An opening system monitoring dam health

Z.P. Wen
Dept. of Computer Engineering, Nanjing Institute of Technology, Nanjin, 210013, China

H.Z. Su & Z.R. Wu
College of Water Conservancy and Hydropower Engineering, Hohai University, Nanjing, 210098, China

ABSTRACT: Based on a great deal of data and wide knowledge in the field of dam health monitoring, a system monitoring dam health is developed. The system abides by the principle that application software is modular, extensible, operational. The system utilizes network technique, database technique and development technique of decision supporting system. This paper putts forward the design thought of "one engineering and four base systems". Three layers Client/Server mode is designed. Dynamic reborn system plot is developed. The system can monitors dam work character in real time.

1 INTRODUCTION

Dam construction has developed very fast in China since 1950. There are now 17,526 dams 15-30m high and 4,578 dams exceeding 30m. These projects bring huge benefits in flood control, irrigation, power generation. However, hidden troubles exist in some dams due to hydrology, geology, design, construction and aging. Some non-determinate factors, like computation parameters and simulation of geological structure and randomness of load etc., maybe occur during operation period. Thus, the results obtained from indoor experiment and numerical simulation analysis can not reflect the true operation behavior of the dam. The prototype monitoring data of dam can describe the integrative action of all kinds of influence factors. The analysis for prototype observations is an effective measure appraising dam health.

To solve above-mentioned problems, considering the actual characteristics of dams, an opening system monitoring dam health (for short OSMDH), is developed with the modern advanced hardware and software technique. This system can implement quickly analysis and appraisal for dam health. In the meantime, the system can give play to optimal design, construction and operation, and to improving the design theory and method of dam, and to replenishing the current design and operation standard. Therefore, the system has not only notable society and economy benefit, but also great science worth.

This paper is organized as follows. Section 2 presents the development aim and conformed principle of system. Global structure of system is proposed in Section 3. The system is consisted of integration control module, intelligent inference machine, project database, model base, graphics base, information management and input/output modules. In Section 4, three layers Client / Server pattern is introduced. A dynamic and regenerative flat is present in Section 5. Section 6 summaries the main conclusions reached in this work.

2 DEVELOPMENT AIM AND CONFORMED PRINCIPLE OF SYSTEM

2.1 Development aim of system

According to the characteristics of dam and the needs of health analysis and appraisal, by use of the modern advanced computer hardware and software technique and advanced analysis method and ripe software, the system may manage and analyze the large number of health monitoring data at first. In the meantime, it can comprehensively analyze and appraise the health state of dam on the basis of absorbing the knowledge of specialists. For the found doubtful points and unsafe factors, it can make the physical genesis and integrative diagnosis analysis, and propose the corresponding suggestion for auxiliary decision. Thus, by use of the system, dam health state can be quickly appraised from the monitoring data collected from all of monitoring instruments, and bring its engineering benefit into full play. The system mainly includes following contents.

(1) Information management of dam health

Large numbers of observation instruments are usually disposed in dam body and dam foundation to

monitor dam working characteristics. The observation items include commonly deformation, seepage, stress and strain, temperature, environment observation, which are all implemented by many observation points. A vast number of observation data are collected by these equipments and means. With some mathematical or mechanical methods, the dam health status can be analyzed, diagnosed and evaluated based on these prototype observation data.

It is an important work to manage scientifically and rapidly observation data, data on design and construction, expert knowledge about dam health monitoring, as well as mathematical or mechanical methods and their analysis results. An information management subsystem need be developed to fulfill above functions, which can provide the reliable information resources, excellent interface of graphics and images, tools of programs management for users.

(2) On-line real-time analysis

The system collects the monitoring data, and carries out their reorganization and error analysis in time. Subsequently, by application of the many kinds of monitoring models, monitoring indications and safety standards, it compares the measure values with calculation values, finds out the abnormal appearances. In addition, by use of the routine inspection data and results, the system trails and analyzes the operation state of the dam.

(3) On-line feedback analysis

After completing the on-line analysis and appraisal, the system performs the comprehensive analysis for the doubtful points. In other words, it distinguishes whether the unsafe factors occur. If the abnormal state is caused by unsafe factors, the system performs the physical genesis analysis, and finds or forecasts the dangerous state.

