RESEARCH ON IMMERSIVE DIGITAL CULTURAL COMMUNICATION SYSTEM FOR LOCAL LANGUAGE AND CULTURE

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ABSTRACT

This paper presents an innovative immersive digital cultural communication system focusing on local language and culture. Utilizing virtual reality technology, the artistic, historical and linguistic elements of local culture are transformed into a digital format, which breaks through the limitations of traditional linear information dissemination and realizes two-way interaction. Users were involved in the creation and dissemination of information, and a comprehensive immersive technology platform was also constructed through a multi-stage planning, design, implementation and feedback loop. The results show that the Mongolian language user engagement was 70%, the lowest of all the regions studied. The Hmong language system demonstrated good stability with an operational stability score of 4.4. The Tibetan language users' satisfaction with the system was as high as 42 points, showing a high level of overall satisfaction with the system. It not only confirms the current effectiveness of the system, but also is of great significance in promoting immersive digital communication of local languages and cultures.

KEYWORDS

INDEX

1.   INTRODUCTION

Under the impact of globalization and the wave of digitization, local languages and cultures are facing increasingly prominent challenges [1-2]. Traditional cultural communication methods have gradually lost their inclusiveness towards multiculturalism, while mainstream digital communication platforms focus more on globally common linguistic and cultural elements, leading to the predicament of the inheritance of local languages and cultures in the digital era [3-4]. Many local languages and cultures have not been effectively inherited and promoted due to the lack of communication systems adapted to the digital environment. The digital communication of local language and culture is no longer limited to words and images, but through virtual reality, augmented reality and other technologies, users are placed in immersive cultural scenes, so that the audience can feel, understand and experience the unique charm of local language and culture more intuitively [5].

N.E. Merkish discusses the problem of modeling cultural and linguistic environments in the process of training professionals in intercultural communication. Criteria for selecting media materials, determining the functioning of the multimedia environment and identifying the advantages and controversial aspects of its creation are identified. In the course of the research scientific methods of analysis of theoretical sources, empirical-empirical analysis and systematization were used [6]. Muthusamy, V proposed that each language is a replica of its culture and value system, and since each language is rooted in its native culture, faces the challenge of conquest of a foreign language [7]. Shevchenko, B. In the context of language training for military translators in the professional context, the study of linguistic and cultural realities of translation of the characteristics of the educational profession of military language discourse also includes linguistic and cultural realities related to the designation of weapons systems and military equipment of the armed forces of the country's foreign language is being studied [8]. Shan, L focuses on the role of informational technology foreign language teaching in the promotion of education technology culture in China. The introduction of information technology in foreign language teaching and the implementation of informationalized teaching methods in the foreign language classroom are conducive to the establishment of a multimodal corpus in the course website, the realization of a multidimensional interactive teaching model inside and outside the classroom, and the improvement of the diversity of the evaluation system [9].

Yuxiangt, Xi. suggests that the core and purpose of teaching Chinese as a foreign language is to cultivate students' Chinese communicative competence. For students whose mother tongue is not Chinese, this Chinese communicative competence is an intercultural dialogic competence [10]. Arifin, F uses qualitative analysis and applies the method of language planning to explore the role of language preservation when it is in the industrial revolution. The results of the study showed that the government suggested Indonesian language preservation to fill in the lyrics using local language songs in order to raise awareness of local language use among the Indonesian people [11]. Nersesyan, G explored the characteristics of the verbalization of values in

the discourse of English science teaching. A comprehensive analysis of chapter fragmentation in the process of teaching a foreign language from the perspective of linguistic value theory and pragmatic-discursive discourse is presented and a definition of this type of discourse, which is a set of communicative practices that serve the learning process, is proposed [12]. Wahyuningtyas, D. used a virtual ethnography approach to collect offline and online data on the broadcasting content of four cultural radio stations, and the results showed that each of the radio station has excellent cultural programs with a solid appeal to maintain the loyalty of listeners, and the love of local culture is a strengthening of national identity, which is the richness of Indonesian culture [13].

