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Identification of Structural Parameters of Offshore Platforms Based on Reality and Virtual Technology

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Abstract: Offshore platforms have complex structures, high construction costs and harsh operating environments. To prevent serious and fatal accidents, regular/irregular inspections and safety assessments of outdoor platform systems are required during work. Especially for external platforms in the middle and late stages of operation and platforms that are not running, it is more important to perform effective health detection. The purpose of this paper is to study the identification of structural parameters of offshore platforms based on the reality and virtual technology. This paper summarizes the feedback-based linear structure parameter identification methods at home and abroad in recent years, and makes a comprehensive analysis of its application origin, research importance, research status at home and abroad, existing research methods and existing problems. This paper points out that the main problem in the application of output response-based modal parameter identification technology in the field of water engineering is to eliminate the noise and null conditions of measurement signals and signal keys. Denoising and removing spurious noise is a logical model command. Experiments have shown that the recognition results are very close to the real values, and the recognition accuracy will decrease in the presence of noisy signals, and the use of virtual reality technology can improve the accuracy by about 10%.

1. Introduction

The vibration modes of machinery, building structures, aircraft, ships and offshore platform components are diverse and rapidly changing. The actual vibration response history or response spectrum of the system can be predicted from several known loading time histories. Therefore, modal analysis technology has been widely used and matured in the engineering field. In the field of marine technology, this technology is developing and will become an important way to solve practical problems in the future [1-2].

In the research on the identification of the structural parameters of the offshore platform based on the reality virtual technology , many scholars have studied it and achieved good results. For example , Idrisov IA et al. redefine it and call it frequency domain degradation (FDD). The main idea is to decompose a single value on the response energy scale and decompose the power spectrum into a series of power spectra, each of which corresponds to an independent system [3] . Olak M is suitable for multi-hypothesis or multi-index parameter identification. The identification process ultimately leads to the solution of the linear system of equations. In the solution process, there is a problem that the coefficient matrix of the linear equation system does not dominate the diagonal, and the numerical value is always large, which is not good. The position table cannot guarantee high correction accuracy [4] .

This paper introduces the related theory of modal analysis and various realization methods of determining modal values in time domain: time domain method, eigensystem realization algorithm, least square method. Several common modeling methods are briefly introduced: curve fitting method, error map method, stable design method, Hankel matrix selection method, and the advantages and disadvantages of each method are compared. A virtual reality-based model classification is proposed. Focuses on effective signal suppression methods based on the Cadzow balance principle. Combining the proposed model ranking method with the least squares method, it is applied to the digital model of a 5-DOF spring mass-damper system to verify the accuracy of the parameter identification algorithm combined with model order analysis and signal denoising.

2. Research on the Identification of Structural Parameters of Offshore Platforms Based on Virtual Reality Technology

2.1. Discrimination of True and False Modalities in the Field of Modal Recognition

Because the standard signal is disturbed by noise, the signal must contain the noise level. The identification of true and false patterns has always been a very important problem in the field of pattern recognition. Moreover, the problem of distinguishing between true and false conditions is closely related to the logical determination of model order. Stability map method has been widely used in time period parameter identification methods and software, but this method can not completely eliminate the influence of noise, and with the increase of model order, some error positions remain unchanged, false errors. Modal and true modal becomes difficult. Eigensystem implementation algorithms only use Modality Proof (MAC) and Modality Value (MSV) to distinguish between true and false states, but both have difficulty in accurately determining whether the identified state is the true state of the system. Therefore, it is urgent to develop a detection method that can effectively verify whether the identified transfer mode parameters are the actual modes of the system [5-6] .

2.2. Modal Recognition by Scalar Arma Method

The process of the ARMA method is summarized as follows:

(1) Measurement of vibration signal

First, design a logic sensor setup. We choose a point among the measurement points as a reference point on the principle that the structural conditions of interest can be particularly sensitive to this reference point. In engineering, the reference point is usually taken at the highest point of the system. Then measure the vibration signal at different positions in the system [7-8] .

(2) Calculation of autoregressive coefficients

According to the data of the reference point and one of the measurement points, calculate the cross-correlation function between them to obtain the Yule-Walker equation, and then solve the Yule-Walker equation to obtain the autoregressive coefficient.

