Research Article

Construction of the Human-Computer Interaction Model of Hybrid Course Based on Machine Learning

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The massive open online course (MOOC) is a large-scale open online course teaching method with many advantages such as abundant resources, open access, social interaction, and learning freedom. However, there are also flaws such as low completion rate, lack of personalized consultation, mechanical inspection, and unity. In order to resolve these shortcomings of MOOC, this study proposes a hybrid course model consisting of MOOC and small private online courses (SPOC) based on machine learning. This integrates deterministic rules into our machine learning pipeline in a variety of ways, gradually adding rules as data preprocessing steps and then using object-oriented programming (OOP) to generate novel ML model classes. Finally, it includes data in all deterministic rules through a hybrid model so that we can train it like any other machine learning model. Through experimental analysis, it can be observed that the MOOC + SPOC hybrid teaching mode can effectively integrate MOOC, SPOC, and physical classrooms and make full use of the advantages of the three to provide learners with a unified interactive interface for implementation.

1. Introduction

The MOOC is generally translated into a large-scale open online course [1]. It is an online course based on network and mobile technology, based on curriculum and teaching theory and based on the Internet for online learning [2]. In 2008, Canadian scholars Dave Cormier and BRyan Alexander first proposed the term MOOC that has a low registration threshold, rich curriculum resources, and free access to students from all over the world. This form of online video viewing based on the Internet has attracted many learners from all over the world [3]. MOOC is like a “digital tsunami” in the international education pattern. China’s domestic Peking University, Tsinghua University, Shanghai Jiaotong University, Zhejiang University, Hong Kong Polytechnic University, and other top ten universities have expressed their willingness to work together to build the world’s leading online education platform for Chinese. Nowadays, the well-known online education platform in China includes “School Online” of Tsinghua University, “Netease Open Course” under the name of Netease, “MOOC Academy” under the shell network, and the “Teaching Network of Love Education Center and Love Course Center” jointly launched by “Netease.” University MOOC.

However, people find that MOOC’s rich learning resources, low barriers to entry, and free fees attract many learners, making the number of registered students millions, but the final pass rate is only 5%; if students simply watch online learning videos, they cannot communicate, interact, and discuss with teachers face to face, and students only have the completion certificate and no formal credit certificate or credit mutual recognition; then, the evaluation problem will be difficult to be solved. These problems are gradually revealed and come to the surface [4]. So, researchers propose SPOC (Small Private Online Course), which refers to small-scale restrictive online courses or small-scale private online courses. Among these, small is relative to Massive in MOOC, indicating that the number of students does not have thousands like MOOC. Tens of thousands of people, but the number of students is limited, generally between dozens and hundreds of people. Private is relative to the Open in MOOC, and like MOOC, learning resources are still...
open to students [5, 6]. However, the student’s entry requirements are subject to certain restrictions and are eligible for inclusion in the SPOC program after meeting the preset application criteria [7].

In addition, since the courses are all conducted on the network, the relevant human-computer interaction interfaces and modes also greatly affect the learning efficiency. This study introduces the concept of mind map again and proposes a learning resource integration based on the mind map and online learning human-computer interaction technology, enabling learners to conduct online collaborative learning under the guidance of mind maps, sharing learning experiences, and learning resources. Finally, this study implements the proposed mental-based collaborative and interactive learning scheme and presents a Web-based prototype system. The use of a collaborative human-computer interaction learning system is introduced through an example.

The main contributions of this research work are

(i) This study proposes a MOOC+SPOC hybrid curriculum model based on machine learning
(ii) Integrate deterministic rules into our machine learning pipeline, and gradually add rules as data preprocessing
(iii) Use object-oriented programming (OOP) to use abstract concepts to generate novel ML model classes
(iv) The data are included in all deterministic rules through the hybrid model so that we can train it like any other machine learning model

The rest of this study is organized as follows. Section 2 discusses MOOC+SPOC teaching mode, followed by the application of human-computer interaction in network courses is discussed in Section 3. Construction of human-computer interaction teaching mode under mixed teaching of MOOC+SPOC is discussed in Section 4. Section 5 concludes the study with a summary and future research directions.

2. MOOC + SPOC Teaching Mode

2.1. MOOC Teaching Mode. In 2012, MOOC began to enter people’s field of vision and then quickly warmed up around the world. MOOC has a low registration threshold, rich curriculum resources, and free access to students from all over the world. This form of online video viewing based on the Internet has attracted many learners from all over the world. With the rise of MOOC, online learning platforms relying on various technologies have emerged as the times require and have sprung up [8]. First, famous universities and professors in the United States founded the three major MOOC platforms, Coursera, edX, and Udacity. Some countries in Europe, Asia, and Australia followed the same and established their own MOOC platform.

