Scholar Publishing Group
Frontiers in Ocean Engineering
https://doi.org/10.38007/FOE.2022.030107
ISSN 2790-2706 Vol. 3, Issue 1: 49-56

Multidimensional Maximum Entropy Model and Its Application in Ocean Engineering

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Keywords: Multidimensional Maximum Entropy, Maximum Entropy Model, Marine Engineering Applied Research

Abstract: In order to cope with the challenges of transportation, energy and food production, marine resources have become one of the important resources needed by human beings. 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. In order to solve the limitations of various technical applications in existing marine engineering,this paper discusses the multi-dimensional maximum entropy model symmetric function and the multi-dimensional probability model commonly used in ocean engineering. The parameter settings and data sets in the project are briefly introduced. In addition, the design and discussion of the multi-dimensional maximum entropy model and its model in marine engineering are carried out. Finally, the experimental analysis of the application of the multi-dimensional maximum entropy model in the ocean is carried out. The multi-dimensional maximum entropy model's test values for wave height, flow velocity and wind speed are in the range of the lowest 200 and the highest 217, so the multi-dimensional maximum entropy model and its application stability in marine engineering are verified.

1. Introduction

With the advancement of science and technology, the structure of the offshore platform becomes more and more complex, and it becomes more and more vulnerable in the face of natural disasters (such as typhoons, tsunamis, cold waves, etc.). However, the influencing factors corresponding to the development of marine engineering are too complex. For example, how to construct an effective model for the development of marine engineering is very important for the development of marine engineering.

Nowadays, more and more scholars pay attention to the research of various technologies and

algorithms in the application of marine engineering, and through practical research, they have also achieved certain research results. Amin proposed a maximum entropy-based model, which was used to extract Thai NR information and dictionaries. NR information and dictionary extraction system. Amin divides the system into three components. The first part is a model that determines candidate boundaries composed of Thai words by information heuristics, dictionaries, and the overall number of words. The second part is to extract NR through the maximum entropy model. The last part is to extract undiscovered candidate boundary network elements by combining the extracted analysis with the rest of Thai [1]. Fernandez-Manso A's study of the principle of maximum entropy provides a link between mechanical models of collective behavior in neural networks and testing of real neuronal networks. Mainly to explore the measured connections between neurons. Fernandez-Manso A also proposed another method of the principle of maximum entropy, which is to build a model consistent with the distribution of network activity, that is, Y cells out of X cells in the network produce a consistent potential probability in the same small time period. The problem that needs to be solved when designing the maximum entropy model is dealt with through the analysis of the data, and the response of neurons in a small area of the retina to physical stimuli is analyzed by the principle of maximum entropy [2]. Domps B uses the principle of maximum entropy to analyze the uncertainty parameters of geoacoustic ducts in deep-water marine environments. The marginal probability distribution and statistical data such as mean and standard deviation of each geoacoustic parameter are obtained using the principle of maximum entropy. The theoretical and numerical parts of the maximum entropy principle method are discussed. The method was applied to experimental acoustic measurements on sand ridges on the New Jersey continental shelf, where priority information included sound velocity measurements in the water column and chirped seismic reflectance maps that could provide a geophysical ground truth of the layered structure of the seafloor. The acoustic data used in geoacoustic inference comes from towed multi-frequency sources [3]. Although the existing research on the application of marine engineering is very rich, the research based on the multi-dimensional maximum entropy model and its application in marine engineering is still insufficient.

Therefore, in order to solve the existing problems in the application of ocean engineering, this paper firstly introduces the symmetric function of the model used in this paper and the multi-dimensional probability model commonly used in ocean engineering, and then discusses the selection of the application of the multi-dimensional maximum entropy model in ocean engineering. The range of parameters is set and the data of wind speed, flow velocity and wave height in ocean engineering are selected and designed. Finally, the model structure of the multi-dimensional maximum entropy model in ocean engineering is designed, and the application of the multi-dimensional maximum entropy model in ocean engineering is carried out. Tests and final experiments show the reliability of the proposed multidimensional maximum entropy model and its application in marine engineering.

2. Multidimensional Maximum Entropy Model and Its Research in Marine Engineering

2.1. Multidimensional Maximum Entropy Model Symmetric Function

Regarding the construction of the symmetric function of the multi-dimensional maximum entropy model, a sufficient quantitative function is given in this paper [4]. Let ϖ be a continuous, strictly decreasing function from $[0,2] \to [0, \infty]$, and $\varpi(0) = \infty$, $\varpi(1) = 0$, ϖ^{-1} be the inverse of $H(k) : [0,1]^x \to [0, \infty]$. If E satisfies the equation:

$$H(k) = \varpi^{-1}(\varpi(k_{-1}) + \ldots + \varpi(k_x)) \tag{1}$$

function [5]. In the formula, $k=(k_1,k_2,...,k_x)$. Then for all $v\geq 2$ and $H(k)$ functions of A-element symmetric type, ϖ^{-1} is completely monotonic on $[0,\ \infty]$.

