Design and Implementation of On-Line Practice System Based on Software Testing

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Abstract—As an important branch of software testing, software automated testing has brought many conveniences to the B/S architecture of Web application software testing. At the same time, it has also put forward new requirements for talents in the field of software testing. It is necessary to understand the theoretical knowledge of software testing and to master the use of software testing tools. Therefore, colleges and universities must adopt a teaching model that combines theory with practice to train more excellent test talents. The online practice system adopts the B/S architecture mode, integrates Spring, SpringMVC, and MyBatis open-source frameworks for system development, realizes the function module of super administrator management background, and supports student users to practice theoretical exercises related to software testing online, and write Web-compliant Selenium test script for applying test questions. The system can refer to the Selenium test script according to the standard and compare the test script submitted by the student user. The Selenium tags, positioning methods, elements, and attribute values are regarded as important scoring objects, and finally, judge and make reasonable scoring feedback.

1. Introduction
In the early stage of the emergence of application software, most of the software projects presented some difficult problems in the development process, and the software engineers finally terminated the continuous development of these applications. The economic loss and resource waste caused by many research and development failures gradually make people realize the risks in the process of application software development. Many countries attach great importance to software testing and have developed many excellent software testing techniques and tools. At the same time, it promotes the continuous development and innovation of software testing. In recent years, software testing, as an emerging industry, has developed rapidly. Especially in the field of automated testing, China actively learns from foreign advanced experience to explore and has made certain research achievements in the research and development of testing tools. At present, domestic online practice platforms of this type are mainly nowcoder.com and mooctest.net. The former provides users with a large number of theoretical knowledge topics for practice, while the latter is a service platform for software testing and programming exercises. Users are required to obtain practice keys, download relevant plug-ins, and complete the exercises with practical programming tools. However, domestic research of software test automation is still in the stage of development, a lot of test automation tools are mostly products from abroad, so have been put forward for the test personnel's professional skills a bigger test, not only need testers with good software test theory but also to master the skills of using mainstream test tools. According to the software development process, this paper adopts the B/S architecture mode to design and implement the online
exercise system. It not only provides users with exercises related to the theoretical knowledge of software testing but also adds Selenium Web application automated test exercises to evaluate and give feedback to users on the Selenium automated test scripts submitted by users. Through online practice, the importance of software testing in software engineering is popularized to students, and students are guided to actively participate in the study of software automated testing, making new contributions to the field of software testing.

2. Online Practice System Design
The online exercise system is developed based on THE SSM framework. The system will be composed of the View layer, the Service layer, the Controller layer, and the DAO layer to form a standard MVC pattern. The Spring framework is responsible for managing and coordinating complex dependencies between objects; the SpringMVC framework handles and forwards requests from browser users, and the front end controls the rendering of participating views. MyBatis framework is used to transform program data between persistent state and instantaneous state, which is the bridge between user and database interaction.

Fig. 1. System structure hierarchy diagram

View layer: Mainly responsible for the display of data information on the front page. As it involves data information, it is inseparable from the Controller layer and works in coordination with each other.

Controller layer: Controls the core of the business module process, which needs to be assisted by a Service layer approach. After receiving the parameter request from the front end, the business logic processing is completed and the specified path is forwarded or redirected.

Service layer: After the user's business logic changes, this layer can quickly find the corresponding business module to help carry out certain logical processing. This layer is related to the interface of the DAO layer. When the Service layer is encapsulated, the business logic becomes more independent and reusable.

DAO layer: This layer is used to design the DAO interface, whose implementation classes need to be defined in the Spring framework's configuration file. The interface provides the processing method of the data business. In the implementation function module, the interface is called according to the business requirements to coordinate the processing.

Persistence layer: MyBatis is a framework that can be used in the persistence layer. Integrate MyBatis framework, design database operation through DAO interface, the associate structured query language of relevant business in XML configuration file, and achieve the purpose of interacting with the database.

2.1. System Function Module Design
According to the above system function analysis, the online practice system is mainly divided into super administrator and student user modules.
The main users of the online exercise system are ordinary students, which can achieve the following functions: student users' registration and login, personal information view, modify, participate in exercises and answer questions, and review exercises.

Fig. 2. Student user use case diagram

Registration and login: students are required to fill in the user account (student number), major, login password, real name, and contact information according to the prompts on the page. Then the registration information is submitted to the system, the student logs in with the successful user account and the correct password.

Personal information: Students can browse their personal information on the personal interface and modify the login password, real name, and contact information according to the needs of changing or editing the information.

Take part in the exercise: when there is a new exercise task, students can enter the online exercise page under their home page and complete the questions according to the topic information.

Review exercises: Student users use this feature to browse through the exercises they’ve participated in, view their exercises, and learn the referenced answers to Selenium test scripts from test word questions.

The management and maintenance of the entire online exercise system are mainly completed by the super administrator, whose functions include professional management, student user management, exercise problem management, exercise information management, answer problem management, and exercise statistics.
Professional management: This function mainly carries on the unified management to the school major, realizes the professional basic business operation, is used to distinguish the student user's ownership relationship.

