Research on remote intelligent consultation platform for dam safety monitoring

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Abstract: At present, most dam consultation systems have only video communication functions but lack of in-depth technical support. For this reason, based on the idea of “early warning-consultation-decision”, this paper studied the architecture and hardware deployment of the decision support platform for dam engineering safety monitoring. The video communication module was developed basing on TCP/IP protocol and dam digitalization was realized using virtual visualization technology. Structural safety calculation, data analysis and comprehensive evaluation, etc. were implemented in C# language. Therefore, a comprehensive platform for dam safety and intelligence meeting, which fully supports experts’ remote decision making, was formed. The results have been well applied in the disaster emergency of Shiziping and other projects.

1. Introduction

There are many reservoirs and dams in the remote areas. It is not realistic to call experts to rush immediately to the scene where the danger occurs. Therefore, remote consultation as a cross-regional communication method is an effective way to solve this problem. In January 2000, the Ministry of Water Resources began to set up a long distance consultation system, which used a special satellite to carry out video conferencing communications. The first phase of the project set up nine nodes. On July 2, 2003, The Ministry of Water Resources used the consultation system to realize the video connection between Beijing, the Ministry of Water Resources, the Huai River Flood Control, the Anhui Flood Control, Drought Relief Headquarters, and the Wangjia Dam when Huai River burst into floods. Then the decision of the flood diversion in the Huai Mongolian flood storage area was carried out at one o'clock in July 3rd after remotely viewing live video, water conditions and rain conditions. Apparently, the video consultation system played a great role in the flood control decision[1]. Dahuofang Power Station established its own WEB video system through integrating existing hydrological forecasting system, dam monitoring system and video monitoring equipment, etc. A monitoring video system for discussion of meetings under the control of the host was implemented through the “hand in hand” mode, which used multi-screen technology to realize the split screen and screen display effect of signals. Ningxia Water Resources Bureau purchased the Polycom system to establish a high-definition conference system[3]. Polycom system is the old brand of the video consultation system, which is widely used currently. But at present, many of the dam consultation systems can only make use of advanced video communication technology at home and abroad to achieve a simple remote video conference, which can not achieve real-time sharing of files, graphics, monitoring data and real-time display of dam’s behavior, and does not have professional analysis and calculation support. Therefore, the participants can’t fully grasp the dam operation in a short time but put forward a treatment plan through the information
provided by the reporters and combined with their own experience. For these reasons, there are some drawbacks in the consultation system.

Based on the idea of “early warning-consultation-decision”, this paper developed a conference platform that provided visual dam information query, information analysis, structural analysis, security evaluation and other decision support functions combined with C# and GIS platform to realize the intelligent assistance for remote consultation of dam safety.

2. Consultation process
The dam safety meeting involves the analysis and evaluation of many issues such as water conditions, structural safety, emergency conditions of the reservoir area, possible losses and best response measures. It involves not only the content, but also the challenges of time. It is necessary to give the conclusion of the dam safety evaluation in the shortest time and make a reasonable and feasible emergency plan.[4,5,6] Therefore, the dam safety monitoring and consultation platform should provide as much and accurate information as possible about the water situation, structure, monitoring, population distribution, topographical geology, disaster relief materials, etc. Meanwhile it should have the ability to reliably display the reservoir area and dam body image and give expert real-time technical support. The process of safety monitoring and consultation of the high earth-rock dam project proposed in this paper is shown in figure 1.

![Figure 1. Consultation system program.](image)

(1) Early warning stage
According to the on-site inspection and monitoring data analysis of the dam, the system gives early warning to the monitoring problem according to the set threshold. After the warning, the system reviews the credibility of the warning information firstly. If there is still a problem after the review, a conclusion is given for review by the site manager. After reviewed by the on-site personnel, the management personnel with reporting authority will report the situation.

(2) Conference creation
According to the content of the consultation, experts are selected from the expert database to participate in the meeting. The expert database includes designers, owners, construction participants, university experts, industry experts, etc. Participants access the conference system through the C/S or B/S system. The administrator assigns the rights of each person when logging into the system.

(3) Conference preparation
At the same time as the invitation of the experts, the on-site staff must prepare for the consultation, including data review and disaster relief registration. Data review includes the content of on-site inspection data, monitoring data, video surveillance, data of the reservoir area, and the verification of
water information. This work can be identified in batches using the system's own identification program. The registration of disaster relief includes the registration of disaster relief materials and the entry of disaster relief routes.

(4) Analysis of disaster situation
The video is started under the organizer's organization. Participants can use the data query, 2D or 3D display and live video of the project area to understand the dam situation in an all-round way. According to the knowledge and engineering experience, the experts can analyze the dam disaster, possible causes and safety assessment of the dam. Mathematical modeling, sequence data statistics, safety analysis and evaluation, knowledge base, etc. provided by the system can provide decision support for experts.

(5) Decision-making command
According to the analysis of the disaster situation, the participants must put forward a plan. The participants must continue to observe if the risk of the disaster is not large enough. If the disaster is considered to be risky and affects the safety of life and property of the downstream people, the participants should immediately give an emergency plan. The prepared retreat plan can be simulated on the GIS platform to see if it is feasible or there is room for optimization. Finally, the final resolution was formed after the discussion.

(6) End of the meeting
The organizer records the content of the conference. A final resolution is formed. Then the participants write down electronic signatures and exit the system under expert authorization.

3. System hardware deployment
The hardware deployment of the consultation system is shown in figure 2.

(1) Field monitoring equipment
Field monitoring equipment mainly includes on-site video and monitoring information collection equipment. The video device is responsible for transmitting back real-time image data of the dam and the monitoring information collection device is responsible for collecting the real-time data required.