And the function $f(m)$ is completely monotonic on the interval S means that $f(m)$ is continuous on S, and for any $m\in S, r=0,1,2,...,$, there are:

$$(-1)^r \frac{a^r f(m)}{am^r} \tag{2}$$

The following are some A-ary symmetric functions constructed by this theorem [6].(1) G-HC

The distribution function C(u) of D-element Gumbel-HC is:

$$H(k)=ras\left\{-\left[(-\ln k_1)^{\alpha}+(\ln k_2+...+(\ln k_a)^{\alpha}\right]^{\frac{1}{\alpha}}\right\} \tag{3}$$

In the above formula, the relevant parameter $\alpha\geq 1$, the multi-dimensional symmetric model can be regarded as the distribution of the edge distribution obeying the maximum shear force, and the connection function is the symmetric probability model of the multi-dimensional maximum entropy model [7].

2.2. Multidimensional Probability Models Commonly Used in Marine Engineering

One-dimensional statistical models commonly used in hydrologic frequency analysis in Marine engineering include Gb distribution, Wbll distribution, Pearson type iii distribution, lognormal distribution, etc. [8]. The distribution patterns of these statistical models are briefly introduced as follows [9].

(1) Gumbel distribution

Gumbel distribution is characterized by its simple structure and is often used by hydrologic condition analysts in Marine engineering. However, this model has high requirements on data samples and has a good fit to test data [10].

(2) Weibull distribution

Wbll distribution is a theoretical distribution of the maximum limit of random variables, which has two parameters and three parameters. The latter has one more location parameter than the former, so the parameter estimation is more complicated [11]. When fitting data, the tail of Wbll distribution is smaller than that of Gbl distribution [12].

(3) Pearson type iii distribution

Pearson type iii distribution is a formal extension of Gamma distribution, which can be called generalized Gamma distribution, and it is a kind of Pearson distribution family [13]. Pearson type iii distribution is often used in the reproducible value design of hydrological environment elements in China [14]. When fitting the observed data, the tail of this distribution is smaller than that of the Gumbel distribution and larger than that of the Weibull distribution [15].

(4) lognormal distribution

Lognormal distribution is derived from normal distribution and is often used in hydrologic frequency analysis [16]. It is a skewed distribution, which can study the probability of biased events. In recent years, lognormal distribution has been gradually applied to the calculation of extreme wind speed, period and wave height in coastal and offshore areas. This distribution also contains two types: two-parameter and three-parameter [17].

3. Multidimensional Maximum Entropy Model and Its Investigation in Marine Engineering

3.1. Multidimensional Maximum Entropy Model and Its Parameter Setting in Marine Engineering

This section mainly analyzes the multi-dimensional correlation of random vectors (HT, (HS) and (TS) [18]. According to Skl's theorem and the symmetric function of the multi-dimensional maximum entropy model, the one-dimensional maximum entropy distribution function of ocean engineering is assumed to establish three groups of random vectors. Multi-dimensional maximum entropy model. There are 6 kinds of symmetrical functions of the multi-dimensional maximum entropy model used here, and the corresponding function parameters are set as symmetrical NC ϖ, the range is $\varpi \geq 1$, the range of G-Hl ϖ is $-1 \leq \varpi \leq 1$, the range of CCl ϖ is $\varpi \geq 1$, and the range of FCl ϖ is the range. is $0 < \varpi < +\infty$ and the range of AMH ϖ is $0 \leq \varpi \leq 1$.The details are shown in Table 1.

Table 1. Values of symmetric functions

NC	$\varpi \geq 1$
G-HI	$-1 \leq \varpi \leq 1$
CC1	$\varpi \geq 1$
FC1	$0 < \varpi < +\infty$
AMH	$0 \leq \varpi \leq 1$

3.2. Multidimensional Maximum Entropy Model and Its Data Set Setting in Marine Engineering

In this paper, the data of wave height, wind speed and flow velocity of typhoons and cold waves in 35 marine projects in a certain sea area from 2012 to 2022 are selected, and the combination of wave height, wind speed and flow velocity that makes the basement bend the largest in one year is selected as a sample, as shown in Table 1. , to establish a three-dimensional probability model of (H, W, V). The marginal distributions are fitted by multi-dimensional maximum entropy distribution function, and the three-dimensional maximum entropy model is constructed by three-dimensional (G-H) copula function.The details are shown in Table 2.