This paper utilizes the core concept of immersive experience to model an immersive digital cultural communication system based on VR. Immersive technology is utilized to preserve, disseminate and promote unique local cultural heritage by converting local cultural elements into digital format. And the language recognition function is introduced, the system can automatically detect the user's preferred language, and can provide recommendations and personalized suggestions for relevant content. The cultural communication model is utilized to determine the state of the communication information. In the practical analysis, the effectiveness of the immersive digital cultural communication system is judged through multi-scenario validation, adaptation and stability validation, which proves that the digital cultural communication system is more effective in local language and culture communication, reflecting the diversity and complexity of the local culture. Through immersive experience and digital technology, it provides an innovative method for local language and culture communication.

2. IMMERSION COMMUNICATION PATHWAY OPTIONS

2.1. IMMERSION COMMUNICATION THEORY

Immersion is a psychological state in which people achieve an optimal experience when participating in an activity [14-15]. Users in immersion can better enjoy the experience process, and immersion refers to the immersion of objective existences in the physical space on the one hand, and the immersion of the subject's cognition in the consciousness space on the other. Immersion experience is also known as immersive experience, which refers to a state in which a person is completely devoted to the activity process and forgets about himself. The core concept of immersive experience focuses on the needs and feelings of the audience throughout the process, breaking the traditional linear information dissemination model and realizing two-way interaction, so that the experiencer becomes the creator and disseminator of information. Immersive communication, on the other hand, refers to communication that is immersed in the media and emphasizes that the audience is surrounded by the new technology of the media [16]. Immersive communication is a breakthrough to the

traditional information dissemination methods, so that the information in the interaction with people to produce emotional resonance, focusing on shaping a strong sense of participation and immersion in the process of information dissemination.

2.2. VR-BASED CULTURAL COMMUNICATION

The VR-based cultural communication model is shown in Figure 1, which firstly requires the conversion of local cultural elements, such as art, history, and language, into digital format [17]. This includes 3D scanning of local artwork, digitizing historical documents, etc. Use VR technology to create an immersive experience by creating virtual environments in which users can interact with cultural content. Design how users will interact with the VR environment and how it will provide an educational and entertaining experience. Ensure that the system is open and accessible to users of different skill levels, including those of different ages, cultural backgrounds, and technical proficiency, and that cultural content is appropriately presented and interpreted in the VR environment in a way that respects and reflects the diversity and complexity of local cultures [18-19].
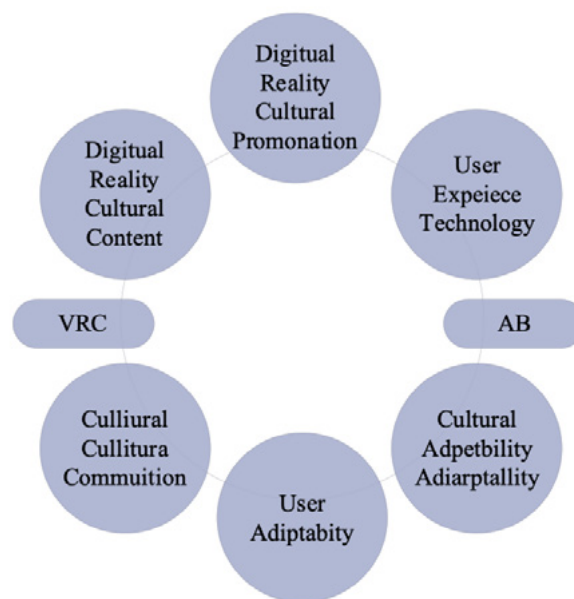

Figure 1. VR propagation model

VR technology is utilized to create an immersive virtual environment in which users can freely explore and interact with cultural content. This type of interaction goes far beyond traditional methods of learning and experiencing, allowing users to gain a deeper understanding and experience of local culture in a whole new light. For example, users can step into historic buildings in virtual reality, experience the process of making traditional crafts for themselves, or experience different local languages and dialects in virtual reality. Such immersive experiences make cultural learning more vivid and intuitive.

