The Design and Implementation of Dam Safety Monitoring Routing Algorithm Based on Wireless Data Transmission Technology

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Abstract — In this paper, the author studies on the design and implementation of dam safety monitoring routing algorithm based on wireless data transmission technology. A mixed repository which based on rule and ANN was studied. The method of reasoning, controlling and repository mange was discussed. Some advice for improving the ES reliability was advanced. As an example, the dam monitoring system was particularly discussed. A practical online/offline system for judging dam safety was researched and introduced.

Keywords - Design and implementation; Dam safety monitoring; Routing algorithm.

I. INTRODUCTION

The reliability of dam safety monitoring system is very important for erecting dam safety monitoring and controlling models, feed backing and controlling the dam safe state and judging of its working character synthetically. The main parts of dam safety monitoring system and some hot points about it were discussed with new theories and methods. Some new methods about estimating or improving the reliability of monitoring system were advanced.

There are about 86000 dams in China, 40% of which are sick and dangerous. The average leak rate is 2.784×10^{-4} from 1982 to 2000 in China, which is higher than the world average level (1.92×10^{-4}). So the traditional management mode has much time to improve; Along with the more people and the rapid developments downstream, what we need to care is not just the engineering safety, but also the public safety, so the risk management mode is necessary to China. Dam’s paper [1] researched the idea, the main techniques and the system of dam safety risk management which has great theory value and practical significance. The paper researched the system info of dam safety risk management, which contains the objects, the frame and the process, the methods and the model of life cycle risk management.

John’s [2] article decked study the mode of dam safety risk management in China, and came up with the total strategy and six suggestions to realize the mode. Based on the modern mode, it paid close attention to the processes of public safety down steam which includes the dam break flood analysis, the risk evaluation and the emergency evacuation. Considering the reservoir regulation function, erosion model was established to simulate the burst development process. Based on double scanning coupling method, a one-dimensional and two-dimensional coupling mathematics model was established to simulate the flood evolution process. Own system and particle technique are used to display the burst development process visually, and GIS is used to display the floods evolution process visually. Based on support vector machine (SVM) theory, considering 13 factors which affect loss of life, the improvement SVM model was established which was superior to the SVM model considering five factors and improved method of Graham. The dam risk standard, probability analysis, calculation of economic loss and social environment evaluation method were summarized in Zhao’s paper [3].

Second development technology was used to achieve the whole process of loss estimation in GIS system. Considering mountain flood characteristics, the method for selecting mountain flood shelter was put forward; Based on risk concept, residents evacuated sequence were evaluated; Considering whether directly connected with the point of origin, the route weight calculation method were proposed , and a mountainous area flood evacuation speed model was established; Considering residents evacuated sequence and shelter capacity, Dijkstra algorithm was improved, and the mountain flood emergency evacuation process was implemented and visualized based on GIS. The article analyzed, evaluated and treated the risk of soil core wall rock fill dam in quarter gradually collapse situation of the largest possible flooding. The loss of life can tolerate, economic loss is intolerable, social and environmental impacts can tolerate. It is need 1.14 hours for residents to evacuate to shelters. With a high-level programming language Delphi as a development tool, combining database management, geography information system, image processing, virtual reality, expert system and second development techniques, with introduction of advanced algorithms, the article realized the whole dam safety risk management visually systemically and digitally, which can provide a convenient, quick and efficient work and information exchange platform for related personnel, and suggest a new management mode for future.
II. THE FRAMEWORK OF DAM SAFETY MONITORING SYSTEM

Analysis theory and Methods for dam safety monitoring data, playing a major role in guaranteeing the dam safety, have been made considerable progress. However, there are still many problems and deficiencies in the data analysis. In Fan's [4] paper, research theory and analytical methods in the other fields are introduced and applied to the analysis of dam monitoring data such as the analysis of deformation monitoring data of concrete dam. The main purpose of study in this paper is to solve some problems and to correct some deficiencies of the analysis of dam monitoring data in the existing, for improving the monitoring data analysis precision of the model and achieving more effective and rational assessment of the state of the dam, in order to meet the needs of practical engineering applications.

In order to avoid possible spurious regression in regression model, in Bo's [5] paper, integration theorem is used to test whether a set of data of dam monitoring variables are stationary time series. The integrated series can be represented by error correction models to describe long run equilibrium and short run equilibrium among them, in order to improve the model fitness and predictions capacity. In order to evaluate the security state and the structural change trend of the dam, a kind of safety monitoring index is introduced, according to the distance to the unit circle of roots which are calculated from the characteristic polynomial of stationary auto regression system reflects the properties of stationary system.

