Research on Underground Pipeline Fault Monitoring Method Based on Big Data

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Abstract—Distributed optical fiber sensors can sensitively sense local temperature changes caused by leakage at any position of the pipeline, but massive monitoring data has significant spatio-temporal non-stationary characteristics, and it is difficult to directly diagnose leakage based on the monitoring data. Under the framework of statistical pattern recognition, a spatio-temporal big data analysis method based on sliding window outlier analysis is proposed. Only the internal characteristics of distributed temperature monitoring data can be used to realize the intelligent identification of pipeline leakage, and the sliding is determined. The value method of window length and abnormal state diagnosis window length, and the physical simulation of prototype insulation steel pipe leakage monitoring was carried out. The results show that when the pipeline is intact, this method will not cause false alarms. Once the pipeline leaks, the method can quickly identify the pipeline leakage event and accurately locate the leak location.

1. INTRODUCTION

The management of urban underground pipeline data information is becoming more and more important. It is not only the needs of urban planning, management, anti-terrorism and disaster prevention, but also an indispensable content for government decision-making, urban Internet of Things, and the era of big data[1-3]. In order to further improve the information management level of urban underground pipelines and obtain higher social use value, it is a very urgent and very important task to realize the sharing of urban underground pipeline data and the dynamic update of information data. A fully functional platform can display underground pipeline resources in a true and standard manner, continuously correct information and data, maximize the comprehensive utilization of underground pipeline resources, reflect the dynamic changes of underground pipeline resources in real time, and improve the overall work efficiency of relevant departments[4-5]. Establishing such a shared platform can realize the full-process supervision of underground pipeline projects by the government supervision department; provide auxiliary decision-making for underground pipeline accident analysis and emergency response; help professional pipeline units guide the production of the department, and communicate with other relevant pipeline units in a timely manner. Information sharing and data updating of urban underground pipelines is not only to solve technical problems, but more importantly, to straighten out the management system[6-9]. At this stage, various pipeline data are managed separately by different departments, and the data format standards are not uniform, which is not conducive to data integration and sharing. In the context of the era of big data, the integration and sharing of underground pipeline data in smart cities under the leadership of the government should be strongly advocated. Government departments at all levels should attach great importance to this work,
fully coordinate all relevant departments, and on the basis of multi-party benefits[10]. A comprehensive urban underground pipeline information sharing platform will bring underground pipeline construction projects into supervision, and realize pipeline data sharing and data correction of various ownership departments of underground pipelines in order to make full use of underground pipeline resources. Various professional pipelines have to be displayed on the same platform due to the large differences in application fields and their own attributes. In addition to the common attributes, the professional attributes of various professional pipelines must also be regulated by referring to a unified standard, so that data can be connected and exchanged with other systems, and ultimately convenient for users. The operating environment of the system involves many factors such as hardware, platform software, application software, and network. Any problem in any aspect may have a serious impact on the system. With the continuous development of urban construction, the system needs to be continuously completed[11-12]. Goodness and improvement, all maintenance work must be based on a familiar system. System data update is a prerequisite to ensure the sustainable development and application of the system.

In combination with online methods, standardized processes such as pipeline data collection, classification, stratification, sorting, and storage are formulated, and the existing data is continuously calibrated and updated through the newly received data.

2. ARCHITECTURE IDEAS OF URBAN UNDERGROUND PIPELINE FAULT MONITORING SYSTEM

Based on the confidentiality and sensitivity of the basic data of underground pipelines, in the past, when designing the information and data sharing system architecture, the main consideration was to share and update offline or lay a private network (secure network) for sharing and update. With the emergence of cloud technology, data storage and transmission methods have also undergone great changes. The underground pipeline information is encrypted, and then transmitted to the government cloud application system for data conversion and update, and shared by accessing the system. This can be used as an exploration

A new way of sharing information about underground pipelines. A vector database (including basic data such as terrain, image, road network and various underground pipeline data) is established on the system sharing platform, and the vector data is processed by data processing such as symbolization and data slicing to generate a picture library. Upload the two databases to the government cloud through the sharing system for data sharing, and control access through system permissions, and publish them using GIS or BIM tools. In this way, all pipeline ownership units and other relevant departments that access the underground pipeline information sharing platform through the government cloud can access the system with authorization to achieve the purpose of query, analysis, and utilization of pipeline data. As shown in Figure 1.

![Figure 1. structure diagram](image-url)
The underground pipeline work is based on the completed underground pipeline survey and the establishment of an information system, and explores the direction of timely data update, comprehensive management in place, and realization of big data services. The dynamic update of underground pipeline repair and measurement data has become a bright spot. Providing the status map of underground pipelines on both sides of the road is a routine work of urban underground pipeline archives management. In the past, data lags caused by pipeline adjustments seriously affected the planning approval and normal construction of the construction unit. In order to ensure the real-time update of underground pipeline data and change the problem of lagging data update caused by centralized supplementary measurement in the past, under close communication and coordination with the housing construction, finance, planning and other departments, the new road pipeline survey is surveyed and mapped by financial investment. Other changed road pipeline information adopts "who first, change the pipeline data, who conducts repairs and tests, and other pipeline units share the management model for free. After nearly a year of implementation, with the active cooperation of the construction unit and the pipeline ownership unit, the goal of "more use of the data, the more new it is" has been achieved. Nowadays, there is an endless stream of units and individuals who go to the Municipal Urban Construction Archives to consult and study the status information and data of underground pipelines. The huge underground pipeline information network has been integrated into the daily life of pipeline management units, street shops, and ordinary citizens, and has become a comprehensive guide for urban pipelines. An indispensable source of information for planning approval and project construction. It can be seen that the failure monitoring method of underground pipelines requires the cooperation and joint efforts of various departments.

