A Web-Based Examination and Evaluation System for Computer Education

Liang Zhang[1 2], Yue-ting Zhuang[1], Zhen-ming Yuan[2], Guo-hua Zhan[2]

[1]*School of Computer Science and Technology, Zhejiang University, Hangzhou, China, 310027*
[2]*School of Information Engineering, Hangzhou Normal College, Hangzhou, China, 310012*
E-mail: zhl@hztc.edu.cn, yzhuang@cs.zju.edu.cn, zmyuan@cs.zju.edu.cn, ghzhan@hztc.edu.cn

Abstract

A web-based operational skills examination and evaluation system is designed and implemented for computer courses. It consists of four systems, including preparation, examination, monitor and auto-grading subsystem. Various techniques involving DCOM, mark-method and fuzzy-match are adopted in this system, and a universal approach is generalized to enable auto-grading system suitable for different operated results. This system has been successfully applied in operational skills' evaluation and training, such as programming, editing documents, using Microsoft Windows.

Key words: *web-based examination, auto-grading system, DCOM, mark-method, Fuzzy-match*

1. Introduction

With the development of computer technology and application, training of computer operational skills boom in China. From students to officials, everyone must pass the first-course, i.e., basic operation skills of applying computer. Therefore, it is necessary to build a Web-Based examination and evaluation system for thousands of people self-evaluating and practicing.

1.1. Testing systems overview

Traditional testing methods are letters, papers and orals. These methods are not adapted to current computer education requirements. While automated testing systems give chances to providing instant feedback, thus enabling a higher degree of interaction with the user. Several Web-Based Training (WBT) and evaluation systems have been designed, such as AsseSQL [1], QuizGuide [2], ASSYST [3], PILOT [4], and QUIZIT [5]. The QUIZIT system has been developed to support adaptive and standard testing, along with automatic grading, record keeping, and test administration using the WWW as a delivery vehicle. In most of them, the widely used questions are correspondence to objective answers, which could be easily judged and evaluated online by matching [6]. Their typical questions include yes/no questions, multiple-choice/single-answer questions, multiple-choice/multiple-answer questions, and fill-in questions. Moreover, they mainly consider programming courses, and such types of systems are not adapted to operational skills testing which emphasize the operated results. For example, they are not support testing the operated results in the client machine, such as the setup of printer in Windows and the document format detail of Word.

We start by presenting some principles of our system in Section 1. Then we introduce system architecture in Section 2. Web-Based examination and Auto-Grading systems are described in Section 3 and Section 4 respectively. Section 5 concludes the paper.

1.2. Principles of our WBT system

For it is difference between skill-purpose testing system and theory-purpose testing system, we propose that our system should satisfy the requirements as following [7]:

1) Training practice skills

Training the practice skills is the essential goal of basic computer skills education, so our system should support not only the objective questions, but also the operation questions, such as programming, editing Microsoft Office documents, operating Microsoft Windows, and taking advantage of internet.

2) Mastering flexible techniques

The basic computer operating skills have distinct character that one can use different methods to accomplish the same task. Therefore, the teaching should not limit the students to use only one technique. In other words, the system should base on the actual software environment at the client machine to support the learners using flexible techniques and different operations, not as the simulation systems.

3) Providing heuristic teaching and learning

Our system organizes a large hierarchical question bank and integrates the Windows Help to help the teachers and students carry out multi-level teaching and self-study.

4) Providing mature and easy testing system

The online testing system should be mature to provide easy using, identical user interface, reliability, and security. It is also urgent to develop an automatic grading system, which can grade the operational questions' answers rather than the objective ones'.

2. System architecture

We have developed a novel online testing system based on Browser/Server framework by state-of-art computer technologies. It is a distributed collaborative system, which is based on DCOM technology. As showing in the figure 1, it has four major components: the examination preparation system, the examination system, the monitor system and the auto-grading system.
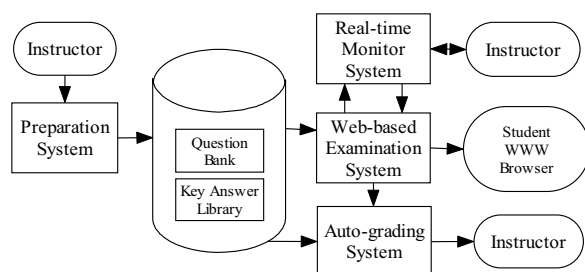

Fig 1. The system architecture

1) The preparation system

The preparation system is used to manage question storage, assign test ID and schedule the test. The question storage is composed of the questions, a set of possible answers, the question types and other metadata, which is indexed by several factors, such as topics keywords, degree of complexity and difficulty. The bank is open to teachers, allowing them to add questions and key answers by template.

