

Evaluation Index System of Hydrogeological Investigation Software

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Abstract: Currently, many types of software including those used for environmental geological survey, investigation of groundwater resources, groundwater pollution investigation and urban geological environment investigation have been developed by hydrogeological investigation industries. In order to rationally and scientifically evaluate the quality of the software and guide software development, a study on hydrogeological survey software evaluation was conducted using an index system. A weighting method was used to establish a three-stage quality indicator system model including technical modules, test items and test sub-items. The evaluation index system model was divided into seven technical modules, 26 test items and 71 test sub-items, and scoring methods and scoring criteria of various evaluation indicators were established. The groundwater resources survey software was evaluated and the evaluation index system model was tested. Hydrogeological survey software evaluation is still in its infancy, so the hydrogeological survey software evaluation index system is the primary probe for hydrogeological survey software evaluation standards and norms.

Keywords: Groundwater, Software testing, Software quality assessment

Introduction

The development of software testing and evaluation in China is accompanied by the development of the GIS industry. The national key science and technology program during the “NinthFive-Year Period” sponsored by the Ministry of Science and Technology from 1996 promoted study and product development of the GIS technology in China (Y.Fang et al., 2003). In March of 1996, the first domestic GIS software evaluation was held so as to make clear the study and development status of GIS software, which was the earliest software evaluation in China (Y.Fang et al., 2003). Later on, software testing in a lot of industries was carried out, further promoting and developing software. Foreign software testing started earlier, developed

more rapidly and was relatively mature. The software capability maturity models CMM and CMMI developed by the Institute of Software Engineering of United States Carnegie Mellon University have actually become the international standard for software process improvement (F.Wang et al., 2011).

Software evaluation is mainly the operation process of some system or software accomplished by manual or automatic means. Its fundamental purpose is to test the software or system to see if it can meet the set requirements or can achieve the desired results (J.Xu, 2003), it is the main means to guarantee software quality. In 2010, the China Geological Survey organized experts to complete the compilation of “geological exploration technology software evaluation in 2010”. The evaluation results involve 8 geological prospecting softwares, covering geophysics, geochemistry and hydro-

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geology. The hydrogeological investigation software testing and evaluation indicator system was established in the course of geological prospecting technology of software evaluation work.

Hydrogeological investigation software is an important part of informatization of the hydrogeology, engineering geology and environmental geology, and the professional application tool for the hydrogeological investigation database construction and hydrogeological investigation and assessment. With the progress of hydrogeological investigation, the undertakers of hydrogeological, engineering geological and environmental geological projects have already developed or are developing informatization application software including environmental geological investigation, groundwater resource investigation, groundwater pollution investigation and urban geological investigation. In order to reasonably evaluate the quality and applicability of hydrogeological investigation software, to regulate the hydrogeological investigation software development, to promote the gradual improvement of software development and application in the aspects of hydrogeological investigation and to guide the healthy and orderly development software and application, the hydrogeological investigation software evaluation has been conducted. The software testing involves a wide range of aspects and is difficult to implement, so the establishment of a software evaluation indicator system is the theoretical basis for accurate software quality evaluation. The hydrogeological investigation software evaluation indicator system has established the three-level evaluation indicator system model containing a technical module, testing item and testing sub-item with the weighting method, given weighting parameters and scoring criteria of each level evaluation indicators and put forward framework for the implementation of hydrogeological investigation software evaluation.

Hydrogeological investigation software evaluation indicator system

Hydrogeological investigation software evaluation principle

The aim of software evaluation is to make an objective, scientific and reasonable assessment of the software based on the software testing, which adheres to the principle of testing justice, openness, operability and verifiability.

Hydrogeological investigation software evaluation standard

The hydrogeological investigation software evaluation consists of three parts: professional evaluation, software evaluation and comprehensive assessment, among which the main evaluation technical indicators belong to professional evaluation content. Each function module has 70 scores, the software maturity assessment accounts for 30 scores. As for the professional evaluation, the total score system and average score system will be adopted, the former of which is used for the assessment of completeness of the software function, while the latter is used for the assessment of software quality with the centesimal system.

The point-scoring of the total score system:

Final score = total score of various technique modules + score of software maturity assessment;

The point-scoring of average score system:

Final score = total score of various modules / number of modules + score of software maturity assessment.