As the higher-order statistics of time series which contains more information than a second-order statistics can better reflect the properties of system, Luo’s [6] paper describes the modern spectral estimation and spectrum estimation theory, principles and methods, the analysis result of a damage experiment of two reinforced concrete beams indicates spectrum can effectively reflect the change of structure status, and try for the analysis of dam monitoring data to assess the structural state of the dam. Considering the importance of time-effect displacement in deformation monitoring data analysis, suppose that the dam system is a time invariable system, the time-effect variable is selected as state variable to describe the structural properties of dam body. The parameters of state space model are estimated by using the EM algorithm. The example analysis result shows that the state space model has good precision of fitness and forecasting, and time-effect variable can effectively extract from the monitoring data of dam used to evaluate the dam status. Multi-collinearity of independent variables and random noise tend to result in over fitting of the regression model, making the model fitting accuracy is high, but the predictive ability is poor, so that the regression model cannot be effectively applied to forecast for dam safety monitoring.

In Jeon’s [7] paper, the group method of data handling (GMDH) of self-organizing data mining is used to make model in order to enhance the robustness of the model and to improve the model's predictive ability, example analysis result validates the effectiveness of the method.

The Ertan Arch Dam safety monitoring system possesses relatively high automatized level, which observes the principle mainly for safety monitoring, of rational arrangement for instrument quantity, multiple use to an instrument, varied supervision methods on key places, as well as mutual supervision and checking of monitoring contents. The dam safety monitoring is emphasized on deformation, percolation pressure of seepage flow and temperature and in the same time combined with project features the special item observations are conducted. The Ertan arch dam safety monitoring system arranges in total 28 kinds of instrumentation equipment, the sum total of measure points and instruments amounts to 1,176 and the main monitoring instruments for arch dam are arranged schematically.

The deformation monitoring includes: horizontal displacement of dam and its foundation, dam top chord length, downstream resistance body span in valley, vertical displacement of dam and its foundation, dam and its foundation inclination, horizontal angle of dam, dam and its foundation joints, as well as dam stress and strain etc.

The seepage flow and percolation pressure monitoring includes: dam foundation percolation pressure, dam and resistance body seepage flow, seepage flow rounding dam, water quality analysis etc. The temperature monitoring includes: dam temperature, dam surface temperature, dam foundation temperature, atmospheric temperature, reservoir water temperature, etc. The special observation includes: weak rock zone deflection of dam foundation, pier structure strain, reinforcement bar stress of peer and opening, dam strong jarring, dam and spillway tunnel hydraulics, gate dynamics and diversion tunnel bulkhead, etc. The first time of monitoring analysis and anti-analysis began from first storage and ended to Oct.

The end of flood season is in same year. During first storage of the dam 1175-1190m elevation grout district had not grouted yet for enclosing arch and 1190-1205m elevation grout district not completed also. In this period, the dam also suffered an exceptionally serious flood in history with discharge into reservoir 10-200m³/s exceeding dam grouted elevation for 7.11m. The analysis result provided sound monitoring and control reference function for Ertan plant safety storage and tiding over flood season first.

The second time of monitoring analysis and back analysis was carried out on Aug. 1999 to Feb. 2000 and the analysis data were onto Oct. 1999. In that time the last transverse joint of dam had been grouted in Mar. 19’h 1999, which marked the dam completing to the end. In this stage the various monitoring data quantity was more added.
and went through high water level operation trial more than one year. The analysis result provided the necessary technical proof basis for Ertan project completing safety check and appraisal for acceptance. The third time of monitoring analysis and back analysis was carried out from Feb 2001 to May 2002 and analysis data were onto Oct 2001. In this stage the dam had gone through 3 years operation, the reservoir water level accomplished four times of rising and lowering for loading and off-loading cycle, the time effect of foundation deformation and the residual deformation of loading and off-loading process had fully reflected, the more stable seepage flow field and temperature field had. The target of monitoring analysis and back analysis is to conduct back analysis simulation by numerical analysis method for the practical mechanical actions in dam operation process. In accordance with back analysis simulation result, the reliable basis is provided for judging structure operation safety and the safety monitoring and control conducted for whole operation process. The estimation analysis under design condition considers permanent operation state and the probably appearing most unfavorable state as control condition. The monitoring analysis and back analysis is a dynamic random analysis. There is non-determinacy inevitably existing in variables of random process.

III. THE WIRELESS DATA TRANSMISSION TECHNOLOGY

Only considering these non-deterministic factors in analysis and back analysis process to fully reflect the dam loading reaction in any time, this random process can be really reflected and the structure working state simulation realized; that is also the essential difference of determine value design. How use their comparison is a key technical problem necessary to be solved for judging dam safety behavior.