2) The examination system

Web-Based online examination system is designed mainly for students, which has the key features including client side control, time control, security control and auto-installation. Benefited from DCOM technology, the system can install and update itself conveniently, better than C/S framework. Because the system is established on Web, the systematic security faces the severe challenge. We guarantee the security by cryptography, real-time monitoring system and data transmission encryption. The cryptography is used to validate student identification before testing.

3) The real-time monitor system

The real-time monitor system requires students not to leave the computer during test by face tracking technology. Data transmission encrypt system transmits examination question and result by secret gentle form through the network to the server. Examination monitor system is also the manager of the examination system, by which we can monitor the test processing, carry through test ID statistic and collect the answers, etc.

4) The auto-grading system

The auto-grading system is designed by means of the fuzzy-match algorithm and the macro programming technology. It is seasoned with variable question types.

In the following of this paper, we will introduce the examination system and the auto-grading system in detail.

3. Web-Based examination system

3.1. Functions of the examination system

As a universal examination system for the education of the basic computer operation, Web based Online Examination System (namely WOES) implements following functions according to the WBT system's principles introduced in Section 1:

Function 1: Using the question bank prepared by the Preparation system, the instructor can choose both scope and difficult degree of questions.

Function 2: The examination system using WWW browser as a unified interface to students. The interface of WWW browser has a uniform and consistent operating interface. Almost everyone is able to use it skillfully, which can eliminate the difference brought by variance of examine systems and guarantee the test plays fair.

Function 3: The examination system can implement various manners of education evaluation, including objective questions and operational questions. For example, this system may ask the student to install an appointed printer's driver, or gives the student an existed Excel workbook file and asks him to figure out the average in the appointed sheet table.

Function 4: All the students' operations are manipulated in actual software environment at the client computer, which means that the web based examination system need to transfer the question files from the question bank database to client computer, and have ability to control the client software. For example, the client of the test embedded in WWW browser can access the client's file system, build the test environment, sense the condition of the running

program, and transfer the answers to test server.

Function 5: As a Web-Based examination system, it is important to ensure its safety and the reliability. The security of Web-Based examination system is an important and difficulty problem up to the present, especially the invigilation. Our system has accounted for the security of networks, the security of identity, and the security of monitoring, and tried many advanced methods to solve the security problem, such as the digital certification and the Webcam-Based face tracking techniques.

3.2. The Multilayer framework of the examination System

Web based Online Examination System (WOES) is a multi-layer system which is composed of Web Server, Database Server, WOES middleware Server, WOES client module and Browser, such as Internet Explorer. In this system, we use Internet Information Server 5.0(IIS) as the Web Server, and the Database Server is Microsoft SQL Server 2000.

The kernel of WOES is the WOES middleware Server and the WOES client module, which is designed according with Microsoft DCOM standard. DCOM is the binary COM object's extension jointing LAN, WAN and Internet, which can instance and bind object over different network. It is an advanced network protocol used to cooperate with COM based components of two processes in different locations. WOES middleware Server is a server-side component, providing communication interfaces between WOES clients and Web Server or Database Server. WOES client is a client-side component, which is called by the Browser to control the client computer and submit to or receive information from WOES Server. This technology guarantees the feasibility and the extension of the test system.
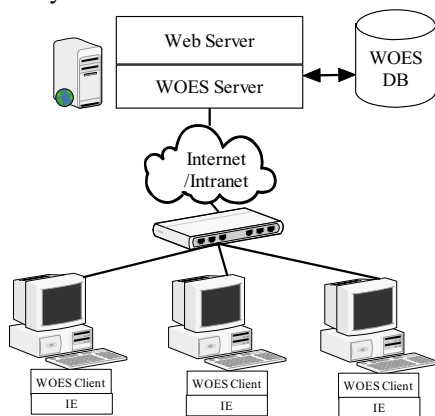

Fig 2. Multilayer WOES

3.3. Client control of the examination system

According to the version of the client's ActiveX, the WOES client can be downloaded or updated automatically from WOES middleware Server in Internet. They also can move from one client to the other and communicate with WOES Server. The clients constitute an Agent society communicating with KQML language, which is a centralized Agent system controlled by only the WOES Server. Benefiting from it, the instructor can update the system or the question storage or student storage only in Server, needless to update client system while the Client/Server must to do.