When designing VR environments for interactivity, it is vital to consider both educational and entertaining aspects. Designers need to balance these two aspects to ensure that users can gain knowledge and understanding while enjoying entertainment. To this end, VR environments can integrate a variety of interactive elements, such as gamified learning, task challenges, and interactive guided tours, aimed at increasing user engagement and learning. In addition, ensuring that the VR system is open and accessible to users of different skill levels is also an important point of consideration. The system should be designed to be simple and intuitive, making it easy to use for users of all ages and technical proficiency levels. This may involve simplified design of the user interface, multilingual support, and customization of content to accommodate users from different cultural backgrounds. For example, for older users, more intuitive and simple operating instructions could be provided. For users from different cultural backgrounds, appropriate language options and cultural explanations could be provided. Finally, ensuring that cultural content is appropriately presented and interpreted in VR environments is crucial and needs to respect and reflect the diversity and complexity of local cultures. Cultural communication is not only about presenting cultural elements, but also about conveying the meaning and values behind them. Therefore, VR content needs to be developed in close collaboration with local cultural experts, historians and community members to ensure cultural authenticity and depth. In addition, VR experiences should include detailed explanations and background information on cultural elements to help users gain a deeper understanding of their cultural and historical significance.

2.3. SAMPLE SELECTION

In local language and culture communication, feature selection is an important task of the maximum entropy model, assuming that the categorical attribute values of feature selection constitute all output values Y of a stochastic process P. For each $y \in Y$, its occurrence is influenced by the decision attribute values X associated with it. Knowing that the set consisting of all decision attribute values associated with Y is X, the goal of the model is to compute the conditional probability that the output is $\{y \in Y\}$, i.e., to estimate $P(y \mid x)$, for all decision attributes $\{x \in X\}$ given where $y \in Y$ and $x \in X$.

Which linguistic information serves as predictive information i.e., it is a matter of feature selection. Therefore, the criterion for judging whether the features are effective or not is to see whether the model succeeds in selecting from the many decision attributes the features that have obvious characterization effects on the categorical attributes, and thus play an obvious role in determining the entropy value. The feature selection process is based on sampled data, so the accuracy of the sampled data is critical. The sampling data comes from a reliable sampling database and for the feature space also contains spatial data information, which can be represented as $(x1, y1), (x2, y2), \ldots, (xi, yi), \ldots, (xn, yn)$.

where xi denotes a decision attribute, either spatial or non-spatial data, and yi is a categorical attribute, a class labeling number provided by an expert. The lexical properties of the word to be labeled are related to the language and culture in which the word is found, and the contextual environment information is described by features.

3. IMMERSIVE DIGITAL CULTURAL COMMUNICATION SYSTEM CONSTRUCTION

3.1. BUILDING AN IMMERSIVE TECHNOLOGY PLATFORM

The aim of this paper is to preserve, disseminate and promote unique local cultural heritage through the use of immersive technologies such as virtual reality, augmented reality and mixed reality. In this research, building an immersive technology platform is a central aspect that involves multiple stages of planning, design, realization and feedback loops. The structure of the technology platform is shown in Figure 2 and includes the following modules:

1. Detailed research is needed on local cultural characteristics, language usage habits, and the needs of the target audience. For example, if the research object is the folktales of a certain place, it is necessary to understand the traditional narrative style of these stories, the characteristics of the characters, and the connection with the local society and culture. It is also necessary to determine the ultimate goal of the technology platform, such as whether it is for educational popularization, cultural preservation, tourism promotion or other purposes.

2. The technology selection and design phase determines the technical infrastructure framework of the platform, including the selection of appropriate immersive technologies, hardware devices, and software tools. In addition, a data architecture needs to be designed to store and process cultural data to ensure that the platform can operate efficiently.

3. The content development and interface design phases are the core of creating an immersive experience, which requires digitizing cultural elements, creating 3D models, and writing interactive scripts. The interface design, on the other hand, needs to focus on the user experience to ensure that the interface is intuitive and easy to understand, and can guide users to naturally explore the culture.

4. The system development phase involves transforming the designed content and interface into an actual operable platform. This includes coding, integrating various media elements, and testing interactive performance. During this phase, the development team needs to work closely together to ensure that the technical implementation is consistent with the creative design.

