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# DESIGN AND IMPLEMENTATION OF CHINESE LANGUAGE TEACHING SYSTEM BASED ON VIRTUAL REALITY TECHNOLOGY

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**Abstract.** Traditional Chinese language teaching methods have always had problems, such as a lack of practical opportunities and interest and an inability to provide sufficient language environment and context. Virtual reality technology provides new possibilities to solve these problems. Through in-depth research and analysis, this article designs and develops a Chinese language teaching system based on virtual reality technology. This system utilizes virtual reality technology to create a simulated 3D Chinese language environment, enabling learners to experience interactive experiences firsthand. The system includes speech recognition, natural language processing, and artificial intelligence, enabling real-time language communication and student interaction. This system s design considers students learning needs and interests, allowing them to practice their Chinese application skills in real-world simulated environments. This system has broad prospects in Chinese language education and provides new research and innovation directions for educational institutions and developers.

**Key words:** virtual reality technology, Chinese language teaching, system design, teaching innovation

**1. Introduction.** Chinese is one of the most widely used languages in the world. With China s rise and globalization, more and more people have become interested in learning Chinese. They hope to master Chinese to facilitate communication with Chinese people, conduct business transactions, and gain a deeper understanding of Chinese culture [1]. In this context, Chinese language teaching has become an important topic, and Chinese language education faces a series of problems and challenges. On the one hand, the complexity and uniqueness of the Chinese language bring great learning difficulties to learners. As ideographic characters, learning Chinese characters requires a lot of effort and time, and learning Pinyin systems also require a certain amount of time and skills. In addition, the grammatical system of Chinese is different from that of Indo-European languages, with significant differences in grammatical structure and sentence organization, which is far less simple and intuitive than Japanese and English. Therefore, in response to this problem, more intelligent and efficient teaching methods and resources are needed to help students master Chinese faster and more systematically.

On the other hand, traditional Chinese language education also needs some help. For example, the content of textbooks needs to be more flexible, teaching methods are single, and communication opportunities are limited. To address these issues, it is necessary to carry out educational innovation, provide more practical textbooks and learning tools, and provide students with more communication opportunities and independent learning platforms to meet their diverse learning needs [2]. Correspondingly, opportunities and challenges are also required for Chinese language education. In the current era of rapidly changing information technology, various advanced technologies such as natural language processing, machine translation, virtual reality, and new media can be utilized to promote the development and innovation of Chinese language education [3, 4]. With the rapid development of technology, the application of Virtual Reality (VR) technology in education is receiving increasing attention [5]. Virtual reality technology can create simulated three-dimensional environments [6], allowing users to have immersive interactive experiences [7]. This immersive learning approach has brought new possibilities to education and has been widely applied in various disciplinary fields [8, 9]. In the field of Chinese education, there are some problems in the traditional teaching methods. Learners usually need to learn Chinese characters and grammar knowledge through classroom teaching or written materials, but this learning mode often lacks sufficient practical opportunities, especially for non-native language learners,

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who need to improve their oral fluency and communicative ability, while traditional teaching methods cannot provide adequate language environment and situation [10], Learners can immersivity experience the Chinese language environment and engage in real-time language communication and interaction with virtual characters [11]. Compared with traditional textbooks, virtual reality technology has higher interest and appeal, which can stimulate students learning interest and enthusiasm [12]. In addition, virtual reality technology can also create various scenarios and scenarios [13], such as shopping, tourism, business negotiations, etc., to help students practice Chinese language application skills in real-life simulated environments. Virtual reality technology has been applied to a certain extent in Chinese language education [14, 26]. Some educational institutions and research teams have begun exploring virtual reality technology for Chinese language teaching, designing, and developing Chinese language teaching software and systems based on virtual reality technology, providing learners with an immersive learning experience [16, 17]. These systems typically include speech recognition, natural language processing, and artificial intelligence, enabling students to engage in dialogue, communication, and interaction with virtual characters. The application of virtual reality technology in Chinese language teaching covers multiple aspects, helping students improve their listening and speaking abilities. Students can engage in real-time dialogue and interaction with virtual characters through virtual reality technology, improving their oral expression and listening comprehension abilities [18]. Secondly, virtual reality technology can also create various scenarios and scenarios, enabling students to practice their Chinese application skills in real-life simulated environments, such as shopping in shopping malls and ordering at restaurants. In addition, virtual reality can also provide immediate feedback and personalized guidance, helping students correct pronunciation and grammar errors and improve learning outcomes. However, the application of virtual reality technology in Chinese language education is still in its infancy, and there are some challenges and problems. First, the technical aspects need to choose the appropriate hardware equipment and stable and reliable software platform for development. Second, content creation requires collaboration between educational experts, linguists, technologists, and content creators. Learner interactions need to be designed in ways that are effective and employ speech recognition and natural language processing techniques to provide timely feedback. Finally, the maintenance and updating of the system requires the establishment of a dedicated team and close cooperation with educational institutions and students. Despite these challenges, virtual reality technology still has broad prospects in Chinese language education. With the continuous progress of technology and the accumulation of application cases, virtual reality technology will gradually become an essential component of Chinese language teaching, providing students with a more immersive, personalized, and practical learning experience.