The hybrid teaching mode combining MOOC and traditional classroom teaching is no longer full-filled teaching, but more learning-centered, adhering to the constructivist view of knowledge and focusing on the context, approach, and process of constructing and generating knowledge [9]. At the same time, important changes have taken place in the role of teachers. In traditional classroom teaching, the role of teachers is mostly “knowledge imparters.” The problem factors such as the schedule of the course and the large class capacity limit the teacher’s targeted guidance to a certain extent, and there is a lack of guidance in the individualized learning of students. With MOOC, teachers do not have to record the video resources of the course but must integrate various online and physical resources according to different course contents and different needs of students. In this way, teachers can be freed from the role of imparting knowledge, using more time and energy to “scramble” to promote and help students generate knowledge. In addition, the use of MOOC to provide learners with different learning resources is not only limited to teaching courseware, in addition to the teaching materials provided by the teachers who teach the course, as well as video courses, texts, and so on of major universities. These learning materials help learners build knowledge in different ways.

2.2. SPOC Teaching Mode in the Post-MOOC Era. The Small Private Online Course (SPOC), short for small-scale restrictive online courses, is a combination of online courses and offline classrooms developed on the basis of MOOC [10]. It was first proposed by Armando Fox in 2013. The basic form of SPOC is to assist classroom teaching and reconstruct the teaching process through MOOC video and online evaluation and recording of learning data in the existing classroom teaching, so as to realize the effective application of MOOC in school teaching [11]. The small-scale and private curriculum advocated by SPOC aims to solve the problem of high dropout rate and unsatisfactory teaching quality due to a large number of electives in the MOOC and the uneven level of learners’ enrolment. The relevant comparison between MOOC and SPOC is shown in Table 1.

The connotation of SPOC mainly refers to the following. In order to integrate MOOC with the traditional campus, through the reasonable and effective design and selection, a high-quality online learning resource such as MOOC is introduced into a new teaching mode of the physical classroom, through diversified resource selection and design. Enrich the learning resources of the course, expand the learning environment, and enhance the teaching effect. At the same time, we also believe that SPOC has the following characteristics when it is applied: learning resources are open and supporting platform flexibility and teaching methods are mixed.

2.3. SPOC-Based Hybrid Learning Curriculum Design. The theory of the mixed learning process as discussed in detail with the principles and basic characteristics of mixed learning by Huang Ronghuai from Beijing Normal University proposed the “design framework for mixed learning courses” [12]. It was believed that when designing mixed learning courses, the following can be three-stage
In order to achieve good interaction effects, three elements must be considered in the interactive system: interactive devices, interactive software, and human factors [17].

The interactive device is the basis for the system to realize human-computer interaction, and it provides the necessary conditions for user interaction. The human-computer interaction process includes two parts, input and output, so the interactive device is also divided into input/output devices [18]. The commonly used interactive input/output devices can be classified into three categories, that is, digital and alpha input/output devices, graphics and image input/output devices, and audio input and output devices.

The interactive software is software for human-computer interaction implemented in a computer system and includes system software and interactive application software. System software refers to the computer operating system, which provides a development and operation environment for the human-computer interaction interface. The interactive application software is software that is developed for the interaction requirements. It usually provides a specific user interaction interface so that the user can complete a specific task by interacting with the interface [19].

The design principles of the interactive interface are

(i) User-centric: from the user’s point of view, the user must always consider the user as the primary consideration in design
(ii) Consistent interface design: it is mainly reflected in the three aspects of color use, element appearance, and interaction behavior
(iii) Good feedback: in terms of technology, the system response time should not be too long; in terms of design, during the interaction process, the system should give the user enough feedback for the operation

### 3. Application of Human-Computer Interaction in Network Courses

#### 3.1. Human-Computer Interaction Theory

Human-computer interaction (HCI) is a technical discipline that studies the communication and information between people and computers through mutual understanding, and, to the greatest extent, people-computer interaction management, service, and processing functions [14]. Interdisciplinary, marginal, and comprehensive disciplines: human-computer interaction refers to the communication between the user and the computer system, that is, the two-way information exchange between the person and the computer through symbols and actions [15, 16].