5. Testing is a critical step to ensure platform stability and quality of user experience. Through internal testing, small-scale user testing and multiple rounds of iteration, the platform performance is continuously optimized. After confirming that there are no major technical problems, the platform can be officially released for public use.

6. The released platform also requires regular maintenance and updates. Collecting user feedback is an important way for continuous improvement, which includes user's usage data analysis, direct user evaluation, and so on. Necessary content updates and functional iterations are made based on the feedback so that the platform can continue to adapt to changes in user needs.
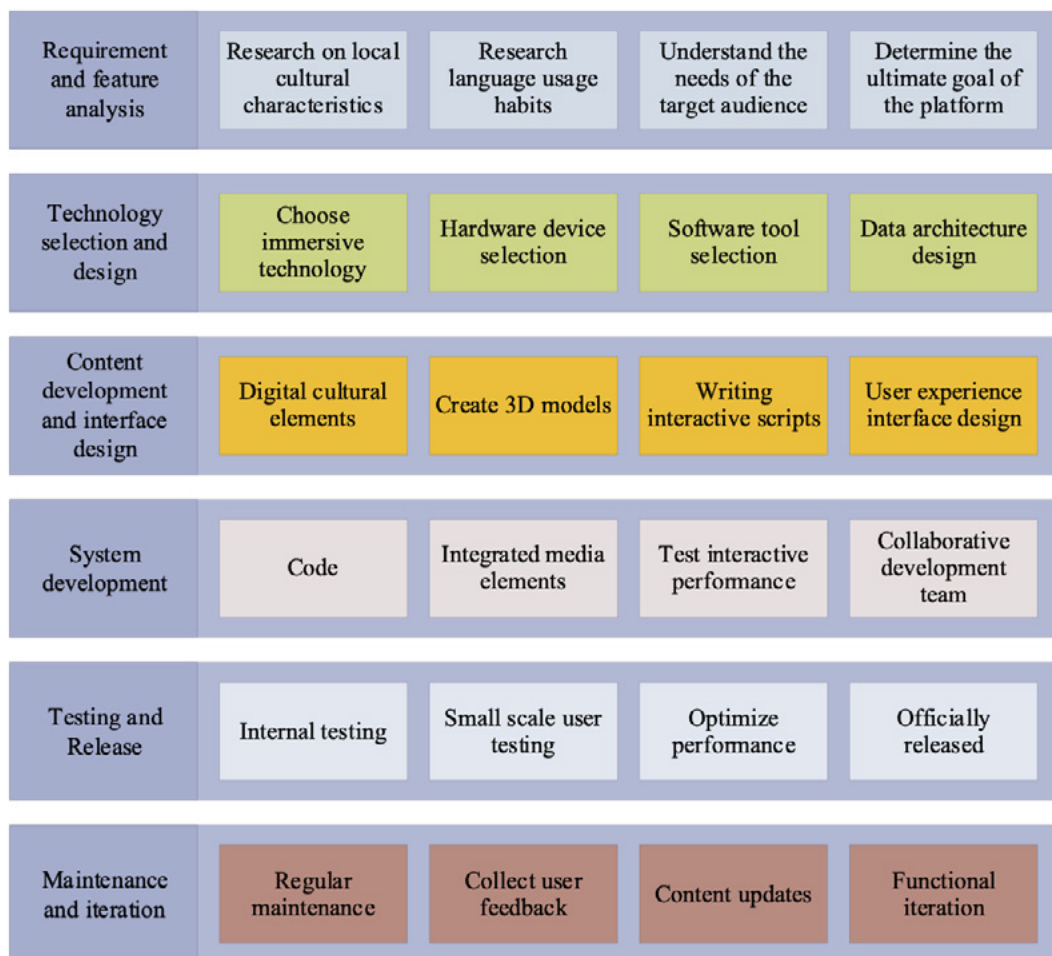

Figure 2 Technology platform architecture

3.2. DEVELOPMENT OF COMMUNICATION SYSTEMS TO SUPPORT LOCAL LANGUAGES AND CULTURES

Local languages and cultures are the unique cultural heritage of a country or region; they carry specific histories, values, and traditions that are essential to community identity and cultural diversity [20]. Therefore, the aim of this paper is to study and design a digital cultural dissemination system that supports the

dissemination of local language and culture. The design of the dissemination system is shown in Figure 3. Before starting the design of the system, it is first necessary to clarify the goal of the system to create an immersive digital cultural dissemination system to support and promote local language and culture. The system should be able to effectively disseminate and present local language and culture content, including articles, videos, and music. The system should support multiple local languages, including full localization from user interface to content. Provide a powerful content management system so that content creators can easily upload, edit and manage works of language and culture.