This study aims to design and implement a Chinese language teaching system based on virtual reality technology to improve the effectiveness and fun of Chinese language learning. Through this system, students can use virtual reality devices to enter simulated natural scenes and engage in language communication and interaction with virtual characters, thereby improving their language application and communication skills. In addition, the system will also provide a rich and diverse Chinese language environment and scenarios, helping students flexibly use Chinese in different situations and improving their comprehensive language abilities. The research in this article is expected to provide a new teaching tool and method for teachers and learners in the field of Chinese language education, promoting innovation and development in Chinese language education.

## 2. Design Scheme of Chinese Language Teaching System Based on Virtual Reality Technology.

**2.1. System Designing Objective.** The Chinese language teaching system based on VR technology is an innovative solution based on virtual reality technology aimed at helping learners better learn Chinese and understand Chinese culture [19]. Through centralized management of teaching resources, the system provides remote teaching and three-dimensional virtual teaching scenes to meet the needs of modern learners [20, 21]. As shown in Table 2.1, the advantages and disadvantages of mainstream software and a comparison table of application fields are presented. 3ds Max has advantages such as ease of use, rich architectural and renderings, and good interactivity, making it particularly suitable for designing Chinese language teaching systems as a virtual reality technology.When using 3Ds Max for Chinese learning, students can further enhance their learning interest and effectiveness by creating a virtual reality environment. Students can choose courses through the gaze function, learn details, and freely control Settings such as sound. The system sets up 3D models and animations for teachers, and the teachers will react accordingly according to the content in the class, increasing the sense of reality.

Table 2.1: Comparison Table of Advantages, Disadvantages, and Application Fields of Mainstream Software

| **Software Name** | **Advantages** | **Disadvantages** | **Main application areas** |
|---|---|---|---|
| Maya | Strong rendering ability and high modeling accuracy | Difficult to master | Film and television industry |
| C4D | Good rendering effect and comprehensive functionality | Poor animation effect | TV packaging and advertising |
| Blender | Open source, comprehensive functionality | Poor FBX support | 3D animation |
| 3ds Max | Easy to use, low hardware requirements, and plugins | Slow update and large volume | Rich architecture and renderings |
| Zbrush | The modelling process can be freely utilized. | Poor topology | Digital carving and painting |
| Solid works | High modelling accuracy and good model proportion | High design requirements | Mechanical manufacturing, non-standard design |

Table 2.2: Comparison Table of VR Engine Characteristics

| **Name** | **Characteristic** |
|---|---|
| Unity 3D | Strong system compatibility and quick to get started |
| Unreal Engine 4 | Good screen display effect, high hardware requirements, and simple visual programming |
| Cry ENGINE | Fully functional and challenging to learn |

Develop teaching software based on virtual reality technology, and use VR headsets for teaching to provide a more realistic virtual reality experience. The design of the system is an auxiliary teaching tool for school Chinese classroom to help students better understand Chinese knowledge and improve language ability. Through virtual reality technology, students can better understand Chinese pronunciation, intonation, grammar, and other aspects, improving learning effectiveness and fun. Secondly, the system supports remote teaching, allowing students to participate in learning anytime and anywhere without being limited by time and space.

**2.2. Virtual Reality Engine Selection.** To achieve the goal of experimental teaching, it is necessary to design and develop human-machine interaction functions for virtual scenes, and human-machine interaction needs to be developed and implemented through simulation running platforms. Currently, the commonly used simulation interaction platforms at home and abroad mainly include Unreal Engine 4, Unity 3D, Cry Engine, Cocos 3D, and others. These engines have their characteristics, and Table 2.2 shows a comparison table of the characteristics of each engine.

Considering factors such as one's learning level and system development cycle, Unity 3D was ultimately chosen as the simulation development platform for system functions. At the same time, Unity3D comes with a high-performance lighting system, supports FBX format model files, supports Direct and Open GL low-level rendering, has a concise and easy-to-understand development interface, supports multiple scripting languages, and has realistic particle effects, which can fully meet the development needs of the virtual simulation experiment teaching platform for motors.

**2.3. Texture mapping technology.** In order to make the 3D model built in 3ds Max closer to natural objects, simple color adjustments are made to the geometric features of the model to present good surface texture details. Therefore, texture mapping technology is selected to optimize the texture surface of the model, which can significantly enhance the realistic visual effect and level of detail of the 3D model [22].

**2.3.1. Texture Mapping Principle.** The process of texture mapping is to map texture pixels from texture space to screen space. During the entire mapping process, there are mainly two types of mapping relationships: first, mapping from the texture coordinate system to the world coordinate system; The second

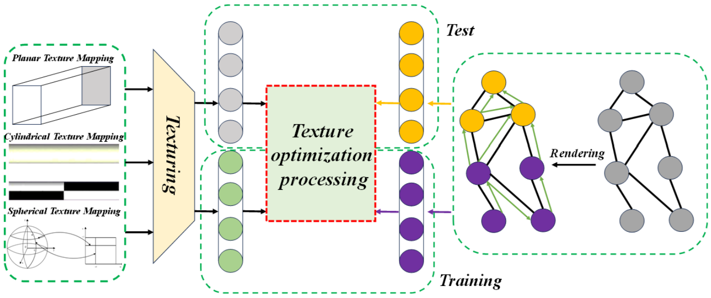


Fig. 2.1: Texture Mapping Diagram

is to map from the world coordinate system to the screen coordinate system, and the texture mapping process is shown in Figure 2.1. According to the mapping process, assigning corresponding color information to the vertices on the model surface can reflect the texture information of the object surface.

