EAI Endorsed Transactions
on Energy Web

Research Article **EAI.EU**

New Approach to SCADA System Screen Configuration Based on the Model of Oil and Gas Pipeline Network

He Huang[1,2,*], Yafeng Li[1], Liang Ma[3], Bingqiang Mao[1], Lin Zhang[1], Jingli Yang[1], Haishan Wang[3], Yanguo Sun[1], Xiaochuan Zhao[1] and Muhao Lv[1]

[1] PipeChina Oil and Gas Control Center, Beijing 100000 , China
[2] School of Software, Tsinghua University, Beijing 100000, China
[3] Kunlun Digital Technology Co.,Ltd., Beijing 100000, China

Abstract

INTRODUCTION: With the continuous progress of science and technology, the monitoring and control of oil and gas pipeline networks have become more and more critical; SCADA systems, as a kind of technology widely used in industrial control, play a key role. The screen configuration of the SCADA system is the core part of its user interface, which is directly related to the operator's mastery of the status of the pipeline network. In order to improve the monitoring efficiency and reduce the operation risk, this study is devoted to exploring a new method of SCADA system screen configuration based on the oil and gas pipeline network model.
PURPOSE: The purpose of this study is to develop an innovative SCADA system screen configuration method to present the operating status of the oil and gas pipeline network more intuitively and efficiently. The design based on the pipeline network model aims to enhance the operators' understanding of essential information, such as pipeline network topology, fluid flow, etc., so as to make monitoring and control more intelligent.
METHODS: The study adopts a new method of SCADA system screen configuration based on the oil and gas pipeline network model. First, the topology, sensor data, and control nodes of the oil and gas pipeline network are comprehensively modelled. Then, through the design principle of human-computer interaction, the modelling results are integrated into the screen configuration of the SCADA system to realize the intuitive presentation of information. At the same time, advanced visualization technology is introduced so that the operators can understand the real-time changes in the pipe network status more clearly.
RESULTS: After experimental verification, the new method shows significant advantages in oil and gas pipeline network monitoring. The operators can recognize the abnormalities of the pipeline network more quickly and accurately through the SCADA system screen configuration, which improves the efficiency of troubleshooting and treatment. The visualized interface design makes the operation more intuitive and reduces the possibility of operating errors, thus improving the safety and reliability of the pipeline network.
CONCLUSION: The new method of SCADA system screen configuration based on the oil and gas pipeline network model has achieved significant results in improving monitoring efficiency and reducing operational risks. Through a more intuitive and intelligent interface design, operators can have a more comprehensive understanding of the operating status of the pipeline network, which provides practical support for rapid response and decision-making. This approach introduces new ideas to the field of oil and gas pipeline network monitoring, which is of positive significance for improving the overall performance of the system. Future work can be carried out to optimize the interface design further and expand the applicable scenarios.

Keywords: oil and gas pipeline network; SCADA system; screen configuration; pipeline network modelling

Received on 29 February 2024, accepted on 15 March 2024, published on 19 March 2024

doi: 10.4108/ew.5247

[*]Corresponding author. Email: 345795778@qq.com

1. Introduction

Over the past few years, PetroChina has played an essential role in the strategic development plan of the Belt and Road, becoming a significant market for the strategy(Xiaozhong et al., 2022). The region is not only a secure area for natural resources but also a place for favourable capacity combinations in international strategic oil and gas corridors. In terms of energy cooperation, PetroChina has developed strategic cooperation with other countries, of which cross-border safety and emergency response measures for oil and gas pipelines are vital components(Yu et al., 2021). However, there are a number of things that could be improved in the safe operation and maintenance of offshore oil and gas pipelines. First, it involves operations on land and near pipelines in other countries, far from China's mainland, where the complex geopolitical situation complicates long-term safety. Second, harsh environments can lead to natural disasters, challenging the safe operation and long-term integrity of foreign oil and gas pipelines. Third, the Belt and Road countries have a complex environment with difficult social security and accident control(MINGLisen & WANGShu, 2022). However, PetroChina has limited experience and contingency plans in crises, so proper simulation drills and tests are needed to avoid and prevent accidents.

Meanwhile, with the development of 3D modelling technology, its application in the field of oil and gas pipeline networks has become more widespread. This technology not only improves the management level of oil fields but also helps reduce their energy consumption (Geng et al., 2021). Virtual reality technology also plays a vital role in the field of 3D oil and gas pipelines and has become another research hotspot.

Currently, virtual modelling research methods at home and abroad are divided into bottom-up development, tool-level development and tool development based on advanced applications. Among them, most of the bottom-up development tools use OpenGL, while the parent tools include Vega Prime, OSG, and ArcGIS.OpenGL, as a virtual reality graphical user interface library, has unique advantages in the use of hardware and operating systems. However, as modelling becomes more complex, OpenGL's performance has some drawbacks. For example, although OpenGL supports models generated by popular modelling software such as 3DMax, the conversion process is complex and lacks flexibility and precise control(Asare et al., 2021). In addition, SGI OpenGL is very slow to update and has a very high frame rate when using complex modelling systems. As an advanced virtual modelling platform, OSG not only encapsulates and integrates OpenGL but also defines scene object models as downloadable object nodes. All models are independent of OSG, so a variety of programs can be used to create complex models and manage 3D scenes(Raanan, 2023). This provides the oil and gas pipeline field with a more flexible and efficient modelling tool that helps to manage better and maintain oil and gas pipeline systems(Xu et al., 2021).

Therefore, by strengthening safety cooperation and emergency preparedness in oil and gas cooperation, as well as adopting advanced virtual modelling technology, the efficiency and sustainability of PetroChina's "Belt and Road" strategy can be improved(Jiang et al., 2021). However, it has no human-machine interface, which perpetuates OpenGL errors and increases the workload of subsequent developers. Changing scenarios requiring complex workloads, lack of flexibility, and modular design concepts made OSG development even more difficult. Vega Element has been released, which significantly improves on the initial OSG bugs. Not only does it feature Vega graphics and performance scripting, but it also has a powerful GUI that significantly reduces the burden on developers(Sharma & Damle, 2022). The Scenario Graphics Library not only allows staff to realize targeted functional projects but also to develop and configure interactive interfaces quickly. At the same time, the combination of robust modelling and ease of use creates realistic modelling results and speeds up the modelling system.

Currently, pipeline management focuses mainly on integrating and analyzing historical data, which makes it challenging to model and visualize data analysis of different process instances(Q. F. A. et al., 2022). In order to ensure scientific management of oil and gas pipeline 3D systems, it is necessary to develop and study complex multi-purpose BIM programs in complex mountainous geographical conditions. On this basis, simulations and exercises are performed in the environment.

