Remote Monitoring and Management System for Oil and Gas Facilities with Integrated IoT and Artificial Intelligence Data Analysis

Shu Haowen, Zhang Bin, Gao Shiyu, Gu Li, Jia Yanjie
PipeChina Southwest Pipeline Company, Chengdu 610036, China

Abstract—**An important trend in the development of digitalization is the expansion from digitalization to intelligence. For the intelligence of oil and gas facilities, it is to apply the multi-intelligent judgment and analysis technology to the actual production of oil and gas facilities, so as to realize the real-time data acquisition, analysis and "monitoring tube" integration of remote oil and gas facilities. As a flexible monitoring configuration software, force control provides a good development interface and a simple engineering implementation method under the trend of intelligent oil and gas facilities, which can facilitate users to realize and complete the functions of the monitoring layer. Its humanized application, such as trend curve, report output, limit alarm and other system functions, can also be more intuitive for users to monitor and process control on-site production data, and provide strong technical support for the intelligent process of oil and gas facilities. Based on this, this paper studies the design of remote monitoring and management system of oil and gas station by integrating the Internet of Things, artificial intelligence and big data analysis technology.**

Keywords*—*Internet of Things; artificial intelligence; data analytics; remote monitoring; management system

I. INTRODUCTION

In the harsh environment of the work site, snow, fog, wind and sand and other natural phenomena are very common, the temperature fluctuation is large. Moreover, the oil and gas station is generally located in a remote open area, with a wide coverage of the whole area, and the distribution of each oil and gas facility in the operation area is relatively dispersed. With the changing needs of collection progress, oil production points can be added or removed at any time [1]. As a key link in the intelligent process of oil and gas facilities, coupled with the prevention and control of unsafe factors, real-time monitoring of all facilities information 24 hours a day has become an essential security work.

In terms of remote monitoring of oil and gas facilities, Eden et al. (2005) studied an electrochemical sensor used for corrosion monitoring in harsh environments. Zheng (2009) used an online monitoring probe to conduct online monitoring of the three top positions of a distillation unit in a refinery. After a period of time, it was found that the monitoring results were basically consistent with the analysis results of the three top condensate water, indicating that the use of an online monitoring probe is an effective means of corrosion monitoring. Payne (2012) designed an oil and gas recovery detection instrument, which made up for the shortcomings of the previous oil and gas recovery detection system [2]. It proposed that the collected value could be compared with the standard value through the pressure sensor and digital processor, and the detection device could realize the automatic detection of the oil and gas recovery system, but it could not store the relevant data. Li (2019) developed a PLC-based oil and gas recovery device, which used PLC to control the field equipment, realized the monitoring of the oil and gas recovery process through configuration software, and designed and realized the functions of liquid level balance and real-time operation of the oil and gas recovery device.

In the use of the Internet of Things and artificial intelligence for remote monitoring research of oil and gas facilities, China Petroleum and Chemical Corporation proposed the concept of intelligent oil field in the early 21st century. Through relevant communication and transmission, all links are integrated together, so that the staff can monitor, adjust, command and control the entire production process of the oilfield through the dispatching system in the background laboratory. CNPC has developed a set of monitoring system in the general dispatching center, on which an information base and data analysis platform containing parameters of each major oil field are built, which can carry out remote real-time monitoring of the oil well platform of each major oil field in China. The "Drilling 3D development platform", developed by leading foreign oil companies, is known as the visual virtual operating system [3]. The application of this operating platform can see the operating status of each development link in the drilling process and obtain relevant data, which is convenient for operators to be able to exchange information and communicate with experts in the remote background, and issue instructions in time according to the adjustment strategy, so that the drill can quickly locate and track according to the real-time status, and determine the drilling target in time. Greatly reduce the working time, improve work efficiency, and maximize the reduction of work costs.