**2.3.2. Common Texture Mapping Methods.** A regular lighting model whose texture is only generated when surface properties change. The expression for a regular lighting model is given by formula (2.1):

$$I = I_a K_a + I_p + K_d(N \times L) + I_p K_s(N \times S)^n \tag{2.1}$$

Among them, Ia is the light intensity, Ka is the reflection coefficient, Ip represents the incident light intensity, Kd is the diffuse reflection coefficient, and Ks is the specular reflection coefficient. From this expression, it can be seen that by changing the average vector of the model surface or the diffuse reflection coefficient value, the cooler of the model itself can be changed.There are many mapping methods from texture mapping to image space, which can be divided into forward mapping and reverse mapping according to the mapping relationship between them. At present, plane texture mapping, cylindrical texture mapping and spherical texture mapping are mainly used, and the main application objects are non-parametric models.

1. **Planar texture mapping:** Planar Texture Mapping considers a plane as a basic geometric shape. Then, it projects a texture map from a two-dimensional plane onto it to simulate the appearance and details of the plane. For example, mapping a rectangular ABCD, making $|AB| = |CD| = |X|, |BC| = |AD| = |Y|$, establishing a correspondence between $0 \leq u \leq 1 and - \frac{X}{2} \leq x \leq \frac{X}{2}$ and establishing a correspondence between, $0 \leq v \leq 1 and - \frac{Y}{2} \leq x \leq \frac{Y}{2}$. The mapping function of this mapping method can be obtained from formula (2.2):

$$\begin{cases} u = \frac{1}{X}x + \frac{1}{2}, & -\frac{X}{2} \leq x \leq \frac{X}{2} \\ v = \frac{1}{Y}y + \frac{1}{2}, & -\frac{Y}{2} \leq y \leq \frac{Y}{2} \end{cases} \tag{2.2}$$

2. **Cylindrical texture mapping:** Cylindrical Texture Mapping considers a cylinder as a basic geometric shape. Then, it projects a texture map from a plane onto the surface of the cylinder to simulate its appearance and details. Assuming a cylindrical surface with a radius of r and a height of h, its relationship can be expressed by formula (2.3):

$$(u, v) = (\theta, z), \quad 0 \leq \theta \leq 2\pi \tag{2.3}$$

The parameter equation for the cylindrical surface can be obtained by formula (2.4):

$$\begin{cases} x = r \cos u \sin v \\ y = r \sin u \sin v \\ z = r \cos v \end{cases} \tag{2.4}$$

Mapping to a cylindrical surface through linear transformation as formula (2.5):

$$\begin{cases} u = \frac{2\pi s}{3} 0 \leq s, t \leq 1 \\ v = t \end{cases} \tag{2.5}$$

The parameter equation of the cylindrical surface is expressed as follows formula (2.6):

$$\begin{cases} u = \tan^{-1}(y/x) \\ v = z \end{cases} \tag{2.6}$$

The inverse transformation equation of the final linear transformation is as formula (2.7):

$$\begin{cases} u & = \frac{3u}{2\pi} = \frac{3}{2\pi} \tan^{-1}(y/x) \\ t = v = z & \end{cases} \tag{2.7}$$

3. **Spherical texture mapping:** In spherical texture mapping, a sphere is considered as a basic geometric shape, and a texture map on a plane is projected onto the surface of the sphere to simulate its appearance and details. For example, a point u1 on the$u-axis$ of the UV Cartesian coordinate system is vertically mapped onto a meridian with a longitude of $\theta$ in the spherical coordinate system; A point v1 on the $v$ axis of the UV Cartesian coordinate system is mapped horizontally onto a latitude line of $\phi$ in the spherical coordinate system. From the above process, the functional relationship between the texture coordinates $(u, v)$ and the spherical coordinate system can be determined, as shown in formula (2.8):

$$(u, v) = (\theta, \varphi)(0 \leq \theta \leq \pi/2, \pi/4 \leq \varphi \leq \pi/2 \tag{2.8}$$

For a sphere, the parameters on it can be expressed using formulas (2.9):

$$\begin{cases} x = r\cos(\phi)\sin(\theta) \\ y = r\sin(\phi)\sin(\theta) \\ z = r\cos(\phi) \end{cases} \tag{2.9}$$

Map to a sphere through linear transformation, as shown in formula (2.10):

$$\begin{cases} u = \frac{\theta}{2\pi} \\ v = \frac{\varphi}{\pi} \end{cases} \tag{2.10}$$

The resulting mapping relationship is shown in formula (2.11):

$$\begin{cases} u = \frac{\arctan\left(\frac{y}{x}\right)}{2\pi} \\ v = \frac{\arccos(z)}{\pi} \end{cases} \tag{2.11}$$

**2.4. Improved Matrix Decomposition Algorithm for Implicit Semantic Model.** After analysis, it can be found that the user s mastery of knowledge points is not fixed as assumed by conventional implicit semantic models [23] but gradually decreases over time [24, 25]. Therefore, the traditional matrix decomposition based on the implicit semantic model needs to meet the actual situation of this article. This article improves the traditional matrix decomposition based on the implicit semantic model by combining the scale of knowledge forgetting, using the knowledge point correlation matrix as the algorithm s input. It proposes an improved implicit semantic matrix decomposition method.