(4) Auxiliary decision

After performing physical genesis analysis, if the genesis that gives rise to the doubtful points or abnormal state can not be found, or the environment factors have taken place obvious change, the expert comprehensive diagnosis should be performed. The suggestion of control water level during operation period can be made. For the dangerous state of dam, the urgent measure preventing the dam should be proposed, and the corresponding alarm level should be determined.

2.2 Development principle of system

The main characteristics of this system are quickness, accuracy and reliability. Thus, the following some principles are adopted during the development period.

(1) Practicability

According to the actual situation of dam, the system should solve the problems of the safety analysis and comprehensive appraisal during operation period. Thus, the collected monitoring data must be done the error analysis and reliability testing in order to ensure the reliability of data. The analysis software must be evaluated and examined and accepted in some other engineering application in order to ensure the analysis method is correct. The operating system should have menu system and fine graphics interface, and can display and print the process and conclusion of analysis and appraisal. In other words, the system should have convenient operation and practical facilities. In the meantime, after the data of automatic or semi-automatic or manual collection are inputted into the engineering database, the reorganization and analysis should be completed in time. If the doubtful points are found out, the comprehensive analysis and physical genesis analysis should be done immediately. When the doubtful points are determined as an unsafe factor, the susceptibility analysis should be done. In a word, this system should truly deal with the issues of on-line real-time analysis and feedback analysis for dam health.

(2) Advanced stage

Utilizing international advanced computer hardware at present, the application software in this system is researched and developed. Furthermore, the positive and inverse analysis theories and methods are improved, and the dependable monitoring models and monitoring indications are established and used. So the system can make the accurate and rapid predication for the dam health state. Simultaneously, considering the analysis technique and procedures may be updated and improved continuously, this system adopts the fashion windows graphics user interface and normalized and standardized design according to the needs of system application. So the maintenance, upgrade and expansion of system are very easy.

(3) Reliability

The system application software must run stably over a long period of time. In this system, the accurate and reliable data are collected, and the reorganization and analysis of data are carried out by the developed software. The large number of data collected must be safely stored into the database firstly, and then, the analysis and back analysis and the safety appraisal are completed with these data. All these work must be done automatically and without errors. The system fully utilizes the ripe software, and follows the TCP/IP network communication protocol. In addition, the manual input interface is adopted.

(4) Putting stress on key points

This system puts stress on the deformation monitoring and seepage monitoring, and regards the plumb line monitoring as a key point of global deformation of the dam. Simultaneously, from the angle of project safety, it catches hold of the key suits and key problems of dam health. This system gives

consideration to both global monitoring system and key suits and problems.

3 GLOBAL STRUCTURE OF SYSTEM

The system is consisted of integration control module, intelligent inference machine, project database, model base, graphics base, information management and input/output modules. Its global structure is shown as Figure 1.

3.1 Integration control

The integration control module is a multilevel control menu, which can harmonize intelligent inference machine, project database, model base, graphics base, information management and input/output modules.

3.2 Project database

The project database is used to store the large number of project archives and observing data. According to the property and source of data, the project database is divided into four sub-databases, called project archive database, origin database, reorganization database and generation database, respectively. The project archive database mainly stores the design, construction and operation data on safety monitoring. The origin database stores prototype observations collected by sensing system. The reorganization database stores the processed data. The generation database mainly stores all kinds of results obtained from intelligent inference machine.

3.3 Model base

The base mainly includes the analysis programs of observed data, structure analysis programs, seepage analysis programs, diagnosis programs and assessment programs etc. By use of these programs, the system can establish the monitoring models, check the strength and stability. When the abnormal cases occur, they can be used to implement all kinds of numerical analysis.

3.4 Graphics base

The graphics base mainly includes the figures and tables for project safety, monitoring data analysis, structure and seepage analysis, comprehensive evaluation and auxiliary decision etc.

3.5 Intelligent inference machine

Intelligent inference machine is an aggregate of knowledge and expert experience. It is the central processing unit of OSMDH, which carries out the integration and analysis of safety information, diagnoses and evaluates dam health, and makes decisions. The inference flow is shown in Figure 2.