2. Background of the study

At present, the research on the oil and gas pipeline network in China is still at an early stage, and the 3D object management system of the oil and gas network contains various multifunctional data(Zhu et al., 2021). In the simulation system, it is difficult to display images through various training and intuitive accident simulation. Realistic rendering of the simulation environment is an essential direction in the development of information technology and technology(Ali et al., 2021). The aim is to achieve a realistic resemblance to the real world in three dimensions by modelling the visual environment. In the field of emergency modelling and pipeline training, it has been observed that pipeline research started relatively late, without proper decision support models, simulation environments, and comprehensive multi-data fusion research systems(Shabanova & Maluka, 2023). In addition, relatively comprehensive research to support scientific decision-making has not yet been conducted, nor has significant progress been made in related research and application areas. The above text refers to the urgent need for an information management technology platform, especially in support of pipeline network studies, pipeline lifecycle data collection, scientific visualization of historical data, and real-time assessment(Hawash et al., 2021). The text describes in detail the essential functions and critical processes of the virtual modelling system, as well as the design of the critical processes for virtual modelling and distribution station objectives through the 3D engine. In terms of 3D modelling, key components and operational parameters of oil plants, service stations, pipelines and instruments are visualized through realistic 3D scene modelling, which provides a solid virtual modelling foundation for the physical structure and daily operation of oil and gas stations(Paulo et al., 2022). The paper also mentions an accident simulation study, which uses virtual reality to simulate the state of various components and equipment in an accident, as well as the ability of users to interactively change the perspective of the scene for observation and emergency rescue drills.

In order to meet the needs of the oil and gas pipeline emergency decision-making system, the core module of a 3D virtual simulation visualization engine with abstract architecture is designed and developed. The layered 3D engine architecture distinguishes between essential physical equipment and higher-level applications. It separates the data layer of the algorithm from the logic layer to provide more flexible configuration and 3D modelling capabilities(J. K. A et al., 2021). This is of great significance for China's energy cooperation and the safety and emergency response of cross-border oil and gas pipelines. Finally, the text refers to engine design methodologies, including model matching, adaptive studies and engine development based on statistical findings(Al-Mishwat, 2021). Emphasis is placed on the fact that design is primarily based on performance rather than specific characteristics and on the development of data loading standards and similar data structure models based on past research to support more efficient engine design and performance optimization (Miranda et al., 2021). A multi-data fusion approach based on XML scripts was designed and developed as a 3D data structure for oil and gas networks(Wang et al., 2022). This approach not only considers many features and their relationships but also helps to extend the data types and subsequent functionality.

The 3D pipeline network modelling engine supports scenario modelling training and information visualization. Still, it is primarily based on large-scale, complex mountain scenarios requiring the integration of multidimensional and multidimensional data types. Multidimensional modular models have high granularity and require precise multi-step parameter determination. Patrol navigation is dynamically displayed in 3D virtual scenes, and oil and gas spills are simulated in analogue scenes. Multi-data data organization distinguishes between geographic environments, pipelines, stations and auxiliary roles in the 3D scenario, as well as hierarchical abstraction packages based on XML scripting technology(Li et al., 2023). Describe the language and syntax rules used to model multiple data objects in 3D scenes semantically.

3. Research methodology

3.1 SCADA system simulation for oil and gas pipeline network modelling

Virtual modelling is an advanced computer graphics-based modelling technique designed to achieve virtual implementations in the real world. Today, with the rapid development of computer software and equipment, the oil and gas network visualization object modelling technology continues to encounter the problems of weak simulation applications and inaccurate quantitative data analysis under the complex geographic conditions of large mountainous regions. In order to solve this problem, the modelling solution is mainly based on the relevant technology of oil and gas networks and its virtual reality-based modelling. Local node diagram, as shown in Figure 1.

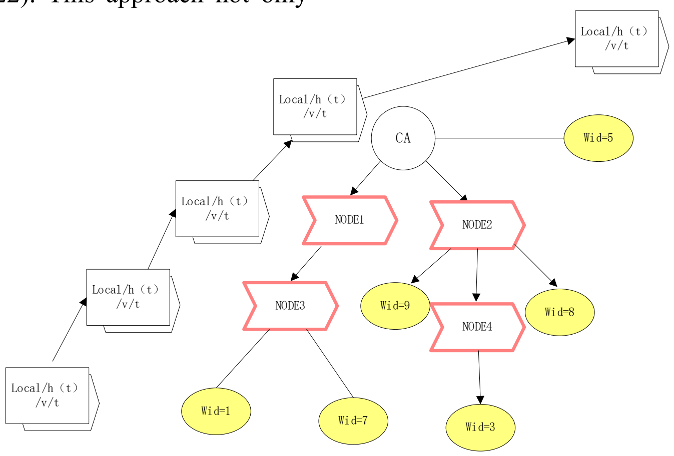

Figure 1 Local node diagram

In the field of information technology research on oil and gas pipelines, with the rapid development of computer application technology, experimental research on oil and gas pipelines in three-dimensional virtual environments has become a new trend in solving temporary problems in this field. Scientific supervision and related work planning, such as oil and gas exploration, oil and natural gas accident simulation, oil and gas transportation, and oil and gas pipeline systems, can be used to develop preventive measures corresponding to simulation techniques for plant management systems. The management of oil and gas pipelines in remote mountainous areas should be based on appropriate GIS and monitoring system data, as well as data collected during the operation of the network. Practical algorithmic models should be developed to support complex simulation studies of oil and gas pipeline extraction systems based on technical knowledge and theoretical guidance from relevant fields. Reduced risk of network security and accidents. Compared with foreign software industries, China's oil and gas software industry still has a big gap. In China, many oil and gas companies use computer software, some of which is purchased from abroad. However, the specific algorithms, strategies and problem-solving principles used in third-party software still need to be clarified, and simple application methods can only be learned through textbooks without understanding and comprehending the system. Domestic and foreign cross-border pipelines are complex, and road accidents are difficult to predict. Complex oil and gas transportation in mountainous areas is a problem that is difficult to solve with multiple problems.

Modelling of oil and gas pipeline technologies mainly includes oil and gas hydrodynamic modelling techniques, with a focus on the analysis of pipeline oil flow processes and EPR-based technology modelling. Currently, standard implementation methods mainly include modelling, creating precise mathematical functional equations to describe specific problems, using certain parameters as input conditions, analyzing specific results and obtaining similar decision support procedures. The software that can perform these functions and apply them successfully to oil and gas pipelines is mainly PLC, which is capable of computer modelling long oil and gas pipelines. In practice, the exact mathematical equations of the functions are complex to describe accurately. The modelling needs to be more credible and accurate due to the unprecedented growth in the amount of data and the increasing size. Therefore, ERP technology for managing oil and gas pipelines is gradually being introduced. Supply chain modelling techniques are also used in the operation and management of LNG receiving terminals, but they are limited to small-scale supply chain modelling. Currently, supply chain modelling techniques have yet to be used to solve complex problems related to pipeline management. Therefore, the current supply chain modelling is still in the theoretical research stage and cannot be effectively applied in practice.