1. **Time effect function** People s memory of information will gradually fade over time in daily learning and life. The forgetting curve of memory information proposed by German psychologist Hermann Ebbinghaus indicates that people gradually forget the knowledge they acquire over time, with the later

parts forgetting more slowly. Based on this, this article introduces a time effect function to evaluate the user knowledge point mastery trend over time. However, after directly introducing the forgetting curve, the time effect influencing factors of the two-time points closer to the virtual teaching test interval will be excessively amplified, while the time effect influencing factors of the two-time points more distant from the test interval will be ignored by the base because they are too small. Based on the above reality, combined with the Ebbinghaus forgetting law and the user s mastery of knowledge points, the time effect function is defined as formula (2.12):

$$f(t) = \mu + (1 - \mu) \cdot (1 - e^{-(t-t_0)}) \tag{2.12}$$

Among them, t represents the current time, and 0t represents when the user conducted virtual teaching tests. $\mu$ is the time effect influencing factor, representing the degree of time effect on the user, used better to match the user s mastery of knowledge points, and$\mu \in [0, 1]$. If $\mu = 0$, it is considered that forgetting the user s knowledge completely follows the time effect function. Conversely, if μ=1, it is not followed. As time goes by, the content of knowledge points forgotten by users will increase, and the score loss of users on specific knowledge points will gradually increase, reflecting a continuous decline in users' mastery of knowledge points.

2. **Recommendation algorithm incorporating time effects.** According to the implicit semantic model and formula definition, formulas (2.13) and (2.14) are obtained:

$$P = U_{m\times r} \sum_{r\times r} \tag{2.13}$$

$$Q = V_{n\times r} \tag{2.14}$$

The user knowledge point mastery matrix R can be expressed as formula (2.15):

$$R = PQ^T \tag{2.15}$$

Among them, $Pm \times f$ is the implicit semantic matrix of the users classification of knowledge point attributes, $Qn \times f$ is the proportion and weight of each knowledge point in attribute classification. The user s mastery of knowledge points $\widehat{(r_{ui})} = R(u, i)$ can be transformed into formula (2.16):

$$(\widehat{r}_{ui}) = R(u, i) = \sum_{f=1}^{F} p_{uf} q_{if} \tag{2.16}$$

Among them, the implicit class $f \in (1, F], p_{ui} = p(u, i)qif = Q(i, f)$. This article assumes that the difference between the actual results of user's knowledge mastery and the predicted results of knowledge points follows a Gaussian distribution. A knowledge point correlation matrix that integrates multiple factors is constructed as the distribution matrix of existing users' knowledge mastery, and the relevant parameters of the implicit class matrices P and Q are calculated. This article uses root mean square error (RMSE) to evaluate the degree of consistency between the predicted results and the user s actual grasp, and the loss function is expressed as $C(p, q)$ in formula (2.17) and (2.18).

$$\text{RMSE} = \sqrt{\frac{\sum_{(u,i)\in T} (r_{ui} - \widehat{r}_{ui})^2}{T}} \tag{2.17}$$

$$C(p, q) = \sum_{(u,i)\in\text{Train}} (r_{ui} - \hat{r}_{ui})^2 = \sum_{(u,i)\in\text{Train}} (r_{ui} - \sum_{f=1}^{F} p_{uf} q_{if})^2 \tag{2.18}$$

To prevent overfitting during the learning process, it is necessary to add overfitting terms to formula (2.18), then the equation is transformed into formula (2.19):

$$C(p,q)=\sum_{(u,i)\in \text{Train}}\left((r_{ui}-\sum_{f=1}^{F}p_{uf}q_{if})^2+\gamma\|p_u\|^2+\gamma\|q_i\|^2\right) \tag{2.19}$$

Optimize the loss function $C(p,q)$ using the gradient descent method (SGD), and optimize the $p_{uf}$ and $q_{if}$ the partial derivative can be obtained as formula (2.20) and (2.21):

$$\frac{\partial C}{\partial p_{uf}}=-2f(t)\left(r_{ui}-\sum_{f=1}^{F}p_{uf}q_{if}\right)q_{if}+2\gamma p_{uf} \tag{2.20}$$

$$\frac{\partial C}{\partial p_{uf}}=-2f(t)\left((r_{ui}-\sum_{f=1}^{F}p_{uf}q_{if})q_{if}+2\gamma q_{if}\right) \tag{2.21}$$

After multiple iterations of optimization, the following results were obtained as formula (2.22) and (2.23):

$$p_{uf}=p_{uf}+\tau\left((r_{ui}-\sum_{f=1}^{F}p_{uf}q_{if})q_{if}+\gamma p_{uf}\right) \tag{2.22}$$

$$p_{if}=p_{if}+\tau\left((r_{ui}-\sum_{f=1}^{F}p_{uf}q_{if})q_{uf}+\gamma p_{if}\right) \tag{2.23}$$

Among them, $\tau$ is the learning efficiency, and the larger the value of Among them, $\tau$ is the learning efficiency, and the larger the value of $\tau$, the faster the gradient decreases. Its value needs to be obtained through multiple experiments, where $\tau = 0.02$. After multiple iterations above, the parameters $p_uf$ and $q_if$ can be obtained, and then the user s knowledge point mastery score can be predicted.According to this algorithm, the corresponding implicit semantic matrix P and Q can be obtained. After calculation, a complete user knowledge mastery matrix can be obtained. Based on the predicted value of this matrix, the corresponding weak knowledge points can be recommended for users. The larger the value, the higher the recommendation degree, and vice versa., the faster the gradient decreases. Its value needs to be obtained through multiple experiments, where $\tau = 0.02$. After multiple iterations above, the parameters $p_uf$ and $q_if$ can be obtained, and then the user s knowledge point mastery score can be predicted.According to this algorithm, the corresponding implicit semantic matrix P and Q can be obtained. After calculation, a complete user knowledge mastery matrix can be obtained. Based on the predicted value of this matrix, the corresponding weak knowledge points can be recommended for users. The larger the value, the higher the recommendation degree, and vice versa.

