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Safety Performance of Structures in Ocean Engineering Based on Neural Network Surface Method

Aditiya Kumarien*

Universiti Teknologi MARA, Malaysia

**corresponding author*

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Abstract: In the actual marine engineering analysis, the structure is often connected by multiple components or multiple units according to the corresponding laws. We regard this structural safety research from the perspective of the whole as the systematic reliability of the structure. Sexuality analysis and research on safety performance. Therefore, the purpose of this paper is to study the safety performance of structures in marine engineering based on the neural network response surface method. In the experiment, using the function algorithm, the research on the safety performance of the structure in marine engineering based on the neural network surface method is investigated and analyzed. The experimental results show that the neural network-based structural system reliability method proposed in this paper has a general, practical and effective function for the safety performance of structures in marine engineering.

1. Introduction

Many years ago, people realized the objective existence of uncertainty in the practice of ocean engineering. In recent decades, people began to study the uncertainty in marine engineering [1]. In the past, the safety factor in the engineering structure was mainly obtained by experience. In this way, the safety degree obtained only by experience has no scientific basis, resulting in huge economic losses and even a painful life cost. Therefore, a scientific method must be found to analyze the actual structure of ocean engineering. In this context, the reliability theory and safety performance for analyzing marine engineering structures have been proposed and studied so far.

With the rapid development of floating structures in ships and offshore engineering, the demand for corresponding hydrodynamic analysis continues to increase, and the importance of wave loads is also increasingly prominent. Gao M studies plankton, aerosols, clouds, marine ecosystems. NASA's planned launch will carry a hyperspectral scanning radiometer called the Ocean Color Instrument

and two multi-angle polarimeters. Polarimeter measurements contain rich information on the microphysical properties of aerosols and hydrosols and can therefore be used to retrieve accurate aerosol properties of complex atmospheric and oceanic systems. Most polarimetric aerosol inversion algorithms iteratively utilize the vector radiative transfer model in an optimization approach, which results in high computational costs, limiting their use in operational processing of the large data volumes acquired by polarimetric imagers. In this work, a deep neural network forward modeling model is proposed to represent radiative transfer simulations of coupled atmospheric and oceanic systems [2]. Komen D studied sound source localization and environmental inference as common problems in ocean acoustics, requiring computationally intensive algorithms and knowledge of search spaces. Convolutional neural networks learn useful features directly from gridded input signals to make predictions, avoiding the expensive practice of selecting features or comparing with forward-propagation models. To take advantage of these advantages, a convolutional neural network was trained and validated on simulated stress signals generated using four different environments for environment class and range predictions for multiple ranges. The network was then found to make predictions on simulated validation datasets, but it was difficult to make unbiased predictions on measured data [3]. With the rapid development of science and technology, the research and application of reliability theory have also been developed and applied in more and more fields.

This paper studies the background of ocean engineering, the concept of ocean engineering, neural network and response surface method, including an overview of neural network and response surface method. In the experiment, in order to verify the safety performance of the structure based on the neural network response method in marine engineering, the function algorithm was used to calculate the function and the neural network application method for the neural network response method with fuzzy-random variables. Three aspects of the reliability of the surface method structural system are investigated and analyzed. The experimental results show that the neural network-based structural system reliability method proposed in this paper has a general, practical and effective function for the safety performance of structures in marine engineering.

2. Research on Safety Performance of Structures in Ocean Engineering Based on Neural Network Surface Method

2.1. Background of Marine Engineering

To meet challenges such as transportation, energy and food production, the ocean will provide humanity with a vital resource. There are abundant resources in the vast ocean, such as oil and gas deposits, biological resources and various other renewable resources [4-5]. With the continuous development of human beings, the demand for resources is increasingly strong, but the land resources are constantly decreasing, so it is imperative to develop the ocean. my country has abundant marine oil and gas and biological resources in coastal and offshore areas. The rational use of marine resources will be the top priority of the national development strategy. For the development of offshore oil and gas resources, mining, storage, transportation and supporting equipment are essential. Although my country has made great progress in some areas, there is still a big gap between China and the equipment powerhouse in other aspects, especially in design and innovation. The transformation and development of future equipment requires solid basic research results, and only by making technological breakthroughs can a firm position be established in ocean development in the future [6-7].