(3) Construction of cross spectrum

Based on the obtained AR coefficients and cross-correlation function, a cross-section of the two-point data is obtained from the ARMA model. The Cross Spectrum tool is obtained by solving a polynomial equation consisting of AR coefficients. The remaining spectrum is obtained by multiplying the cross spectrum .

(4) Identification of conversion parameters

The natural frequency and elastic ratio of the system are taken from the shaft. The shape value of the measurement point is taken from the remainder. By specifying a reference point and selecting each measurement point in turn, the modal parameter values of each series corresponding to each measurement point can be obtained. Since the transport mode parameter is a general characteristic of the system, the sum of the transport mode values obtained at all measurement points is used as the identification result [9-10].

2.3. Signal De-Noising

When the measured impulse response sequence $\{h_\lambda\}$ is interfered by random noise, it can be expressed as:

$$h_\lambda = \bar{h}_\lambda + e_\lambda = \sum_{k=1}^{2M} A_k e^{S_k \lambda \Delta t} + e_\lambda \tag{1}$$

where $\bar{h}_\lambda$ and e_λ represent the real signal and noise, respectively. Theoretically, the Hankel matrix H formed by the noisy signal in $\{h_\lambda\}$ equation (1) can be divided into two parts [11-12] :

$$H_{m\times n} = \bar{H}_{m\times n} + E_{m\times n} \tag{2}$$

where $\bar{H}$ and E represent the Hankel signal matrix and the noise matrix composed of real signals, respectively. Since the number of signal $\{h_\lambda\}$ participating modes is M, $\bar{H}$ the rank is equal to 2M.

2.4. Classification of Modal Parameter Identification Methods in the Time Domain

With the development of structural strength test technology and science, modal parameter identification methods have been developed rapidly in recent years, and effective identification methods have emerged, mainly time domain method and frequency domain method, to perform equivalent instability and stability. Input and structural responses, non-white and nonlinear noise, and computational speed improvements [13-14]. Among them, the frequency domain method also uses FFT, but there are many improvements; the classification of time domain methods is shown in Figure 1, and each method has its practical application limitations. This paper mainly introduces the widely used methods in time domain modal parameter identification methods, such as ITD (Ibrahim Time Domain) method, Eigensystem Realization Algorithm (ERA), Time Series (ARMA) method, complex exponential method, etc. [15-16] .