**2.5. Overall System Framework Design.** The VR Chinese language teaching system is an innovative solution based on virtual reality technology, which utilizes VR technology to create a virtual classroom with a sense of realism and immersion. Its focus is to provide high-quality Chinese language education resources for users in different geographical locations, making Chinese language learning more convenient and efficient. The development engine of the system adopts 3ds Max, with the 3D model module and human-computer interaction module being the two core modules of the system. The 3D model module is mainly used to construct various models in the scene, while the human-computer interaction module is responsible for achieving interaction between users and the system. In the 3D model module, the 3ds Max software performs 3D modelling of the objects required for teaching. Various technologies are used to construct the required models during the

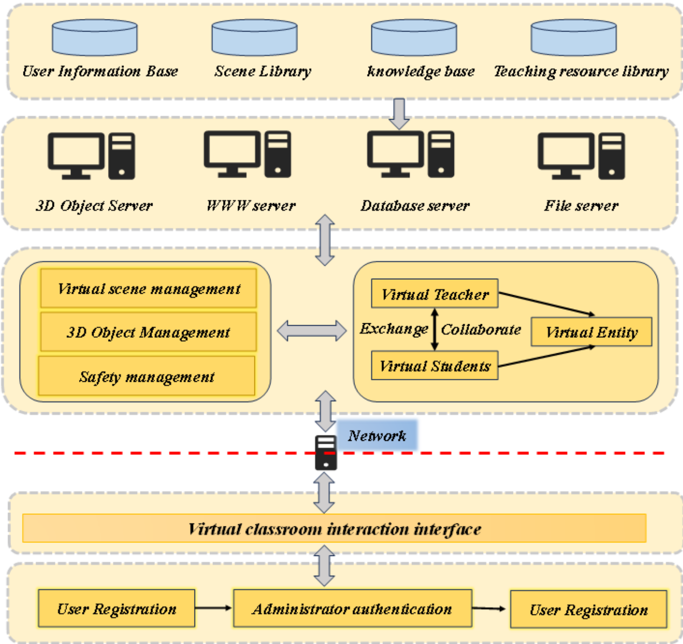


Fig. 2.2: System Architecture Diagram

modelling process quickly. At the same time, in order to improve the realism and quality of the model, it is necessary to render the relevant model. 3ds Max software has a very powerful modeling function, but its disadvantage is that the model data is often large, which is not conducive to scene fusion and network transmission. Therefore, after the model construction is completed, optimizing the established 3D virtual model is necessary to make it more suitable for VR teaching systems. In the human-computer interaction module, it is mainly necessary to consider the interaction between users and the system. It is necessary to design a set of interactive methods to connect users with the system and ensure that users can quickly and conveniently obtain the required information and learning materials [15]. The Unity engine is mainly used during this process, and programming uses the # language. In this way, functions such as interactive operations and data transmission can be easily implemented. The system architecture diagram is shown in Figure 2.2.

## 3. Construction of Chinese Language Teaching System Based on Virtual Reality Technology.

**3.1. Implementation of Chinese Language Teaching System.** 3D scene synthesis is a method that utilizes computer technology to transform real or fictional scenes into 3D models and endow them with functionality and interactivity [27]. It is mainly divided into three stages: the data collection stage, scenario modelling stage, and function implementation stage. The data collection stage is to obtain basic information about the scene, including teaching scene maps, authentic images, and model planning maps. These data can help designers determine the structure and style of the scene [28]. The scene modelling stage is to create a three-dimensional model of the scene, including text, graphics, texture mapping processing, 3ds Max modelling, and Vary rendering, to give the scene a realistic appearance and effect. The function implementation stage adds functionality and interactivity to the scene, including gaze function, animation function, interactive Chinese teaching system, and model planning.

The perception layer in virtual teaching testing is the simulation and reproduction of the perception layer in the three-layer structure of the real Internet of Things. This part mainly consists of virtual sensors and intelligent devices, which only exist in the simulation experimental environment but have data parsing and transmission functions, mainly including receiving or sending control instructions and parsing the received control instructions according to a specific protocol format; finally, based on the analysis results, the linkage