Content of hydrogeological investigation software evaluation indicator system

The hydrogeological investigation software evaluation mainly includes the software function evaluation and software maturity evaluation, the evaluation indicator system is divided into three levels, the first level is the technical module, mainly including main function module evaluation and software maturity evaluation of hydrogeological investigation software. The second level is the testing item, which is a function item after

the functional division of the module. The third level is the testing sub-item, which is division of function items and is the minimum evaluation unit of evaluation indicators.

The hydrogeological investigation software evaluation includes seven modules: data management, data query, data analysis and processing, hydrogeological investigation and assessment, thematic mapping, data output and software maturity evaluation. The former six of which are for the evaluation of the software function. The main content and the scoring of each module are as

follows:

Data management module

The testing items and subitems will be classified based on the main functions such as data input, data backup and recovery, data summarization, data browsing, geographic base map allocation and authority management of the hydrogeological investigation software. The concrete indicators are shown in Table1.

Table1 Main indicators and standard score of data management technique module

Testing item	Testing sub-item	Weight value
Data input	Groundwater resources investigation form input	5
	Database software upgrade	5
Data backup and recovery	Data backup	5
	Data recovery	5
Data summarization	Multi-edition data source aggregation	5
	Data consistency review	5
Data input	Multidata format import	5
	Data consistency review	5
Data browsing	Data sequencing	2
	Data search	2
	Graph browsing	2
	Graph data and attribute data linkage browsing	4
Allocation geographic base map	Allocation geographic base map	5
	Allocation base map parameter	5
Authority management	User management	4
	Role management	4
	Operation log	2

Table2 Main indicators and standard scores of data query technique module

Testing item	Testing sub-item	Weight value
Attribute query	Data word-paragraph based fuzzy query	10
	Multi-word or paragraph based combined query	10
Space query	Single click query	10
	Rectangle query	10
	Arbitrary polygon query	10
	Buffer zone query	10
	Query in accordance with coordinate	10

Data query module

The testing items and testing sub-items have been classified based on output query object and query mode with the total score 70, the details are shown in Table2.

Data analysis and processing module

The indicators will be classified based on the data processing mode and analysis tool. The data statistics is an important tool for data analysis, so the weight value in this testing item is relatively higher. As for the sub-item of data statistics, the adjustment can be made according to the given weight value of data statistics sub-item. The concrete indicators are shown in Table3.

Table3 Main indicators and standard scores of data analysis and processing technique module

Testing item	Testing sub-item	Weight value
Data statistics	Groundwater table measurement and curve drawing	15
	Groundwater temperature measurement	15
	Groundwater exploitation statistics	15
	Meteorological data statistics	15
Groundwater analysis	Determining groundwater chemical type of sampling site	5
	Drawing Piper map of sampling site	5

Table4 Main indicators and standard scores of hydrogeological investigation and assessment module

Testing item	Testing sub-item	Weight value
Groundwater quality assessment	Groundwater quality data selection	5
	Evaluation indicator selection and reference value set up	5
	Choosing different assessment methods to make water quality assessment (GB/T14848-2007)	10
Groundwater pollution assessment	Groundwater pollution assessment data selection	5
	Groundwater pollution assessment indicator selection and reference value set up	5
	Choosing different methods to make groundwater pollution assessment	10
Groundwater resource quantity calculation	Choosing hydrogeological unit and water table data	5
	Setting up calculation parameters	5
	Choosing different assessment method to calculate groundwater resource quantity	10
Garbage site suitability assessment	Choosing single factor indicator map layer	2
	Setting up calculation parameters	3
	Conducting garbage site suitability assessment	5

Table5 Main indicators and standard scores of thematic mapping module

Testing item	Testing sub-item	Weight value
Creating distribution map of investigation site	Choosing data needed for distribution map	5
	Setting up subject classification	5
	Creating investigation site distribution map	10
Compilation of assessment achievement	Compilation of groundwater quality assessment map	15
	Compilation of groundwater pollution assessment map	15
	Compilation of groundwater resource quantity map	10
	Compilation of garbage site suitability assessment map	10

Table6 Main indicators and standard scores of data output module

Testing item	Testing sub-item	Weight value
Attribute data output	Attribute data export	20
	Report printing	15
Achievement output	Achievement map export	20
	Graph printing	15

Hydrogeological investigation and assessment module

The module is a characteristic module in the hydrogeological investigation and assessment software. The researchers probably need to use various assessment methods and assessment indicators to make the analysis and assessment considering the study area and study object. The four commonly-used hydrogeological investigation and assessment functions have been provided in the indicator system, the adjustment of weight value can be made with the reference of given assessment standard if the supplement is needed. The concrete assessment indicators are shown in Table4.