3. DYNAMIC UPDATE METHOD OF URBAN UNDERGROUND PIPELINE FAULT MONITORING DATA

The traditional dynamic update method of underground pipelines cannot fully meet the needs of reality, mainly because the underground pipelines cannot be dynamically updated to the integrated system management platform in time. In addition, the integrated system platform and various professional pipeline information management systems have problems such as inconsistent data standard formats and data incompatibility, which affects data sharing and exchange and dynamic updates. Therefore, after the above-mentioned information sharing system architecture is established, the dynamic data update can be achieved in the following two ways:

(1) The measurement result data generated by the government-led pipeline survey (including supplementary exploration and supplementary survey) is automatically imported and updated. The construction unit (or survey unit) is submitted to the construction unit (or survey unit) according to the formulated unified detection standards, formats and specific requirements of the urban construction archives management department The electronic achievements and archive data of underground pipelines are directly imported into the database, and the archive data is automatically linked to the topographic map to realize dynamic update.

(2) The data submitted by each professional pipeline ownership unit is directly updated. According to the specially formulated underground pipeline archive information data submission procedures and requirements, the data of each professional pipeline ownership unit can be transmitted to the sharing system in two ways to realize data dynamics Update. The first is a sharing system that transmits underground pipeline data to the government cloud. Professionals import the vector database. After comparing with the original data, the technicians remove duplicate data, perform format conversion, symbolization, slicing, and other data processing before entering the database; The second is that each professional pipeline ownership unit establishes a shared database locally, and performs data processing according to the standard requirements, and then submits the offline data, which is imported into the database by professional and technical personnel.

There are also new models for the failure analysis of urban pipelines. The traditional two-dimensional map management mode for urban underground pipelines can no longer meet the actual needs of urban planning and development for the expression, information analysis, and application of underground pipelines. Based on this, the three-dimensional visual management of underground
pipelines is realized. By combining the aboveground and underground building planning and management functional modules such as urban geographic information, office business and auxiliary decision-making, computer virtual reality technology is used to solve many problems in underground pipeline management. It not only helps to avoid the frequent excavation of urban roads in the process of municipal construction, but also greatly reduces the conflicts and hidden dangers of underground facilities during construction, and improves the accuracy and scientificity of pipeline construction planning, design, construction and management. It saves a lot of time and costs for road section excavation and pipeline location verification in planning approval, and minimizes the economic loss caused by planning errors, which has a very positive significance for urban construction and development.

In the process of underground pipeline monitoring, in view of the current problems encountered by underground pipeline equipment, real-time monitoring of underground pipeline environmental information, analysis and display of early warning information can effectively solve these problems. Therefore, this paper proposes the research and design of environmental monitoring system. This system adopts current mature monitoring methods and modern network information technology, based on the rapid development and application of current sensor technology, combined with the characteristics of underground lines, set up necessary environmental monitoring items, arrange corresponding sensor equipment, and realize data sampling. In addition, for a large number of underground pipeline equipment, distributed data acquisition technology and corresponding transmission equipment are used to automatically collect monitoring data and transmit it to the computer of the environmental monitoring center. The monitoring system performs real-time calculation and analysis of the data. When the data reaches the warning threshold, it is immediately Alarm notifications are issued to realize all-weather online automatic real-time monitoring of cable and channel status, which is convenient for managers to control the environmental information of cable equipment and channels in time, and then make preparations and judgments to provide guarantee for safe operation.

The fault monitoring system is divided into data collection, data processing, and environmental monitoring management in terms of business functions. Data collection requires the deployment of sensors in underground power grid pipelines and pipe corridors, including temperature and humidity monitoring, gas monitoring, and stagnant water monitoring, which are converted into data. After the signal is uploaded to the front-end data collection server through the wireless network and wireless data acquisition switch, due to the business requirements of the system, it is necessary to deploy the information exchange server, database server, application server, etc., after business processing, the system display business at the workstation. After years of research and application, the sensor technology has been successfully applied to the power system. The system uses sensor devices to be deployed in the corresponding positions of the underground pipelines to monitor the surrounding environment or special substances, including temperature and humidity, water level, harmful gases and fire protection, etc. The analog signal is converted into a digital signal, and the environmental information is finally converted into temperature and humidity parameters, harmful gas concentration parameters, and fire-fighting signal parameters through the processing of the central processing unit. The data is uploaded to the server through the wireless transmission network to facilitate data management.

Due to the long underground pipe gallery, it is necessary to select an appropriate distance to monitor environmental information. The requirements for the layout of sensors and alarms are as follows:

1. For monitoring temperature and humidity data, a measuring point can be set at 200m.
2. For the setting of the water accumulation sensor, choose low-lying or easy-to-water areas.
3. Gas detectors should be installed at personnel entrances and vents in the pipe gallery.
4. The access controllers are set at the entrances and exits of the pipe gallery and the separate areas of different equipment.
5. Fire monitors are arranged in each fire compartment.
4. CONCLUSION
With the rapid development of Internet technologies such as cloud computing, Internet of Things, and mobile computing, the continuous maturity of new technologies promotes the development of urban informatization to smart development, and the technical requirements for big data, multi-source, and heterogeneous mass data management are becoming more and more important. Underground space pipelines have always been the "vessels" and "nerves" of cities, and their operation and development will directly affect the future of a city. Therefore, it is very necessary to pay sustained attention and research on this, and find a suitable urban land. The construction of a comprehensive urban infrastructure management database is an inevitable trend for the future development of urban infrastructure and an important way to ensure the quality of urban safety management. Faced with the increasingly complex types of pipelines and the increasing amount of pipelines, it is necessary to make full use of big data and other high-tech technologies to improve the quality and efficiency of management work.

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