Table 2. Wave height, wind speed, velocity data

Wave heigh(m/s)	2.5	2.6	3.1	2.8
Wind speed(m/s)	16.9	18.5	21.6	22.9
Velocity(m/s)	0.56	0.61	0.65	0.68

4. Multidimensional Maximum Entropy Model and Its Application in Marine Engineering

4.1. Multidimensional Maximum Entropy Model and Its Model Construction in Marine Engineering

In this paper, based on the constructed three-dimensional maximum entropy model, when the return period of wave height, wind speed and flow velocity of (HT, (HS) and (TS) are constant, the maximum wave height, wind speed and flow velocity shear force correspond to the closest wave height, The upper limits of wind speed and flow velocity are 2.8 (m/s), 22.9 (m/s) and 0.68 (m/s). The specific model structure steps are shown in Figure 1:

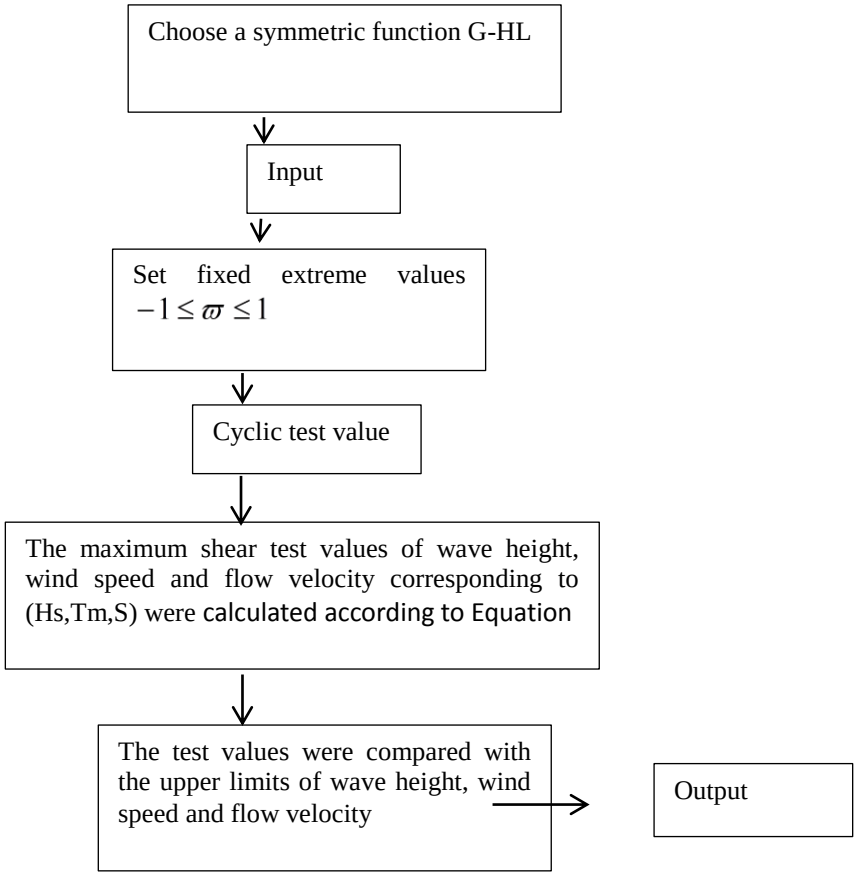

Figure 1. Multidimensional maximum entropy model

(1) Select the symmetric function G-Hl in the multi-dimensional maximum entropy model to solve the (HT, (HS) and (TS) base shear forces corresponding to the return period of wave height, wind speed and flow velocity.

(2) Make the extreme value wind speed of wave height, wind speed and flow velocity constant (20m/s), and make the extreme value wave height take a value within a certain range (take 2m/s to 4m/s) to circulate and make the extreme value of flow velocity constant (0.6 m/s)

(3) For a fixed wave height, wind speed, and flow velocity m/s, calculate the test values obtained by all combinations of (Hs, Tm, S) according to formula (3), and find the maximum shear force and its corresponding (Hs, Tm, S) Tm, S) value.

(4) Circulate the base shear force, compare all base shear forces, and select the base shear force corresponding to the group (Hs, Tm, S) that is less than the upper limit of wave height, wind speed, and flow velocity, and is the closest to it as the lower limit. The maximum shear force value under the return period of one-year wave height, wind speed and flow velocity.

4.2. Multidimensional Maximum Entropy Model and Its Application in Marine Engineering

This paper selects the data samples of wave height, wind speed and flow velocity of typhoon and cold wave in 35 marine projects in a certain sea area from 2012 to 2022, and uses three functional forms in the multi-dimensional maximum entropy model to design the multi-dimensional test of wave height and the extreme value of wind speed and flow velocity. Entropy model, according to formula (1), formula (2) and formula (3), respectively establish a multi-dimensional maximum

entropy distribution model to test the wave height, flow velocity and wind speed base shear force.

