Application of information technology in hydrological survey

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Keywords: information technology; Hydrologic survey; Taiyuan City; Application status; A question; Development trend

Abstract: Hydrological survey is the basic work of water resources management, and the development of information technology provides a new opportunity for hydrological survey. Taking Taiyuan hydrology and water resources survey station as an example, this paper discusses the application status, existing problems and future development trend of information technology in hydrology survey. The research shows that the application of information technology in hydrological survey mainly focuses on data collection, transmission, storage, analysis and visualization, which greatly improves the efficiency and accuracy of hydrological survey. However, there are still some problems in practical application, such as hydrological monitoring equipment to be optimized and hydrological model system to be perfected. In the future, with the development of emerging technologies such as the Internet of Things, cloud computing, big data and artificial intelligence, information technology will be more widely and deeply applied in the field of hydrological survey, providing more scientific and effective decision support for the sustainable use of water resources.

1. Introduction

Water is the source of life and the basis of sustainable economic and social development. With the rapid economic and social development, water resources shortage, water environment deterioration and other problems are increasingly prominent, and strengthening water resources management has become an important issue for governments around the world. As the basic work of water resources management, hydrological survey provides important data support for the rational development and utilization of water resources, flood control and disaster reduction, and ecological environment protection. The traditional hydrological survey mainly relies on manual observation and recording, which has some problems such as heavy workload, low efficiency and difficult to guarantee data quality. In recent years, with the rapid development of information technology, it has been widely used in the field of hydrological survey, which greatly improves the level of automation, networking and intelligence of hydrological survey.

2. Overview of Taiyuan hydrology and water resources survey station

Taiyuan Hydrology and water resources Survey Station is a professional organization that undertakes the monitoring, evaluation and information service of the whole Taiyuan hydrology and water resources. The main responsibilities include the monitoring and evaluation of the city's surface water and groundwater resources and water environment, the monitoring of the city's water situation and drought, hydrological forecasting and water resources investigation and evaluation, the construction and management of hydrological water resources information systems, and the preparation and release of various hydrological information reports and bulletins.

After years of development and construction, Taiyuan Station has built a relatively complete hydrological station network system, with 49 hydrological (water level) stations, 260 rainfall stations, 4 evaporation stations, 6 moisture content stations, 101 groundwater level monitoring Wells and 9 key water quality monitoring sections, basically covering the hydrological monitoring tasks of Taiyuan City. And the automation of the network is steadily increasing.

Over the years, Taiyuan Station has accumulated a large number of detailed hydrological data, which provides valuable information support and scientific decision-making basis for water

  DOI: 10.25236/icmmct.2024.040

resources management, water conservancy project construction, flood control and drought relief, ecological protection and so on in Taiyuan City and Shanxi Province. As the backbone of hydrology, Taiyuan Station will continue to give full play to its professional advantages, strengthen station network construction, improve monitoring capabilities, deepen data analysis, expand information services, and provide strong support for the modernization and high-quality development of Taiyuan water conservancy[1].

3. Application status of information technology in hydrological survey of Taiyuan Station

3.1 Hydrological data collection

The hydrology and rainfall stations under the jurisdiction of Taiyuan Station are mainly distributed on the Fen River and its main tributaries (LAN River, Wenchuan River, Wu River, etc.). In order to improve the automation level of hydrological data collection, Taiyuan Station is equipped with a variety of modern hydrological monitoring equipment, including self-recording rainfall meter, self-recording water level meter, online flow measurement, automatic moisture monitor, sand content tester, etc., which can realize the real-time monitoring and data collection of many hydrological factors such as rain, water, moisture and sand content. It greatly improves the timeliness and accuracy of data collection, and helps to realize real-time analysis and prediction of hydrological data. In addition, all the hydrographic stations under the jurisdiction have installed video surveillance systems, real-time monitoring of river water conditions and surrounding environment through high-definition cameras, providing intuitive image data for hydrological analysis and early warning and forecasting. Through the networking application of these advanced equipment, the all-weather, all-dimensional, multi-factor, high-spatio-temporal resolution automatic monitoring of the main control sections in the Fenhe River Basin has been realized, greatly improving the accuracy, continuity and timeliness of hydrological data.

