Development of Networked NC Practical Training System

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Abstract. With the development of information technology, networked education has become the trend. It is one of the effective measures to solve many problems in higher education to make full use of the modern information technology educational resources and to carry out the professional teaching based on network widely. To meet the needs of networked teaching and experiments of NC (Numeric Control) principle course, this paper develops a web-based NC practical training system based on WINDOWS operating system, which uses Tomcat to build a WEB server, and uses JAVA language to manage ORACLE database. The networked NC practical training system provides a good platform for the students majoring in numeric control. This platform can not only deepen their understanding and mastery of numerical control expertise, but also cultivate their ability of system design and development.

Keywords: Networked teaching; Numeric control; Project practice.

1. Introduction

With the widespread use of network technology and information technology in the education field and the promotion of education informatization, the construction of campus network of colleges and universities in China has been expanded and improved. The construction of teaching resources, teaching websites and network courses has been gradually carried out. As the core of education informatization, the construction of network teaching resources has been paid more and more attention\cite{1}.

The numerical control principle and system is a subject which has more abstract theoretical knowledge, and it is closely related to engineering practice as well\cite{3}. A balance between theory and practice can be found through the construction of the platform of the networked practice system. Through the networked NC practical training system, students can use the system online learning theoretical knowledge, carrying through practical project at any time and any place. In this system, the theoretical knowledge learned in the class can be transformed into practical knowledge. It can improve students' initiative and enthusiasm in learning, enhance their ability to analyze and solve engineering problems, and cultivate students' practical ability and engineering awareness.

2. System Function

The networked practice system is consisted of three modules, the system management module, learning center module and the NC practice module respectively. The functions of these modules are separated and totally independent of each other. The system function structure chart is shown in figure 1.

The login mode of the system management adopts authority management. If students log in, this module will not be seen. Only teachers and system administrators can manipulate this module. In this module, the whole project can be displayed, and the user rights can be managed also.
NC practical module is the core module of the system, in this module, students can upload the NC machining program (also called G-code program) written by themselves. After uploading, it can also read the program, and then carry out decoding, diagnosis, tool radius complement calculation, interpolation calculation and the corresponding results can be displayed on the screen.

The main function of learning center module is that students can learn the theory knowledge of NC principle course online. Through this module, students can do pre-class preview and after-class review anytime and anywhere through mobile phones, computers and other online devices.

3. Schematic Design

This system adopts B/S architecture, there are three layers in the system: Stuts2 is the presentation layer, Spring is the business layer and the Hibernate is the persistence layer, the system composition block diagram is shown in figure 2[3]. All the functions are achieved by manipulating the browser JSP page. The browser sends a service request to the server, the server responds to the request by means of the Action class of corresponding modules in Stuts2 firstly, and then calls the Spring to perform specific business, finally the Spring calls the corresponding ways of SQL in the Hibernate, the corresponding table in the database is associated with Hibernate through POJO entity class, so the operations to add, delete, revise, and search a table can be realized[4].

Whether the operation on the data is successful or not, the database will have a corresponding return value. First, the return value will be encapsulated as an Object class or collection in the Hibernate layer and then it is transmitted to the Spring layer. The encapsulated Object class or collection is logically processed in the Spring layer and the return value is passed to the way of the Action class of the corresponding module in the Struts layer. The String text return value of the method in the Action class will match the property tag content of the Struts configuration file, if the String text is identical, then it can achieve page jump, query content display, and so on.
4. System Development

4.1. System management module
There are three roles of login users in networked NC practical training system, that is, students, teachers and administrators. Users can be classified by assigning different roles, and then different system modules can be assigned to each role. Through the Shrio security framework, the modules of the logged-in user can be displayed on the title bar and sidebar of the JSP page by authorization. The login interface is depicted in figure 3.

![Figure 3. System login.](image)

4.2. NC practical training module
The NC practical training module is divided into three sub-modules: (1) file upload module, (2) file list module, and (3) project display module. The function of the file upload module is that students can upload the G-code program written in advance to the server. File list module can view the uploaded file content, students can write new G-code program or modify/delete the program. The project display module is the most important module in this module. The main functions of the numerical control system, such as decoding, tool complement processing and interpolation calculation can be simulated in this module[5]. The debug results of project display module is shown in figure 4.