(2) Display equipment
The display device needs to accept the input of the analog signal, which can be configured according to the needs of the site. The main venue can be equipped with multi-screen display devices. The branch venue can be equipped with LCD TVs and other devices. Experts can use computer equipment with video and audio input.

![Figure 2. Hardware deployment of safety monitoring and consultation system for dam engineering.](image-url)
(3) Audio equipment
Audio devices include audio input devices such as microphones and audio output devices such as loudspeakers.

(4) Total control equipment
The main control equipment is mainly a conference control server. The server is installed with a detection system, which is responsible for compressing and decoding video and audio, and sending user commands to related devices.

(5) Network equipment
The network device is responsible for the access and transmission of information. The conference system involves the transmission of large-traffic data. The internal network of the company recommends the use of DDN connections, and the VPN technology is used for access in different places. The switch recommends Gigabit Ethernet switches.

(6) MCU controller
The MCU is responsible for switching video and audio devices and setting multi-interface video information.

(7) Calling equipment
The calling device is mainly responsible for the notification and information of the meeting, including telephone, mobile device, SMS cat and other instruments.

4. Key technologies to realize the consultation

4.1. Video communication technology
Text, image and file communication uses data flow based on TCP/IP protocol. First, the text entered by the user or the image file to be transferred is converted into a data stream by the StreamReader command. Then the data is encrypted and transmitted through the TCP/IP protocol. Next, the received commands are merged, decrypted again. Finally, the received commands are converted to the original files by the StreamWriter command. In order not to affect the fluency of the dam consultation, the process uses asynchronous transmission.

Video and audio transmission use the acquisition device to collect the signal firstly. Then the collected signal is compiled and compressed by MPEG-2 encoder. The key frame uses DCT transform and the interframe compression adopts the motion compensation technology. Next the compressed data is sent to the network by subcontracting and the network still adopts asynchronous transmission. Data is assembled and decoded after the client accepts the data. Finally, play video and audio in a given window. This method does not affect the transmission of other modules of the program, but the display will have a certain lag.

4.2. Visualization technology
In order to realize the visual display and information query of the dam, the system uses virtual reality technology to establish a conference platform, including visual basic database, engineering digitization and visual display machine technical support. The visual architecture is shown in figure 3.
(1) Database establishment
The spatial database stores the three-dimensional topography, buildings, roads, regional information, and environmental information of the main areas of the project. The attribute database stores the hub name, description information, watershed area information, traffic status, and so on.

(2) GIS digital integration
Compared with the traditional visualization engine, GIS has a greater advantage in spatial characteristics query, spatial analysis and space computing. GIS is mainly responsible for integrating the terrain and the image of the building, and combining C# language to realize the intercommunication between the spatial information and the database information. The GIS visualization integration is shown in figure 4.

(3) Structural analysis
To achieve planar or 3D calculations, we need to digitize the structure first, including structure partition, region parameter assignment and boundary information. The corresponding calculation method and digital structure are used for calculation at the time of structural analysis. The digital structural model of the stress and strain calculation of the Shiziping core wall rockfill dam[7] is shown in figure 5.
5. **Engineering case**

The Shiziping Hydropower Station is the main-reservoir for the cascade development of the Zagunao River Basin. The project is II (2) type project and the dam is designed as a first-class building.

The remote consultation platform of the Shiziping dam safety monitoring provides technical support for dam safety monitoring and intelligent decision making. The interface is shown in figure 6. The platform supports video conferencing, text discussion, monitoring equipment access (There is no on-site monitoring equipment for the Shiziping dam currently), information collection and transmission, multi-function information inquiry, monitoring data reorganization analysis, dam safety real-time analysis, evaluation, etc. It provides comprehensive information and technical support in dam safety early warnings.

6. **Conclusion**

(1) Based on the idea of “early warning-consultation-decision” and combined with GIS and c# platform, the remote consultation platform and hardware deployment plan for high earth-rock dam safety monitoring are realized. The platform has reasonable structure, reliable operation, and provides comprehensive, intuitive and fast information. It can provide technical support for auxiliary decision-making of dam safety monitoring.
(2) Integration platforms solves the problem of digitization of dam hub and river basin, including SQL sever, GIS, Terra Vista and so on. The digital content is applied to the system visualization interaction and structural safety calculation, which provides a feasible digital case for the more interactive and visible dam system.

(3) The results have been successfully applied in the Shiziping project, which provides functions such as information query, real-time safety analysis and decision-making simulation. It also provides a support platform for the dam to realize remote intelligent decision-making, which can be used for similar projects.

References
[1] Fang, M., Ding, J., Gao, G.L., Zhang, J.G.(2003) Construction and application of water conservancy consultation system. J. China Water Resources, (22): 62-66.
[2] Ma, T., Ma, C.B., Gao, F., Liu, Z.X.(2008) Construction of flood control consultation system for Dahuofang Reservoir. J. Modern Agricultural Science and Technology, (10): 215-216.
[3] An, L.P.(2012) On the application of Polycom video conference system in Ningxia water conservancy system. J. SME Management and Technology (Early Issue), (12): 206-207.
[4] Kang, L., Wang, C., Wu, Z.R.(2004) Design of dam safety remote expert consultation system. J. Hydroelectric Power, (04): 60-62.
[5] Chen, K.(2016) Design and implementation of the mid-term expert consultation scheduling system for reservoir groups. D. Huazhong University of Science and Technology.
[6] Hu, D.Y.(2016) Design and implementation of the adjustment strategy for hydropower stations (groups). D. Huazhong University of Science and Technology.
[7] Zhang, H., Chen, J.K., Hu, S.W, et al.(2016) Deformation Characteristics and Control Techniques at the Shiziping Earth Core Rockfill Dam. J. Journal of Geotechnical & Geoenvironmental Engineering, 142(2):04015069.