Student user management: to achieve the basic operation of student users must. Among them, the requirement of adding student users is similar to that of student users when they register and log in to the system. In the process of adding, students' user account, login password, professional information, real name, contact information, and other detailed information shall be filled in.

Exercise problem management: Super administrators are supported to increase the number of exercise questions in the system database by importing exercise questions. During the process of importing exercise questions, it is required to include the correct answers of the choice questions and the judgment questions, as well as the reference Selenium test scripts for Selenium Web application automated exercise questions.

Exercise information management: Generally, before generating exercise questions, the super administrator needs to set some basic information associated with the exercise questions, such as the major of the exercise, total score of the exercise, the start and end time of the exercise questions, and the limited time of the exercise.
Answer situation management: With this feature, the super administrator can see the practice status of the student users, as well as the practice answers and final scores submitted by the student users.

Practice statistics: generate an intuitive line chart according to the scores of students in each major, for the reference of super administrators.

In the functional design and development of the online exercise system, two functional requirements need to be addressed. On the one hand, how to randomly generate a specified number of exercises of different types; On the other hand, when student users answer the automated exercises of Selenium Web application, how does the system recognize the Selenium test scripts submitted by student users, give reasonable scores on the correctness of these scripts, and finally give feedback to student users.

2.1.1 System Core Function Module Design

Compare the Selenium script submitted by student users with the reference script of the system, take the Selenium positioning method, label element and element attribute value as the step points, and score them reasonably according to their matching similarity, therefore, to realize alignment between the script, can be regarded as a comparison between two strings, the script assumes that the standard reference for sequence \(X = x_1 x_2 \cdots x_m\), bring students the user submits the test scripts for the sequence \(Y = y_1 y_2 \cdots y_n\), compare two script output after the completion of the longest common subsequence, then the length of the sequence and the length of the sequence \(X\) is concluded the similar degree between the two scripts.

When this problem is solved using the exhaustive search method, each subsequence contained in sequence \(X\) is searched to determine whether it is a subsequence of sequence \(Y\), thus determining whether the subsequence is a common subsequence of sequence \(X\) and \(Y\), and finally selecting the longest common subsequence. When searching the sequence, it can be seen that there are \(2^m\) different sub-sequences of sequence \(X\) and \(2^n\) different sub-sequences of sequence \(Y\). The exhaustive search method requires exponential time \((2^m \cdot 2^n)\), so it is not suitable for the long sequence. Therefore, the dynamic programming method is used to solve the problem.

I use dynamic programming to solve the problem of LCS (Longest Common Subsequence, Longest Common Subsequence); I assume that sequence \(Z = z_1 z_2 \cdots z_k\) is any Longest Common Subsequence of sequence \(X\) and sequence \(Y\) then:

1. If \(x_m = y_n, z_k = x_m = y_n\), and \(Z_{k-1}\) is \(X_{m-1}\) and \(Y_{n-1}\) one of the longest common subsequences.
2. If \(x_m \neq y_n\), then \(Z_k \neq x_m\), and \(Z\) is the longest common subsequence of \(X_{m-1}\) and \(Y_n\).
3. If \(x_m \neq y_n\), then \(Z_k \neq y_n\), and \(Z\) is the longest common subsequence of \(X_m\) and \(Y_{n-1}\).

Summarized as the following formula, where \(i\) and \(j\) are the total length of two strings:

\[
dp[i, j] = \begin{cases} 
0 & \text{if } i = 0 \text{ or } j = 0 \\
\max(dp[i-1, j-1] + 1, \max(dp[i-1, j], dp[i, j-1])) & \text{otherwise}
\end{cases} 
\]  

(1)

Thus, it can be seen that the time complexity of dynamic programming to solve the LCS problem is \(O(mn)\), and this method is advisable in system design and implementation.

2.2. System Workflow Design

As the online practice system is divided into two operation modules, student user operation interface and super administrator operation interface. Among them, the student user logs in through the login page and USES the student user account and the correct password. The system will verify the legitimacy of the information in the login process. First, it will judge whether the student user information exists in the system; otherwise, it will remind the student user to register. Then determine whether the student user's login password is correct, otherwise prompt login error. After all login information is verified, the student user enters the student operation interface of the online practice system to edit and modify his/her personal information and password. Among them, the login password belongs to personal privacy information. Due to security considerations, students need to enter the correct original password to
successfully modify the password. When there are exercise tasks under the exercise list and the exercise time has not expired, student users can choose to practice and submit the exercise answers within a fixed time.

![Student user module flow chart](image)

**Fig. 4. Student user module flow chart**

When the super administrator logs in to the work module, it is consistent with the login process of student users, and the legitimacy of login information shall be verified. Only after the login information is successfully verified, can the user log in the background management interface. After logging in the background management interface, the super administrator can conduct unified management of functional modules such as majors, students, and exercises, mainly realizing the basic operations such as adding, deleting, modifying, and inquiring of these functional modules.

