Scholar Publishing Group
Frontiers in Ocean Engineering
https://doi.org/10.38007/FOE.2020.010201
ISSN 2790-2706 Vol. 1, Issue 2: 1-8

The Impact of Geological Hazards on Marine Engineering Based on Machine Learning

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Keywords: Machine Learning, Geological Hazards, Marine Engineering, Disaster Impact

Abstract: With the development of marine resources, more and more marine geological disasters are encountered to the construction of marine engineering (such as submarine cables, submarine oil production equipment and oil and gas pipelines). The purpose of this paper is to study the impact of geological hazards on marine engineering in the context of machine learning. On the basis of collecting, sorting and analyzing the existing landslide, subsidence and rockfall geological disasters, the cause of block movement and the impact of geological disasters on marine engineering are studied, and the marine engineering geological environment of an oilfield in the sea area is evaluated. The landslide risk assessment model based on support vector machine is applied to the marine engineering geological environment information system. The results show that the landslide risk assessment results are consistent with the actual landslide distribution, indicating that the constructed landslide risk assessment model has a good effect.

1. Introduction

Landslides, subsidence, rockfall, these are very common phenomena in nature, which gradually flatten the uneven surface of the earth. This flattening process is a process from unstable to stable in nature [1-2]. Block motion is the movement of a block moving from one position to another under the action of gravity or other forces [3]. As an unstable event that often occurs in nature, mass motion has direct and indirect effects on human activities, and this effect is often catastrophic. People's understanding of mass movement has been developing with the pace of human exploration of the earth. Research on the movement of blocks on land has been carried out for a long time, and the movement of blocks on the seafloor is closely related to the pace of human development of the ocean [4].

At present, although the research on marine engineering geology is still relatively small, due to the actual needs of production, the research on marine engineering geology will develop rapidly [5].

Some scholars claim that special geological bodies refer to geological bodies that adversely affect the stability of marine engineering foundations, which are potentially dangerous geological factors. Their existence complicates engineering site conditions, and they may cause foundation instability or drastic changes under external forces. The formation conditions, distribution characteristics and induced engineering hazards of mud diapirs, mud volcanoes, coral reefs, and ancient river channels are analyzed and discussed [6]. In the relatively short life cycle of wavelet transform, it has been widely used in various applications. There are also scholars who will briefly discuss the development of continuous and discrete wavelet transforms for digital signal analysis, and provide many examples that have found wavelet analysis useful in their research on identifying and characterizing transient stochastic processes involving marine engineering, wind [7]. It is of practical significance to study the impact of geological disasters on marine engineering.

This paper focuses on the genesis mechanism of block movement, the impact of geological disasters on marine engineering and the interaction between block movement and marine engineering. On this basis, the landslide risk of an oilfield marine engineering is evaluated. The research results can provide a scientific basis for the development of marine regional resources, marine functional zoning, offshore engineering construction and the formulation of marine development strategies according to local conditions.

2. Study on Influence of Geological Hazards on Ocean Engineering

2.1. The Cause of Mass Motion

(1) Earthquakes and faults

Earthquakes and faults are trigger mechanisms caused by plate tectonic activity. Earthquakes cause the increase of stress on the slope and the liquefaction of the soil through the seismic acceleration, thereby reducing the decompression strength of the soil [8].

(2) Mud volcanoes

Mud volcanoes are raised features on the ocean floor that are associated with the eruption of gases and fluids. The formation of mud volcanoes requires the presence of high air pressure or fluid pressure below the seafloor surface along a compression fault or along a diapir [9]. In addition, high deposition rates are often a factor in the formation of mud volcanoes. Mud volcanoes can cause the seabed to be too steep, or cause additional stress to the soil, resulting in soil damage [10].

(3) Tsunami

Tsunamis are large-scale sea surface fluctuations caused by earthquakes and submarine landslides. A tsunami can exert enormous hydrodynamic stress on the seafloor, and can also cause a drop in sea level in a short period of time [11]. These all reduce the stability of the seafloor.

(4) Sea level fluctuation

The fluctuation of sea level is mainly influenced by the global climate. A drop in sea level reduces the pressure on the seafloor, causing the breakdown of gas hydrates. At the same time, the decline of sea level will also increase the deposition rate, which will also cause seafloor instability [12].