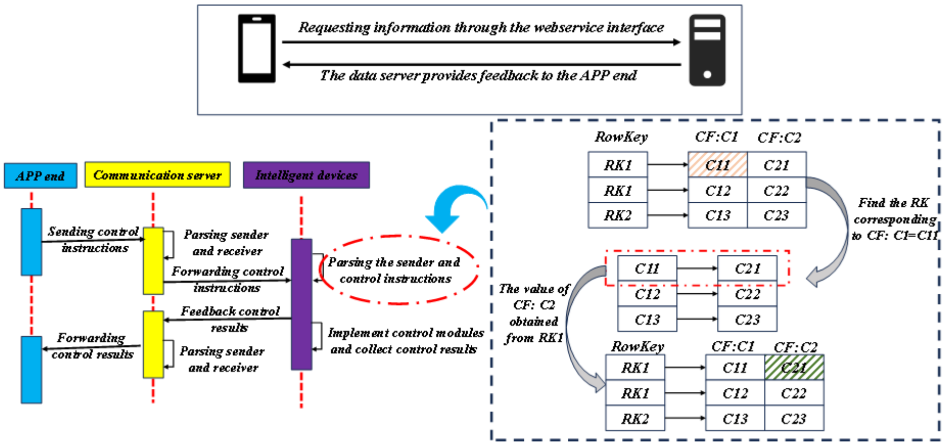


Fig. 3.1: Information transmission process of VR Chinese language teaching system

effect of devices in the virtual scene is achieved [29]. The network layer in the virtual teaching testing of the Internet of Things simulates the communication process between users and intelligent devices in the scene. It can be divided into two parts: the communication server side and the data server side. The network layer plays an indispensable role between users and smart devices. It receives control instructions issued by users through the mobile app, parses the instructions in a specific format, and forwards them to the smart devices in the scene. In turn, it can also transmit the information obtained by the smart devices in the scene after operation to the user s mobile app, completing bidirectional feedback.

Based on the virtual teaching system s actual requirements in this article, establishing a secondary index is used to optimize data retrieval. In order to meet the basic requirements of multi-condition queries, multi-dimensional fields are usually used to combine and assemble Row keys or to find the target data through complete table scanning and filtering. However, this method could be more efficient and meet the system s basic requirements of low latency. Therefore, this article solves this problem by designing a secondary index. The current data table has a Row Key column with RK1 and RK2, including CF: C1 and CF: C2 column families. To establish an index on CF: C1, you only need to establish a mapping relationship between the column value of one of its columns and the row key RowKey. When the user needs to query the value of CF: C2 corresponding to C11, first find the primary key RK1 of the original data table corresponding to C11 through the index table in the diagram, and then query to obtain the value of CF: C2 as C21. The overall implementation process is shown in Figure 3.1. A secondary index utilizes a non-primary key to map the primary key, Row Key, using the non-primary key column names and values as the primary key of the index table. This allows for using the index table s primary key (non-primary key of the original data table) to query and obtain the Row Key when the Row Key of the original data table is not given.

Before using extensive data analysis for prediction and recommendation, it is necessary to migrate the data from the database server (MySQL) to HBase. This article uses the Sqoop tool for data extraction and migration [30, 31]. In addition, this paper designs two data tables in HBase database, which are user information table and knowledge information table. The former stores the user's basic information and assistance behavior, while the latter stores the knowledge point loss information.When conducting data calculations, the two are continuously correlated and queried to obtain basic information about the user s mastery of each knowledge point. Finally, this article adopts the HBase secondary index scheme described earlier, storing the correspondence between primary and non-primary keys in a separate index table to improve query efficiency. The structure of the secondary index table is shown in Table 3.1.

**3.2. Implementation of Personalized Teaching Resource Recommendation Module.** The system is designed for students of different ages and Chinese proficiency, including beginners, intermediate learners,

Table 3.1: HBase Index Table Structure

| Primary key | Knowledge point information | Information value | User Primary Key |
|---|---|---|---|
| (rowkey) | k-rowkey: k-poperty | (value) | (u-rowkey) |

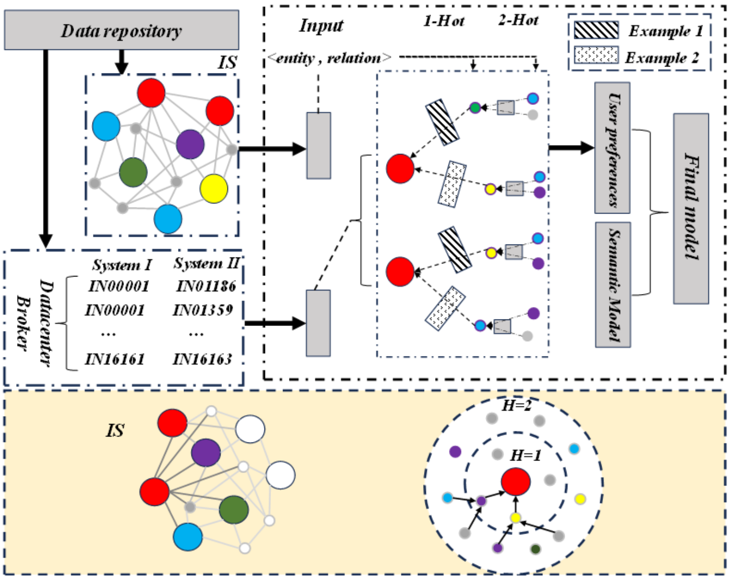


Fig. 3.2: Implementation process of personalized teaching resources

and advanced learners. Some students need to learn Chinese for daily life, while others need to learn Chinese for career development or academic research. The system helps students improve their Chinese skills in listening, speaking, reading, and writing. In addition to the language itself, the system helps students understand the Chinese cultural and social context and promotes cross-cultural communication and understanding.