2.2. The Concept of Ocean Engineering

With the advancement of science and technology and the infinite development and exploration of the ocean, compared with land engineering construction projects, a new type of engineering construction has emerged—“ocean engineering” [8-9]. Both are construction projects, but they are completely different from land construction. In recent decades, marine engineering construction projects have been mainly used in the development of oil, natural gas, and some mineral resources, as well as the construction of submarine tunnels and cross-sea bridges. Risky, high pollution characteristics. Offshore engineering refers to new construction, reconstruction and expansion projects with the purpose of developing, utilizing, protecting and restoring marine resources, and the main body of the project is located on the seaward side of the coastline. Marine engineering is a new concept formed with the development of marine economy [10-11]. "If you want a country to be prosperous and strong, you must not ignore the ocean." Throughout history, my country's development of the ocean, from the Maritime Silk Road, Zheng He's voyages to the Western Ocean, to today's strategy of becoming a maritime power, can be described as ups and downs. Although our country has made the conclusion that "the prosperity and decline of a country is often in the sea and not in the land" in the understanding and utilization of the ocean since ancient times, in the early stage of the development of ocean engineering, there was not enough for the backwardness of science, technology and ideological concepts. Understand and make relevant laws and regulations lag behind the development of the ocean in terms of norms. The definition of "ocean engineering" originates from "coastal engineering", which can be said to be similar to coastal engineering, but beyond the scope of traditional coastal engineering, and belongs to a new type of marine construction engineering project [12-13].

2.3. Neural Network and Response Surface Method

(1) Neural network

Artificial neural network is constructed by analogy to biological neural network. In the reliability analysis, the first order second moment method and simulation methods are generally used to analyze the structure with a clear functional function [14-15]. For complex structures whose functional functions cannot be clearly expressed, a large number of complex numerical analysis tests are required to obtain their reliability. With the proposal of artificial neural network and its research and development, it has been found that artificial neural network can process and analyze a large number of complex nonlinear structures, and has the advantages of excellent learning ability, data reasoning ability and the ability to build complex mapping. Artificial neural network not only solves the problem of implicit structure function function, but also greatly improves the calculation and analysis efficiency of actual numerical experiments. In recent years, with the research and development of artificial neural networks, a number of representative theoretical models and learning algorithms have been successively proposed. Theoretical models mainly include self-organizing mapping models and various fuzzy artificial neural network models. Including fixed point learning algorithm and fuzzy neural network learning algorithm and so on. These theoretical models and algorithms provide theoretical basis for the research and development of artificial neural networks [16-17].

(2) Response surface method

The response surface method belongs to an effective mathematical calculation method for analyzing structural reliability. The limit state surface is replaced by the surface, and then the structural reliability analysis of the structure is carried out [18]. Among them, most of the undetermined coefficients are determined based on numerical analysis experiments, using the principle of least squares and the idea of iteration, so that the polynomial function determined by

the undetermined coefficients can approximate the functional function to the greatest extent, or the response surface can be fitted to the test sampling points to the greatest extent. When the accuracy required in engineering can be met, the purpose of structural reliability analysis of the complex structure can be achieved. The response surface method mainly obtains sample points through a large number of numerical analysis experiments, and uses these sample points to construct a polynomial function, so that the polynomial function can well approximate the implicit limit state function function (that is, it cannot be expressed by a specific mathematical expression. function of the functional relationship between variables). With the development of response surface methodology, the method has now been applied to industrial production design, structural optimization, reliability analysis and other fields.

3. Investigation and Research on Safety Performance of Structures in Ocean Engineering Based on Neural Network Surface Method

3.1. Research Content

In order to verify the safety performance of the structure based on the neural network response method in marine engineering, the neural network response method with fuzzy-random variables, the neural network response method calculation function and the neural network response method structure system are respectively studied in the research. reliability was investigated and analyzed.