Chauhan's work demonstrated the effectivenes of MQTT, OPTICS clustering, and spiking neural networks within a mist computing framework that enhance real-time IoT data analytics. In a similar vein, we apply these advanced data processing and edge computing techniques in our proposed work to analyze sensor data from oil and gas facilities that enable prompt detection of anomalies and efficient management through integrated AI-driven insights [4]. Our proposed remote monitoring and management system adopts a distributed edge, fog, and cloud computing framework emphasized by Yalla et al, (2022), enabling efficient and scalable IoT data processing for real-time analytics in oil and gas facilities [5]. Swapna Narla (2025) proposed secure and scalable anomaly detection using Hidden

Markov Models, SMPC, and decentralized federated learning in cloud environments. We adopt their privacy-preserving and distributed learning framework to detect anomalies in IoT data from oil and gas facilities. This ensures secure, real-time fault detection while maintaining data confidentiality across remote monitoring systems [6]. On the whole, although many companies have realized local remote information monitoring and data collection functions of oil and gas facilities, and can analyze, integrate and save on-site data [7]. However, the integration of on-site and backstage technical support of oil and gas facilities is still not high, and the field application needs to be further improved. Based on this, this paper studies the remote monitoring system of oil and gas station by integrating the Internet of Things and artificial intelligence technology.

The research organization and innovation points of this paper are as follows: based on the force control configuration software, the development of each functional module of the oil pump production monitoring system software is completed, so that it has the functions of data collection and management, data analysis and diagnosis, alarm processing and so on. The article first for the force control configuration software is briefly introduced, and then combined with the monitoring system design requirements, gives the overall design scheme, on the basis of the design and implementation of each functional module were elaborated, and finally through the test analysis, verify the practicality of the monitoring system.

II. Force Control Configuration Software

Force control software is a kind of configuration software that can realize the information acquisition and related program control in the production site. The way it uses is not the traditional way of programming, but a way of configuration construction[8]. This method is favored by many users because it can provide a simple interactive interface for developers and related users, as well as an intuitive system building platform. Force control configuration software can carry out real-time transmission and communication of major factory information through the network. This configuration software can combine the client machine and the Internet to realize the overall control and scheduling of the system. In addition, the software can directly realize the information interaction of all levels and the establishment of transmission interface, so as to integrate between the upper computer and the lower computer.

The main components of the force control configuration software are described below:

- Project Manager is applied in each management link, executing functions such as establishment, replication, homing, elimination and project setting.
- It is an integrated System to develop System, establish system interface, and build and deploy parameters, graphics and accessory programs of each link.
- Interface Operation System, responsible for operating the graphics built by the project, running scripts and related dynamic graphics.
- Real-time Database, which is the information analysis platform of the whole system of configuration software, is also the foundation of the distributed control system.
- I/O Driver: performs data communication between external hardware facilities and related control systems, and can read and write information in memory.
- Net Client/Net Server, communication between different links on the data chain through the network.
- Communication Server, remote data communication platform through a variety of data transmission methods to achieve client information interaction, using the specified communication interface to achieve the specified client data transmission.

III. The Overall Scheme of Remote Monitoring System for Oil Pump Production

A. Demand Analysis

Based on the real-time monitoring of the dynamic parameters of oil and gas station production, with the goal of improving the efficiency of the whole operation, a production monitoring system of oil and gas station based on force control configuration is researched and developed by using the advantages of force control configuration software.

The parameters that the system needs to monitor in real time are: oil pressure, electrical parameters (current, voltage, active power, reactive power), indicator diagram (displacement, load) and other indicators.

The system needs to calculate and analyze the optimized control parameters are: the working condition of the tank, the best stroke, the target frequency and the balance and other indicators.

The parameters that the system needs to optimize control are: the stroke of the oil tank, the speed of the motor and other indicators.

B. Design Scheme

Based on the full investigation of domestic and foreign oil and gas station monitoring system, combined with the specific needs of users to build intelligent oil and gas station, it is clear that the monitoring system should achieve data collection and management, data analysis and diagnosis, alarm and processing and other functions [9]. In terms of technical design, first of all, it is necessary to monitor the operation status of each key module of the system, involving the process monitoring of the data synchronization software of the field operation, and solve the technical problems of the communication between the field production and the system; Secondly, it is necessary to realize intuitive and friendly monitoring and display diagram, to solve the technical problems of data visualization and chart display, and to realize the conversion of the data format of the configuration software and the information reflected in the indicator diagram; Need to be able to be monitored according to the abnormal state of the scene, so as to design different alarm levels, and to solve the technical problems such as the transmission mode and transmission time of the warning. This paper selects the force control monitoring configuration software, using the advantages of flexible and diverse “configuration mode” provided by the configuration software, to establish a three-layer oil pump production monitoring system