The SCADA system model is specifically shown below:

$$y_j = f\left(\sum_i w_{ji} x_i + b_j\right) = f(net) \tag{1}$$

The reason for using the net as the independent variable is that the number of nodes is to be calculated using the discontinuity function.

$$O_1 = f_0\left(\sum_j w_{oj} y_j + b_0\right) \tag{2}$$

The w in Equation (2) is the weight of each function y. The Ja total is performed to calculate the O_i function.

$$E = \frac{1}{2}\sum (O_i - R_t)^2 \tag{3}$$

E in Equation (3) is the global error, and R and O are the maximum and minimum vectors, respectively.

$$\lambda(x) = \exp\left[-\frac{(w-x)^t (w-x)}{2\sigma^2}\right] \tag{4}$$

The λ-function is the function obtained from the expectation of the variance, and exp is the process of finding the expectation.

$$f_t(x) = \frac{1}{(2\pi)^{p/2}\sigma^p}\frac{1}{m} \tag{5}$$

Equation (5) is calculated by taking 1/m of the normal distribution to yield the function $f_t(x)$.

3.2 Virtual reality-based simulation

With the development of digital earth and digital modelling, virtual reality modelling techniques are increasingly being used in the areas of emergency preparedness, rescue, and safety event modelling. From aviation safety training to accident simulation and rescue exercises, experience plays a valuable role. However, there are two apparent areas for improvement in the development process of traditional 3D visualization modelling tools. First, ad-hoc modelling is fully integrated into a specific application, and the model can only be used in certain situations without considering its reusability and versatility; second, each simulation model has its complete implementation, leading to storage and computational redundancy. As a result, the use of modelling methods could be more generic and scalable, leading to the reuse and consumption of resources in modelling applications. In China, research on 3D modelling training for virtual reality modelling systems started late but has developed rapidly. In 2001, China's first emergency telephone system was launched in Nanning. In 2002, the city established a natural disaster management system. For businesses, PetroChina launched an emergency response platform in 2011.

The Australian Virtual Reality Advanced Research Group and the 3D Visualization Modeling Group are building on these two systems to research and develop safety accident simulation and training systems, including rig training simulators and on-site virtual mining modelling tools. Underground Accident Risk Analysis and Identification, High-Frequency Accident Recovery and Virtual Mining Training System. The University of Pennsylvania has also developed a virtual mining simulation system specifically designed for mine accidents. The main objective of this research is to help people perform safety checks, including whether people are adequately prepared, whether the equipment is correctly positioned and malfunctioning, and how people can independently carry out rescue and relief operations in an emergency. This is critical to improving worker awareness of post-accident safety and emergency response. These emergency assistance and management systems contribute significantly to research on data visualization in pipeline systems by improving the effectiveness of emergency response support in areas such as data connectivity, rapid access and transmission, and multidimensional data inspection.

Although the above studies have produced some results, there are some limitations to the specific scope of the modelling. The benefits of virtual reality modelling do not coincide with those of oil and gas networks. Although there are some specific theoretical foundations, some are just ideas without concrete implementation, while others focus on specific applications in certain areas. Therefore, combining virtual reality modelling with oil and gas network modelling is very important in practice. On the basis of analyzing the structure of the oil and gas network visualization data model, the development of the oil and gas network modelling tool is of great significance. It can provide adequate support for the analysis of the modelling process and data visualization of oil and gas pipeline systems. The power tool uses component design and modularization concepts to make it professional for oil and gas networks. It can support the development and implementation of various simulation scenarios in the field of oil and gas networks, adapting the simulation process to specific scenarios and extending the simulation functionality. Global node diagram, as shown in Figure 2.

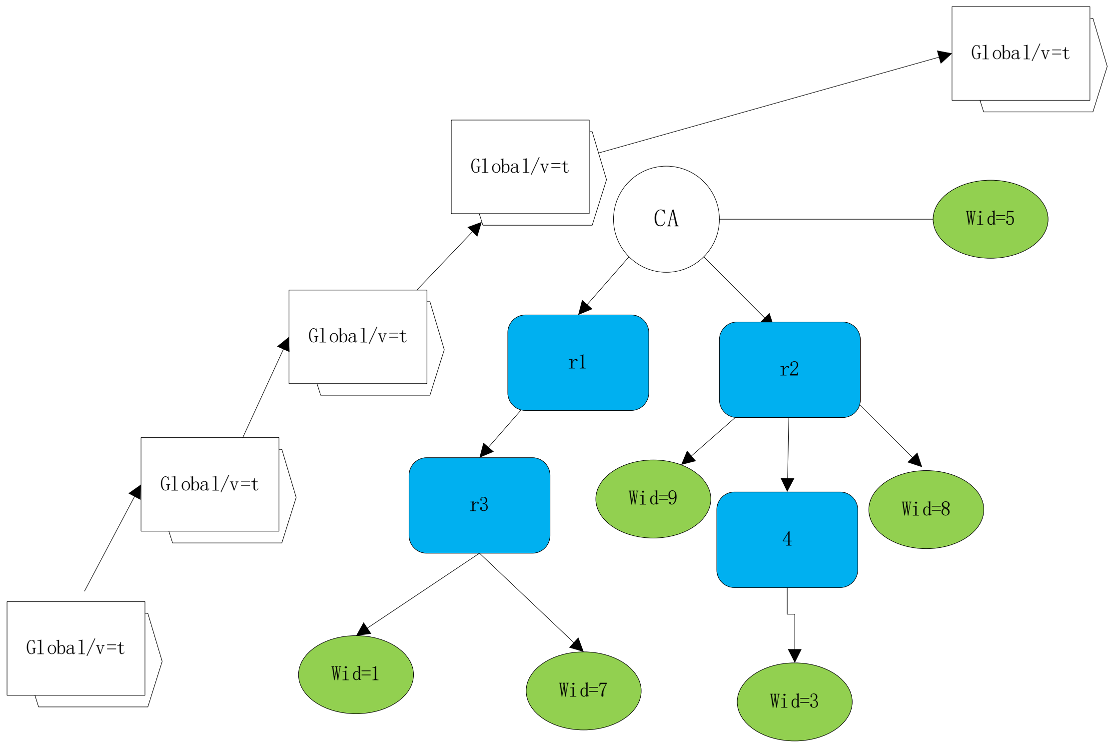

Figure 2 Global node diagram

4. Results and discussion

4.1 SCADA System Requirements Analysis for Oil and Gas Pipeline Network Modeling

In the field of oil and gas networks, especially in coastal areas, long-distance gas pipelines often face difficulties such as natural disasters and accidents, slow social assistance for the transportation of oil and gas fields, and safe use in complex mountainous areas. For this reason, a three-dimensional simulation of the safe operation and maintenance of oil and gas pipelines has been carried out, which is mainly used to simulate the operation and maintenance of large and complex mountainous areas and their surroundings, on-site stations and pipeline valve chambers. A simulation training platform was created to analyze data from pipelines with frequent accidents.