2.2. The Impact of Geological Disasters on Marine Engineering

Detrital flows are widely distributed in areas with high seabed slopes, and submarine cables are the most vulnerable marine engineering to the movement of such blocks [13-14]. Judging from the location of the occurrence and the state of existence after the fault, the cable is like a crumpled string, tangled and finally broken, which is different from the flow (rolling) of the debris flow along the slope, which "rolls" the cable in. Large burial depth and overlapping effects. In addition, the movement of the debris flow not only has horizontal displacement, but also has a difference in the linear velocity of its interior rotating from the edge of the fluid to the center, so that the cable is not only subjected to horizontal pulling force, but also the cable in the debris flow is subjected to the debris flow. The huge shear force generated by the difference in internal linear velocity [15]. The debris flow is most destructive in the early stage of movement. As the flow velocity of the debris flow increases, the mixing amount of the surrounding seawater will increase, and the density of the debris fluid, the cohesion between particles and the shear force in the layer will increase. down, the destructive power is relatively reduced. With the increase of water content, the debris flow gradually becomes fluid and diffuses away [16].

2.3. Interaction between Mass Motion and Marine Engineering

The marine engineering structures will break the dynamic equilibrium system originally formed on the seabed. In order to achieve a new balance with the newly added marine engineering structures, a new geological process will occur on the original seabed, and the hydrodynamic conditions will also change. Human structures may have been destroyed when they were established [17-18]. This situation is very common in modern marine engineering, such as the erosion of submarine pipelines and the lodging of oil platforms.

3. Investigation and Research on the Impact of Geological Hazards on Marine Engineering Based on Machine Learning

3.1. Background of Oilfield Marine Engineering Development

Since the official development and investment of oilfield marine engineering in 2017, more than 50 platforms have been built, which are connected to each other through underwater cables and pipelines, and plans to develop submarine oil and gas transportation, water injection, power transmission and offshore oil and gas integrated transmission. The oil field is located in extremely shallow waters, and the characteristics of sea conditions, shallow geological conditions and the distribution of offshore soft sediments are very complex. Shallow strata are prone to many dangerous geological events, which pose a great threat to the safety and stability of machinery and equipment in the marine environment, especially water pipelines and cables.

3.2. Requirement of Marine Engineering Geological Environment Information System

With the in-depth development of oilfields and the increasing application of technologies, geological conditions play an increasingly important role in oilfield marine engineering. Since the characteristic factors involved are complex, the evaluation factors are many, and the data are reflected in both characteristics and spatial characteristics, it is necessary to establish a scientific information system suitable for environmental monitoring. Determine the unified management and analysis of various types of data and information such as marine engineering regional data, and provide technical support and services for marine engineering production on this basis.

3.3. Machine Learning Method for Landslide Risk Assessment

Support Vector Machine (SVM) is a relatively mature and better-performing machine learning algorithm. The SVM algorithm solves the nonlinear classification problem by finding the broadest classification boundary of the two-class feature space. Compared with other learning methods based on empirical risk minimization, such as neural networks, it has better generalization ability, and the formula can be expressed as:

$$f(x)=\sum_{i=1}^{n}(a_i-a_i^*)K(x_i\cdot x_j)+b \tag{1}$$

For displacement monitoring data that is nonlinear in most cases, the RBF kernel function can be preferred as the kernel. The most commonly used radial basis function is the Gaussian kernel function, and its formula is:

$$K(x,y)=\exp\left\{-\frac{|x-y|^2}{\sigma^2}\right\} \tag{2}$$

In the formula, σ represents the kernel width parameter gamma, which determines the distribution range of the data in the feature space to a certain extent.

4. Analysis and Research on the Impact of Geological Disasters on Marine Engineering Based on Machine Learning

4.1. Geological Hazard Monitoring Data Management

Geological disaster monitoring data management can query the high-precision displacement data of GNSS monitoring stations according to the type of equipment. Users can filter the data according to the hidden danger points, monitoring points and collection start time, and click the export data button to export the data files in the format supported by the Excel software platform.

As shown in Figure 1, the monitoring data statistics of GNSS monitoring stations are displayed. Users can query the monitoring data statistics and chart content of the specified time range according to the filtering conditions, which mainly include 2D and 3D displacement data display and expected and actual data volume, etc. Data summary information, etc. The bottom of the page draws the displacement data charts of the x, y, and z axes of the GNSS monitoring data within the specified time range, and supports users to download charts and export data, as shown in Table 1.