In addition the user interface is the face of the system and the design is critical. The interface should be kept simple and intuitive so that users can easily navigate and interact with it, using clear navigation bars and menus so that users can easily find the content they need. Provide an intuitive search function so that users can quickly find content of interest. In addition to this, the interface should support multiple local languages so that users can choose the interface language according to their language preference. Provide language switching options so that users can change the interface language at any time. The user help documentation should also be fully localized to ensure that the user understands the instructions for using the system.
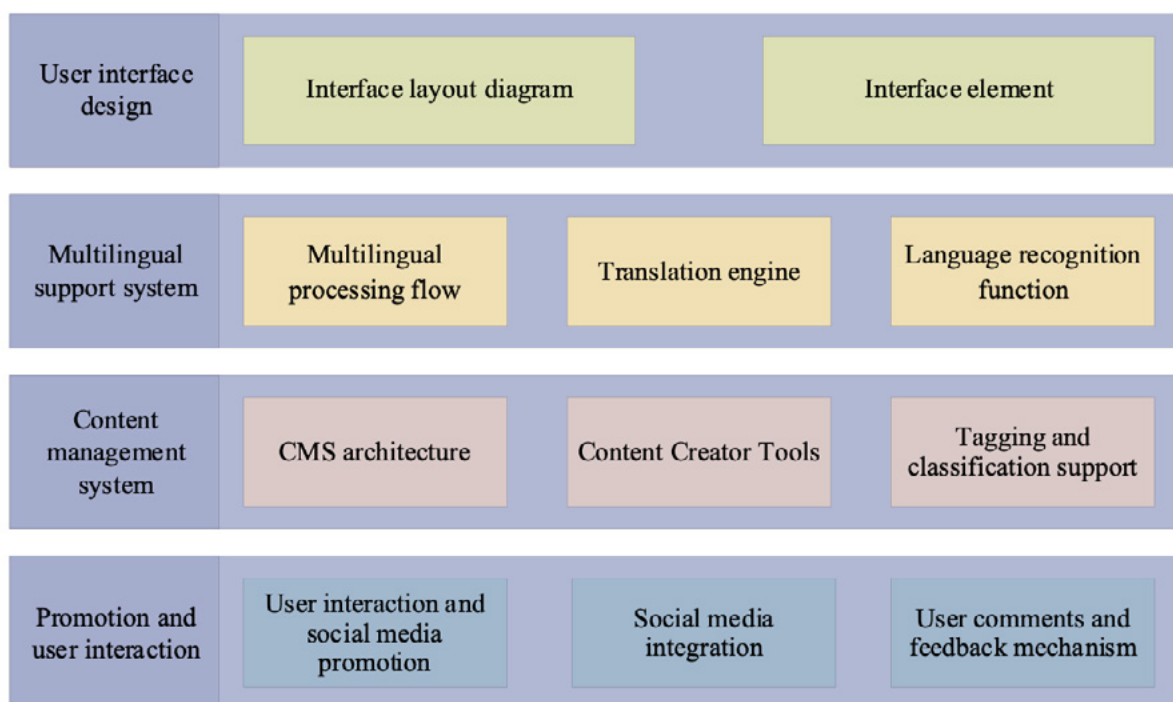

Figure 3. Dissemination system design

The multilingual support system is the core component that ensures that the system is able to showcase and disseminate local language and culture [21]. A powerful translation engine is introduced that can support instant translation of user uploaded content. The engine should have high-quality translation capabilities to ensure the accuracy and fluency of the content. User uploaded content should be able to automatically recognize the language and provide translation options. With the

introduction of language recognition, the system can automatically detect the user's preferred language. Based on the user's preferred language, the system can provide recommendations and personalized suggestions for relevant content, and the user should also be able to manually select language settings [22].