Building complex large-scale mountain modelling and simulation learning scenarios suffers from slow data loading, difficult data conversion, integration of simulation elements and attributes, and semantically identified data. Building an oil and gas network platform requires a wide range of information, including much complex information about the region and its geography. The surrounding geography and scenarios associated with pipelines have significant topography, complexity, and variability. Visual device object model data and associated attribute data (e.g., pipelines and stations), as well as raw data (e.g., vector location request detection), are also available. The vector identification files mainly contain data on different types of pipelines and branches, areas affected by geologic risk points, power plant and valve chamber data, pipeline discharge data, unstable slopes, and geologic risk data. In addition, the size and extent of vector and remotely sensed data generated by the 3D spatial data platform and the inconsistent coordinate system make quantitative analysis by the simulation platform difficult. However, because they are from the real world and are very complex, there is a high degree of correlation and connection between them. FedTor and Domingo functions, as shown in Figure 3.

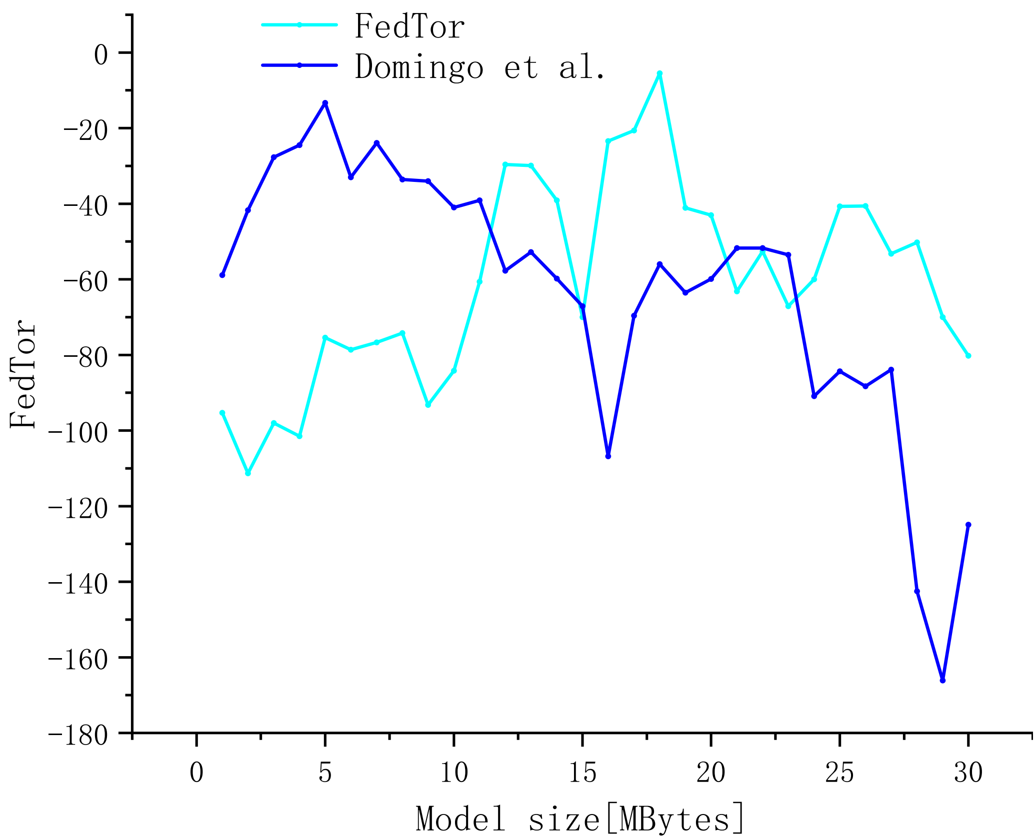

Figure 3 FedTor and Domingo functions

This paper develops a set of tools for oil and gas trunk engines based on component and semantic modelling. The 3D oil and gas pipeline simulation tool has the following features: the 3D oil and gas pipeline simulation engine can support the simulation of environmental and safety incidents in the field of oil and gas pipeline networks. The 3D modelling engine for oil and gas pipelines can load multiple data objects onto the platform and combine different data and data. The 3D simulation engine for oil and gas pipelines integrates the essential functions required for the simulation system and realizes the encapsulation of the main functional subsystems. Each module is independent of itself and the specific modelling system. The 3D simulation engine for oil and gas pipelines can use motor mounts to meet specific simulation requirements. Still, the implementation of parts requires scenario configurations that can be loaded with simulation processes with good scalability.

Oil and gas network modelling mainly includes 3D visualization technology and real-time dynamic modelling technology. In this paper, the author uses OSGeerth and Fluent software for development and data acquisition, encapsulates some core modules, extends the capsule-based application layer, and implements the workflow modelling function of the oil and gas network in the application layer.OSG and OSGeerth are important modelling methods based on 3D scenes and geography.OSG is an open-source library based on the C++ platform. As an intermediate software for the simulation process, it includes advanced features and essential application functions. When creating virtual 3D modelling scripts, most developers do not download or develop the scripts directly. Instead, basic functional modules are encapsulated on top of existing 3D virtual skeleton modelling (OSG) for functional development.OSG has an intuitive and powerful scene tree that significantly reduces the stress of working on a scene, relies on continuous process modelling in the scene, handles batch details in real time, and converts various file formats. It significantly reduces system pressure, system development time, and computer storage costs compared to basic functional interfaces.OSG is mainly composed of OSG function libraries, various generic plug-in mechanisms, OSG utilities, and functional interfaces that are independent of different programming languages.OSG mainly uses wooden structures to create memorable scenes, which reduces the cost of loading and rendering the scenes.

There is only one controller node in the scene tree that contains the entire scene, including each branch node and its leaf nodes. Diagram nodes contain templates for individual objects, while group nodes provide more information about the state of object model attributes. The main task of the group node is to organize and manage various objects and other related nodes in the complex scene model, such as the LOD node at the detailed level, the transform node responsible for various transform operations, and the exchange node responsible for displaying objects. With the rapid development of 3D modelling technology, OSG functions based on OSG technology have been further developed to enable developers to build 3D GIS modelling systems based on geographic data quickly.OsgeArth has made some changes to the stored data sources, initially dividing them into multiple levels to simplify their management, including the field file height, image level, and template level. The model level is primarily used to add a variety of external data, the most common of which is vector data identification. Data driver downloads have also been improved. Different data drivers use different drivers that mainly implement OSG plug-ins and are quickly launched through OSGDB. The mean bit rate of the Li and Lyu functions is shown in Figure 4.