3.2. Algorithm Processing

Suppose the input vector of an artificial neuron is X, the connection weight vector is W, the threshold value is θ, the activation value is $\sum_{i=1}^{n} W_i X_i = W^T X$, and the activation function is $f(\cdot)$, then the output function Y is:

$$Y = f\left(\sum_{i=1}^{n} W_i X_i - \theta\right) \tag{1}$$

In addition, the actual input variable is usually set to $X_1, X_2, \ldots X_{n-1}$, and then set to $X_n = -1, W_n = \theta$, so that the threshold value θ can be regarded as a connection weight to simplify the neuron. The output function Y of the simplified artificial neuron is:

$$Y = f\left(\sum_{i=1}^{n} W_i X_i\right) = f\left(W^T X\right) \tag{2}$$

4. Analysis and Research on Safety Performance of Structures in Ocean Engineering Based on Neural Network Surface Method

4.1. Neural Network Response Method with Fuzzy-Random Variables

The equivalent transformed limit state function is calculated according to the neural network response method, and the fuzzy variable of the structure is equivalently transformed into a random variable, and the first-order second moment method combined with the reliability theory is used to calculate the structural reliability problem with only random variables. The calculation results are

shown in Table 1 and Figure 1:

Table 1. Comparison of the reliability calculation results

Method	Failure probability	Reliability index	Relative error /% of the failure probability
MCS	9.64	3.142	0
FOSM	9.84	3.129	5.47
RSM	9.23	3.167	3.84
Fourier-RSM	9.34	3.164	3.47
Fourier-WRSM	9.48	3.168	2.36

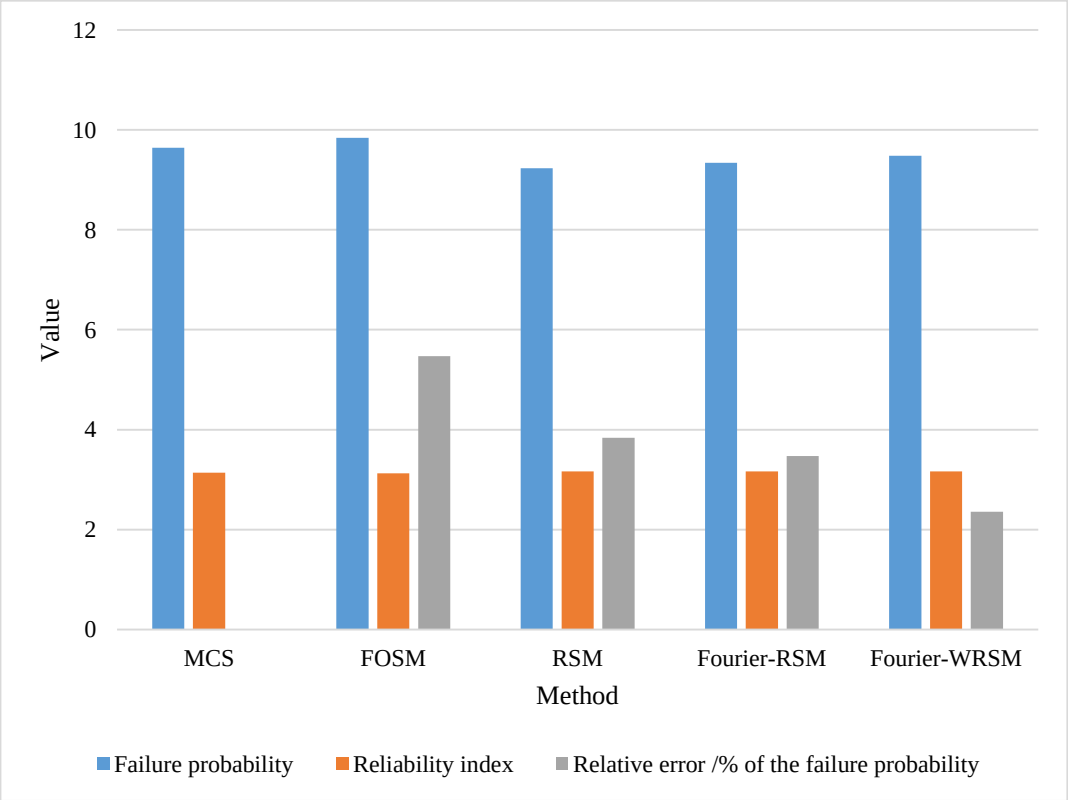

Figure 1. Comparison diagram of the algorithm data

Through the MCS method, the calculation is performed 500 times, and the reliability index is 3.142. The calculation result can be considered as an exact solution. The reliability result calculated by the Fourier-WRSM method is 3.168, and the calculated reliability result of the Fourier-RSM method is 3.164. It can be found that the neural network response surface method is feasible in solving the reliability calculation problem with a class of random parameters, which shows that the neural network response surface method has adaptability in marine engineering practice.

