conceptualizing the plan. Among the many plans, it is necessary to select the optimal one from them. After determining the recommended solution, a series of processes such as the full bridge skeleton model, parameterized components, and the full bridge parameterized model need to be determined. Finally, adjust the parameters and observe whether they meet the design requirements. If they are not suitable, the parameters need to be readjusted. ChengW F E I proposed that the establishment of parameterized models is very important [14].

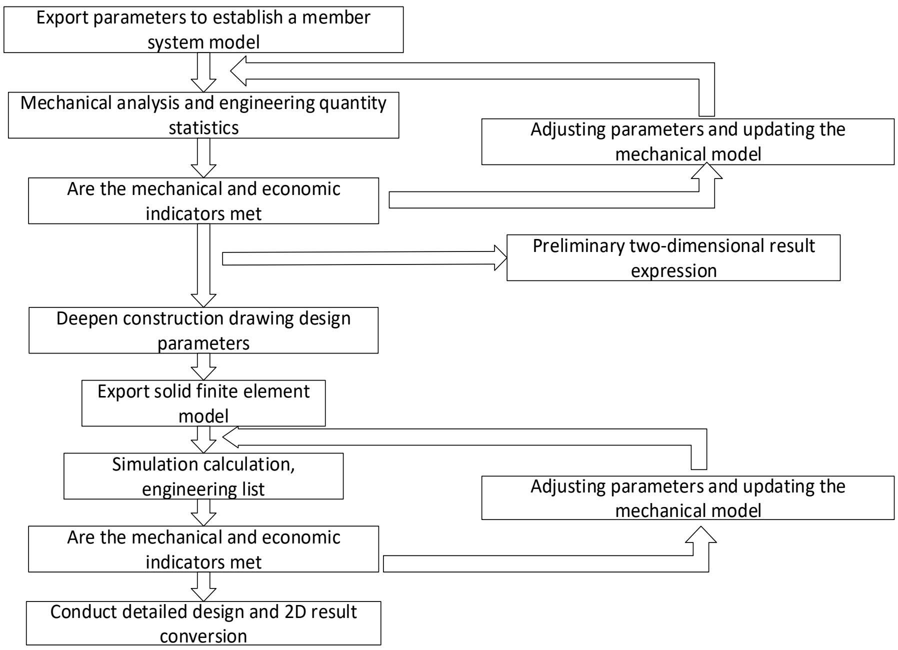

Fig.2 Design part in bridge parametric design

The further design part is shown in Figure 2. After completing the determination of the plan and composition, the adjusted parameters should be first exported, and a member system model should be established based on these parameters. Then, mechanical analysis and engineering quantity statistics should be carried out to observe whether it meets the mechanical and economic indicators. If it does not meet the requirements, the parameters need to be adjusted and the mechanical model updated. If it does, the model should be expressed as a preliminary two-dimensional result and the construction drawing design parameters should be deepened. Afterwards, a solid finite element model needs to be exported, and simulation calculations and engineering lists need to be conducted. It also needs to be tested by mechanical and economic indicators. If it does not meet the requirements, parameters need to be adjusted and the mechanical model needs to be updated. If it does, detailed design and two-dimensional result conversion need to be carried out. It can be seen that the entire parameterized design process of the bridge is extremely lengthy. Xavier M S applied finite element modeling to his research on soft fluid actuators [15].

In this design process, the calibration of the finite element model is a complex task, and Liu J K proposed establishing a sensitivity matrix for analysis [16]. Let S be the sensitivity matrix, D_{ab} be the sensitivity of the structural state parameter b to the action effect of the a target (a=1,2,.., x, b=1,2,.., y), while x is the dimension of the action effect vector, y is the dimension of the structural state parameter vector, R is the structural action effect parameter, and P is the structural parameter. The sensitivity matrix can be constructed as follows:

$$S = \left[D_{xy}\right] = \left[\frac{\partial R_x}{\partial P_y}\right] = \begin{bmatrix} \frac{\partial R_1}{\partial P_1} & \frac{\partial R_1}{\partial P_2} & \cdots\cdots & \frac{\partial R_1}{\partial P_y} \\ \frac{\partial R_2}{\partial P_1} & \cdots\cdots & \cdots\cdots & \cdots\cdots \\ \cdots\cdots & \cdots\cdots & \cdots\cdots & \cdots\cdots \\ \frac{\partial R_x}{\partial P_1} & \frac{\partial R_x}{\partial P_2} & \cdots\cdots & \frac{\partial R_x}{\partial P_y} \end{bmatrix} \tag{1}$$