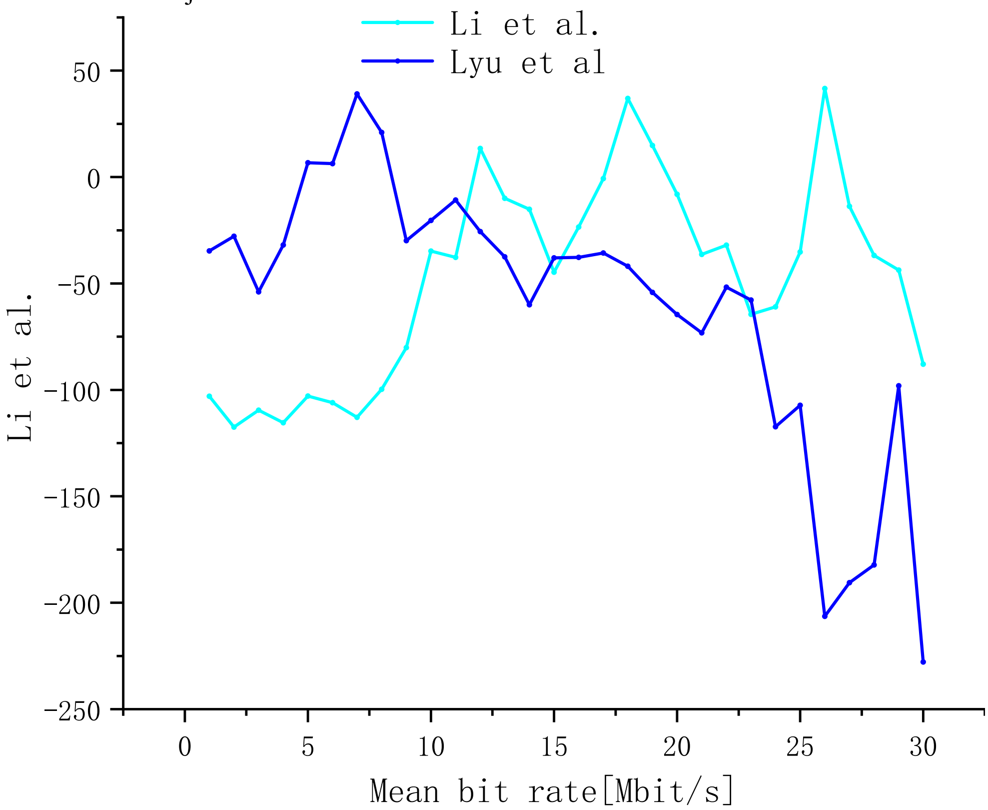

Figure 4 Mean bit rate of Li vs Lyu function

When downloading data, it is stored as a tile called a pyramid data model, arranged in pyramids of different resolutions. When uploading tile data, a quadtree branch is used as a centralized organizational structure. The principle of constructing a quadtree begins by dividing the large scene environment into four sections and dividing each section in the same way to obtain results for each node containing four or zero nodes. The entire data file has zero at the top and 0, 1, 2 and 3 quadrants at the bottom. Each quadrant is divided into four lower nodes at the next level. After indexing, the script can be localized according to the number of specific nodes.

4.2 Application analysis of SCADA system for oil and gas pipeline network modelling

Oil and gas pipelines in mountainous areas are prone to accidents such as oil and gas pipe leaks. The analysis is usually based on Fluent software. Currently, fluid modelling software has been used in many fields and has produced many research results. Continuous 3D modelling software for simulating complex pipe flow distribution models in fluid dynamics. Calculate the corresponding fluid parameters and obtain results using standardized technical tools. Export network files and leakage data to simulate oil and gas pipeline systems.

Widely used fluid modelling software is fluid and flexible in its application. The program imports relevant field files and pipeline models, determines appropriate physical model functions and constraints for simulation calculations, and creates network data, corresponding data files and other necessary property files. Finally, the modeller uses the grid files to find the appropriate geographic area and downloads the modelling results from the data files. In order to reduce the difficulty of the simulation, the accuracy of the leakage movement of the pipeline in the mountainous area can be reduced. The algorithm only calculates the leak area and reduces the number of square grids to 5,080,000, while Fluent can generate 11,107,000 grids that accurately isolate the flow field. As the number of network nodes increases, so does the quality of the network and, ultimately, the rendering. The distribution and selection of the network directly affect the results of fluid modelling. A high-quality eye promotes smooth speed and accurate simulation output. The NDN has no caching transform level, as shown in Figure 5.