The arch dam temperature load is the main basically load only less important than water pressure, therefore, in arch dam monitoring analysis to determine temperature field rationality and accuracy is especially important, Through estimate analysis of boundaries such as morphemic temperature, reservoir water temperature and foundation temperature the reliable dam temperature field change and temperature load may be obtained to favor real reflection of dam force-bearing behavior.

In design stage the reservoir water temperature field and dam temperature field are ascertained with norms mainly according to statistic data of at morphemic temperature, ground temperature and natural river water temperature to determine average temperature and equivalent linear temperature difference in dam profile. Due to very complex reservoir water temperature affecting factors the predicted long-term average water temperature and annual variation estimated with norm recommended statistical experience formula and heat budget method frequently fall far short of practice for high dam and large reservoir, therefore, the reservoir water temperature, dam temperature and time-space variation estimated by using observation data of in dam temperature measuring instrumentation are more coincide with practice and reliable.

120 joint meters buried in Ertan arch dam with wide distribution scope, long measure value series, better regularity are main basis of regression statistics, but if only three joint meters are installed in one profile, it is difficult to seek profile average temperature and equivalent linear temperature difference. In statistical analysis by means of 7 profiles temperature measure values combined with the mo-meters and strain-meters in 11#, 12# and 33# dam blocks, the temperature distribution law along profiles is obtained by regression statistics and characterized by cubic curves, then the cubic curves are generalized as three straight line sections and according to principle of area equal to linear moment the profile average temperature and equivalent linear temperature difference expressed for joint meter existing place. Simultaneously the comparison proof is conducted by using finite element estimate result that shows the statistic model completely satisfying accuracy requirement.

In sensor network, each node determines its own position in the space of a space coordinate system called node localization process. Due to limited energy wireless sensor networks, large number, low cost, Each sensor node is equipped with a GPS receiver, or prior to the specified location information for each node, where that are unrealistic. Therefore, we can only make a small part of the node assembly positioning device, or prior to the node at the specified location coordinates. These few nodes through some means to know their location called beacon nodes or anchor nodes. Due to restrictions of cost and energy consumption, the anchor node in the network node a small proportion. In the sensor network, in addition to the known location information beacon nodes, the nodes that need some kind of algorithm to calculate the location information, call these nodes is unknown node.

Beacon nodes is a small proportion in a network node. It can get its exact location by means of portable GPS positioning equipment, a reference node location is unknown. Beacon node broadcasts its own location information to unknown node, to determine the location of unknown nodes provide information.

Wireless sensor network node localization problem can be expressed as: Rely on the limited position known beacon node to determine the location of other unknown nodes in layout area, and builds a certain spatial relationships between the sensor nodes. Although for different wireless location systems, methods and techniques to achieve location are different. From the principle of speaking, wireless positioning system generally consists of the following three steps:

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The first step, measure one or several parameters (amplitude, frequency, phase, propagation time) of radio signals. According to the radio wave propagation characteristics, the electrical parameter measurement is converted to a distance, the distance difference and angle of arrival, etc. used to represent the positional relationship.

The second step, use a variety of algorithms or techniques to achieve the position estimate;

The third step, the optimization of the estimated value.

The same applies for wireless sensor networks localization of these three steps.

IV THE WIRELESS DATA TRANSMISSION TECHNOLOGY

Though the measured stress, the estimate result is affected by many factors such as instrument burying installation, datum value selection, concrete non-stress, creep age estimate, concrete elastic modulus value selection and measured value stability reliability etc. However, the comparison analysis of measured stress result and whole process simulation result of arch dam has important significance for evaluating arch dam working stress state.

The arch dam measured stress estimate indicates that: first, before water storage due to dam hanging inverted and weight, the dam heel 973.5m elevation compression stress is maximum 8MPa, after water storage due to water load action the decreased compression stress at dam heel 4MPa, the dam toe compression stress increased to some 3.2 MPa, but the dam heel position is still in compression state; second, in initial period operation at age the crown beam position has not appeared the tensile stress and the maximum compression stress is about 7 MPa. The typical stress variation process of crown beam position 1,123.5 elevation is shown as Fig. 2 and Fig. 3.

V. CONCLUSIONS

In this paper, the author studies on the design and implementation of dam safety monitoring routing algorithm based on wireless data transmission technology. Considering the reservoir regulation function, erosion model was established to simulate the burst development process. Based on double scanning coupling method, a one-dimensional and two-dimensional coupling mathematics model was established to simulate the flood evolution process. Own system and particle technique are used to display the burst development process visually, and GIS is
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