4.2. Neural Network Should Face Method Calculation Function

The relationship between the approximated function function value and the real function function at the same number of iterations is calculated by the neural network should face method, and finally the calculation is converged through 15 iterations. The real function function value is basically the same as the simulated function function value. The function body relationship is

shown in Table 2 and Figure 2:

Table 2. Function relationship data sheet

Iterate steps	True value	Analog value
3	158	145
6	92	135
9	82	105
12	21	21
15	0.41	0.42

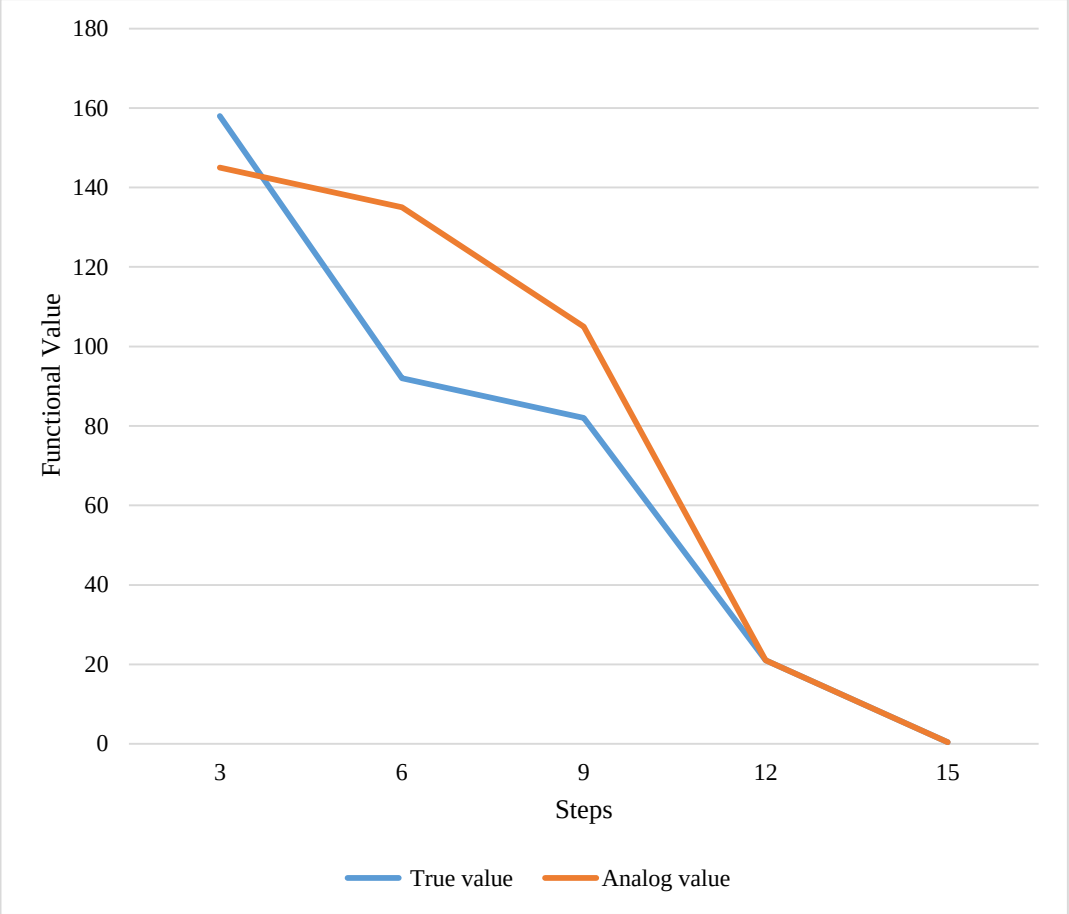

Figure 2. Functional function data comparison figure

The results show that the neural network surface method has little difference with the calculation results of the exact solution, and the accuracy is slightly better than that of the unweighted calculation. It shows that the neural network response method is feasible and effective in calculating the reliability of fuzzy random variables.