Intelligent inference machine includes observation value judgment, observation examination, comprehensive analysis, expert diagnosis and auxiliary decision and so on. It is an aggregate of all sorts of knowledge and expert experience, and is the core of this system. The intelligent inference machine can carry out following main facilities. By use of the judgment criterion, it can distinguish the property of each observation value that is reorganized and corrected, viz. normal, basic normal or doubtful. If the observation value is a doubtful point, it will continue the genesis analysis. Firstly, it will check the monitoring system. If the doubtful point is caused by the abnormal monitoring system, this system will send out an alarm and warn the operators to repair the monitoring system. The system may exclude the doubtful point and the inference is over. If not, the unsafe factor maybe occur, and the external cause (viz. environment factor) is analyzed. In the meantime, the effect of external cause on dam foundation and dam body is analyzed, and if it is necessary, the back analysis on structure will be made. If the cause is found out, the system will make the auxiliary decision. If the cause is not found, the expert fuzzy diagnosis will be used, and a suggestion of decision for the heads will be made.

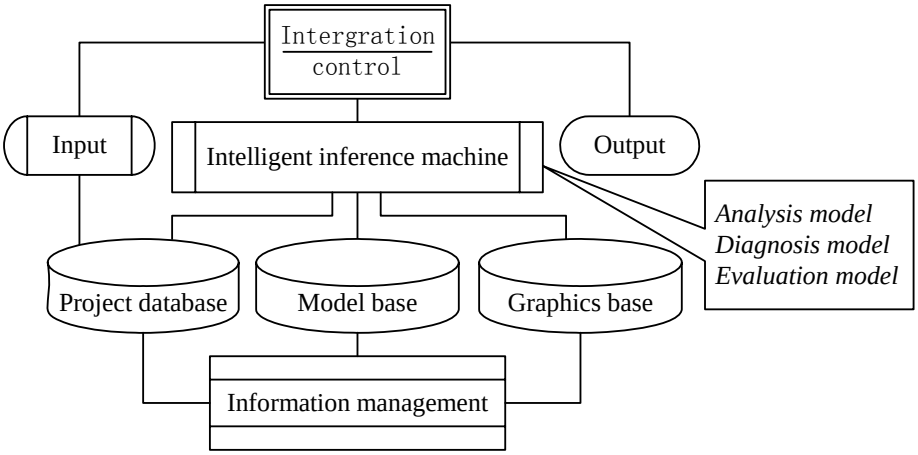

Figure 1. Global structure of OSMDH.

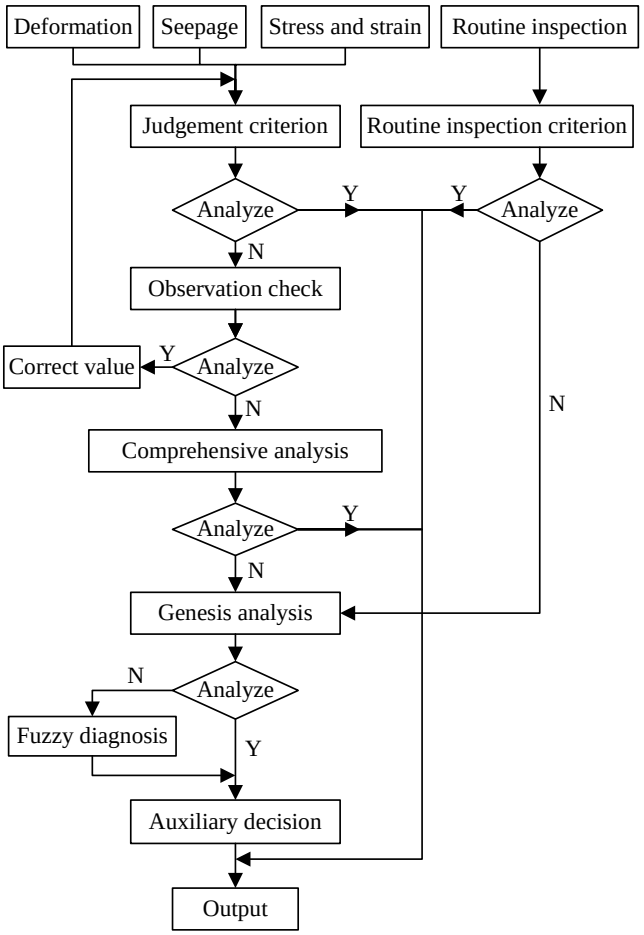

Figure 2. Work flowchart of intelligent inference machine.

4 WORKING PATTERN OF OSMDH

This system adopts three layers Client / Server pattern (See Figure3.).

User server layer provides a visualization interface, which can indicate information and collect data. Any business can not be handled in user server layer.