Thematic mapping module

This module is an important display tool for hydrogeological investigation achievements,

mainly including the compilation of various investigation site distribution maps and hydrogeological investigation and assessment maps. The assessment achievement map can directly reflect professional analysis results and also is widely used, so the weight value of the assessment achievement map is relatively higher. The concrete indicators are shown in Table5.

Data output module

The data output model is classified based on the output content and output mode. The attribute data export and achievement map export are important modes of data exchange and reutilization, so the weight value is relatively higher. The concrete indicators are shown in Table6.

Software maturity assessment module

The total score for software maturity is 30. The

classification has been made for testing item and sub-item in the light of system friendliness, completeness, reliability, operation efficiency, technique advancement and application effect, of which the completeness and actual application

effect of the software function is an important representation of the software maturity, therefore, its weight values are relatively higher, the concrete indicators are shown in Table7.

Table7 Main indicators and standard score of software maturity assessment module

Testing item	Testing sub-item	Weight value
System friendliness	Document description completeness	0.5
	Document description correctness	0.5
	Installation and un-installation	0.5
	Interface friendliness	0.5
	On-line help	0.5
System reliability	Error detection capability and error tolerant capability	1
	System operation function consistency	1
System operation efficiency	System operation speed	2
Material integrity	Introduction to method and principle related to software	1
	Manual for software operation system	1
	Introduction to software system application	1
System integrity	System integrity	8
Technique advancement	Technique Development	2
	Algorithm advancement	2
Actual application effect assessment	Application industry, realm and extent	2
	Actual effect, scale and quantity of processing data	2
	Software number of promotion or sale	2
	User's assessment	2

Testing achievement evaluation standard

The total score evaluation system is used for the assessment of software system completeness, the higher the score is, the better the system completeness will be.

Based on the total scores of evaluation object, the results will be assessed with the following standard:

Total score $\geq$ 85, excellent;
85>total score $\geq$ 75, good;
75>total score $\geq$ 60, passed;
Total score<60, not passed.

The evaluation expert will determine the overall analysis based on the scores of each software item and sub-item as well as the total scores and average values, and finally, will make the comprehensive assessment and put forward the suggestion for application and popularization.

Hydrogeological investigation software evaluation indicator system application

Based on the hydrogeological investigation software evaluation system, the software evaluation of groundwater resource investigation information system software has been conducted. The software of groundwater resources investigation information system is developed under organization of the China Geological Survey and in the light of assessment of technical requirements of groundwater resources investigation and environmental geological problems, which is used for the database construction, data analysis and evaluation of groundwater resources investigation and so far has been well promoted and applied in the new round of groundwater resources investigation.

The evaluation expert group worked out the evaluation table covering the main features of groundwater resources investigation information system software. They assigned scores for 26 testing items and 71 testing sub-items through the operation of software and comprehensive analysis. Among them, the total score of six software function modules is 303.5 with the average score of 50.58. The software maturity score is 25.3 with the average score of 76.88. The final total score is 329.8. Based on the software evaluation results, the evaluation group held that the system possesses the complete hydrogeological software function modules, in which the data management, data query, data analysis and processing modules have very good function, the algorithm of hydrogeological evaluation function is advanced, convenient to operate and in accordance with the professional norms and requirements. It is also featured that the thematic mapping function is rich in content, diversified in data output module mode and the file format is more complete, however, some evaluation items need to be perfected and added. The software has promotion and application conditions in the field of groundwater resources investigation and assessment.

Discussion and analysis

At present, the hydrogeological survey has been more and more focused by the state and concerned hydrogeologists. With the development of hydrogeological survey, the development of hydrogeological survey software has also been greatly promoted. However, the hydrogeology survey software testing is still in the initial stage, and software testing standards and specifications are not prevalent. The hydrogeology survey software testing index system is the preliminary study for the hydrogeological investigation software testing system, of which the main content and weight value in the testing index classification and testing index maybe possess shortcomings, so it is hoped that the experts can make supplements and adjustments appropriately, in accordance with software application requirements in the course of testing.

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