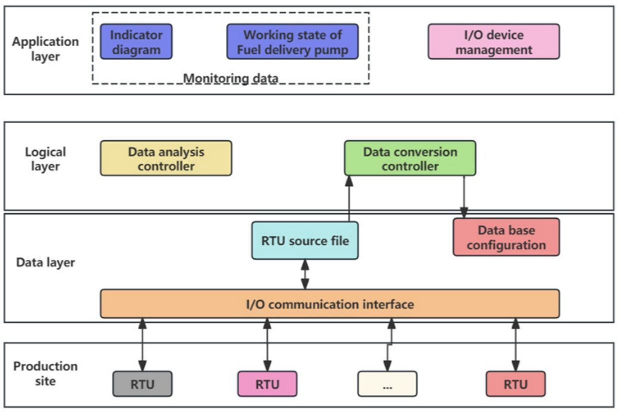

Fig. 1. Frame of production monitoring system for oil pump.

software framework, including application layer, logic layer and data layer. The system framework is shown in Fig. 1 below.

The application layer provides a human-machine interface for the user and the system. The system can visually and friendly display the equipment working condition analysis and indicator diagram by means of visual graphics, and assist the user to judge the working condition of the oil pump. The system provides a management interface, and the user can realize the control and management of the number and state of the equipment through this system.

Logic layer provides control strategy generator through force control configuration software to realize data analysis and processing calculate the output of oil pump, query and analyze the historical work chart.

The data layer is responsible for storing and monitoring the data, which is collected by the RTU equipment distributed in the production site of the oil pump [10]. The RTU equipment returns the monitoring data to the RTU data source file through the I/O configuration communication interface provided by the force control configuration software. The RTU source data is processed by the data conversion controller of the control layer and stored in the configuration database.

IV. Function Module Design and Implementation

A. I/O Equipment Configuration Design

I/O device configuration is the bridge of communication between the force control configuration software and various intelligent devices, the main role is to send data commands to the specified device, the device responds back to the data back to the configuration to unpack the data, and data classification, and finally separate the required data type. The data flow of I/O device configuration is shown in Fig. 2.

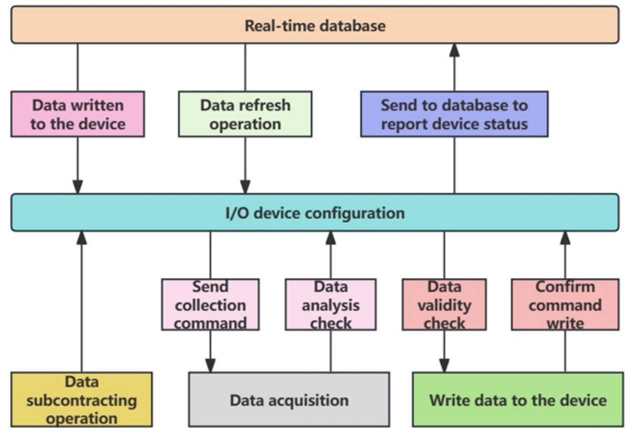

Fig. 2. I/O Device configuration data flow.

I/O device configuration is how you configure the I/O driver. First of all, in order to meet the specific needs of practical applications, I/O device configuration can select the matching I/O driver for the specified I/O device; Secondly, the configuration will carry out the corresponding parameter setting and physical definition of the I/O device to ensure the operability of the device; Finally, the I/O configuration will debug and test the equipment to check whether the equipment is correctly set to adapt to the actual production. The I/O configuration of the system can complete the functions of: through the collection of data for link maintenance, real-time link database, I/O command management output queue. It can be seen that the I/O device configuration can view the driver process status in real time and browse the driver communication messages, and can also complete the remote start and stop control of the I/O driver and other functions, and is a tool to monitor the operation of the I/O driver.

B. Database Configuration Design

Db Manager is the main tool of database configuration. As a collection toolbox of configuration, it can complete many configuration functions such as point configuration, point parameter configuration, data connection configuration, historical data configuration, etc. In the database, the system stores all kinds of information in the unit of TAG, and organizes points in a tree structure. Multiple nodes can be built under the tree structure, and multiple sub-nodes can be built under each node, and multiple different types of points can be established under each node [11]. In this paper, the DbManager monitor is used to establish the database configuration, which corresponds to the A11 standard for the construction of the Internet of Things system in oil and gas production. Byte8-bit unsigned data format is selected through the HR hold register, and more than 180 data points such as storage addresses and acquisition addresses are established. Through the database configuration data points can establish the connection with the corresponding data items in RTU, and display the relevant data in real time. The sample information of the corresponding child node name in the data configuration is shown in Table I below.