Business layer is a bridge connecting users and data server. It can implement the response for the request sent by users, and carry out some business treatment.

Data server layer is used to implement data definition, maintenance, accessing, updating and management, the response for the data request of business layer. It can be an aggregate of nonhomogeneous database.

For three layers Client / Server pattern, Client pays attention to users alternation and data denotation. Background database can fulfill data accessing and management. Application server is absorbed in handling application business. These three layers can work in phase, and form an organic whole.

Under three layers Client / Server pattern, the work flow of this system is following as.

(1) The checked observations are inputted original database. Data in original database are reorganized automatically, and stored into reorganization database.

(2) Project data, graphs, judgment criterion and model information are stored respectively into project archive database, graphics base, knowledge base and model base. According to the time sequence list of real-time analysis or stochastic drive mode, the system implement real-time and online analysis for safety status of dam.

(3) Input of all data and information is fulfilled by user server layer in client. Four bases, namely, database, model base, knowledge base, graphics base, lay into data server layer in data server. By calling data, models, judgment criterions in data server, business server layer in application server implements treatment and analysis for data, analysis and evaluation for dam safety. The results are returned to users of client.

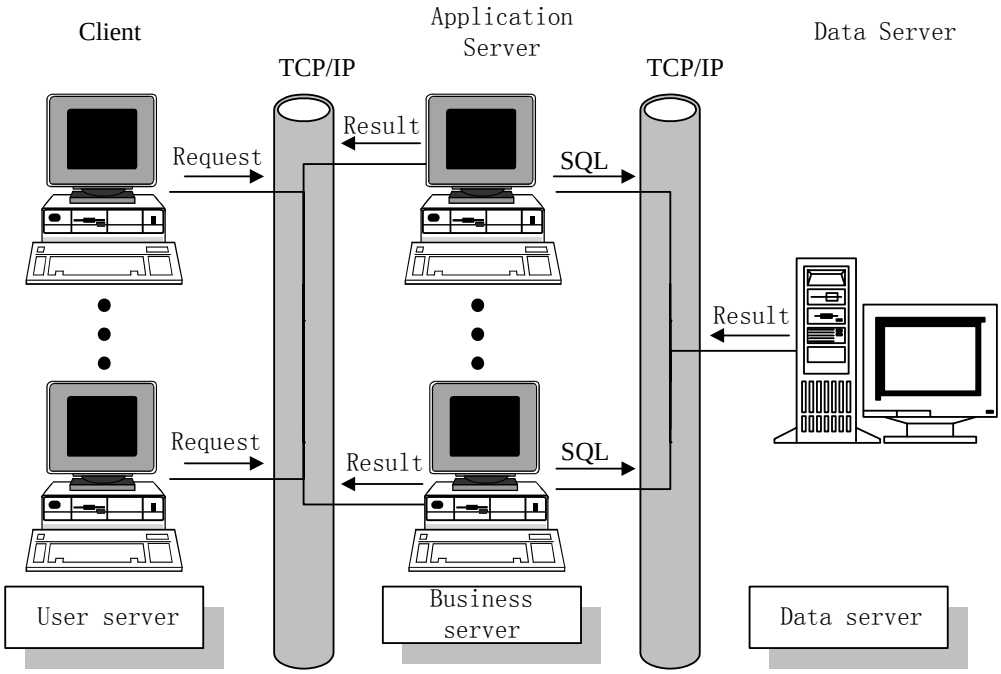

Figure 3. Three layers Client / Server structure.

With three layers Client / Server pattern, maintenance, extension, and reliability of OSMDH are advanced. The system can be developed with parallel mode.

5 DYNAMIC AND REGENERATIVE FLAT

The frame design of OSMDH adopts the design method of dynamic and regenerative flat.
The dynamic and regenerative flat is an opening structure. To load all kinds of implemental modules and their explains, the system designs a file named 'source file of system design'. This file is compiled by simple expression rules. The system structure is described with nature language format, which can be written and modified with user's own way. Source file of system design need be compiled with precompiler, and embedded in the system maker. So an executable system is built, which has dynamic and regenerative function.

The structure of dynamic and regenerative flat is shown in Figure 4.

In the plat operation organ, C represents system maker, D represents precompiler, A represents explain display organ, B represents system transfer organ, E represents the transfer organ of PC toolbox, and F represents online help organ. Explain display organ is used to browse the system explain. System transfer organ is used to transfer main system, subsystems, system of user definition. General tools and software are set with PC toolbox. Online help organ is used to look over the content of system help.