Implementing a personalized teaching resource recommendation module is based on learners' personal information and many teaching resources provided by the system [32]. Firstly, the system will collect and analyze students' personal information, such as language proficiency, learning goals, learning habits, and learning history. This information can be obtained through learner's registration forms, learning records, and self-assessment [33]. The system will match and filter resources based on learners' personal information and learning needs, combined with the attributes and labels of teaching resources. It uses recommendation algorithms and machine learning techniques to analyze learners' preferences and recommendation history, inferring their potential interests and preferences. Students can obtain teaching resources matching their language proficiency, learning goals, and personal preferences through the personalized teaching resource recommendation module. Such recommendations can help learners learn Chinese more efficiently and improve learning motivation and outcomes. At the same time, the system will continuously optimize personalized recommendation algorithms based on learners learning progress and feedback to provide more accurate, tailored, and diverse teaching resources. The implementation process of personalized teaching resources is shown in Figure 3.2.

MapReduce is an offline batch computing framework in the Hadoop system. The system uses MapReduce to preprocess data and then decompose the matrix of users' lost points in knowledge points with the help of user behaviors.The data preprocessing section mainly cleans and filters the behavior logs of users participating in virtual teaching experiments and assists the data on users score loss in various knowledge points. On the one hand, the distribution matrix of user knowledge point loss is first iterated through the Map stage to generate a user-implicit class matrix. This matrix describes the user s weak knowledge domain; that is, the knowledge

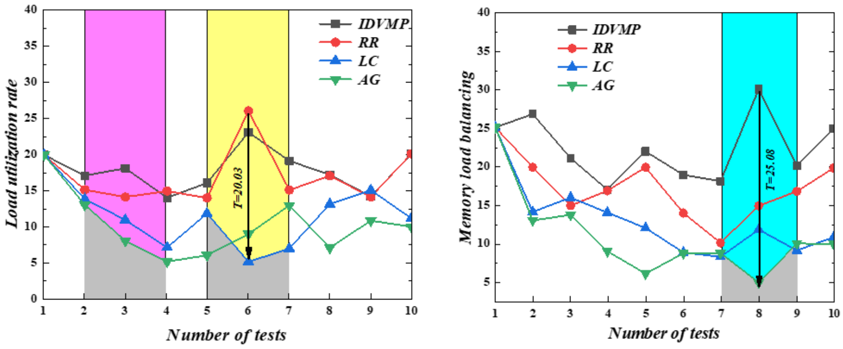


Fig. 4.1: Load balancing tolerance under different algorithms

point loss in that domain is relatively high. Secondly, the data completed by Reduce will be imported into the HBase database and stored as columns in the user information table. Finally, the efficiency of querying relevant information in HBase SQL will be improved by constructing a secondary index table to cope with the subsequent Spark Streaming stream computing user behavior data, updating predictive recommendation models, and completing online recommendations. On the other hand, the user knowledge point loss matrix can also be iteratively generated through the Map stage to generate knowledge point-related implicit class matrices.

## 4. Analysis of Experimental Results.

**4.1. Load Balancing Capability.** This section evaluates the load balancing ability, with the primary evaluation criteria including system load utilization. Similarly, the IDVMP algorithm was compared with RR, LC, and AG in experiments, and the experimental results are shown in Figure 4.1. Although the LC algorithm has a slightly lower load balance than the AG algorithm, it still has significant advantages in load utilization compared to IDVMP and RR algorithms, with a maximum load rate of 20.03. LC performed well in terms of load balance, with a maximum difference of 25.08 compared to IDVMP. When the number of tasks is low, there is no difference in execution time among the algorithms. As the number of tasks continues to increase, the execution time of the RR and IDVMP algorithms significantly improves. However, they have significant advantages compared to the LC algorithm, which requires multiple iterations. Therefore, the LC algorithm designed in this article reduces the additional communication overhead generated during the load-balancing process and has better load-balancing capabilities than other algorithms.

**4.2. Value of Time Effect Factor $\alpha$.** Considering the impact of time effect on the user s mastery of knowledge points, this paper aims to minimize the solution s root mean square error and obtain the time effect factor µ currently. After conducting several experiments on the time effect influencing factors under different weights, the RMSE under the influence of different time effect factors µ was obtained, as shown in Figure 4.2. The horizontal axis represents the number of implicit classes f under the implicit semantic model, and the vertical axis represents the RMSE under the influence of µ. The experimental results show that when the time effect influence factor $\mu = 0.5$, the matrix decomposition algorithm based on the improved implicit semantic model has the highest accuracy.