The human-computer interaction interface has undergone several stages of development, from computer-based considerations to computer-adaptive features. The development stage of the human-computer interaction interface is shown in Table 2.

<table>
<thead>
<tr>
<th>Related comparison</th>
<th>SPOC</th>
<th>MOOC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is it free to open online?</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Student size</td>
<td>Limit number of people</td>
<td>Massive</td>
</tr>
<tr>
<td>Is there an entry requirement?</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>Development form</td>
<td>Online learning, flipping classrooms, and blended learning</td>
<td>Online learning</td>
</tr>
<tr>
<td>Whether to assess</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Essential feature</td>
<td>Ordinary small class and resource school</td>
<td>Knowledge unitization and rich media</td>
</tr>
</tbody>
</table>

### 3.2. Mind Map

As a kind of thinking display and communication tool, a mind map has been applied in many fields, including education and learning [20]. There are many advantages to using a mind map to assist learning. The main ones are as follows: significantly improve learning efficiency, users can focus on key knowledge points, express the connection between knowledge points, and build knowledge points through creative mind maps [21]. The relationship between the left and right brains is promoted. A typical mind map is shown in Figure 2.

Jena is an open Java language toolkit developed by HP Labs [22]. It is a Java framework for creating a semantic web
application system. It provides a program development environment for RDF, RDFS, and OWL. By calling the function interface provided by Jena, the ontology can be parsed, reasoned, queried, and stored to apply the ontology to the program.

Based on the Jena system, resource integration and recommendation system framework can be built. The Learning Resource Integration and Recommendations system framework covers technologies in a variety of areas, including knowledge management, information retrieval, educational technology, and personalized recommendations. In order to effectively realize the integration and sharing of learning resources, we must first use the metadata to describe the learning resources in a unified way and use

<table>
<thead>
<tr>
<th>Development stage</th>
<th>User</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manual operation stage</td>
<td>Designer himself or a colleague</td>
<td>Manual and binary machine code approach</td>
</tr>
<tr>
<td>Job control language and interactive command language stage</td>
<td>Programmer</td>
<td>Operate the computer in a batch job language or an interactive command language</td>
</tr>
<tr>
<td>GUI</td>
<td>Ordinary computer user</td>
<td>Desktop metaphor, WIMP technology, direct manipulation, and “what you see and gain”</td>
</tr>
<tr>
<td>Network user interface stage</td>
<td>Internet users</td>
<td>Using the browser as the interface to achieve the foundation, rapid development, and new technologies continue to emerge</td>
</tr>
<tr>
<td>Multichannel intelligent human-computer interaction phase</td>
<td>General user</td>
<td>Interact with computers in parallel, inaccurate ways using multiple sensory and motion channels</td>
</tr>
</tbody>
</table>

Table 2: Development of human-computer interaction interface.
the techniques of semantic annotation and natural language processing to automatically mark the metadata. Secondly, combined with the knowledge provided by the ontology, the connection between the teacher and the teacher’s teaching experience creates the course mind map, binds the learning resources and exercises, and sets the learning path for the knowledge points. Finally, the system recommends the appropriate learning resources according to the learner’s personalized information, thereby improving the learner’s learning efficiency.

A standard learning resource integration and recommendation system can be divided into resource layer, syntax layer, semantic layer, service layer, and application layer from bottom to top. Its contents and related functions are shown in Table 3.

Based on this hierarchy, we can build the framework of the system. The learning resource integration and recommendation system include three data storage modules: learning resource library, ontology library, and user model; in addition to metadata extraction, ontology construction and update, and learning resource integration, the user needs analysis and learning resource recommendation. The frame structure is shown in Figure 3.

3.3 Human-Computer Interaction System. Learning is usually a process from easy to difficult. In the process of learning, the learner’s level of knowledge about the knowledge points determines the difficulty of the acceptable learning resources. When the learner’s cognitive level of knowledge points is insufficient, the system should recommend learning resources with lower difficulty levels to help learners improve their mastery of knowledge points. As the learners deepen their knowledge level, the system provides learners with learning resources of the appropriate level of difficulty. Learners are prone to learning to lose in the process of learning, and learning path control can provide some help. To this end, we propose a cognitive level model and a path control model.

The learner’s cognitive level score can be calculated by equation:

![Figure 2: Mind map example.](image-url)
Table 3: Learning resource integration and advancing system hierarchy.

