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Safety Assessment Method of Bridge Crane Based on Cluster Analysis and Neural Network

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Abstract

Bridge crane is one of the most widely used hoisting equipments. The safety assessment of bridge crane can prevent potential failure in time. However, there is no comprehensive and accurate safety assessment method for bridge crane. This paper presents a safety assessment method of bridge crane based on cluster analysis and fuzzy neural network. First, we establish the safety assessment index system of bridge crane. Then, we revise the weight allocation of expert by cluster analysis, which can make expert evaluation set more rational. Next, we construct fuzzy membership function and the fuzzy neural network of safety evaluation model. Finally, this safety assessment method is verified by an engineering example, and the assessment result fits well with the actual situation.

Keywords: Bridge crane; Safety assessment; Cluster analysis; Fuzzy neural network.

1. Introduction

Bridge crane is the most widely used and the largest number of hoisting machinery in modern industrial production, it is applied frequently in complex occasion such as port terminals, logistics transportation, mining and metallurgy. With the increase of service life and operating frequency, the wear and tear of mechanism parts is aggravated. In addition, because of lacking of timely maintenance, the failure rate of bridge crane would be soared and more potential safety hazard is brought. According to the study [1], it is showed that bridge crane accidents accounted for 35%, which are far more than other types of crane accidents. Therefore, it is great significant for the

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safe operation of bridge crane that we conduct a comprehensive and accurate safety assessment and find out potential risk source before failures occur.

There are quite a few safety assessment researches about crane. However, there is not a complete, universal and reasonable safety assessment standard. There are some commonly used assessment methods, such as traditional empirical method, expert assessment method, probability assessment, hierarchical evaluation model and Fuzzy judgment method. In recent years, some scholars began to apply machine learning to safety assessment of bridge crane. G.N. Xu [2] used Bayesian networks to evaluate the safety of general bridge crane metal structure. K. Huang [3] made a safety assessment on the deformation structural defects of shipbuilding gantry crane by fuzzy hierarchy analysis. W.J. Shu [4] established a safety assessment system of bridge crane metal structure, using support vector machine algorithm. Qu [5] established the general failure probability model and the failure impact factor hierarchy model of the crane parts basing on the reliability theory. A.H. Li [6] applied fisher discriminant analysis to the safety assessment of the crane. J.Z. Liu [7] adopted the method of fuzzy theory to build the second-level evaluation model for safety assessment of gantry crane. Most of these studies only evaluated a module of crane. The safety assessment methods are not comprehensive or systematic. Although there are some other studies can make a comprehensive safety assessment on crane, there are still some drawbacks. For example, there is too many manual intervention, the expert evaluation set is not reasonable and the assessment accuracy is not high enough.

This paper presents a safety assessment method of bridge crane based on cluster analysis and fuzzy neural network. Firstly, the safety assessment index system of bridge crane is established. According to the bridge crane safety conditions, the index system is stratified and the assessment criteria is ascertained. Then, the weight allocation of expert is revised by cluster analysis, to improve the rationality. Next, fuzzy membership function is constructed and fuzzy neural network safety assessment model is established. Finally, taking the safety assessment data of bridge crane provided by Shaoxing Special Equipment Testing Institute as the sample, the above safety assessment method is verified.

2. The safety assessment method of bridge crane

Bridge crane is a complex electromechanical integration system, which has different assessment criterion from different evaluation perspectives. First, combining expert advice with the maintenance data of crane which is sorted, we study the crane structure and common faults. Then, we ascertain the indicators that reflect the safety of bridge crane and establish the safety assessment index system. Finally, based on the safety assessment index system, the safety assessment method of bridge crane is presented.

Combining the relevant studies data [8] with the test data provided by Shaoxing Special Equipment Testing Institute, the statistical analysis of crane hidden trouble is carried out. As can be seen from Table 1, Crane failure are mainly concentrated in electrical and control system, main components, safety devices, metal structure, performance testing, and other related contents.

Table 1.Crane hidden trouble statistics.

Items	Frequency	Cumulative number	Accrual rate (%)
Safety device	920	1138	35.8
Electrical and Control system	618	1589	50.0
Performance testing	671	2176	68.5
Metal structure	443	2601	81.9
Main components	326	2993	94.3
Other relevant content	197	3105	97.8

According to the statistical analysis of crane hidden trouble and refer to Design Rules for Cranes GB3811-2008 [9] and lifting appliances safety and technical regulation, we divide the safety assessment index system structure of bridge crane into four levels and ascertain the assessment criteria of the safety indicators. As shown in Fig. 1, the second layer divides the whole machine index system into six subsystems, including electrical and control system,