### 2.3. Database Design

Database design is an optimal design pattern that can be constructed under current conditions. However, the main purpose of establishing a database is to store data and meet the application requirements (information requirements and processing requirements) of different users. The database design of the online practice system is not only related to the operation efficiency of the whole system but also closely related to the business increase in the later period. To sum up, the status of database design in system design is relatively important. Consistent with the database design of the system, it is beneficial to improve the running speed of the system, shorten the response cycle of data interaction, and provide a good user experience.

Database conceptual design on the characteristics of the entire System structure, comprehensive induction, and abstraction, to form a Database Management System independent of the specific concept model. The conceptual model can truly and fully reflect the connection between various entities in the online practice system, and meet the requirements of different users for data processing. The E-R (Entity-Relationship Approach) model, which embodies the concept to a certain extent.

According to demand analysis, there are mainly the following links between entities:

1. There are several students in a major, and a student can only belong to a major.
2. There are many students under one exercise, and one student can take part in more than one exercise.
3. A super administrator can manage several majors, several students, and several exercises.
4. One exercise information corresponds to one exercise. One exercise has several exercise questions, and one exercise has only one answer result.

According to the relation between the above entities, the global E-R diagram is designed by the online practice system.

![Global E-R diagram of practice system](image)

Fig. 5. Global E-R diagram of practice system

Database logic design is mainly to achieve DBMS user needs and model optimization.

The above E-R model is analyzed, and the transformation from the E-R graph to the relational model is realized according to the transformation rules.

3. System Implementation and Testing

In this section, the online practice system is implemented and tested to verify whether each function module can achieve the best goal of system function design by the workflow. The online practice system is mainly divided into student user work module and super administrator work module. Therefore, corresponding test cases are formulated to conduct functional tests on the two modules respectively, to determine whether there are defects, vulnerabilities, and errors in the system, and to fix them in time.

3.1. Core Component Testing

The system has implemented the function of judging and scoring for Selenium test scripts, and the whole judging process needs to be tested, mainly reflecting whether the final score meets the expected results, to verify the reasonable design of the process.

Select the automated exercise of Selenium Web application, "Use Baidu to search ctrip.com and open it, and query the one-way train ticket from Beijing to Shanghai on May 26, 2020." As a test case, the final score is set in the range $[0 - 100]$ (points). Open the Ka Talon Recorder script recording tool in the Firefox browser (version number: 76.0_win64), record the script according to the requirements of the test questions, and playback the script after the recording is completed. The playback results show that the recorded script is accurate, which can achieve the requirements of Selenium Web application automation exercises.

Copy the test script as a standard reference test script, and add it to the corresponding Selenium Web application automation exercises, practice system paths on the Web application before the test, prescribed student users to write test scripts, as shown using the Eclipse compiler tool to write the test script, and Gecko Driver (version number: 0.26.0) drives the Firefox browser (version number:76.0_win64), can also achieve the basic requirements of Web application test, compared with the recorded script, not good enough, there are certain defects.

There are some differences between the script under test and the standard reference script. The standard reference script USES annotations in a way that not only realizes the basic requirements of Selenium Web application automation exercises but also can throw exception information generated...
during the running of the test script, making the whole test script more fully and accurately.

However, the test script was written by student users only realized the basic requirements without throwing exception code blocks. If the test script made an exception error during the running process, the system would automatically terminate the program running and could not fully realize the automated test.

Therefore, the final score of the pre-specified input test script only falls within the range $[50 - 60]$, which is consistent with the reality and falls outside the range, which proves that the discriminant scoring process and logic are incorrect and inaccurate.

Next, you need to practice the system on the line and enter the test script consistent with the above in the text box. The submission system then checks and prints the final score in the background.

The running result finally falls within the specified interval, and it is correct to judge the functional logic and implementation process of Selenium test scripts. Under the condition that the test scripts cannot be run directly, the corresponding scoring results are relatively reasonable, so it is advisable to use this method to judge Selenium test scripts.

4. Conclusion and Acknowledge

First of all, as an online practice system, there will be more new functional requirements in the subsequent use. To avoid the trouble caused by multiple development and coding, we can consider designing the interface for the implementation of related basic functions of the system. The super administrator can add corresponding menus and buttons in the background according to the business requirements.

Second, compatibility is inconsistent across different versions or types of browsers, and the various languages that Selenium test scripts support are implemented in, and the tools and environments for compiling in different languages are different. The content of different Web pages can vary, such as multimedia information such as pictures and videos, making the way Selenium tags are located complex. It is inaccurate and unreasonable to use these existing influences as a basis for the online exercise system to evaluate Selenium scripts and then match them with reference scripts. In the future, it is suggested that on the premise of reducing system expenses and not affecting system performance, a relatively compact and stable version compilation tool should be embedded in the online practice system, and the driver download of the corresponding version browser should be provided to students and users. Based on the script comparison score, a qualified score is set as the threshold. When the Selenium test script submitted by student users exceeds the threshold, the system can add the script to the running environment and directly run it. By driving the browser, the running results and script score can be shown to student users more intuitively.

Finally, on the project framework side, you can choose the Spring Boot new framework, which not only preserves the inherent features of the Spring framework but also simplifies the initial setup and coding of the project by eliminating the need for developers to define the template configuration files necessary for the development process.

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