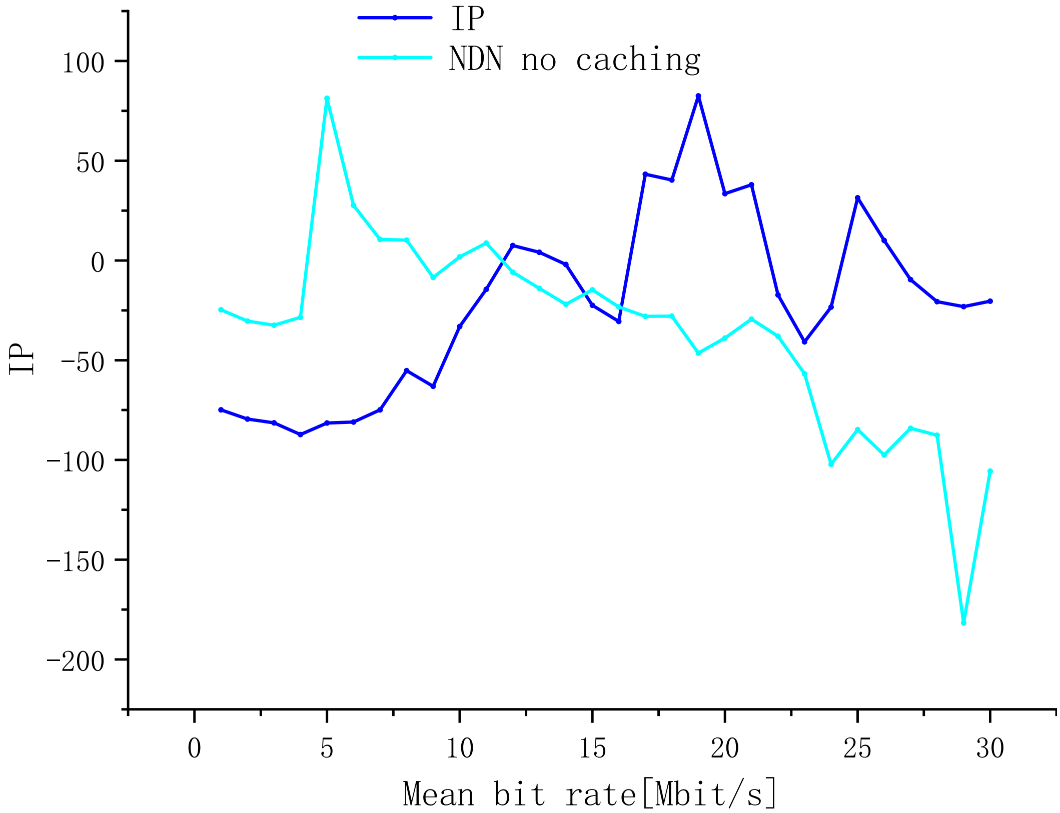

Figure 5 NDN no caching transformation level

When the networks are separated from each other, a computational model is chosen, and different computational models predict the same contaminated pipe leakage. Due to the accuracy of the calculations, leaks are often investigated using improved flow models that bring the calculations closer to actual values. After successful sampling, a number of fluid parameters are determined, usually including adhesion limits such as velocity, pressure, temperature and limit sampling index. The data used in flow modelling consists mainly of historical cumulative data and calculated areas. Studies have shown that Fluent has expertise in hydrodynamic modelling and quantitative analysis of accident scenarios in different leakage areas. However, it is difficult to observe and analyze multiple perspectives and multifunctional modelling and to provide good immersion for scenario modelling. If multiple models are added, the integration of 3D spatial structures is poorer than in 3D spatial modelling software. With various advantages, integrated simulation engine tools can be developed for large and complex oil and gas pipelines.

Currently, 3D modelling is increasing in complexity and data volume. Due to the use of traditional spatial databases, many objects and their connections cannot be stored uniformly. Therefore, it can be uploaded to big data as external files. Spatial integration objects are created based on an abstract analysis of different objects that extract the same properties and behaviours for consistent processing. Specific implementations of spatial integration objects are saved and loaded as XML-based scripts. Therefore, this paper proposes a script-based development approach. More and more developers are gradually using this approach, and it has become a hot research topic to support load deployment in various application scenarios.

Semantic script modelling is the basis for the development of simulation engine technology. This research developed a consistent set of syntax validation rules and modified the scripts according to the content and attributes of the data elements and related constraints. Scripts are a very close characterization of the basic information required by the engine. The scenario can contain geographic information about basic terrain information such as elevation and imagery, but it can also contain a large amount of vector data identifying information. During the design process, scripts are stored in a public structure of XML files and checked for appropriate syntax validation mechanisms. The hierarchical model structure provides a more straightforward and more intuitive representation of the entire modelling process and the changes that occur in its workspace. The NDN of the Model size function is compared with IP6, as shown in Figure 6.

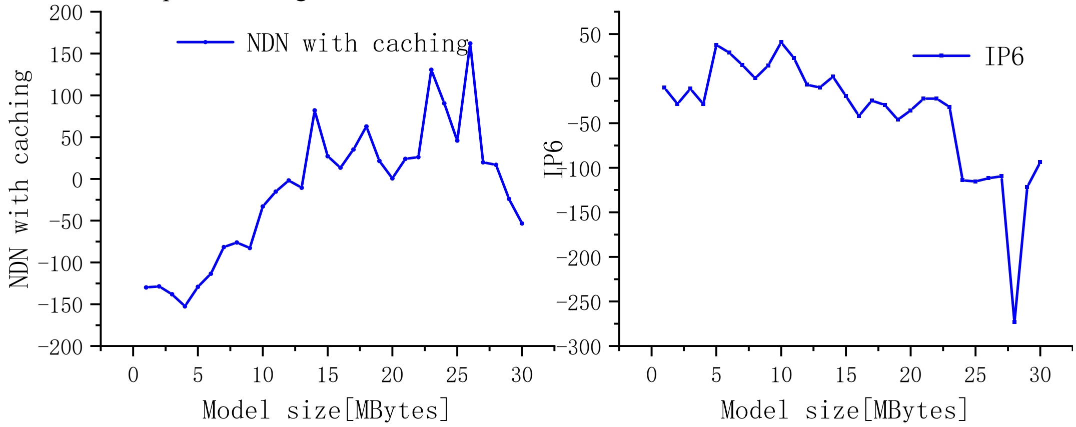

Figure 6 Comparison of NDN and IP6 for Model size function

This is accomplished through appropriate class structures at each stage of software development. Scripts are not only capsules of data elements but also mapping properties and functions in the class structure. Setting up scripts in classes is also an important step. For example, when designing XML scripts, one can use the script syntax to check the corresponding scripts in XMLSpy, or one can use UML to create class objects. The mapping between them mainly requires the transformation of XML rules into a UML class infrastructure.

In summary, the script-based development approach consists of three main phases: creating the script, checking the rules of the script, and structuring the script into a script. This approach provides greater abstraction, better development efficiency, and better scalability than traditional development approaches. The 3D visualization engine scene framework mainly consists of the following components: simulation block module: the 3D scene contains a large number of objects that can be divided into modules based on pipeline model blocks, platform model blocks, and vector files. GIS and other unit models based on data types. Each module typically contains information about the model and attributes and organizes each object into a node to manage tree-based functionality. If changes are required, only the appropriate module hierarchy needs to be changed.

In machine simulation learning, the execution of the simulation task is mainly controlled by time, i.e., the simulation process is controlled by moving to different phases and modes according to the specified time so that the simulator can automatically execute actual examples of the simulation process. The component can simulate the whole process or any of them with automatically selected parameters. For example, when simulating oil contamination in a mountainous area, it can be the entire run of the oil contamination, a period, or a tilted state. During this simulation training, the interaction between the training operator and the virtual simulation system is relatively small and, in principle, no external actions are required. Path and time scripts precisely guide the execution of the detection.

In the teaching and training of operational modelling, the instructor performs the operational implementation of a simulation case in a 3D modelling learning environment under the control of the modelling system. Execution of simulation tasks. Thus, the simulation training evolves in real-time throughout the process, and the realization of these functions comes mainly from the interaction with the user. For example, roaming modes can be configured and configured during target patrols, mainly when the roaming used by the worker can be managed in real-time via keyboard and mouse. In the simulation learning training mode, the simulator can perform simulation processes independently using standardized specification data. Once these simulation actions are complete, the system can also evaluate and predict changes in state and results during the run. For example, as part of 3D modelling, by studying the degree and area of infiltration in mountainous areas, scientific predictions and assessments can be made to determine if infiltration will cause pollution and environmental impacts.