Content Management System is a workbench for content creators, providing a convenient content upload interface that supports various types of media, including articles, videos, audios and more. Content creators can easily edit and format their work and upload related multimedia files. At the same time, content creators are allowed to add tags and categories to their works so that users can easily search and discover related content. The system can automatically suggest tags and categorizations to improve content discoverability.

3.3. PROPAGATION CALCULATIONS

Let the following variables N be the total number of people, $s(t)$ be the proportion of people who have not heard the local language at that moment t and $i(t)$: be the proportion of people who have transmitted the local language at that moment t. λ is the daily contact rate between each person who transmits the local language and those who have not heard the local language, assuming that the number of people infected per unit of time by each local language transmitter is proportional to the number of people who are not infected at that moment, and according to the assumption, each transmitter can turn $\lambda s(t)$ ignorant people into local language transmitters per day, because the number of local language transmitters is $i(t)$ so that there are $\lambda N s(t)i(t)$ ignorant people who are being transmitted per day, and so $\lambda N s i$ is the rate of increase of the number of local language The rate of increase in the number t of propagators i.e:

$$\frac{di}{dt} = \lambda si \tag{1}$$

When $i = \dfrac{1}{2}$, $\dfrac{di}{dt}$ reaches its maximum value of $\left(\dfrac{di}{dt}\right)_m$, and this moment is $t_m = \lambda^{-1}\ln\left(\dfrac{1}{i_0} - 1\right)$. This is the moment when the number of dialect speakers increases the fastest, signaling the arrival of the dialect transmission period, which is a moment of concern for the officials. Obviously the increase of daily contact rate and the innovation of dialect transmission media, the dialect transmission period will come earlier. However, when the time increases infinitely, eventually all the people become dialect transmitters, which is obviously not realistic.

The reason for this is that it does not take into account the fact that there is a clear and essential difference between the transmission of information and the transmission of dialects. For example, information communication is memorized, while dialect communication is not. Information dissemination is socially reinforcing, whereas

dialect dissemination is not. For a message, each link of communication is generally used only once, while dialect communication can be used several times. Based on these three considerations, this paper proposes a new model of cultural communication. For each time step, each body is in one of four states, namely, the unaware information state, the known information state, the confirmed information state, and the exhausted state. There are seven differences between information communication and dialect communication:

1. Information propagation activity decays rapidly over time, whereas dialects generally do not.

2. The different types of information communication differ not only in their propagation power, but also in their mode of propagation, whereas the intensity of contact in dialect communication only causes differences in the probability of propagation.

3. Information dissemination is significantly influenced by the content of the information, and the effective network activated by each dissemination is different.

4. There are qualitative differences in the roles of different communicators in information dissemination.

5. Information dissemination has a memory effect, which is influenced by previous exposure to information.

6. Information dissemination has a social reinforcement effect, for example, if a local language is heard from two places at the same time, its persuasive power is twice as high as if it is heard from one place.

7. A link in information dissemination is generally used only once.

4. PERFORMANCE AND USER EXPERIENCE EVALUATION

4.1. MULTI-SCENARIO VERIFICATION

4.1.1. VALIDATION OF MULTILINGUAL SUPPORT

In order to test whether the system correctly supports various local languages, tests were conducted using Tibetan, Uyghur and Mongolian from 2012 to 2022. Figure 4 shows the analysis of minority language usage frequency. Before the construction of the immersive digital cultural communication system, the usage frequency of the three languages fluctuates a lot, showing high and low fluctuations, but not more than 100%. And after the application, the usage frequency of the three languages shows a