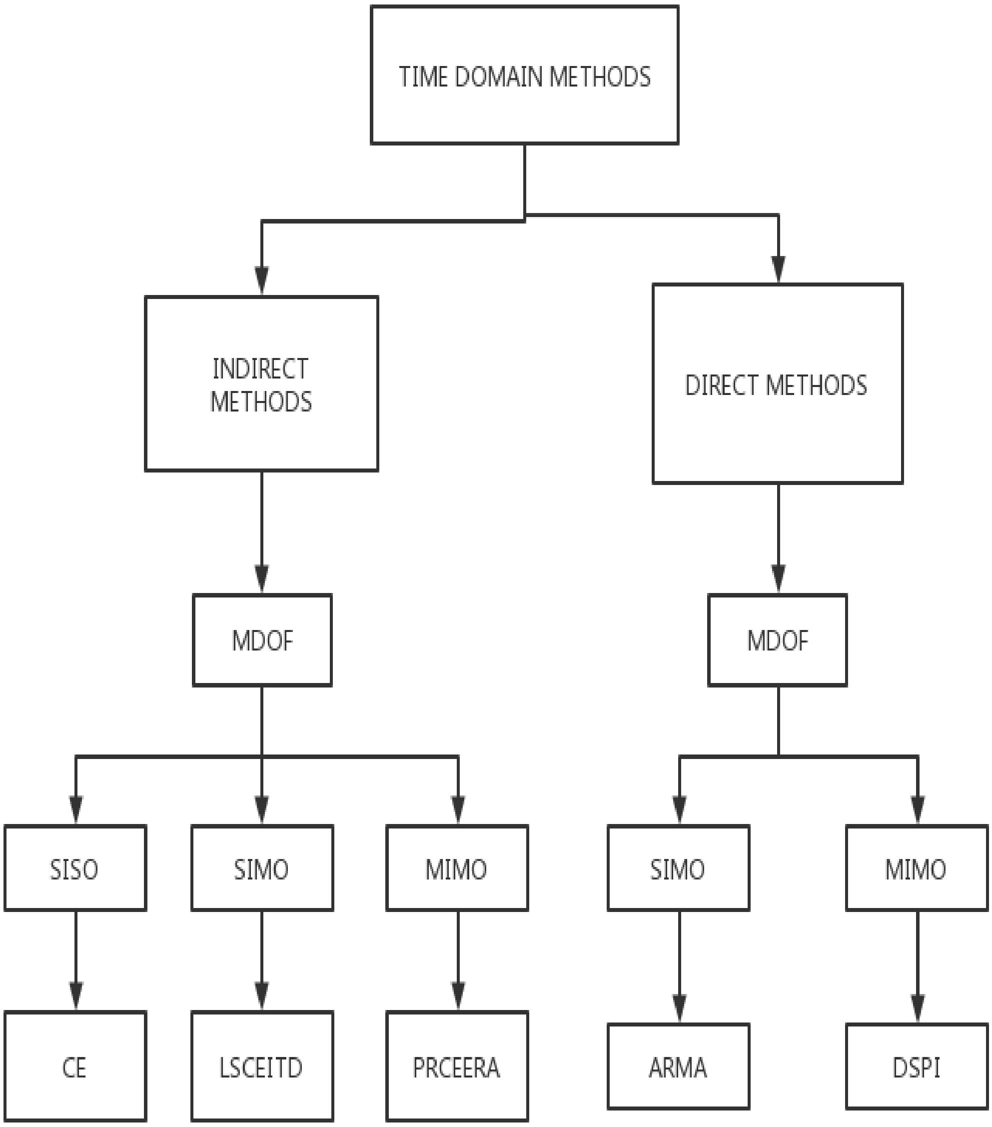

Figure 1. Classification of the modal parameter identification method in the time domain

3. Research and Design Experiments on the Identification of Structural Parameters of Offshore Platforms Based on Reality and Virtual Technology

3.1. Signal De-Noising and Model Order Determination

The signal denoising method used in this paper is Cadzow theory, which belongs to the structural low-rank approximation technology. To put it simply, the structural low-rank approximation technology is based on a specific matrix form (such as Hankel matrix) and a certain "low rank" to approximate, that is, to perform low-rank approximation on the Hankel matrix constructed from the original signal to obtain de-noising. The signal matrix of , and the matrix still maintains the form of

Hankel, but the rank becomes a predetermined value. The model order method we proposed in Chapter 4, the Hankel matrix rank estimation method, is precisely for the Hankel matrix, and the purpose of order determination is to determine the number of modes contained in the impulse response signal, and the number of modes Twice is the rank of the Hankel matrix. Therefore, the model order determination can be linked with signal de-noising, that is, the Hankel matrix is constructed from the measured impulse response signal, the rank of the Hankel matrix is determined by the model order determination, and the structural low-rank approximation calculation is performed based on the determined rank, so as to achieve the best signal de-noising effect. purpose, and provide an important basis for the subsequent identification of modal parameters [17-18] .

3.2. Experimental Design

This paper addresses the identification difference under different frequencies and signals, mainly for the identification error change under the presence or absence of noise signal. Secondly, this paper improves the recognition accuracy of the recognition parameter system in the structure parameter recognition.

4. Experimental Analysis on the Identification of Structural Parameters of Offshore Platforms Based on Reality and Virtual Technology

4.1. Modal Frequency

In this paper, the Prony method is used to identify the modal parameters of the denoising signal based on the model order of 8, and the 4th-order modal frequency and damping ratio are identified. The data are shown in Table 1.

Table 1. Mode frequencies identified using precise signal, noise cancellation signal and mode frequency with 20% noise signal, respectively

	1	2	3	4
Accurate signal	34.499	100.7	158.73	203.89
Noise-elimination signal	34.499	100.69	158.84	161.82
With a 20% noise signal	34.65	101.18	161.82	198.66