4.3 Simulation analysis of SCADA system for oil and gas pipeline network modelling

The 3D Virtual Control Network Simulation Engine (VPLength) project, based on the OSG and OSGeerth platforms, has been discontinued. The tool focuses on upstream integration, i.e., application layer integration, which enables developers to quickly implement features related to oil and gas pipeline networks in the subsequent development process to make them more efficient and scalable. The K function of the Model size function is compared with the L function, as shown in Figure 7.

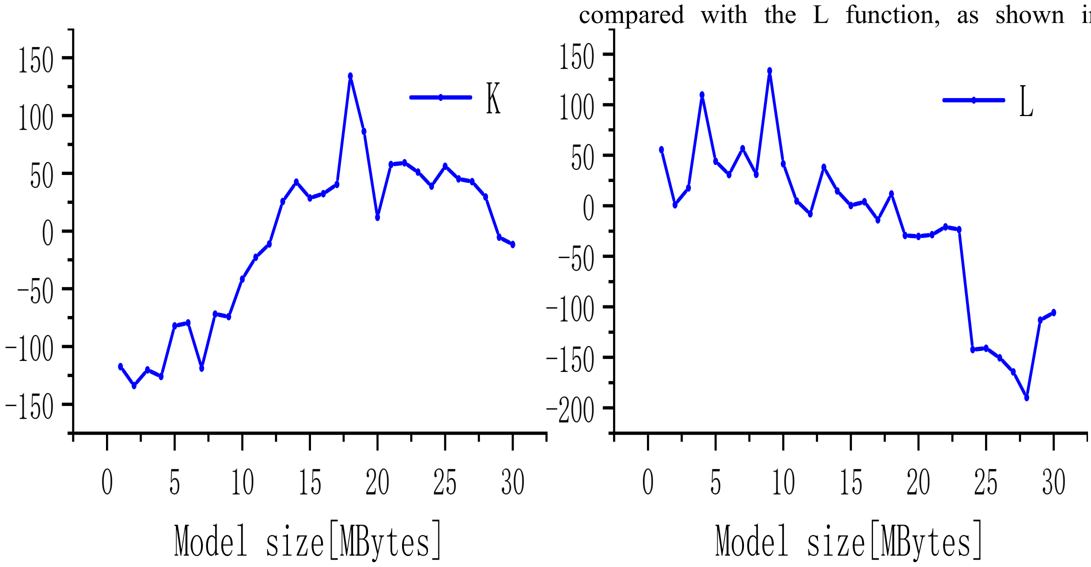

Figure 7 Comparison of K-function and L-function of Model size function

VPengine provides an extensible software architecture that meets the software modelling requirements of oil and gas pipeline platforms, supports software interfaces in many applications, and has good scalability. The 3D modelling system engine achieves the following goals: First, multiple communication connections from different sources, types, analysis methods and complex site structures are implemented at the construction site in the oil and gas network environment. Multiple data downloads are defined as script files in which VPengine downloads and analyzes the script files so that users can download and view basic information about attributes such as large terrains and the environment surrounding the scene. Valentine can create and display hierarchical nodes for different objects in the script by compressing the essential support tools without having to focus on the details of the application-level implementation. oSG and OSGeerth platforms automate the scene rendering process by configuring multiple data connections at different levels using only the appropriate script files. The VPL engine executes the static introductory scene by downloading scripts that display simulated accidents in the dynamic scene. The top interface interacts with devices such as the mouse and keyboard to display data at the correct location on the construction site or at the ignition point. Navigational patrols are performed from different perspectives, selecting different keywords to fulfil investigation requirements, obtaining relevant information, and providing visual support for decision-making. Firstly, the environment is viewed from different perspectives through different forms of roaming.

Meanwhile, suitable fixed roaming routes can be defined to detect devices and routes. After browsing the requested location, the appropriate credentials are displayed, and the corresponding data graphs are shown. This enables oil and gas network experts to perform further data analysis, exchange equipment, and make decisions in the event of an incident. Enable VPL engine support for the Control Center Intelligent Information System platform.

Meanwhile, VPLengine designs and implements virtual effects to simulate complex natural disasters and oil and gas spills caused by various uncontrollable factors in mountain pipelines. Depending on the leakage pattern and impurities, it will leak into the environment in time to prevent and control pollution. Suppose the simulation system fully realizes the engine's functionality. In that case, a large amount of data is enough for the scenario, and there will be no need to worry about it at all. If the system still needs to be rebuilt, it maximizes cost savings, shortens cycle times and reduces risk. The platform integrates a primary functional graphical user interface, making it a platform for real-time 3D visualization of oil and gas networks. Model size function of the M function with the N function, as shown in Figure 8.