![Figure 4. System login. A: NC program, B: decoding buffer, C: tool compensation trajectory, D: interpolation trajectory.](image)
The decoding function realizes reading one data from the G-code program, identifying its attribute and then processing the data in accordance with its attribute. The result of decoding is stored in decoding buffer according to the prescribed format. Since the user programs the G-code according to the parts drawing, but the motion path controlled by the NC system is the trace of the tool center. Tool radius compensation is calculated, the path of the tool center, including calculation connection points coordinates and output tool center trajectory. In interpolation module, point to point interpolation algorithm, digital differential analyzer interpolation algorithm and data sample interpolation algorithm are implemented, both the coordinates of each interpolation point and interpolation trajectory are outputted[6].

4.3. Learning center

The learning center module is composed of learning note, learning resource and problem feedback. It is convenient to record the important knowledge and the study experience in learning note interface, which is shown in figure 5. Click the new button in figure 5, a new note displays the date of creation so that we can find the note we created. Click the edit button to enter a note. we can also delete unwanted notes by using the delete button on the note.

![Figure 5. Learning note.](image)

The networked NC practical training system is aimed at the theory teaching and practical teaching of NC principle course. In the module of learning resource, the theory knowledge of textbook are displayed in web page. Which is arranged according to the chapters of textbook, each chapter contains the basic knowledge, the key points of this chapter, thinking questions, exercises, etc. Students can study anytime and anywhere according to their needs.

If students encounter any problem in the learning process, they can consult the teacher by Email in the problem feedback interface, and the teacher can answer the question by checking her own Email. The principle of Mail sending is to call the Jar package of Java Mail in the background software of the Server, implement the corresponding interface method, and then call the administrator account in the Mail Server configured in the Server to send an email.

4.4. Database development

There are 9 database tables in this system, User table (USER-P), role table(ROLE-P), module table(MODULE-P), class table(CLASS-P), file table(FILES-C), label table (MEMO-C), user expansion information table (ROLE-USER-P), role authority table(ROLE-MODULE-P), and role user table(USER-INFO-P). When the user logs in to verify the account, the user table will be used, the user information extension table will be used to view the user's personal information, and the role table and class table will be used for role management and class management. The file table is used to save the information of uploaded files by users. Instead of storing uploaded files directly in the table, the file table is used to store the path address of uploaded files. When the upload file is needed to open, file content can be obtain from the Java IO stream by accessing the path address. The label table stores the full contents of the learning note, which is used to retrieve the note created by the current user[7].

There are three types entity relationship(E-R) in the nine database tables, (1)one-to-one, (2)one-to-many, and (3)many-to-many, the E-R diagram is illustrated in figure 6. The one-to-many relationship is the most common relationship in relational database, the user table with the label table, the user table with the role table, and the user table with the file table are all belonged this relationship. The role authority
table and role user table in the database tables are two intermediate tables. The function of the intermediate table is divided the many-to-many relationship into one-to-many. This facilitates the system cascading queries for SQL statements.

Figure 6. System E-R diagram.

5. Conclusion
The networked NC practical training system adopts the B/S architecture, which utilizes the existing Internet/Web technology, puts the Java program on the Web server, the client only needs to install a standard Web browser, they can access the Web server and run their program. The architecture adopts the standard TCP/IP technology and HTTP protocol, which can be well integrated with the existing network. Students can use this system online learning theoretical knowledge, carrying through practical project at any time and any place, teachers can interact with students through this system also. The practical application shows that the NC practical training system has certain practical value for the theoretical teaching and practical teaching of NC principle course. The networked NC practical training system developed currently is version 1.0, the algorithms involved in tool compensation and interpolation are much limited, the next step is to add student-developed modules to the system. The students can develop its own tool compensation or interpolation algorithm program according to the interface parameters provided by the system, and then upload the program and check it, and this can improve their ability of NC system development much better.

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