The inherence of WWW browser and HTML limits the client of the Web-Based examination system to access the local file system. We stride over this obstacle by using the digital signature technique. After signed by the digital certification, the WOES's clients communicate with the WOES's server, download the question files, control the client's software environment, and finally upload the students' answers to the server.
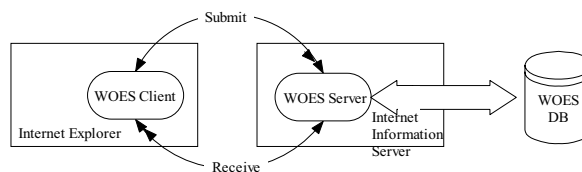

Fig 3. Communication of client and server

3.4. The security of the examination system

The Web-Based examination system can be used on Internet or WAN in a city, so it faces the great security problem, including the transmission security, the password security, the certification and the invigilation security, etc. We have tried many methods to solving these problems.

1) The transmission security: To avoid the data being changed on the Internet, all the questions, materials and answers are transmitted in bits stream format after encoded. The encoding process adopts asymmetric encryption technique. In each test, the test server produces a pair of public key and private key, issues the public key to the test clients. Then the clients produce a random symmetric encryption key, which are used to encrypt the session between the client and the server. This encoding technique can insure not only the security in transmit process, but also against the inside job.

2) The password security: To avoid the fraud people access the test system from the illegal client on the

Internet, we using a password security technique combining with the authentication of the hardware. When one student starts his test, the system will assign him a password produced according to his client's hardware and operation system environment, which can prevent cribber to login from other client imitating this student.

3) The certification security: The newest effort to prevent the distant student from leaving the client or transposition is making use of the Webcam-Based face detection and recognition technology. Before the examination starting, the student is asked to sit in front of the computer camera, which can monitor the whole scene. Then the test system recognizes the student's face and tracking his face automatically. Our face detection and tracking algorithm is based on the colored space transforming, the complexion modeling, and the face orient algorithms. As soon as the validation performs, the student must stay in front of the camera until the examine finish.

4. Auto-grading system

Auto-grading system can automatically grade students' answers, which are collected by the examination system. It helps teachers to obtain the score with ease.

4.1. Mechanism of the auto-grading system

We proposed a universal and versatile grading system, which is not necessary to modify grading program code as questions and key answers changed.
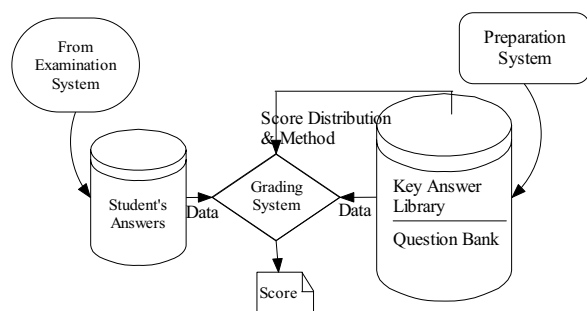

Fig 4. Grading process and data flow

Auto-grading system puts out score according to score distribution table by means of comparing student's answers to the correspondence key answers. As showing in the figure 4, in the process of grading, the score and method inputted to grading system are determined by method-name and score distribution, which are recorded in key answer library.

The inputted score relate to the weight of the answer, and the process method may be different according the question types and content of the answer. For example, objective questions, such as choices questions, yes/no questions, and fill-in questions, can be graded effectively by accurate matching or fuzzy matching. However, it is difficult to grade these answers by simple matching techniques, such as Microsoft Office documents, Windows and Internet operational results. To grade the MS-Office documents, the alternative solution is: (1) reading the answer file directly and comparing its binary data to the key answer. Nevertheless, it is not feasible for us, because the format of Microsoft Office file is complexity. The other one is: (2) taking advantage of MS-Office OLE object. This method is convenience and efficiency, while another problem coming forth, that is, the program code of the grading module is closely relative to the special questions, which results in large amount coding works when the questions are changed. In the following, we will discuss our universal implementation technology in detail.

4.2 Implementation techniques of auto-grading system

1) Representation of the key answers
Key answer is one of the source data for grading process, which built up in preparation system. Teachers build up key answers, including: (1) key answers content, (2) method-name, which points out method in grading process, (3) original materials, which are prepared for student's operation, (4) score distribution, and (5) marks, etc.