After a series of optimization analysis, the sensitivity matrix can be used to calibrate the finite element model. If J is the optimization objective function, $\Delta P, \Delta R$ are the increment of Structural mechanics parameters and action effects, λ is the parameter weight, which is generally set to 1, then the objective function is:

$$J = \frac{1}{2}[(\Delta R - S\Delta P) + \lambda \Delta P] \tag{2}$$

3 Practical Application of Improved Damage Algorithm

The improved damage algorithm is mainly used to calculate the degree of fatigue damage of building materials after they are put into use. The classic P-M criterion (Palmgren and Miner, the founders of the improved damage algorithm) stipulates:

$$D = \sum r_i = \frac{\sum n_i}{N_i} \tag{3}$$

D is the Cumulant of damage, r_i is the percentage of damage caused by the ith stress level, n_i is the number of cycles corresponding to the ith profit level, and N_i is the fatigue life under unipolar fatigue corresponding to the ith stress level.

Wang J F proposed an S-N curve for conducting unipolar constant amplitude fatigue tests at different stress levels in the same material [17]. The so-called S-N curve refers to the process of obtaining multiple different N (fatigue life values) under different S (stresses), and setting m as the fatigue strength index and C as the material related parameter. This parameter is quite special, as the material constantly receives new damage, this parameter would also change accordingly. Therefore, it needs to be continuously corrected

$$S^m N = C \tag{4}$$

or

$$\lg N = \lg C - m \lg S \tag{5}$$

And each correction of C is related to the degree of damage to the material, so its correction formula is:

$$C_i = (1 - D_{i-1}) C_{i-1} \tag{6}$$

It is not difficult to see from it that the coefficients in the i-th C and i-1st C are the damage values of the material under the i-1st level load. After correcting C, the S-N curve can be re expressed as:

$$\lg N_i = \lg\left[(1 - D_{i-1}) C_{i-1}\right] - m \lg S_i \tag{7}$$

The improved damage algorithm based on S-N curve and its prediction process are shown in Figure 3:

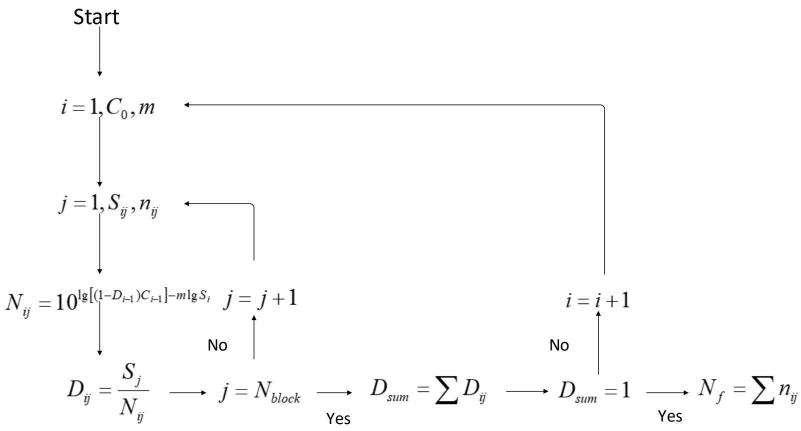

Fig.3 Improved damage algorithm and prediction process

4 Overview of Automatic Identification System

4.1 Operation Mechanism of Automatic Identification System

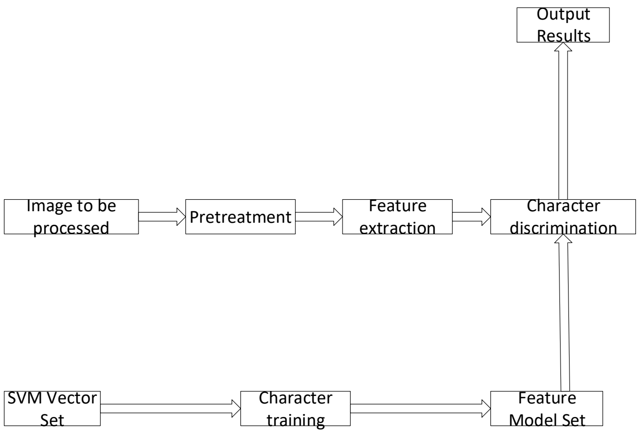

Fig.4 Process of Automatic identification system

AIS (Automatic Identification System, or Automatic identification system) is widely used in ship navigation. During navigation, electronic data are exchanged through satellites and other equipment to avoid traffic accidents in maritime traffic. Now Automatic identification system is also used in other fields. For example, Wang X has established a set of Automatic identification system in its research to enable robots to recognize letter labels in picking operations [18].