3.2 Transmission of hydrological data

In order to ensure the real-time and security of hydrological monitoring data, an efficient and reliable data transmission system has been built in Taiyuan Station. On the one hand, the collected hydrological data is transmitted in real time through the Internet of Things, satellite communication and other technologies, and the monitoring data of each station is unified to the Taiyuan Station to ensure the timeliness and reliability of the data. On the other hand, data backup and disaster recovery systems should be set up reasonably, and information encryption technology should be adopted to ensure data security and prevent data leakage or tampering[2].

At the same time, Taiyuan Station has also established a data sharing mechanism with Taiyuan Water Bureau and related units. Through the dedicated optical fiber network, the station can realize the interconnection of hydrological data with the Taiyuan Municipal Water Bureau and other departments, providing authoritative information support for flood control and drought relief and water resource scheduling. In case of major flood situation, Taiyuan Station can also launch video conference system, carry out remote consultation with superior business departments, timely study and judge the disaster situation, and guide the flood control work.

3.3 Storage and management of hydrological data

The effective storage and management of massive hydrological monitoring data is an important part of hydrological information. Taiyuan Station has built a hydrological database system, which uses SQL Server database to store basic hydrological data, monitoring data and thematic data, and conducts standardized management through metadata, data dictionary and other means to ensure data consistency and integrity. At the same time, the Taiyuan Station also regularly carries out data quality control, including the measurement and calibration of installed sensors, the elimination of outliers, and the review of the section flow relationship curve, etc., to ensure the accuracy and reliability of hydrological data.

In terms of data management, Taiyuan Station follows the principle of hierarchical management and implements hierarchical authorization management for hydrological data. The station clearly

define the responsibilities and authorities of the measurement station and sub center, as well as the sub center and Taiyuan station in data collection, review, and reporting. At the same time, we establish a sound data security guarantee system, take measures such as physical isolation, network encryption, and remote backup to minimize the risk of data leakage and loss, and establish a data recovery plan to ensure that data can be quickly recovered in the event of data loss or damage, ensuring the integrity, accuracy, and security of data, and improving the value and utilization efficiency of data.

3.4 Hydrological data analysis and application

Relying on rich hydrological monitoring data, Taiyuan Station has established a series of hydrological data analysis and application systems to give full play to the value of hydrological data. First, a comprehensive analysis platform for hydrological data was built, using data mining and statistical analysis techniques to conduct multidimensional analysis of precipitation, runoff, sediment content and other data in Fenhe River basin and reveal the spatial-temporal distribution of hydrological elements. Second, the flood forecasting and early warning system is developed. Based on the rainfall runoff model, combined with the forecast of short impending heavy rainfall and the risk map of flash flood disaster, the possible flood disaster can be warned[3]. The third is the establishment of water resources analysis and evaluation system, regular water resources bulletin, water resources demonstration and other work, to provide a scientific basis for the rational allocation of water resources in Taiyuan, conservation and protection.

In response to the extremely heavy rainstorm and flood disaster in Shanxi Province in October 2021, Taiyuan Hydrology and water resources Survey Station gave full play to its professional advantages, used the hydrological comprehensive analysis platform, combined rainfall observation data and hydrological data of Fenhe River control stations, and simulated the flood evolution process. The study shows that the flood has a multi-peak form, and the flood peak discharge is large and the flood total amount is large, which has reached the rare level in history.

After mastering the basic situation of the flood, Taiyuan Station submitted the flood analysis report to the higher authorities and local governments in a timely manner. The report assessed the causes, characteristics, scope of impact and damage of the floods, and made recommendations for emergency response to the disaster situation. The report has been highly valued by the municipal Party committee and the municipal government, and provides a decision-making reference for scientific dispatch, rescue and disaster relief.

3.5 Hydrological information sharing and service

Taiyuan Station attaches great importance to the socialized service of hydrological information, actively strengthens the interaction with government departments and the public, and vigorously promotes the sharing of hydrological information. On the one hand, through portals, new government media and other channels, timely release of water situation information, science knowledge and disaster prevention early warning, and guide the public to enhance the awareness of disaster prevention and risk aversion. On the other hand, focusing on the needs of water resources management, flood control and disaster reduction, and ecological civilization construction, accurate and efficient hydrological information services are provided to government departments and social water users. With its professional hydrological monitoring and analysis capabilities, Taiyuan Station provides accurate and efficient hydrological services for government departments and enterprises. Through close cooperation with the Municipal Water Bureau, Ecological Environment Bureau and other departments, Taiyuan Station provides scientific basis for urban flood control, water resources management, ecological protection, etc., and helps the government to coordinate water relations and make emergency dispatching decisions.