Key answers content present in different forms according to various types of question. For example, they are strings in choices questions, yes/no questions and fill-in questions, while they are documents in editing tasks, and files or directories in file-directory operating tasks. If one sets up key answers content only, there is not enough information for the grading module to put out score. As showing in the figure 4, another source data is method-name, which points out method in grading process. After setting method-name and score, the approach of the judging process is determined. By now, we can compare student's answers with the key answers. However, in the process of comparing two MS-office documents (student's answer and the key answer), we also meet the problem, that is, where is the absolute position that we should compare? So, marks must be made in preparing key

answers in order to point out positions for grading. As showing in figure 5, student's answers and the key answers may consider as two objects, and then the marked parts are their sub-objects. Comparing properties value of the sub-objects is the main work of grading system.
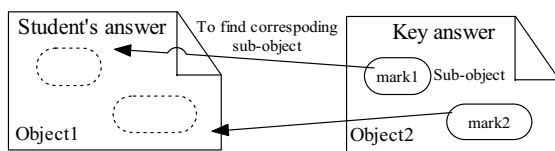

Fig 5. Representation of key answer

For example, in MS-Office document, all part of the document can be labeled as sub-objects by user-defined Macro in order to point out the location for the comparing work of grading system. In preparation system, we label sub-objects by "bookmark" and "tag" in MS-Word and Excel document respectively. After marking sub-object, one property name of the sub-object should be pointed out in order to imply comparing method for grading module, such as "Size", "Name" or "Color-Index" property of "Font" in Word-Document, "Value" or "Formula" property of "Cell" in Excel-Sheet. As mention above, Mark-method was used to key answers' representation for all types of operational tasks.

2) Sub-object locating and matching algorithm
Although we marked sub-object in the key answer, the correspondence sub-object is not labeled in the student's answer, as showing in the left of the figure 5. It is difficult for grading system to locate and analyze the proper position of student's answer, in which reflects student's real operating result. Now we introduce how to deal with the problem in MS-Office document.

First, grading system extract several characteristic property values of the marked sub-object in the key answer, such as Range.Text, TextFrame.Text. Then, grading system searches all the document of student's answer to find out possible sub-objects, which have similar property values. Then, grading system can locate the corresponding sub-object in student's document according to similarity. Finally, grading system extracts sub-objects' property values from key answer and student's answer respectively, and then analyze these two values to put out score.

In the course of locating and comparing, String fuzzy matching is used frequently. Here, we take advantage of dynamic-programming algorithm. By counting the maximum length of common sub-sequence in two original strings, we can get similarity

degree of two strings. In addition, if the normalized similarity degree is greater than the threshold value, we consider these two strings are identical. Then, we determine sub-object location in student's answer by counting start position of common sub-sequence in these two strings respectively.

5. Discuss and Conclusion

We have developed an overall solution of the examination system for the operational skills. It provides a feasible platform for the basic computer education in universities, civil servant training and nationwide examination for graduation qualification of high school students in Zhejiang Province, China. There are more than 2 Million of students and teachers have used this system. It saves teachers from laborious and tedious of grading works. Profiting from instant feedback, it greatly alleviates the conflict between students and teacher for the real time instruction in the time of training. Therefore, students have explored more tasks and accessed a larger variety of tasks than before.

Taking advantage of adaptive auto-grading system, teachers may not only add new questions and tasks in question bank, but also grade students' answers automatically.

6. References

[1] Julia Coleman Prior, "The Backwash Effect on SQL Skills Grading", The 9th Annual Conference on Innovation and Technology in Computer Science Education(2004), pp.32-36.
[2] Brusilovsky P., Sosnovsky, S., and Shcherbinina, O., "QuizGuide: Increasing the Educational Value of Individualized Self-Assessment Quizzes with Adaptive Navigation Support", Proceedings of World Conference on E-Learning(2004), pp. 1806-1813.
[3] Jackson D., Usher M., "Grading student programs using ASSYST", In Proceedings of the 28th SIGCSE Technical Symposium(1997), pp.335-339.
[4] Stina B., Michael T., Stephen G., Roberto T., "PILOT: An Interactive Tool for Learning and Grading", SIGCSEB: SIGCSE Bulletin, 2000.
[5] Tinoco L., Fox E. Barnette D., "Online evaluation in WWW-based courseware", In Proceedings of the 28th SIGCSE Technical Symposium(1997), pp. 194-198.
[6] Peter Brusilovsky, Philip Miller., "Web-based Testing for Distance Education", Proceedings of WebNet'99, World Conference of the WWW and Internet, pp.149-154
[7] RuiMin Shen, Yiyang Tang, Tongzhen Zhang, "The intelligent assessment system in Web-Based Distance Learning Education", FIE 2001.