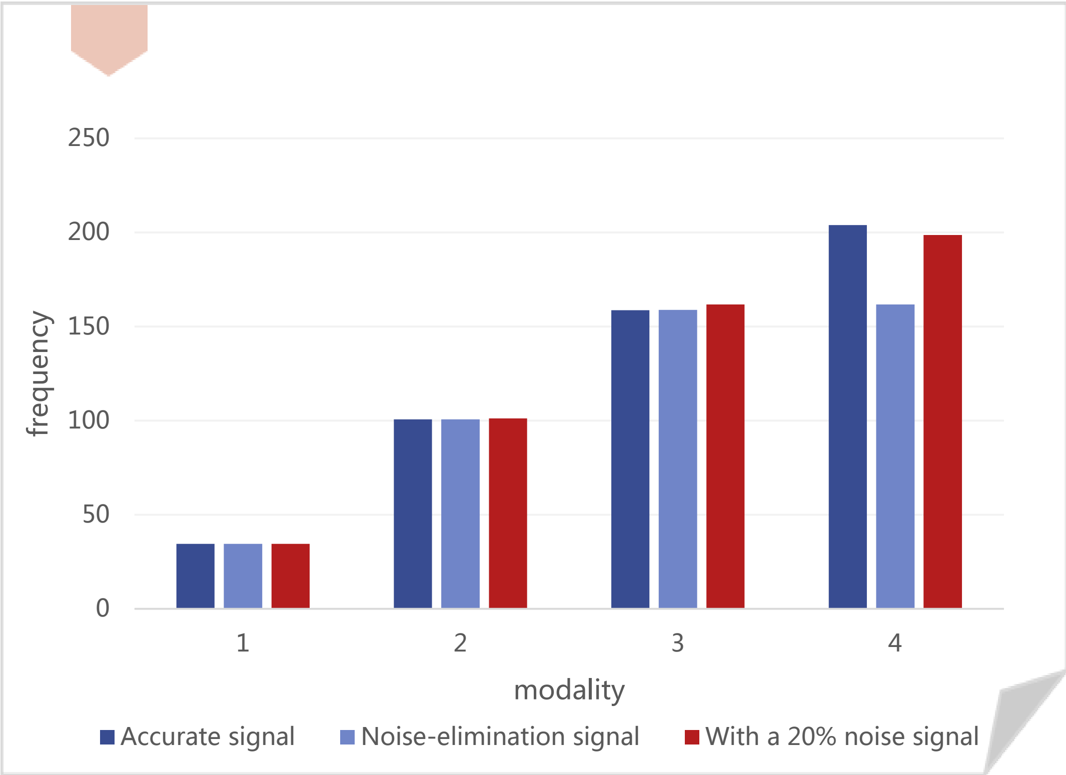

Figure 2. Comparison of modal frequencies for multiple signal recognition

It can be seen from Figure 2 that the identification results are very close to the real values, in which the relative error range of the modal frequency is 0%-0.363%, and the relative error range of the damping ratio is 1.109%-8.778%. On the contrary, if the signal with noise is used, the relative error range of modal frequency is 0.438%-2.565%, and the relative error range of damping ratio is 11.905%-207.275%.

4.2. Application of Reality Virtual Technology

This paper compares the structural parameter identification system of offshore platform and the traditional structural parameter identification system of offshore platform based on the reality virtual technology constructed in this paper. At the same time, a number of different offshore platform structural parameters are identified, and the identification accuracy is shown in Table 2.

Table 2. Comparison of the two different structural parameters identification results

	1	2	3	4
Traditional identification system	87	86	89	83
The Virtual Reality Identification System	96	97	94	97