C. Monitoring System Module Design

The monitoring system is divided into the following six functional modules: polling control module, data acquisition module, data management module, feedback control module, output module and alarm module. The six modules have a division of labor, and work together to complete the collection of data, processing data and output data functions. Its basic composition and function are shown in Fig. 3.

TABLE I. EXAMPLES OF DATA POINT NAMES

Numbering	NAME	DESC	%I/OLINK	%HIS
1	I_A		PV=RTU....	PV=1s
2	I_B		PV=RTU....	PV=1s
3	I_C		PV=RTU....	PV=1s
4	V_A		PV=RTU....	PV=1s
5	V_B		PV=RTU....	PV=1s
6	V_C		PV=RTU....	PV=1s
7	yougonggonghao		PV=RTU....	PV=1s
8	wugonggonghao		PV=RTU....	PV=1s
9	P_W		PV=RTU....	PV=1s
10	P_R		PV=RTU....	PV=1s
11	P_fanxiang		PV=RTU....	PV=1s

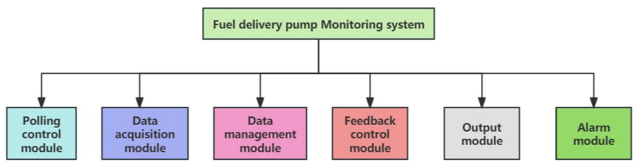

Fig. 3. Composition of monitoring system module of oil pump.

1) Polling control module: This module can detect online devices, implement polling device management, and configure multiple acquisition commands.Now the automatic input function of RTU and other equipment parameters is used to collect and control data. PING each IP to be connected before the polling check operation can reduce the error message interference caused by the network delay. As a communication protocol, the PING command can check whether the network is connected, which helps us analyze and determine whether there is a network fault [12]. After the PING command is used to determine whether the IP address is normal, the IP address that cannot be pinged can enter the polling program. The system records the IP address that cannot be pinged, and PING the IP address again after the network environment recovers. In this way, the target IP address is restored to the normal polling process and the next IP address polling is performed.

2) Data acquisition module: This module mainly realizes data monitoring functions such as automatic collection of operating parameters, automatic monitoring of production environment, automatic monitoring of IoT equipment status, automatic monitoring of production process and remote control of start-stop operation. Through the connection between the RTU equipment and the host computer and the feedback setting of the sampling frequency, the system can automatically collect different types of parameters, such as oil pressure, oil temperature, electrical parameters, load, displacement and stroke, which are closely related to each link of production.

The real-time data collected by the monitoring system are displayed on the monitoring screen in the way of numerical value or real-time curve display, and the information of any four different oil pump can be monitored at the same time on the main page interface, which is convenient to compare different working conditions. Users can read and print the values and real-time curves [13]. The relevant requirements for RTU data storage are specified in the manual of Construction Specification for Internet of Things System in Oil and Gas Production (QSY1722-2014). The relevant parameters of remote terminal unit system property data storage address and oil pump alarm function parameter control command storage address are shown in Table II and Table III below.

TABLE II. REMOTE TERMINAL UNIT SYSTEM PROPERTIES DATA STORE ADDRESS

No.	Data item Description	Storage address	Data type
1	Apply the type of oil and gas terminal	40001H	Integer type
2	System time	40005-40007.	BCD Code
3	System date	40008-40010.	BCD code
4	RAM battery voltage	40011	Whole shape
5	RTU cabinet temperature	40012	Integer shape

TABLE III. STORAGE ADDRESS OF OIL PUMP ALARM FUNCTION PARAMETER CONTROL INSTRUCTION

No.	Data item Description	Storage address	Data type
1	AI1 Instrument-shaped signal form	43001	Integer type
2	AI1 Meter range lower limit	43002-43003.	Solid type
3	AI1 meter range upper limit	43004-43005.	Solid type
4	AI1 Meter alarm Lower limit	43006-43007.	Solid type
5	AI1 meter alarm upper limit	43008-43009.	Solid type

3) Data management module: The function of data management module is mainly divided into data screening and data storage. Data screening is the index data management module through the induction and sorting of the original data to achieve the standardization and structure of the data, so as to get meaningful performance indicators that can be identified by users in the original data, and these effective performance indicators into the database that has been established [14]. Data warehousing means that after the data management module realizes the specific functions of viewing, deleting, modifying and statistical analysis of the management data, the establishment and storage of the real-time database can be completed.