At the same time, the station has also actively carried out publicity of hydrology law, organized and carried out various forms of science popularization activities through the "World Water Day" and "Disaster Prevention and Reduction Day", and created a good atmosphere of water love, water cherish and water protection in the whole society. The station organize students to walk into the survey station, learn hydrology knowledge and observe the river on the spot, and enhance the awareness of water safety by means of edutainment. Through these popular science activities,

Taiyuan Station has established a good social image and expanded the influence of hydrology work[4].

4. Problems existing in the construction of hydrological survey information in Taiyuan Station

After years of exploration and practice, great progress has been made in the informatization construction of Taiyuan Station's hydrological survey, but there are still some problems to be solved:

First, hydrological monitoring equipment needs to be optimized. At present, the hydrological monitoring equipment of Taiyuan Station needs to be further improved and optimized in terms of adapting to the characteristics of northern rivers and meeting the needs of flood control and drought relief. The selection, configuration and layout of some equipment need to better combine the hydrological characteristics and monitoring tasks in Taiyuan area to improve the pertinence and effectiveness of monitoring. At the same time, the daily maintenance and management of the equipment should also be strengthened to ensure the stable operation of the monitoring system.

Second, hydrological data sharing needs to be strengthened. In recent years, Taiyuan Station has continuously improved the standardization and normalization of hydrological data, established unified coding rules and format standards, and greatly improved data quality and reliability. However, in the actual work, the lack of effective information sharing mechanism among various business departments leads to data dispersion and duplication, and the comprehensive utilization level of data needs to be further improved. In the next step, we should continue to strengthen the construction of data standards and metadata, agree on a unified exchange agreement, realize data interoperability and sharing, and promote the in-depth application of hydrological data in flood control and drought relief, water resources management and other fields.

Third, the hydrological model system needs to be improved. Although a number of hydrological analysis models have been established in Taiyuan Station, the model applicability and accuracy stability need to be improved. Limited by computer hardware and model algorithms, some complex models (such as distributed hydrological models) are difficult to realize business operation, which brings challenges to the fine management of flood control and drought relief.

Fourth, information security risks cannot be ignored. With the improvement of information technology, problems such as network security and data security have become increasingly prominent. The hydrological data of Taiyuan Station involves sensitive information such as flood control and drought relief, water resources management, etc. Once it is leaked or tampered with, the consequences are unimaginable. Therefore, it is urgent to establish a sound information security guarantee system and strengthen the security protection of hydrological information system.

Fifth, the construction of talents is relatively backward. Hydrologic informatization involves many fields such as computer, communication, Internet of Things, etc. At present, Taiyuan Station is still in short supply of professionals engaged in informatization work, and the knowledge structure and skill level of existing personnel are difficult to meet the development needs of new technologies and new businesses, which affects the depth and breadth of informatization construction. To this end, we should adopt the method of combining training and introduction, improve personnel's information literacy, introduce high-end talents and advanced information technology, and further enhance the comprehensive strength of talent team.

5. Development trend of information technology in hydrologic survey

5.1 Intelligent sensing equipment

The sensor is the "eye" of hydrological data acquisition, and its performance is directly related to the quality of monitoring data. At present, driven by communication technologies such as 5G and low-power wide-area networks, hydrological sensors are developing in the direction of miniaturization, low cost, low power consumption, and flexible networking. In the near future, smart sensors and their networks are expected to be deployed on a large scale to achieve accurate perception of multiple elements such as precipitation, water level, sediment content, and water quality. At the same time, the introduction of new technologies such as drones and video

recognition will also greatly expand the means and dimensions of hydrological monitoring. By carrying out three-dimensional monitoring, Taiyuan Station can obtain more comprehensive and dynamic hydrological information of Fenhe River basin, laying a solid foundation for flood forecasting and water resources management[5].