Table 1. Statistics of monitoring data

Date	X-axis	Y-axis	Z-axis
May 1	2	5	6
May 10	-2	4	6
June 1	-6	1	5
June 10	1	-2	-1
July 1	3	6	-3
July 10	-1	8	2

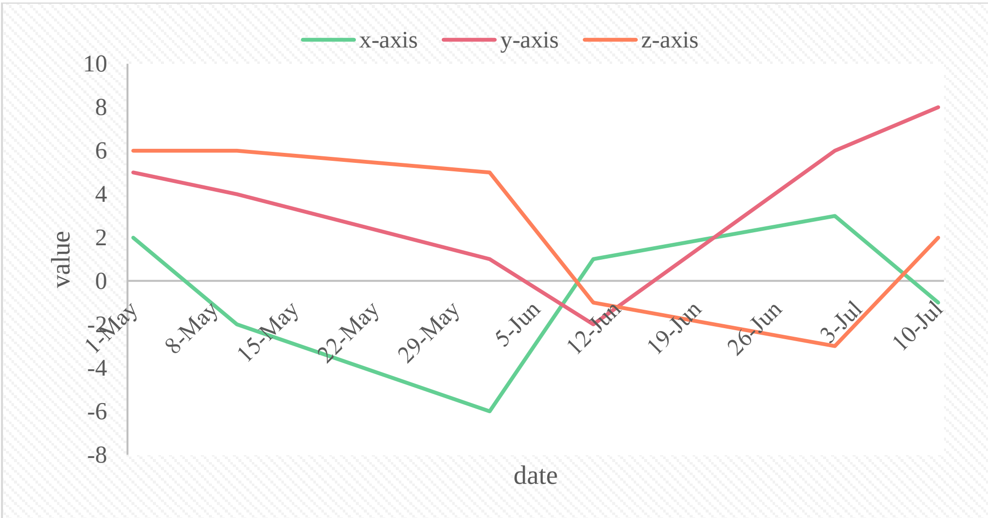

Figure 1. Statistics graph

4.2. Prediction and Early Warning Module

The main process of the prediction and early warning module is shown in Figure 2. In addition to obtaining the data collected by the monitoring equipment, the system will also call the interface provided by the displacement prediction algorithm module service through the scheduled task to obtain the prediction data. Whenever new data is obtained, the system will query the early warning rules associated with the monitoring point. It contains the corresponding warning thresholds of different levels. By comparing the data obtained by monitoring or prediction with the thresholds, it is judged whether to trigger the warning.

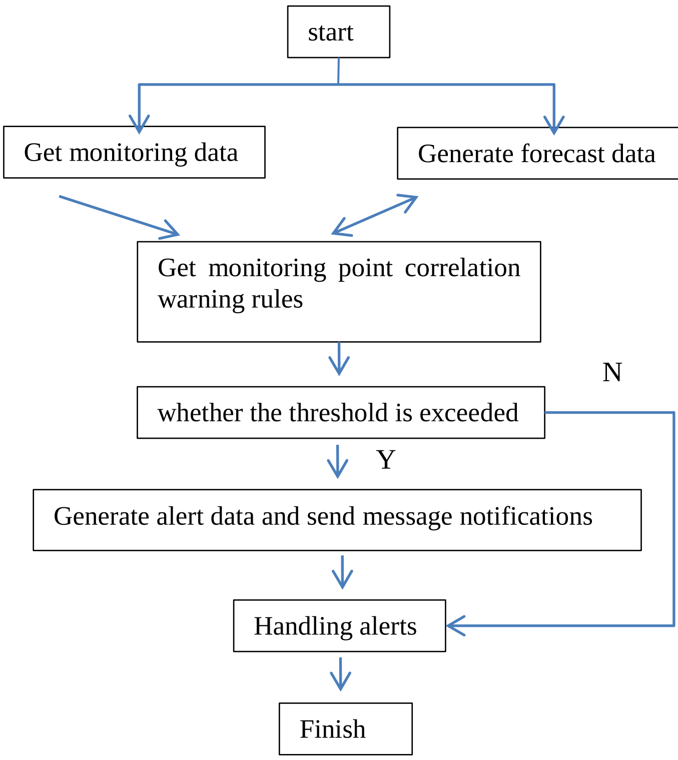

Figure 2. Alert flow chart

The algorithm module service mainly provides SVM algorithms. In this paper, the combination of grid search and cross-validation is used to search for the best parameter combination, and the method of 5-fold cross-validation is selected in this paper. After grid search, the optimal parameter combination of the obtained model is ['kernel'='rbf', 'C'=3'gamma'=0.1]. At this time, the training set classification accuracy of the model is up to 0.90. According to the built model and the results of parameter tuning, the final landslide risk assessment model based on SVM is determined.