The source data collected by RTU is processed by the control layer data conversion controller and stored in the configuration database. At present, the data that needs to be called by the user can be displayed in the front end of the upper computer in real time. The obtained data type is projected to the output module according to the user's command, and the specific data or report content is directly displayed. The data that does not need to be displayed in real time is stored in the database, waiting for the next command.

4) Feedback control module: The operation logic of feedback control module is mainly divided into three steps. The details are shown in Fig. 4 below.

a) Operation status judgment: First of all, the system will screen the data points collected by RTU, discard the data points with large errors, and then convert the reasonable

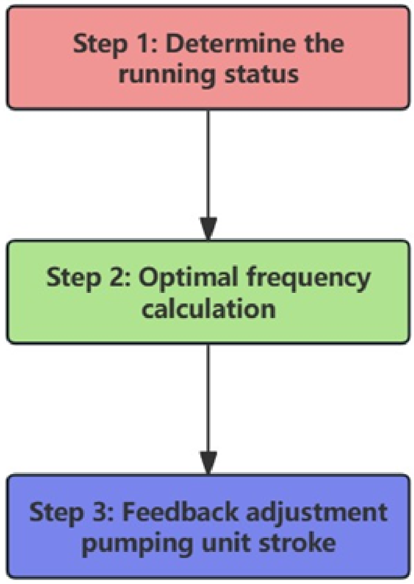

Fig. 4. Feedback control module Operation logic diagram.

data points after screening into the indicator diagram curve that can express the quantitative relationship between load and displacement [15]. The indicator diagram will transfer the relevant data to the pre-programmed Matlab platform for simulation and identification, through the shape, area and other information of the indicator diagram, with the help of the classification discriminator for logical verification, so as to show the corresponding working conditions and fault types reflected in the diagram, and further provide reference and judgment basis for adjusting the frequency and stroke of the oil pump.

b) Optimal frequency calculation: According to the electrical parameters, stroke, stroke and other information of the oil pump site, the quantitative relationship between the amount of liquid produced and the stroke and frequency can be calculated, and the frequency obtained through this quantitative relationship is the frequency corresponding to the maximum amount of liquid produced under a certain working condition, that is, the best frequency.

c) Feedback adjustment impulse times: After calculating the best stroke and the best frequency of the oil pump, combined with the fault type determined by the indicator diagram, the feedback control module can change the stroke of the oil pump by controlling the output frequency of the inverter, so that the oil pump works in an efficient state.

5) Output module: The output module can display the temperature, voltage, current, active/reactive power, power factor and other parameters of the oil pump in real time. The history record shows the data uploaded by a certain RTU in a certain period of time, and supports the export of text in Excel format [16]. At the same time, it supports the output of indicator diagram and fault identification function, and can edit and beautify the image.

6) Alarm module: Detect the electrical parameters and the temperature of the oil pump, set different alarm labels, and alarm is realized when the maximum range is exceeded. Set the specific alarm value, then the variable below the low value or higher than the high value will produce the alarm over the limit value. The monitoring software has a memory function, when there is an alarm or failure occurs, or when an accident occurs, there will be a detailed record in the "Event display bar" of the monitoring main interface. When a certain oil pump through the remote data monitoring alarm and other serious abnormal situation, you can remote stop the abnormal oil pump.

V. System Testing

Build a simulated test environment in the laboratory to check whether the functional modules of the developed intelligent monitoring system software for oil pump production meet the expected requirements, test the connection between the data acquisition and management modules and other modules, and focus on the test data management and the monitoring of the connection status of the oil field and the monitoring of the product receiving status.

A. Configuration of Network Environment

Set up the environment of IP polling mode, and test it in the designed system. At the same time, after connecting RTU to the computer, start to set the relevant operations of RTU configuration. Select the MODBUS(TCP) device with I/OManager monitor, debug the TCP standard serial port of MODBUS connecting RTU to the upper computer, and the RTU standard serial port of MODBUS connecting RTU to RTM, connect RTU to the external 5V power supply and then connect it to the computer [17]. At the same time, I/O Tester is used to monitor the connectivity status of RTU. The real RTU is shown in Fig. 5 below.

Fig. 5. RTU Physical map.

B. System Application Test

1) Data acquisition and storage: In the main interface of the system, the operation status of four different oil pump can be displayed at the same time, which is convenient for customers to monitor the safety of operation at a glance. In addition, the buttons on the left side of the main interface correspond to different functions such as data collection and data query. The data acquisition module is shown in Fig. 6.