5.2 Data processing automation

Timely processing of massive heterogeneous hydrological data is the key to improve business efficiency. With the development of new generation information technologies such as cloud computing and big data, Taiyuan Station will speed up the construction of an intelligent hydrological data processing system. The use of ETL (data extraction, cleaning, loading), data mining and other technologies can realize the automatic reception, quality control, classification and storage of hydrological data, greatly improving the efficiency of data processing. Based on the distributed parallel computing framework, it can quickly calculate and analyze massive data such as high density radar precipitation and high resolution remote sensing images. In addition, the application of intelligent technologies such as knowledge mapping and data visualization will also promote the correlation analysis and intuitive presentation of hydrological data. By creating a one-stop, automated data processing platform, Taiyuan Station can fully release the value of data and provide strong support for various business applications.

5.3 Refinement of model simulation

Model is an important tool for understanding hydrological process and guiding business decision. At present, with the rapid improvement of computer performance and in-depth analysis of hydrophysical mechanisms, a number of new hydrological models are emerging at an accelerated pace. For example, SWMM (Stormwater management model), MIKE (river hydraulic model), GEO-WEPP (soil and water loss model), etc., through the coupling of atmospheric, surface, underground and other multi-media processes, can realize the fine simulation of rainfall runoff, soil erosion, groundwater migration and so on. At the same time, the progress of numerical weather forecasting, radar precipitation forecasting and other technologies has also created conditions for improving the accuracy of hydrological forecasting. In the future, Taiyuan Station will further strengthen the research and development and application of new forecasting technologies such as multi-model ensemble forecasting and probabilistic forecasting, strive to make new breakthroughs in refined simulation and intelligent forecasting, and provide more accurate forecasting and early warning services for flood control and drought relief and water resource scheduling.

5.4 Business process mobility

The rapid development of mobile Internet is profoundly changing the way people work and live. In line with this trend, Taiyuan Station will vigorously promote the mobile application of hydrology business, and provide information services anytime and anywhere for internal and external users. Internally, mobile terminals (such as smart phones and tablets) are used to extend data collection and on-site inspection to the work line, and information sharing and efficient collaboration are achieved through mobile office platforms (such as OA and instant messaging). Externally, we will develop mobile applications (apps) for water situation inquiry, early warning broadcasting, science popularization and education for the public, innovate service methods, and expand service radius. Through process reengineering and platform reengineering, Taiyuan Station will further improve work efficiency, optimize user experience, and promote the transformation of hydrological management from "business-oriented" to "customer-oriented

5.5 Integration of intelligent facilities

Hydrological monitoring facilities are the basic support of hydrological undertakings. In the future, Taiyuan Station will be based on the development concept of "multi-station integration, one station multi-capacity", and accelerate the intelligent transformation and comprehensive utilization of hydrological facilities. While strengthening the construction of the hydrographic station network, cutting-edge technologies such as the Internet of Things and artificial intelligence are used to deeply develop the sensing, calculation, control and other functions of the station to achieve self-diagnosis,

self-repair and self-adaptation of the station[6]. While strengthening the construction of hydrological station networks, cutting-edge technologies such as the Internet of Things and artificial intelligence are utilized to deeply develop the sensing, computing, and control functions of measurement stations, achieving self-diagnosis, self-healing, and adaptive capabilities of the stations. At the same time, the station fully utilize municipal infrastructure such as smart light poles and video surveillance, expand monitoring methods, and save construction investment. Exploring the construction of a "smart river chief system" platform that integrates data collection, video monitoring, early warning broadcasting, water quality monitoring, and other functions in key sections of the Fenhe River, promotes the integration and intelligence of monitoring and supervision, command and dispatch, and emergency response. By building smart hydrological facilities, Taiyuan Station will further consolidate the foundation of modern hydrological monitoring and expand the breadth and depth of hydrological support service.

6. Conclusion

The integrated development of information technology and hydrological survey provides a strong impetus for improving the level of hydrological modernization and ensuring sustainable economic and social development. Taking Taiyuan hydrology and water resources survey station as an example, this paper analyzes the application status of information technology in hydrology survey, analyzes the existing problems, and looks forward to the future development trend. It can be predicted that with the accelerated penetration of the new generation of information technology, intelligent sensing equipment, automatic data processing, refined model simulation, mobile business processes, and integrated intelligent facilities will become important features of hydrological modernization. As the vanguard of Taiyuan's hydrological cause, Taiyuan Station will keep up with the pace of information development, accelerate the intelligent upgrading of hydrological monitoring, forecasting, service and other links, strive to achieve the goal of more sensitive perception, more accurate forecast, and better service, and make greater contributions to the flood control safety, water resources protection and ecological civilization construction of Taiyuan City and Shanxi Province.

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