linear growth trend, up to 140%. It shows that the immersion constructed in this paper can support multiple minority languages and has made long-term progress.
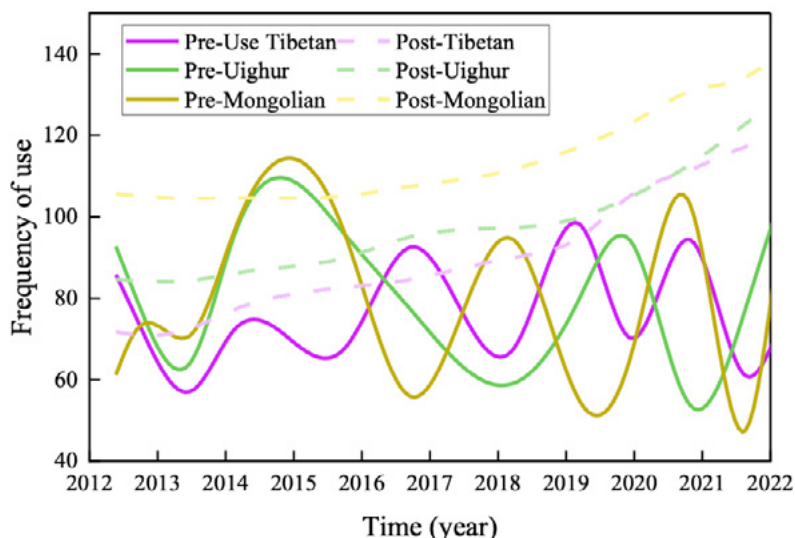

Figure 4. Frequency of use of minority languages

Meanwhile, the accuracy rate of immersive digital cultural communication is compared with machine learning methods for the three languages, and the accuracy results are shown in Table 1. The immersive communication method shows a high accuracy rate in digital cultural communication in these three languages, with accuracy rates above 95%, and the machine learning method has a lower accuracy rate in these languages, which is only 66% for Manchu translation, and the work performance still needs to be improved. Multimedia dissemination methods also achieved good results, but there is still some room for improvement, with accuracy rates ranging from 81-86%. Overall, immersion communication methods seem to be more effective in local language and culture communication.

Table 1. Minority language translation accuracy results

LANGUAGE	Immersive Communication	Machine Learning	Multimedia
Tibetan	99 %	80 %	86 %
Uyghur	98 %	76 %	84 %
Mongolian	95 %	75 %	83 %
Hmong	98 %	72 %	83 %
Korean	96 %	78 %	85 %
Manchurian	97 %	66 %	84 %
Hani	96 %	86 %	81 %

4.1.2. CONTENT MANAGEMENT SYSTEM VALIDATION

In order to assess the performance of the immersive digital culture dissemination system for local language and culture, the leakage rate of the immersive system is shown in Table 2, which shows that the immersive dissemination system shows a decreasing trend in the leakage rate from 5% to 0.5% with the continuous increase of feature vectors of the language text. It shows that the immersive dissemination system is able to better capture and disseminate local language and culture, and the performance improves with the increase of feature vectors. Machine learning and multimedia methods have relatively high miss rates, especially at smaller feature vectors. As the feature vector increases, the underreporting rate of the machine learning approach gradually decreases, but at a minimum of 6% and 4%, it is still higher than that of the immersive communication system. The advantages of immersive digital cultural communication system in disseminating local language and culture are emphasized. With the increase of feature vectors, the performance of the system continues to improve and the underreporting rate decreases significantly. Compared to traditional machine learning and multimedia approaches, the immersive communication system performs better in keeping the underreporting rate low, which is crucial for effectively communicating local language and culture. These results provide strong support and evidence for the application of immersive digital cultural communication systems in promoting cultural diversity and communication.

Table 2. Linguistic textual feature underreporting rate

Linguistic Text Feature Vector	Immersion communication underreporting rate/%	Machine learning underreporting rate/%	Multimedia underreporting rate/%
0	5	15	10
200	3	12	8
300	2	10	6
400	1	8	5
500	0.5	6	4