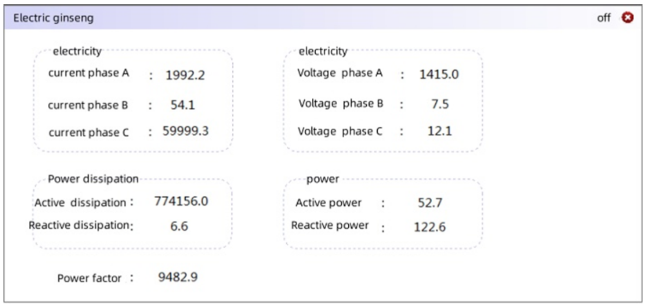

Fig. 6. Data acquisition module icon.

The system can display real-time data and historical data. The system can collect and store data such as three-phase current, three-phase voltage, reactive power and power factor by generating different types of random numbers (all data are random numbers generated by the system, one decimal point is reserved, and do not represent any actual meaning).

At the same time, the system can also display the data stored in a certain period of time in the past for the user to view [18]. History report as a collection of browsing, printing, statistics and other functions in one tool, can be used from the database historical data of one or more points, one time period or multiple time periods can be obtained by the setting of the user, and the data can be displayed visually in the form of a table and supported by output.

2) The Reading and processing of indicator diagram of production data: Manually set the measuring interval and number of points of indicator diagram collection point, and can directly generate real-time indicator diagram curve or indicator diagram curve of a certain period in history, as shown in Fig. 7. And through the connection with Matlab directly determine the type of fault, in order to carry out the next step of fault alarm and processing.

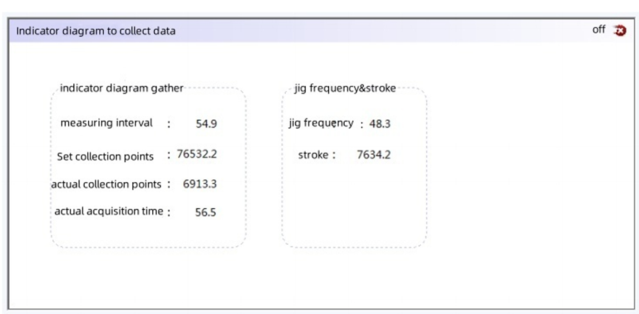

Fig. 7. Data acquisition output module icon.

VI. Conclusion

As a powerful integrated environment software, force control configuration software has a relatively mature configuration of various system parameters, create project screen, script compilation and animation Settings and other rich functions. Users can realize various monitoring requirements through it. Through the force control configuration software, various I/O devices and database components can be invoked to complete the reading, collection and management of production site data. In addition, using the various controls of the force control configuration software, you can fully call the related reports, functions and trend curves after editing the function. In this paper, the requirements of intelligent monitoring system for oil pump production are analyzed comprehensively and deeply, and the overall design of monitoring system software is completed. Then, based on the force control configuration software, the development of each functional module of the oil pump production monitoring system software is completed, and the data collection and management, data analysis and diagnosis, alarm processing and other functions are preliminarily equipped. Finally, the indoor test environment is built, and each function module is measured and tested, and the main functions are basically completed.

Due to the time limit, the intelligent monitoring system software of oil pump production developed in this paper has only completed the indoor coordination and testing, and has not been installed, debuted and run in the oil pump site, and the functions of the system can not be verified. The function of the system still needs to be checked, improved and perfected in the actual field.

Funding

Authors did not receive any funding.

Conflicts of Interests

Authors do not have any conflicts.

Data Availability Statement

The data generated and analyzed during the current study are available from the author Shu Haowen upon reasonable request but are not yet publicly available due to ongoing research.

Code Availability

Not applicable.

Authors' Contributions

Shu Haowen, Zhang Bin is responsible for designing the framework, analyzing the performance, validating the results, and writing the article. Gao Shiyu, Gu Li and Jia Yanjie is responsible for collecting the information required for the framework, provision of software, critical review, and administering the process.

References

[1] T. R. Wanasinghe, R. G. Gosine, L. A. James, et al., "The internet of things in the oil and gas industry: A systematic review," *IEEE Internet of Things Journal*, vol. 7, no. 9, pp. 8654–8673, 2020.