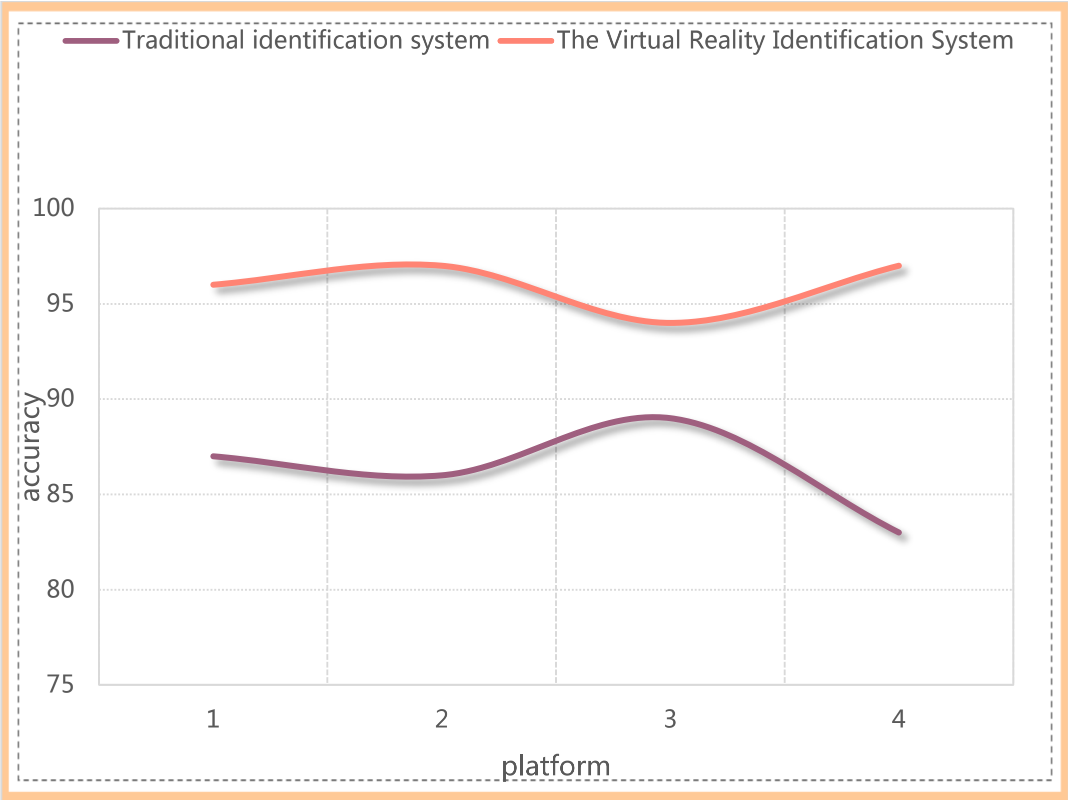

Figure 3. Comparison of structural parameter identification accuracy between virtual reality and traditional systems

It can be seen from Figure 3 that the recognition accuracy of the offshore platform structure parameter recognition system based on virtual reality constructed in this paper is significantly higher than that of the traditional system, which is about 10% higher. And with the continuous progress of virtual reality technology, the recognition accuracy of the parameter recognition system in this paper will be higher and higher.

5. Conclusion

The type and quantity of the participating modes of the measured signal are closely related to the initial displacement of the structure and the position and direction of the sensor arrangement. Based on the free vibration acceleration response data, this paper adopts the complex exponential method (Prony method) to identify the modal parameters of a four-legged marine jacket platform. The results show that when the tension method is used to simultaneously apply loads to two legs of the platform in the same direction, the initial deformation of the platform is mainly translation, and the measured signals also mainly include translation modes; when a load is applied to one leg of the platform, The initial deformation of the platform is translation and rotation, and its signal participating modes also include translation mode and rotation mode. This conclusion can provide guidance for the optimal arrangement of sensors in the field measurement of marine structures. In addition, for the acceleration response signal, the participating modes in the initial part include both high-order modes and low-order modes; because the high-order mode decays faster, the dominant mode in the latter part of the signal is the low-order mode. Therefore, when the modal parameters are identified based on the initial part of the acceleration signal, multi-order modes can be identified;

since the higher-order modes are easily affected by noise, the latter part of the signal is often used for parameter identification in practical applications. When the measured signal contains modes with similar subdivision frequencies, there will be a "beat" phenomenon. In the process of modal parameter identification, it becomes more difficult to identify multiple modes with similar frequencies.

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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.

References

[1] Zhang L , Xu R , Miao H , et al. Research on infrared dim and small target detection algorithm based on frequency domain difference. International Journal of Remote Sensing, 2022, 43(8):2942-2964. https://doi.org/10.1080/01431161.2022.2075245

[2] Idrisov I A , Shishlina N I . Identification of Ancient Anthropogenic Activities in Steppe Regions on the Basis of Holocene Deposits in the Southeastern Part of Rostov Oblast. Arid Ecosystems, 2022, 12(3):327-335. https://doi.org/10.1134/S2079096122030040

[3] Bakhshi M , Ebrahimi L , Zare R , et al. Development of a Novel Diagnostic Tool for Cercospora Species Based on BOX-PCR System. Current Microbiology, 2022, 79(10):1-8. https://doi.org/10.1007/s00284-022-02989-0