<table>
<thead>
<tr>
<th>Level</th>
<th>The main function</th>
<th>Related technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application</td>
<td>Learning resource integration and recommendation</td>
<td>jsPlumb and BootStrap</td>
</tr>
<tr>
<td>Service layer</td>
<td>Learning resource management and query</td>
<td>SPARQ and Jena</td>
</tr>
<tr>
<td>Semantic layer</td>
<td>Learning resource semantics</td>
<td>QWL</td>
</tr>
<tr>
<td>Grammatical</td>
<td>Learning resource description structure</td>
<td>Metadata</td>
</tr>
<tr>
<td>layer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resource layer</td>
<td>Get learning resources and build and update the semantic</td>
<td>Learning resource acquisition and ontology method</td>
</tr>
</tbody>
</table>

The learning path control model is used to realize the generation of the learning path and the control of the learning process: the teacher establishes the dependency relationship between the knowledge points when the course mind map is created; when the learner uses the course mind map to learn, the system learns according to the learning progress and knowledge point. The learning progress and knowledge point dependences dynamically update the learned knowledge points, and the learner can select the interested knowledge points to learn according to the needs and finally form a personalized learning path. The knowledge point dependency graph is shown in Figure 4. The learning path generation is shown in Table 5.

(i) At the beginning, only the knowledge point K1 is learnable. In the first step, only the learning knowledge point K1 can be selected. After completing K1 learning, because K1 is the only dependent knowledge point of K2 and K3, the newly learned knowledge points are K2 and K3.

(ii) At the beginning of the second step, the learned points are increased to K1, K2, and K3. Since the learning point K1 has been completed, the learner can choose between K2 and K3 to learn. The knowledge point K5 depends on K2 and K3, and the learning of K3 is not yet completed, so K5 is not a new knowledge point.

(iii) The third step is to complete the knowledge point K4 learning; there is no new knowable point.

(iv) The fourth step is to complete the learning of K3. Because K5's dependent knowledge points K2 and K3 have been completed, the new knowledge point K5 is added.

(v) The fifth step completes the learning of the knowledge point K5 and finally forms a learning path K1 → K2 → K4 → K3 → K5.

The collaborative human-computer interaction process refers to the human-computer interaction process that works together under the support of a computer. Computer-supported collaborative work (CSCW) can be defined as, in a computer-supported environment, a group which works together to accomplish a common task. Its goal is to design applications that support a wide variety of collaborative

![Learning resource integration and recommendation system framework.](image)

Score = \( \frac{\text{result number}}{11} + \text{rank} - 1 \). (1)

Table 4 is an example of a cognitive level score representation. For example, if you need to answer 11 questions to complete the level of cognitive level assessment and the current learner has answered 7 questions in total, then his score is \( \frac{7}{11} + 2 - 1 = 1.64 > 1.5 \), which means that the learner has reached the level of understanding. The requirements can continue to learn more difficult levels of knowledge. The cognitive level score example is shown in Table 4.
The collaborative interaction process between students, teachers, and human-computer interaction systems is shown in Figure 5.

4. Construction of Human-Computer Interaction Teaching Mode under Mixed Teaching of MOOC + SPOC

The functions of MOOC and SPOC in mixed teaching are defined as follows: MOOC provides a learning platform and high-quality curriculum resources; SPOC is a virtual platform that provides teacher guidance, Q&A, monitoring, assessment, evaluation, student learning, thinking, discussion, and inquiry. It provides a basic curriculum model that integrates teaching and learning activities before class, after class, online, and offline. Based on the distinction between such functions, the support mode of the hybrid teaching can be constructed, as shown in Figure 6.

The MOOC provides high-quality teaching resources for SPOC and physical classrooms. SPOC can introduce one or more courses into the SPOC platform in whole or in part as needed, as the recommended resources of SPOC for users to learn independently. In physical classroom teaching, teachers can also embed MOOC curriculum resources into teaching activities as an important supplementary resource for classroom learning or discussion. Moreover, the physical classroom itself is an important part and component of the SPOC teaching model, that is, offline class. Based on the mind map to build a database, each mind map has multiple nodes and multiple pieces, and its entity-relationship diagram is shown in Figure 7.

Similarly, based on the system development platform VisualStudio2010, we built a human-computer interaction platform for mixed courses in a MOOC + SPOC environment. The data storage uses the SQLServer2008 database, and the ontology storage uses ontology files based on OWL description. The main development technologies used in the system are ASP.NET, C#, jsPlumb, AJAX, Jena, etc., where jsPlumb is used to implement the connection function of nodes in the mind map, AJAX is used to implement asynchronous interaction with the server, and Jena is used to implementing the operation of the ontology library. Keeping the above development platform and technology in view, this study implements a collaborative human-computer interaction system based on the mind map. The coordinated human-computer interaction system response test results are shown in Figure 8.