Table 3. Base shear values of wave height, velocity and wind speed

Maximum shear	Wind speed of extremum	Velocity of extremum	Extreme wave height
10	200	205	208
20	200	203	205
30	200	206	211
40	200	211	217

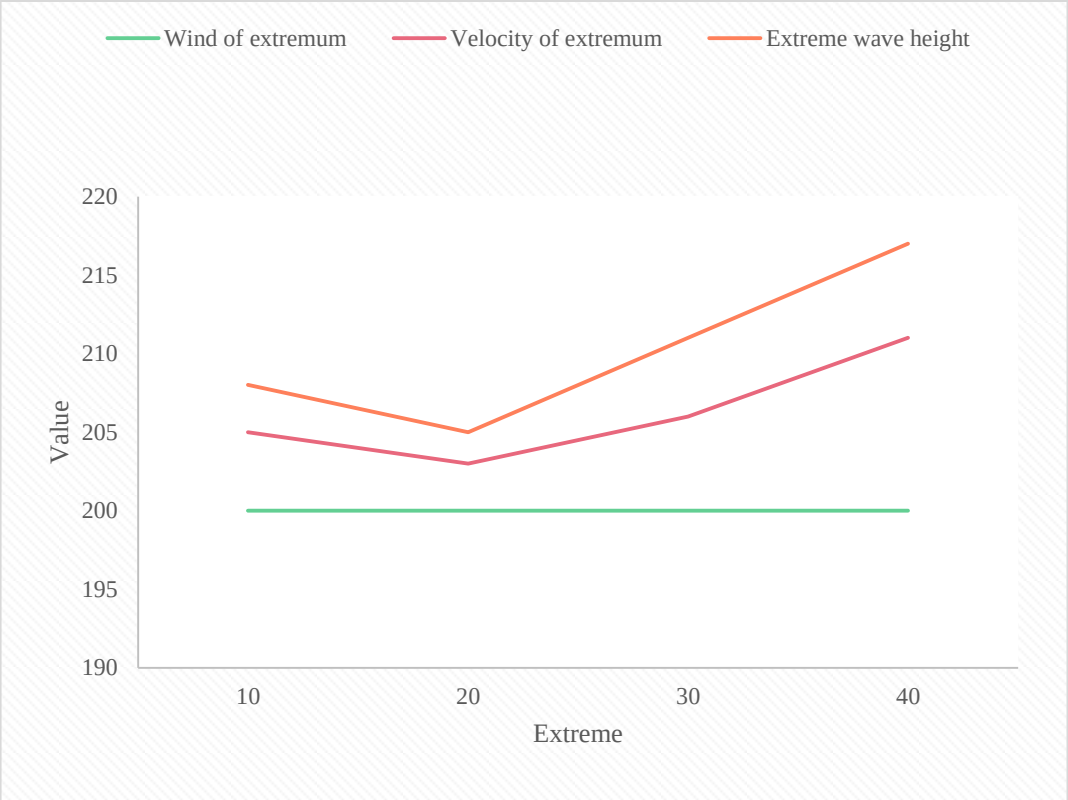

Figure 2. Base shear comparison

As shown in Table 3 and Figure 2, the extreme values corresponding to wave height, flow velocity and base shear force under the input values of the three functions in the multi-dimensional maximum entropy distribution model are relatively different, but it can be seen that the values of wave height, wind speed and maximum shear force of flow velocity are all in the In the range of 200 to 217, it is relatively stable. It can be seen from the data and trends of the three broken lines in the above figure. The three functional forms in the multidimensional maximum entropy model are used to test the extreme values of wave height, flow velocity and wind speed. When the shear force is the largest, the multi-dimensional maximum entropy model test value is larger and more stable. When the base shear force is small, the multi-dimensional maximum entropy model has small test values for wave height, flow velocity and wind speed, which is economical but prone to safety problems.

5. Conclusion

Therefore, in order to enrich the research on applications in marine engineering, this paper first briefly introduces the concept of the symmetric function of the multi-dimensional maximum entropy model and the multi-dimensional probability model commonly used in ocean engineering, and discusses the multi-dimensional maximum entropy model and its application in ocean engineering. Based on the analysis and discussion of the application technology, the parameter setting and data set based on the application of the multi-dimensional maximum entropy model in ocean engineering are investigated and designed. Secondly, the design and analysis of the multi-dimensional maximum entropy model and its application model architecture in marine engineering are carried out. Finally, the experimental data analysis is carried out for the application of the multi-dimensional maximum entropy model designed in this paper in marine engineering. The final experimental results verify the multi-dimensional maximum entropy model in this paper. The advantages of application in marine engineering.

Funding

This article is not supported by any foundation.

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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