[2] S. Asadzadeh, W. J. de Oliveira, and C. R. de Souza Filho, "UAV-based remote sensing for the petroleum industry and environmental monitoring: State-of-the-art and perspectives," *Journal of Petroleum Science and Engineering*, vol. 208, p. 109633, 2022.

[3] J. L. Wang, B. Barlow, W. Funk, et al., "Large-scale controlled experiment demonstrates effectiveness of methane leak detection and repair programs at oil and gas facilities," *Environmental Science & Technology*, vol. 58, no. 7, pp. 3194–3204, 2024.

[4] G. S. Chauhan and J. B. Awotunde, "Advanced-data processing in IoT using MQTT and OPTICS with spiking neural networks and mist computing for real-time analytics," *Journal of Ubiquitous Computing and Communication Technologies*, vol. 6, no. 4, pp. 377–396, 2024, doi:10.36548/jucct.2024.4.005.

[5] R. K. M. K. Yalla, A. R. G. Yallamelli, and V. Mamidala, "A distributed computing approach to IoT data processing: Edge, fog, and cloud analytics framework," *International Journal of Information Technology and Computer Engineering*, vol. 10, no. 1, pp. 79–94, 2022.

[6] S. Narla, S. S. Kethu, D. R. Natarajan, S. Peddi, D. T. Valivarthi, and A. Ravi, "Secure and scalable anomaly detection in cloud environments using hidden Markov models, SMPC, and decentralized federated learning," in *2025 International Conference on Wireless Communications Signal Processing and Networking (WiSPNET)*, Chennai, India, 2025, pp. 1–6, doi:10.1109/WiSPNET64060.2025.11005367.

[7] M. H. Sliem, E. M. Fayyad, A. M. Abdullah, et al., "Monitoring of under deposit corrosion for the oil and gas industry: A review," *Journal of Petroleum Science and Engineering*, vol. 204, p. 108752, 2021.

[8] T. R. Wanasinghe, T. Trinh, T. Nguyen, et al., "Human centric digital transformation and operator 4.0 for the oil and gas industry," *IEEE Access*, vol. 9, pp. 113270–113291, 2021.

[9] T. R. Wanasinghe, L. Wroblewski, B. K. Petersen, et al., "Digital twin for the oil and gas industry: Overview, research trends, opportunities, and challenges," *IEEE Access*, vol. 8, pp. 104175–104197, 2020.

[10] E. Samylovskaya, A. Makhovikov, A. Lutonin, et al., "Digital technologies in Arctic oil and gas resources extraction: Global trends and Russian experience," *Resources*, vol. 11, no. 3, p. 29, 2022.

[11] C. Spandonidis, P. Theodoropoulos, F. Giannopoulos, et al., "Evaluation of deep learning approaches for oil & gas pipeline leak detection using wireless sensor networks," *Engineering Applications of Artificial Intelligence*, vol. 113, p. 104890, 2022.

[12] T. Nguyen, R. G. Gosine, and P. Warrian, "A systematic review of big data analytics for oil and gas industry 4.0," *IEEE Access*, vol. 8, pp. 61183–61201, 2020.

[13] B. F. Alshammari and M. T. Chughtai, "IoT gas leakage detector and warning generator," *Engineering, Technology & Applied Science Research*, vol. 10, no. 4, pp. 6142–6146, 2020.

[14] H. Lu, T. Iseley, S. Behbahani, et al., "Leakage detection techniques for oil and gas pipelines: State-of-the-art," *Tunnelling and Underground Space Technology*, vol. 98, p. 103249, 2020.

[15] D. R. Lyon, B. Hmiel, R. Gautam, et al., "Concurrent variation in oil and gas methane emissions and oil price during the COVID-19 pandemic," *Atmospheric Chemistry and Physics*, vol. 21, no. 9, pp. 6605–6626, 2021.

[16] J. C. Kurnia, M. S. Shatri, Z. A. Putra, et al., "Geothermal energy extraction using abandoned oil and gas wells: Techno-economic and policy review," *International Journal of Energy Research*, vol. 46, no. 1, pp. 28–60, 2022.

[17] F. Bento, L. Garotti, and M. P. Mercado, "Organizational resilience in the oil and gas industry: A scoping review," *Safety Science*, vol. 133, p. 105036, 2021.

[18] M. Ho, S. El-Borgi, D. Patil, et al., "Inspection and monitoring systems subsea pipelines: A review paper," *Structural Health Monitoring*, vol. 19, no. 2, pp. 606–645, 2020.