Source file of system design is the input file of precompiler, which adopts the writing manner of tree structure. #F, #S, #A, #P, #H are used to represent respectively general explain of system, system transfer, system tool, PC toolbox, online help. Their rule is as follows.

(1) For #F, #S, #A, #P, #H, write from first row, denote to begin the definition of corresponding content, and end with #EF, #ES, #EA, #EP, #EH.

(2) For #E, write from first row, denote system end.

(3) For system transfer, the number before the title of system and subsystem expresses the relationship. The first number need to be written from the first row.

(4) If there is executable module, writing form is #@ executable file name.

The compiling process is shown in Figure 5.

6 CONCLUSIONS

The "opening system monitoring dam health" is a huge software system. It is developed by many researchers together. This paper only briefly expounds its design thought and mainly facilities. The system can quickly analyze and evaluate the operation state of dam. It is an important measure for ensuring the project safety and bringing the engineering benefit into full play. The system development goes through following stages: planning, general design, integration, debugging and test run. Every link is examined and consulted from many experts. The development aim of system is feasible. The development principle is correct. The general structure is reasonable.

ACKNOWLEDGEMENTS

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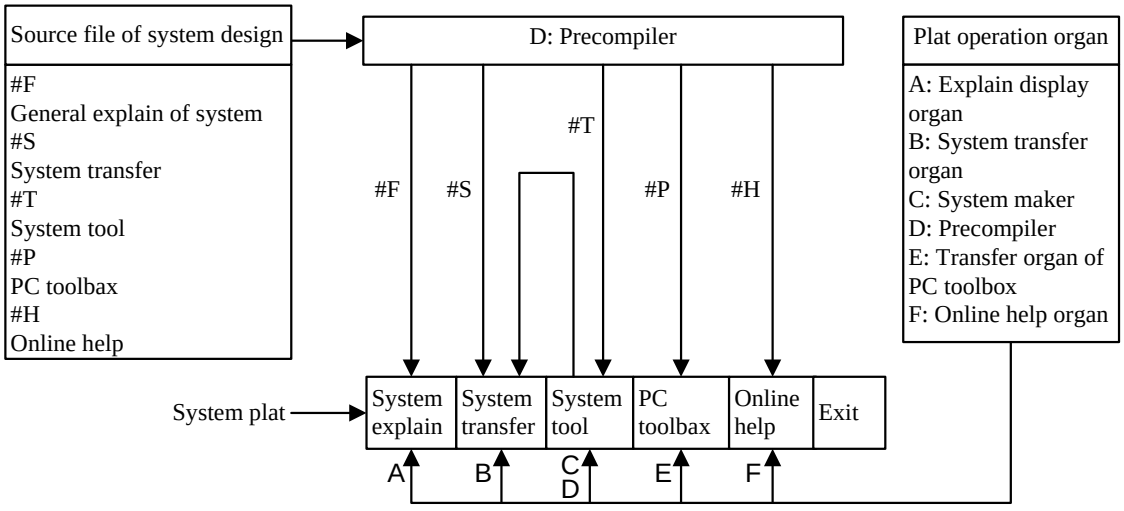

Figure 4. Dynamic regenerative flat of system.

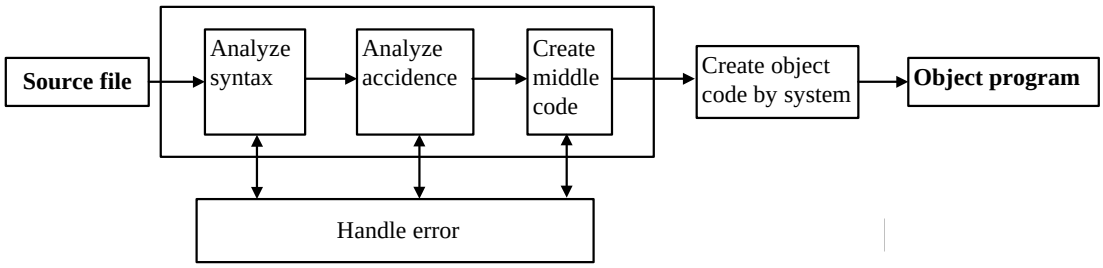

Figure 5. Flow chart of compiling program.

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