4.3. Reliability Analysis of Neural Network Structural System

To establish the structural system reliability model of the neural network. A functional mapping relationship between random variables and structural responses is established through neural networks. The random variables in the structure of the simple beam structure are independent of each other and obey the normal distribution, and their mean and standard deviation are shown in

Table 3 and Figure 3:

Table 3. Statistical characteristic values of the basic random variables

Random variable	Mean	Standard deviation
Section inertia I	0.0002	0.0003
Elastic modulus E	4000000	600000
Extreme bending moment M	25	2.5
External load P	5	2

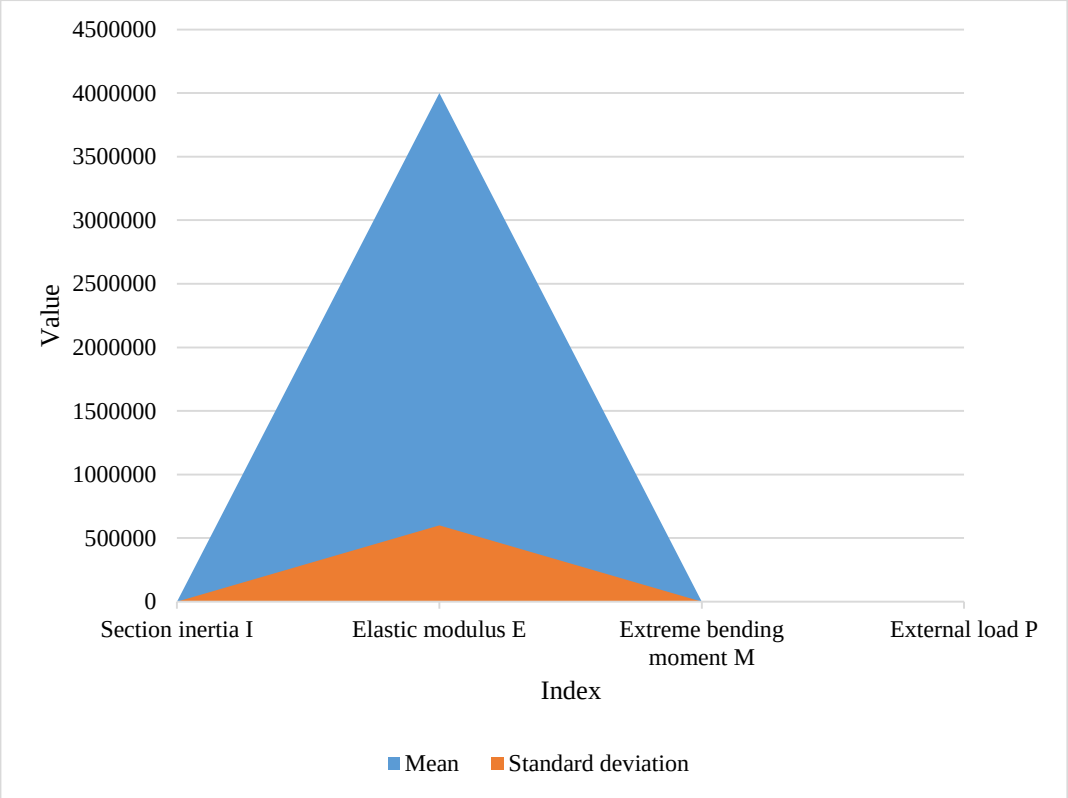

Figure 3. Data diagram of random variables

The numerical example proves that the neural network-based structural system reliability method proposed in this paper has a general, practical and effective function for the safety performance of the structure in marine engineering.

5. Conclusion

The reliability analysis research of marine engineering practice has been involved in many aspects. Structural reliability is an important indicator to measure the degree of safety under these uncertain factors. Traditional design and analysis methods do not fully consider the impact of these uncertain factors, and may have certain limitations, resulting in unreasonable results. Structural reliability theory integrates probability and statistics theory and stochastic process method into analysis, fully considers the uncertainty of structural parameters in actual marine engineering, and can conduct reliability analysis of structures more reasonably. Therefore, the development of marine engineering has become an important development strategy in our country and even in the world. At the same time, it is of great significance to analyze and study the safety performance of

structures in marine engineering based on the neural network response method.

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Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

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