**4.3. Interactive Analysis of Traditional Teaching and Virtual Teaching Systems.** Randomly select 1000 students, use two teaching systems to learn, and obtain the system interaction comparison results shown in Figure 4.3. Through the teaching system designed in Figure 4.4, the number of information submissions is roughly the same as that of information feedback. The degree curve of active and passive interaction fluctuates sharply, indicating that the system interacts frequently and provides real-time active feedback for teaching information to operators using the system. When users ask questions, they promptly provide explanations for the problems. Through comparison, traditional teaching systems have poor interactivity, which affects students' interest in learning. Figure 4.4 shows the distribution of traditional learning methods and virtual

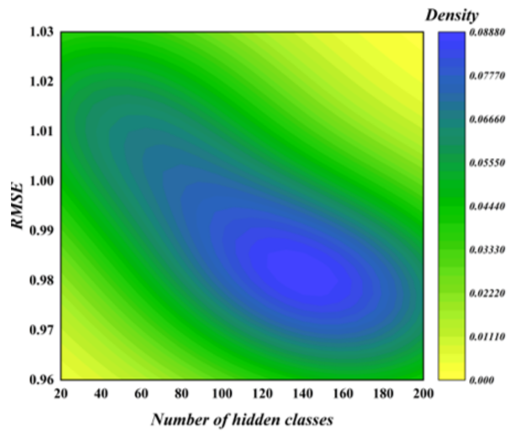


Fig. 4.2: Different Value of time effect factors $\alpha$

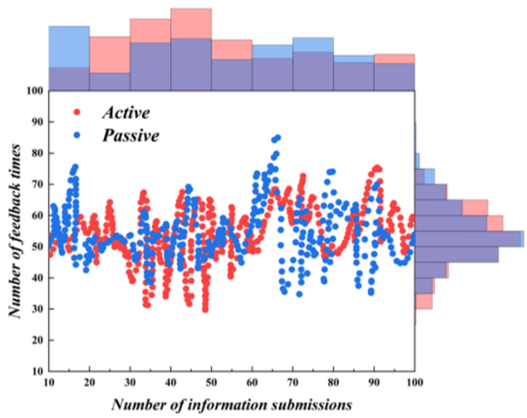


Fig. 4.3: Frequency of Interaction between Active and Passive Learning

reality teaching methods in terms of learning time, homework scores, and test scores. A correlation curve is drawn by collecting the homework and test scores of 1000 students, as shown in Figure 4.4. From the graph, we can see that there is a highly significant positive correlation between learning duration and academic performance (homework and test scores). At the same time, virtual reality teaching technology has a 20% 30% improvement in homework and test scores compared to traditional teaching methods, and students are also more willing to learn. The Spearman correlation analysis results show that traditional teaching methods have R2 values of 0.6953 and 0.0983 for homework and test scores, respectively. Virtual reality teaching methods have R2 values of 0.4944 and 0.3268 for homework and test scores, respectively.

**5. Conclusion.** This study uses virtual reality technology and has designed and implemented a Chinese language teaching system. Through the development and application practice of this system, the main conclusions are as follows:

1. Virtual reality technology can create realistic virtual environments and provide students with an immersive Chinese learning experience. Students can participate in simulations of various real situations through virtual reality technology, increasing their learning interest compared to traditional teaching methods.
2. Although the LC algorithm has a slightly lower load balance than the AG algorithm, it still has a

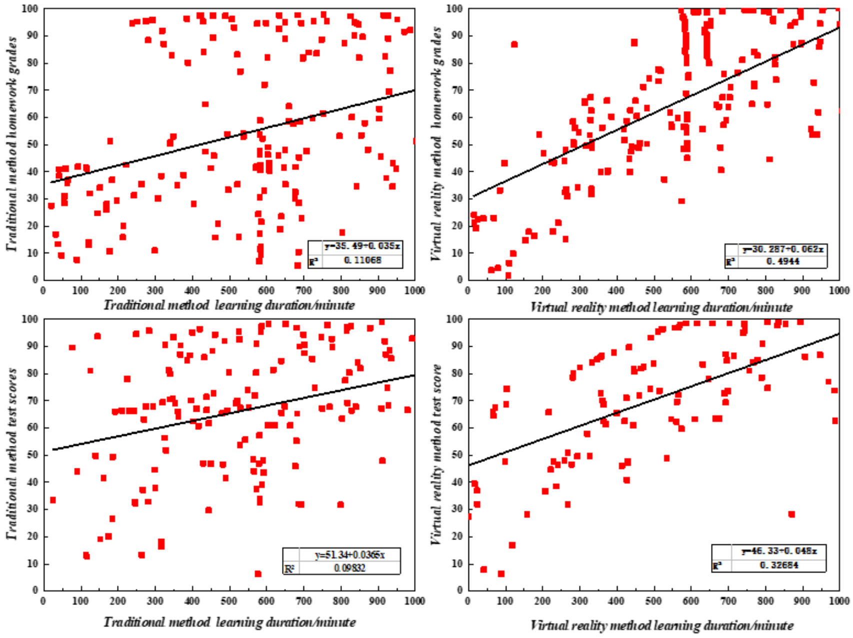


Fig. 4.4: Impact of Traditional and Virtual Reality Teaching on Homework and Test Scores

significant advantage in load utilization compared to IDVMP and RR algorithms, with a maximum load rate of 20.03. Regarding load balance, LC performs well overall, with a maximum difference of 25.08 compared to IDVMP. Therefore, adopting the LC algorithm reduces the additional communication overhead generated during the load-balancing process and has better load-balancing capabilities than other algorithms. For the implicit semantic model, when the time effect influence factor $\mu = 0.5$, the matrix decomposition algorithm based on the improved implicit semantic model has the highest accuracy.

3. Aiming at the low degree of individuation in the teaching system, this paper optimizes the user application layer, recommends personalized teaching methods, builds the knowledge point association matrix integrating multiple factors according to the knowledge point association and the interactive relationship between virtual users, and introduces the rule of time forgetting to decompose the user knowledge point association matrix. According to the decomposition results, personalized teaching guidance for users is realized.

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