It can be seen from Figure 4 that the Automatic identification system for recognizing characters mainly needs to establish a character training set so that the Automatic identification system can grasp the characteristics of characters. The specific process is to first preprocess the image to be processed, then extract features, and perform character discrimination. At the same time, the system needs to train characters in the SVM (Support Vector Machine) vector set, and after a period of time, organize the feature model set, and output the results together with character discrimination. Sarra R R pointed out that establishing feature models is very helpful in improving prediction accuracy during heart disease detection [19].

4.2 Identification of Parameters by Automatic Identification System

Chen Z established a parameter Automatic identification system in his research on permanent magnet synchronous motor [20]. This system can automatically measure various parameters in the motor, such as stator resistance, friction coefficient, and torque coefficient, for auxiliary work in related research. Based on this system, a system UI for bridge structural parameters is briefly designed.

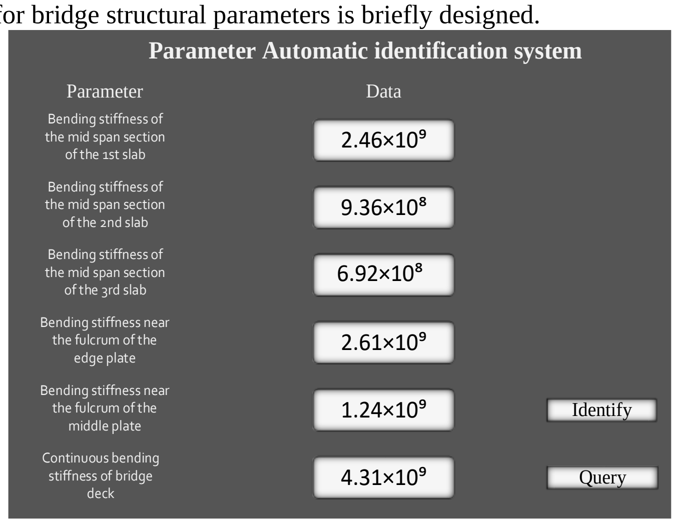

Fig.5 Basic interface of parameter Automatic identification system

The UI of the system is shown in Figure 5. It can be seen that the operating interface of the system is mainly responsible for presenting various parameter data to users. For example, the data in the figure includes parameters such as continuous bending stiffness of the bridge deck and bending stiffness near the middle plate support point, which can intuitively provide data support for bridge designers.

In addition to the underlying logic of the training set and the actual operation interface of the data on the terminal, a qualified Automatic identification system still needs the running program of the middle part. The program envisaged in this paper mainly includes the following functions:

Table 1. Operating procedure of parameter Automatic identification system

Procedure	Function
Serial communication	Composed of serial port configuration, serial port writing, serial port reading, and serial port closing.
Data processing	Identify the parameters, then read out the data and send it to the data processor.
Data access	Store various parameters and support users to access them.

The running program is shown in Table 1, which roughly consists of serial communication, data processing, and data access. Serial communication consists of several parts: serial port configuration, serial port writing, serial port reading, and serial port closing, responsible for preprocessing data. The data processing part would identify the parameters and send them to the processor for data processing. The final data access section supports data storage and reading, allowing users to extract data through the system's operating interface.

5 Conclusions

The research purpose of this paper is to first state the universality of the Automatic identification system, demonstrate that it is competent for real-time monitoring of bridge structural parameters, then discuss the bridge structural parameters, as well as two methods of improved damage algorithm and Automatic identification system, and finally successfully apply these two methods to the work of bridge structural parameters, and establish a prototype system. However, there are still some aspects of this article that have not been thoroughly studied, that is, the designed system has not yet undergone an actual bridge construction test, and only stays at the theoretical level.

In general, it is creative to monitor the structural parameters of the bridge through the Automatic identification system, and the improved damage algorithm can also complete the calculation of the damage degree caused by the external force impact on the bridge during construction and after it is put into use, which is also a very thoughtful consideration. It can be foreseen that bridge construction in the future would become more mature. As a type of infrastructure, the mature development of bridges would inevitably form a chain reaction to drive the local economy and further affect people's lives.

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