4.3. Comprehensive Evaluation Results of Oilfield Marine Engineering Geological Environment

Statistics on the area of various dangerous areas of landslides show that the areas with high landslide risk account for 23% of the engineering area of the oilfield, as shown in Figure 3. The medium-risk area accounts for 28% of the entire oilfield marine engineering area, and the low-risk area accounts for 59% of the oilfield marine engineering area, as shown in Table 2. Among the 84 landslides in the offshore engineering of the oilfield, a total of 20 landslides are located in the high-risk area of the landslide risk assessment. The landslide risk assessment results are consistent with the actual landslide distribution, indicating that the constructed landslide risk assessment model has a good effect.

Table 1. Comprehensive evaluation results of oilfield marine engineering geological environment

Landslide hazard areas	Proportion(%)	Number of landslides
High risk	23	20
Medium risk	28	24
Low risk	59	50

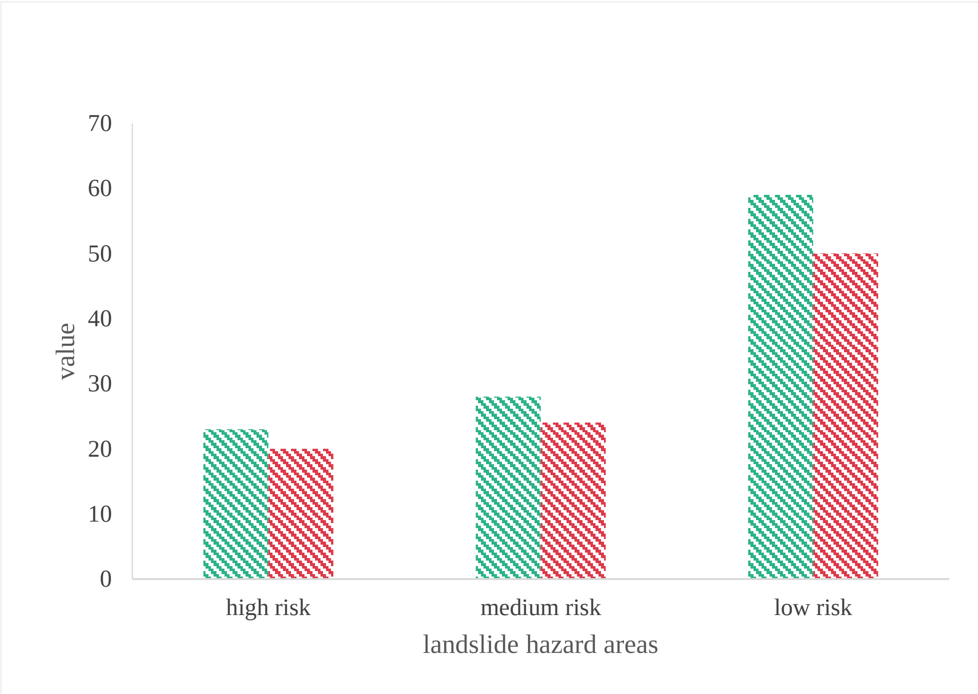

Figure 3. Area statistics of various hazardous areas

5. Conclusion

At present, the research on landslide risk in marine engineering mainly focuses on traditional methods, and there are few studies on landslide risk assessment using machine learning methods. In addition, there are many disciplines involved in landslide risk. Due to the limitations of time, research conditions and my research level, I have insufficient understanding in some aspects, so there is still some room for further improvement in the subsequent research. The research of this paper can also be explored in the following parts: this paper only analyzes the landslide risk of marine engineering, other such as foundation settlement, instability of seabed soil, scouring and embedding of routing pipelines, lateral forces and lateral forces on platforms The resistance and anti-sliding stability, the seismic liquefaction of each layer of soil have not been covered, and the understanding of all aspects should be strengthened in the future work and study. The oilfield marine engineering analyzed in this paper can be said to be a special case of research. The engineering geological conditions and existing problems are far more complicated than the analysis. The principle of specific analysis of specific problems should be followed in the work.

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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