[4] Olak M , Ekerden M . Modelling And Validation Of Effect Of Binder Type On Feeding Behaviour Of Spheroidal Graphite Cast Iron. International Journal of Cast Metals Research, 2022, 35(1-3):9-16. https://doi.org/10.1080/13640461.2022.2064653

[5] Hoseinpour Roudsari H , Monavari S M , Khara H , et al. Developing a conceptual model for risk assessment of aquaculture industry: a case study on the coastline of Caspian Sea. Arabian Journal of Geosciences, 2022, 15(18):1-13. https://doi.org/10.1007/s12517-022-10732-z

[6] González-Olvera, Marcos A, Torres L , Fontes J V H , et al. Characterizing water-on-deck propagation with a nonlinear advection-diffusion equation. Journal of the Brazilian Society of Mechanical Sciences and Engineering, 2022, 44(9):1-13. https://doi.org/10.1007/s40430-022-03718-1

[7] Chan R , Ha Y J , Ahn H J , et al. A Comparative Analysis of the Characteristics of Platform Motion of a Floating Offshore Wind Turbine Based on Pitch Controllers. Energies, 2022, 15(3):716-.https://doi.org/10.3390/en15030716

[8] Berry E A , Hillerton J E . A retrospective on claims regarding clinical mastitis in the subsequent lactation, after use of an internal teat sealant in the dry period. Journal of Dairy Research, 2022, 89(2):173-177. https://doi.org/10.1017/S0022029922000401

[9] Bindu Bhargavi S M , Suma V . A Survey of the Software Test Methods and Identification of Critical Success Factors for Automation. SN Computer Science, 2022, 3(6):1-9. https://doi.org/10.1007/s42979-022-01297-5

[10] Xu Y , Shen G , Zhang Y , et al. Forming numerical analysis and experiment research on hot rolling of straight face gear. The International Journal of Advanced Manufacturing Technology, 2022, 121(11-12):8299-8311. https://doi.org/10.1007/s00170-022-09787-9

[11] Mcelhinney Z , Kennedy C . Enhancing the collective, protecting the personal: the valuable role of composite narratives in medical education research. Perspectives on Medical Education, 2022, 11(4):220-227. https://doi.org/10.1007/s40037-022-00723-x

[12] Barzaman K , Vafaei R , Samadi M , et al. Anti-cancer therapeutic strategies based on HGF/MET, EpCAM, and tumor-stromal cross talk. Cancer Cell International, 2022, 22(1):1-20. https://doi.org/10.1186/s12935-022-02658-z

[13] Bu J , Yu K , Ni J , et al. Machine learning-based methods for sea surface rainfall detection from CYGNSS delay-doppler maps. GPS Solutions, 2022, 26(4):1-14. https://doi.org/10.1007/s10291-022-01320-5

[14] Ametefe D S , Sarnin S S , Ali D M , et al. Fingerprint Liveness Detection Schemes: A Review on Presentation Attack. Computer Methods in Biomechanics and Biomedical Engineering: Imaging And Visualization, 2022, 10(2):217-240. https://doi.org/10.1080/21681163.2021.2012826

[15] Hayashi N , Koyanaka S , Oki T . Verification of algorithm for automatic detection of electronic devices mounted on waste printed circuit boards. Journal of the Air And Waste Management Association, 2022, 72(5):420-433. https://doi.org/10.1080/10962247.2022.2044408

[16] Chen W , Xiong C , Yu L , et al. Dynamic monitoring of an offshore jacket platform based on RTK-GNSS measurement by CF-CEEMDAN method. Applied Ocean Research, 2021, 115(3):102844. https://doi.org/10.1016/j.apor.2021.102844

[17] Hosp B W , Schultz F , Hner O , et al. Soccer goalkeeper expertise identification based on eye movements. PLoS ONE, 2021, 16(5):e0251070-.https://doi.org/10.1371/journal.pone.0251070

[18] Jang S , Kim B , Yoon H , et al. Implementation of Virtual Reality Model for Offshore Gas Field Platform and Evaluation of Gas Hydrate Formation for Subsea Production Pipeline using AI. Journal of the Korean Society of Mineral and Energy Resources Engineers, 2021, 58(2):150-160. https://doi.org/10.32390/ksmer.2021.58.2.150