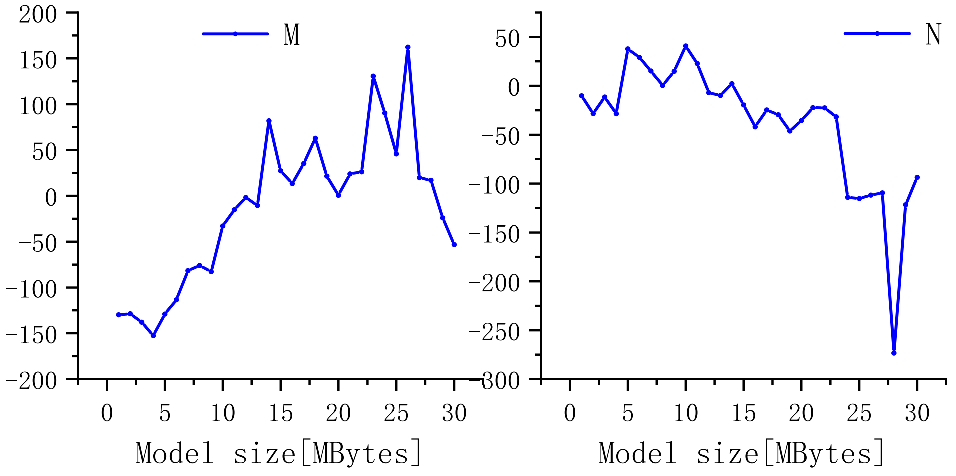

Figure 8 M-function and N-function of Model size function

5. Conclusion

This study has achieved encouraging results in the exploration of a new approach to SCADA system screen configuration based on oil and gas pipeline network modelling. Through in-depth modelling of the oil and gas pipeline network and innovative screen configuration design, this study successfully improves monitoring efficiency, reduces operational risk, and introduces new ideas in the field of oil and gas pipeline network monitoring. First of all, this study has thoroughly researched the topology, sensor data, control nodes and other critical elements of the oil and gas pipeline network and established a comprehensive and accurate model. This model provides a solid foundation for the subsequent screen configuration so that the SCADA system can better reflect the actual pipeline network operation status. Through this model, the operator can understand the structure and fluid flow of the pipe network more clearly, which helps to determine the health status of the network more accurately. Secondly, this study adopts the design principle of human-computer interaction and integrates the modelling results into the screen configuration of the SCADA system. Through the intuitive and intelligent interface design, this study enables operators to recognize pipe network anomalies more quickly and improves the efficiency of troubleshooting and treatment. The visualized interface design not only reduces the possibility of operational errors but also improves the safety and reliability of the pipeline network. This means that the new method in this study not only improves the efficiency of operators but also brings significant benefits to the stability and safety of the whole oil and gas pipeline network system. The experimental results verified the significant advantages of the new method in this research in oil and gas pipeline network monitoring. The operators can understand the real-time changes in the pipeline network status more comprehensively through the screen configuration of the SCADA system and respond and make decisions quickly. This is of great significance to ensure the regular operation of the pipeline network and to cope with unexpected situations. Therefore, the method of this study provides an effective solution for the intelligence and efficiency of oil and gas pipeline network monitoring systems. Overall, the new method of SCADA system screen configuration based on the oil and gas pipeline network model has achieved significant results in improving monitoring efficiency and reducing operational risks. This not only brings innovation to the field of oil and gas pipeline network monitoring but also provides a reference for research in other similar fields. Future work can be carried out to optimize the interface design further and expand the applicable scenarios to enhance the performance and applicability of the system further. This study expects that the results of this research can contribute more valuable experiences and ideas to the development of the industrial control field.

References

[1] A, J. K., A, M. G., & a, T. S. (2021). Digital game-based examination for sensor placement in the context of an Industry 4.0 lecture using the Unity 3D engine – a case study. 56, 26–45.

[2] A, Q. F., A, J. L., & B, T. Z. H. L. (2022). Efficiency evaluation of China's green investment in the "Belt and Road" countries. 74, 45–88.

[3] Ali, S., Ijaola, A. O., & Asmatulu, E. (2021). Multifunctional water treatment system for oil and gas-produced water. Sustainable Water Resources Management, 7(6). https://doi.org/10.1007/s40899-021-00578-w

[4] Al-Mishwat, A. T. (2021). Barrellite and Pillarrite: A Description and a Mode of Formation of a Novel Post-Sedimentary Twin Structures from As-Subbiyah, North of

Kuwait Bay, Kuwait. International Journal of Earth Sciences, 007, 012.

[5] Asare, Y. A., Kwasnicka, D., Powell, D., & Robinson, S. (2021). Health and well-being of rotation workers in the mining, offshore oil and gas, and construction industry: A systematic review. British Medical Journal Global Health, 6(7), e005112.

[6] Geng, W., Lv, X., Wang, L., Wang, K., & Xiao, X. (2021). Development of underwater vehicle application in offshore oil and study on the key problems of anti-disturbance control. Journal of Physics: Conference Series, 1976(1), 012054 (5pp). https://doi.org/10.1088/1742-6596/1976/1/012054

[7] Hawash, B., Mokhtar, U. A., & Yusof, Z. M. (2021). User's acceptance of an electronic record management system in the context of the oil and gas sector in Yemen: An application of ISSM-TAM. International Journal of Management and Enterprise Development, 20(1), 75–98. https://doi.org/10.1504/IJMED.2021.113661

[8] Jiang, W., Zhang, H., & Lin, Y. (2021). Trade Sustainability and Efficiency under the Belt and Road Initiative: A Stochastic Frontier Analysis of China's Trade Potential at Industry Level. Emerging Markets Finance and Trade, 1, 1–13.

[9] Li, Y., Kuang, Z., Fan, Z., & Shuai, J. (2023). Evaluation of the safe separation distances of hydrogen-blended natural gas pipelines in a jet fire scenario. International Journal of Hydrogen Energy, 15, 45–88.

[10] MINGLisen & WANGShu. (2022). Research on the Core of Operation and Maintenance Management Problems and Improvement Measures of Distribution Lines. Engineering, 45, 271–296.

[11] Miranda, J. P. P., Yambao, J. A., Marcelo, J. A. M., Gonzales, C. R. N., Mungcal, V. J. T., & Baluyut, R. J. (2021). Towards the Development of a 3D Engine Assembly Simulation Learning Module for Senior High School. STEP Academic Publisher, 1, 45–77.

[12] Paulo, J., Lima, S. D. M., Souto, T., Farias, M. C. D., & Madalena, B. (2022). Port of the OGRE 3D Engine to the Pocket PC Platform. 27–56.

[13] Raanan, T. (2023). OSG is interested in CO2 carrier trade. Lloyd's List, Nov., 45–87.

[14] Shabanova, D. N., & Maluka, L. (2023). On the prospects for the development of documentation support for the quality management system at oil and gas engineering enterprises in the context of digital transformation. Problems of Economics and Management of Oil and Gas Complex, 1–45. https://doi.org/10.33285/1999-6942-2023-4(220)-52-59

[15] Sharma, A., & Damle, M. (2022). Blockchain Technology: Reinventing the Security and Efficiency Posture of the Indian Banking System. 2022 International Interdisciplinary Humanitarian Conference for Sustainability (IIHC), 364–369. https://doi.org/10.1109/IIHC55949.2022.10060224

[16] Wang, K., Liu, L., Zhang, J., & Zhou, T. (2022). Channel Characterization for Hyperloops Using the Nonstationary Geometry-Based Model. Journal of Circuits, Systems and Computers, 5, 45–61.

[17] Xiaozhong, Y., Lingrui, L., Long, B., & Xi, Z. (2022). Research on Low-carbon Energy Development under the "Belt and Road Initiative" and "Dual Carbon Goals." China Oil and Gas, 29(4), 35–41.

[18] Xu, Y., Liu, Z., Zhou, D., & Zhu, X. (2021). Vibration characteristics of pressure pipelines at pumping stations and optimized design for vibration attenuation. IWA Publishing, 45, 71–103.

[19] Yu, G., Li, W., & Zhou, X. (2021). A realistic study on the assessment system of international competitiveness of service trade using fuzzy-analytic network process. Journal of Intelligent & Fuzzy Systems: Applications in Engineering and Technology, 4, 40.

[20] Zhu, P., Liyanage, J. P., Kumar, R., & Panesar, S. S. (2021). Decision quality related to emergency shutdown system in the oil and gas industry: Influences from data and information. International Journal of Decision Sciences, Risk and Management, 1/2, 10. https://doi.org/10.1504/IJDSRM.2021.117568