During the creation and use of the mind map, the user interface needs to perform multiple data exchange operations with the server. Ajax technology provides an asynchronous method of data transfer, enabling pages to be dynamically refreshed, thereby improving the user experience.

<table>
<thead>
<tr>
<th>Numbers</th>
<th>Current knowledgeable points</th>
<th>Complete learning</th>
<th>New knowledgeable points</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>K1</td>
<td>K1</td>
<td>K2, K3</td>
</tr>
<tr>
<td>2</td>
<td>K1, K2, K3</td>
<td>K2</td>
<td>K4</td>
</tr>
<tr>
<td>3</td>
<td>K1, K2, K3, K4</td>
<td>K3</td>
<td>No</td>
</tr>
<tr>
<td>4</td>
<td>K1, K2, K3, K4</td>
<td>K4</td>
<td>K5</td>
</tr>
<tr>
<td>5</td>
<td>K1, K2, K3, K4, K5</td>
<td>K5</td>
<td>No</td>
</tr>
</tbody>
</table>

Table 4: Cognitive level score example.

<table>
<thead>
<tr>
<th>Rank</th>
<th>Number</th>
<th>Result</th>
<th>Score</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>11</td>
<td>9</td>
<td>0.9</td>
<td>[0.5, 1]</td>
</tr>
<tr>
<td>2</td>
<td>12</td>
<td>8</td>
<td>1.74</td>
<td>[1.3, 2]</td>
</tr>
<tr>
<td>3</td>
<td>10</td>
<td>5</td>
<td>2.51</td>
<td>[2.6, 3]</td>
</tr>
</tbody>
</table>

Figure 4: Knowledge point dependency graph.

Table 5: Learning path generation.

Figure 8: Mind map.
experience of page operations. The system builds a WCF service on the server side, and the web client dynamically interacts with the server through Ajax. The code in Figure 9 shows the data contract definition for the user type. A co-operative human-computer interaction system login simulation is shown in Figure 9.

In addition, the services and services provided by WCF need to be called and accessed, and the related programs do not make much explanation. After the platform is built, it will be put into use. Through the questionnaire survey and classroom interviews, the evaluation statistics of the students on the platform is shown in Table 6.
Through the above data, we can see that the operation of the platform is simple, and the easy-to-use students account for 76.92%. The students who use the platform for self-study before class are very convenient, accounting for 69.23%, which is considered to be convenient for online communication and discussion. The student accounted for 76.92%. 

Table 6: Students’ evaluation of the SPOC platform.

<table>
<thead>
<tr>
<th>Topic</th>
<th>Very much agree</th>
<th>Agree</th>
<th>General</th>
<th>Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>The SPOC platform is easy to operate and easy to use</td>
<td>25</td>
<td>51.29</td>
<td>13.5</td>
<td>9.6</td>
</tr>
<tr>
<td>It is very convenient to use the platform for self-study before class</td>
<td>21.15</td>
<td>48.08</td>
<td>19.23</td>
<td>11.53</td>
</tr>
<tr>
<td>Use the SPOC platform to facilitate online communication and discussion</td>
<td>26.92</td>
<td>50</td>
<td>15.38</td>
<td>7.69</td>
</tr>
<tr>
<td>I like to use this platform for learning</td>
<td>29.23</td>
<td>48.07</td>
<td>19.23</td>
<td>13.46</td>
</tr>
</tbody>
</table>
Students who like to use the platform for learning accounted for 67.3%. It can be seen that the platform has won wide acclaim among students.

5. Conclusion

The key to the pace of development and strengthening of education is to keep up with the pace of the times and to accelerate the transformation of educational models and learning styles. The mixed teaching mode of colleges and universities is to explore the positive factors of MOOC and SPOC, complement each other’s advantages, and promote the deep integration and coordinated development of the two, so as to improve the teaching efficiency and promote the comprehensive development of teachers and students in the interactive mutual assistance. This study discusses the implementation of collaborative human-computer interaction technology in combination with the use of learning resources in learning resource integration and recommendation systems. The learning resource recommendation and learning path control were completed, and the collaborative learning and human-computer interaction based on a mind map were realized. The design and implementation of the prototype system were completed and won favourable comments. The proposed system is a very useful system and deserves further research and development.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The author declares that he has no conflicts of interest.

References