4.1.3. PROMOTION OF VALIDATION

In order to understand the impact of immersive digital cultural communication on the effect of local language and culture dissemination, the role and importance of immersive digital cultural communication in local language and culture dissemination is emphasized for the 18-50 year olds in a province. Figure 5 shows the comparison of the number of people before and after the dissemination, the number of people who mastered Hmong before the dissemination was 1,200, and after the dissemination there were 1,800 people, an increase of 600 people. There was also an increase from 1,100 to 1,600 in the gerund language and from 800 to 1,200 in Tibetan.
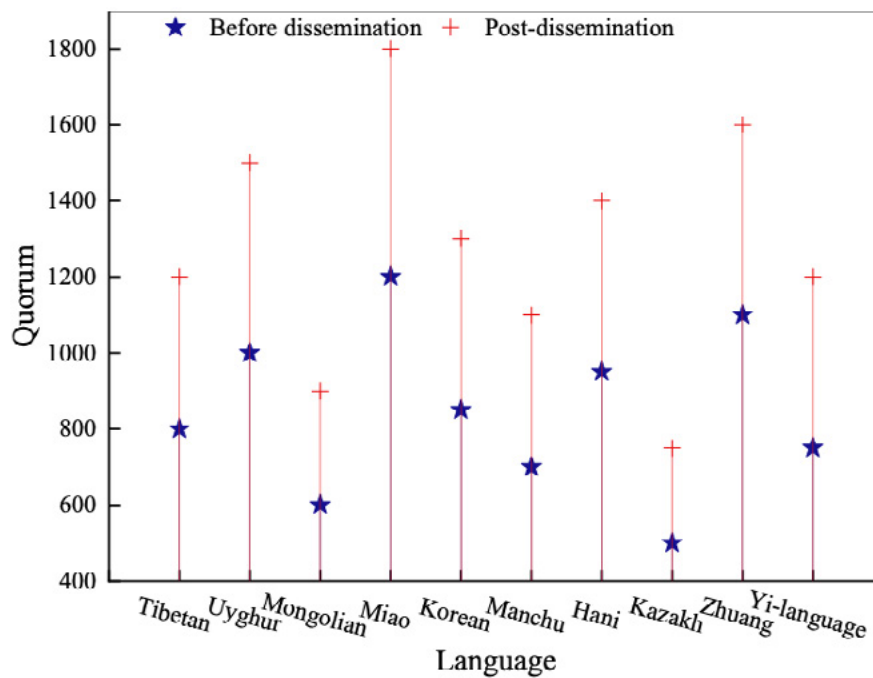
Figure 5. Comparison of numbers before and after dissemination

4.2. ADAPTATION AND STABILITY VALIDATION

In order to assess the adaptability and stability of the immersive digital cultural communication system, in different local language and culture contexts. Several regions with different local languages and cultures were selected for the study, and the immersive digital cultural communication system was implemented in each region to collect data on usage experience, user feedback, and system performance, and the results of the adaptability and stability analysis are shown in Table 3. The Mongolian language user participation rate of 70% is the lowest among all regions, indicating that the system has relatively low attractiveness in Region C. The Mongolian language user participation rate of 70% is the lowest among all regions. The Hmong language unity operation stability is 4.4 points, showing good stability. The Hmong Unity operational stability is 4.4 points, showing a high overall satisfaction with the system. The summary not only proves the current performance of the system, but also provides valuable data support for future optimization.

Table 3. Adaptation and stability analysis results

Area	Local Language	User engagement (%)	User satisfaction (1-5 points)	System operational stability (1-5 points)	Adaptability score (1-5)
A	Tibetan	75 %	4.2	4.5	4.3
B	Uyghur	80 %	3.8	4.7	4.1
C	Mongolian	70 %	4.5	4.3	4.6
D	Hmong	85 %	3.9	4.4	4.2

5. CONCLUSION

This paper studies the stability of immersive digital cultural communication systems around local language and culture, and concludes that increasing the linguistic text feature vector decreases from 5% to 0.5%. It shows that the immersive communication system can better capture and disseminate local language and culture. As the feature vector increases, the machine omission rate gradually decreases, but the lowest is 6% and 4%, which is still higher than the immersive communication system. Adaptability and stability analysis Mongolian user participation is 70%, Hmong unity operation stability is 4.4 points, and Hmong unity operation stability is 4.4 points, in summary the overall satisfaction of the system is high. However immersive technologies such as virtual reality or augmented reality may require expensive equipment and advanced technical support, limiting the popularity and accessibility of the study. Technology implementation may be more challenging in areas with limited resources.

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